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The impact of high-immersion virtual reality on foreign language anxiety

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Abstract

Public speaking, especially in a foreign language, is associated with increased anxiety. Research has shown the potential of virtual reality (VR) for simulating real-life experiences, allowing for public speaking practice in an ecological and safe environment. This between-subjects study investigated the effect of VR on foreign language anxiety (FLA) in public speaking practice. Intermediate learners of English participated in eight public speaking sessions over a three-month period, yielding 160 research observations. The experimental intervention took place in high-immersion VR with subjects wearing a VR headset and speaking in front of virtual audience. In the control intervention, subjects used a videoconferencing platform (Zoom) to speak in front of a real-life audience. Multivariate regression analysis revealed that practicing speaking in VR was associated with statistically significant lower FLA scores, compared with speaking practice using Zoom. The study found that VR technology had a positive effect on practicing public speaking in a foreign language. The research findings have practical implications for professionals and curriculum designers in various domains where public speaking skills are essential. For example, incorporating VR-based public speaking practice can benefit professionals preparing for a job interview, an elevator pitch, or a conference presentation. Curriculum designers can consider integrating VR simulations into language courses to provide students with realistic public speaking experiences. This approach can help students overcome language barriers, reduce anxiety, and develop their communication skills in a controlled and supportive environment.

Keywords: Virtual reality (VR), Foreign language anxiety (FLA), Virtual assistants, English as a foreign language (EFL), Pedagogical agents, Simulations, Speaking practice, Public speaking, Zoom

Introduction

Public speaking is an essential skill for many professionals (Kuai et al., 2020), yet speaking or presenting in public is associated with elevated levels of anxiety (Smith & Sodano, 2011). Speaking in public can trigger fear and the expectation of negative feedback from others (Schlenker & Leary, 1982). Public speaking anxiety is also common to language learners who are concerned about being misunderstood or ridiculed, due to their accent, limited vocabulary, or grammatical errors. This particular type of anxiety is called foreign language anxiety (FLA), and it has been investigated extensively in language

learning research (see Jin et al., 2021; Li et al., 2021), seeking to help language learners reduce FLA or learn how to cope with it.

Some evidence exists that the use of technology can help reduce FLA (Stupar-Rutenfrans et al., 2017). Decreased speaking anxiety, relative to face-to-face interactions, may be due to technology creating a shield or comfort zone. Facing a real person while speaking may evoke undesirable emotions, including anxiety. Examples of technologies used by language educators for speaking practice are videoconferencing tools (e.g., Zoom, Skype), virtual worlds (e.g., Second Life), and high-immersion virtual reality (VR; e.g., Vtime XR, Immerse). The factors influencing the level of anxiety vary depending on which technology is used and, for instance, whether the speaking takes place in front of a real person, on Zoom, or in front of a virtual human in VR. Which platform, video-based or VR, is more effective for public speaking practice for language learners remains unknown.

Recent advances in VR technology and its growing availability have provided researchers with a novel experimental method, combining high ecological validity with experimental control (Parsons, 2015). VR mimics real world interactions, simultaneously sustaining experimental control needed for neurophysiological data collection (Tromp et al., 2018). The VR technology further offers new ways to practice public speaking, including speaking in a foreign language with the intention to reduce FLA.

This paper reports on an empirical, between-subjects design study of public speaking in a foreign language, which investigated settings that could reduce speakers' FLA. The research question examined differences between using VR (the treatment group) and Zoom (the control group). The impact of VR on public speaking in a foreign language compared with an online format (e.g., Zoom) that was measured based on multiple VR interventions is understudied. Therefore, findings and implications of this study contribute to the body of knowledge in the educational technology, computer-assisted language learning, and VR-assisted language learning.

Literature review

Virtual reality

Virtual reality is a rapidly developing technology that allows users to experience simulations of real-life experiences. Two main types of VR exist (Kaplan-Rakowski & Gruber, 2019; Makransky & Petersen, 2021; Xie et al., 2019). One is low-immersion VR, with experiences taking place on a desktop monitor. The other is high-immersion VR, with experiences occurring within "a computer-generated 360° virtual space that can be perceived as being spatially realistic, due to the high immersion afforded by a head-mounted device" (Kaplan-Rakowski & Gruber, 2019, p. 552). The main distinction between the two types of VR lies within the degree of immersion available. High-immersion VR offers a higher sense of presence, and authenticity compared with low-immersion VR. In this study, we focus solely on high-immersion VR.

Immersion happens when users get involved in VR to such a point that they lose their awareness of time and the real world (Radianti et al., 2020). Some researchers posit that immersion is a technological capability of VR, with objective assessment being possible (Slater & Wilbur, 1997). The technological view is that the degree of immersion experienced by the user is determined by technological attributes, such as display resolution

(Bowman & McMahan, 2007). From a psychological viewpoint, the degree of immersion is individualistic but simultaneously based on, as well as restricted by, technological attributes of the VR system (Mütterlein, 2018).

According to Slater (2018), presence can be defined as "the illusion of being there, notwithstanding that you know for sure that you are not" (p. 432). The sense of presence is elevated when a VR scenario triggers emotions (Diemer, et al., 2015). The illusion of presence is mainly a perceptual, not a cognitive, concept because VR triggers the perceptual system first, and the cognitive system reacts subsequently (Slater, 2018).

Slater (2009) showed that when a virtual human and a real human look at each other, the real human has a physical response, such as a change of heart rate, which is an indication that the particular situation triggered internal feelings. Similarly, some participants may feel that their experience is really happening; that is, a plausibility illusion takes place (Gruber & Kaplan-Rakowski, 2020; Slater, 2009). Consequently, participants' responses reflect real-life behavior. For instance, a learner speaking in front of virtual classmates and addressing them with "Hello, class" is an indication that the learner is reacting to the situation as if the classmates were real (Gruber & Kaplan-Rakowski, 2020).

Virtual reality and language learning

Until 2015, literature on VR and computer-assisted language learning mainly covered studies on learning in the virtual world Second Life (e.g., Lin & Lan, 2015; Melchor-Couto, 2017), which is low-immersion VR. A synthesis of literature on VR for foreign language learning from 2015 to 2018 shows a wealth of studies on low-immersion VR, but a limited number regarding the use of high-immersion VR (Dhimolea et al., 2022). Technological advances have offered VR that is increasingly immersive and authentic, prompting foreign language learning researchers to explore the effect of using high-immersion VR for language learning (Gruber & Kaplan-Rakowski, 2020; Gruber et al., 2023; Kaplan-Rakowski & Gruber, 2021; Lan & Grant, 2021; Papin & Kaplan-Rakowski, 2022; Taguchi, 2021; Thrasher, 2022).

Various language-specific aspects in VR settings have been explored, for example, vocabulary (Alfadil, 2020; Papin & Kaplan-Rakowski, 2022; Vázquez et al., 2018), listening (Tai et al., 2020; Ye & Kaplan-Rakowski, 2023), reading (Kaplan-Rakowski & Gruber, 2022, 2023), writing (Barrett et al., 2021; Dolgunsöz et al., 2018), and culture (Cheng et al., 2017). Developing speaking skills in VR has also gained attention (Dooly et al., 2023; Gruber & Kaplan-Rakowski, 2020; Kaplan-Rakowski & Gruber, 2021; Nobrega & Rozenfeld, 2019; Thrasher, 2022; Xie et al., 2019). Another step forward was an exploration of how VR could improve communicative skills (Dooly et al., 2023; Yang et al., 2020) and contributions of ways to reduce FLA (Gruber & Kaplan-Rakowski, 2020; Thrasher, 2022; York et al., 2021).

Foreign language anxiety

Foreign language anxiety is referred to as "the feeling of tension and apprehension specifically associated with second language contexts, including speaking, listening, and learning" (MacIntyre & Gardner, 1994, p. 284). Language scholars have invested substantial effort into studying FLA (e.g., Horwitz et al., 1986; MacIntyre & Gardner, 1991;

Zhang, 2019). FLA is a common phenomenon, negatively influencing second language acquisition (Gardner & MacIntyre, 1993) and considered potentially face-threatening for language learners (Dörnyei, 2001). Horwitz (2017) pointed out that individuals experiencing language anxiety have the *trait* of feeling *state* anxiety when learning or using a language. Sometimes a mere thought of having to use a foreign language may trigger anxiety. State anxiety is the level of anxiety a person feels from moment to moment while trait anxiety describes relatively consistent individual variations in anxiety propensity (Spielberger et al., 1970). A meta-analysis (Botes et al., 2020) of studies on the impact of FLA on academic performance confirmed earlier research (Teimouri et al., 2019) that anxiety affects achievement in all language skills (i.e., reading, writing, listening, and speaking). The impact of FLA on speaking exists in both in-person and online settings (Pichette, 2009; Russell, 2018).

Virtual reality and foreign language speaking anxiety

Researchers have made substantial efforts to study the effect of different computer-mediated communication modalities on FLA (Melchor-Couto, 2017). The means employed included audio and videoconferencing platforms (Hampel & Baber, 2003) and virtual worlds (Dickey, 2005). Study results using low-immersion VR have been inconsistent regarding the effectiveness of computer-mediated communication on FLA (Toyama & Yamazaki, 2021). The general finding of the studies testing the impact of low-immersion VR on FLA is that interacting in a virtual environment allows for shielding through a personal avatar (Kruk, 2020). Given that high-immersion VR can immerse learners in authentic learning settings (Kaplan-Rakowski & Gruber, 2021), VR has become an additional viable platform for language learners to practice speaking.

In computer-generated VR, users interact with avatars. VR offers language learners an environment in which they can make mistakes without feeling embarrassed because they are represented by an avatar and do not show their face. As a result, language learners are more likely to be willing to speak (Yang et al., 2020) and the anonymity in VR is likely to reduce FLA. This affordance of VR sets it apart from videoconferencing platforms which, when web cameras are activated, expose speakers' real faces.

To our knowledge, as of 2023, only three studies investigated how high-immersion VR impacts FLA: Gruber and Kaplan-Rakowski (2020), Thrasher (2022), and York et al., 2021. In a qualitative study by Gruber and Kaplan-Rakowski (2020), 12 university students gave eight presentations in a foreign language (English) in VR. The intention of the study was to explore the potential of risk-free VR technology to simulate a high-anxiety setting such as a virtual classroom. The researchers studied subjects' perceptions of the VR environment, the behavior of the virtual humans, the realism of the experiences, and the subjects' attitudes toward the VR speaking practice. Through the analysis of post-intervention semi-structured interviews, the researchers concluded that speaking practice in VR has the potential to reduce FLA because the subjects perceived the sense of presence and the plausibility illusion of high-immersion VR as useful aspects of speaking practice.

Intermediate learners ($N = 25$) of French in the study by Thrasher (2022) completed oral production tasks over eight weeks. One group interacted in VR while another group interacted in a face-to-face format. The analysis of scores based on

self-reported FLA questionnaires provided preliminary evidence that speaking in VR alleviates levels of FLA, making VR an attractive platform for language practice.

York et al. (2021) tested differences in the level of FLA of Japanese undergraduate learners of English ($N=30$) while they practiced speaking using audio, video, or VR. The analysis of FLA and post-experiment questionnaires yielded no statistically significant differences between the conditions. Each condition equally diminished FLA, with learners reporting to be most entertained and motivated by the VR condition.

In sum, the existing studies (Gruber & Kaplan-Rakowski, 2020; Thrasher, 2022; York et al., 2021) show that high-immersion VR is a promising setting for language learners to practice public speaking and reduce their FLA. The study by Gruber and Kaplan-Rakowski (2020) was limited to qualitative analysis of interviews, focusing on public speaking in a foreign language in VR. The study design did not include a control group. We complement their study by adding a quantitative analysis of subjects' self-reported measures of FLA, comparing them with a control group speaking on Zoom.

The study by Thrasher (2022) was of an exploratory nature and the types of interventions differed from ours. Thrasher compared VR versus face-to-face interventions, while our study compared VR versus Zoom interventions, making both studies contribute to research in a unique and complementary way.

While in York et al. (2021) subjects spoke only once, our subjects had multiple exposures to VR speaking practice. A systematic review of language research in VR by Dhimolea et al. (2022) showed that learners need multiple exposures to VR content to detect significant differences between conditions. In our study, the subjects participated in four speaking sessions, giving two presentations per session, which provided a total of eight opportunities to practice speaking and to measure FLA. In addition, we contribute with a rigorous methodology by employing a fixed effects regression model that is capable of correcting for within-subject and within-session patterns.

Drawing on the existing literature on potential affordances of VR for reducing FLA (Gruber & Kaplan-Rakowski, 2020; Thrasher, 2022; York et al., 2021), and on the theoretical foundations of immersion along with the sense of presence, this study explored the potential of VR to create a viable environment for language learners to engage in speaking practice. The main research question guiding our study was: "Is practicing speaking in high-immersion VR associated with lower FLA scores, as compared with practicing speaking using a videoconferencing tool, Zoom?" In this study, we use "Zoom" as a generic term for videoconferencing.

Zoom is a collaborative, videoconferencing platform that facilitates online meetings. It allows for synchronous communication where individuals can interact using video, sound, and chat. Zoom imitates face-to-face interactions as both verbal and nonverbal cues can be used for communication. Language learners can use Zoom for synchronous speaking practice, for instance, in intercultural online collaborations, where language learners can negotiate for meaning and practice conversational skills with their language partners. Research on online synchronous speaking practice and its impact on FLA (Fondo & Jacobetty, 2020) is growing. However, little empirical research exists on FLA when using Zoom for practicing public speaking in a foreign language. Unlike in VR, interlocutors on Zoom are typically humans who are

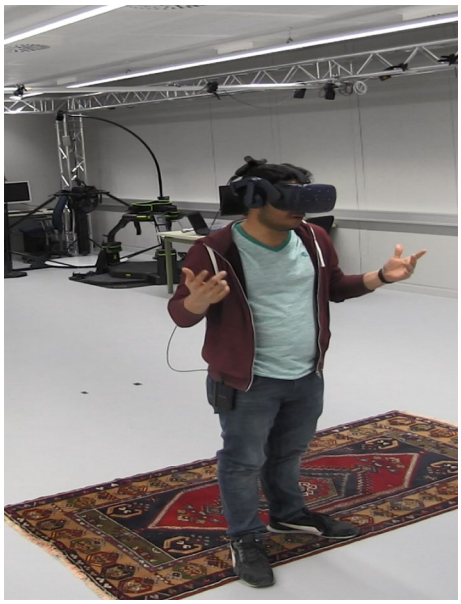

Fig. 1 Participant speaking in front of virtual humans

synchronously in the virtual room. The presence of other humans might negatively influence speakers' anxiety levels.

We hypothesize that speaking in VR in front of virtual humans reduces anxiety because practicing in front of virtual humans, instead of real people, provides a comfort zone for learners to make mistakes which might reduce embarrassment or a feeling of humiliation.

Methods

This experimental, between-subjects study used a repeated measures research design yielding quantitative data on subjects' ($N=20$) self-reported FLA**.** The subjects in the experimental group ($n_1=12$) practiced speaking in a foreign language in high-immersion VR (see Fig. 1), while the subjects in the control group ($n_2=8$) practiced public speaking on Zoom. Both groups practiced speaking on eight occasions over a three-month period. The FLA questionnaire scores served as a dependent variable, and the independent variable was the speaking setting (VR versus Zoom). The study generated 160 observations, drawn from 20 subjects and 8 presentations. The regression modeling included fixed effects to account for repeated observations of each subject (Wooldridge, 2002).

Participants

The study was advertised via newsletter and e-mail to approximately 600 students from Heilbronn University of Applied Sciences in Spring 2019. The researcher contacted the study volunteers on a first-come-first-serve-basis, and then followed with scheduling the volunteers' speaking practice sessions. Initially, we targeted a sample of about 30 learners. However, only 20 learners were able to fulfil the requirement of attending all the public speaking sessions.

The experimental condition was applied to 12 subjects (10 male, two female) consisting of ten native speakers of German, one of French, and one of Korean. The control condition was applied to eight students (three male, five female) from the same university in different study programs. The participants' mean age was 21.12 and they had studied English for 10 years on average. The proficiency level of English ranged from B1 to B2 on the Common European Framework of Reference. The study followed the ethics standards as stated in the Declaration of Helsinki. The participants received monetary incentives for completing all the study steps.

Procedure

Participants in both the VR and the Zoom conditions followed comparable procedures. They completed the same number and types of questionnaires and spoke on the same topics for the same duration. What differed was the setting (either VR or Zoom) where they spoke. VR sessions took place in a VR laboratory at the university. Zoom sessions took place remotely.

After signing consent forms, all study participants proceeded with the following seven steps:

(1) Completing a demographic questionnaire,
(2) Completing a pre-intervention FLA questionnaire,
(3) Speaking on topic #1,
(4) Completing a post-intervention FLA questionnaire after discussing topic #1,
(5) Speaking on topic #2,
(6) Completing a post-intervention FLA questionnaire after discussing topic #2.
(7) Interviews.

Steps 2–7 constitute a session. The sessions with each participant were scheduled individually. Under both VR and Zoom conditions, participants did not receive any prompts or preparation time. Instead, in a straightforward manner, the researcher initiated the intervention with "Could you talk about [topic #1]?".

Approximately two minutes into speaking, the researcher said, "Now, could you talk about [topic #2]?" One topic differed from session to session and was intended to be unexpected so as to induce foreign language speaking anxiety. The other topic remained constant throughout the sessions.

All 20 subjects participated in four sessions, each scheduled on separate days. Two topics were discussed per session, drawing from a pool of topics which included: (1) communication and the internet, (2) healthy living, (3) hobbies and free time, (4) shopping and money, and (5) cities and countryside. Altogether, the study yielded 160 oral presentations and 480 FLA questionnaire responses. Each presentation was associated with three FLA questionnaires. Because each presentation took up to two minutes, the total presentation time for all the subjects was 320 min. We implemented a two-minute time limit for presentations to accommodate the needs of foreign language learners, aligning with the duration of established speaking exams like TELC English B2 of the Common European Framework of Reference. Additionally, given the difficulty for speakers at B2 level to sustain longer monologues on a single topic, the shorter time

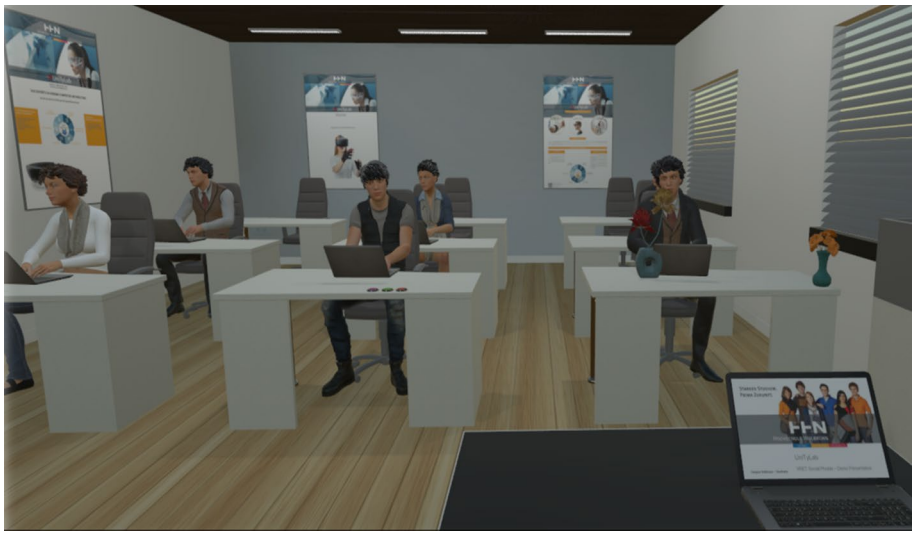

Fig. 2 The virtual humans in the virtual classroom

limit allowed for focused practice and challenged students to perform effectively within a confined timeframe.

During the VR sessions, the researcher indicated a change of topic by raising her hand after taking over one of the avatars, which was done by projecting her movements onto the virtual human, using a motion-tracking camera (Microsoft Kinect v2). The researcher talked to the participants behind a soundproof partition, and the participants heard her voice through headphones. At the end of each session, we conducted interviews on participants' experience with VR and Zoom speaking practice (Gruber & Kaplan-Rakowski, 2020).

The VR and the Zoom settings

The VR system used in the study was HTC Vive, which consists of a headset with high-resolution displays (2160 × 1200) and a refresh rate of 90 Hz. The system uses room-scale motion tracking technology with advanced sensors accurately tracking the position of the user in real-time, enhancing the sense of presence and immersion. Figure 1 shows a participant in the research lab during the VR intervention. The participant is wearing a VR headset which is facilitating the public speaking simulation. Noteworthy are the participant's hand gestures which distinctly indicate his active engagement in the public speaking simulation.

As Fig. 2 displays, the specific scene that the VR participants experienced depicted a virtual classroom.[1] The classroom consisted of virtual humans sitting at their desks, acting as the audience for the presenting students. Such a classroom offered a familiar, customized setting that resembled an everyday real-world context.

The body language, posture, and head orientation of the virtual humans were preprogrammed. The nonverbal affective expressions included nodding, hand gestures indicating reassurance (palm-down gesture), and forward-leaning posture that represents

[1] The virtual classroom was designed using Unity in UniTyLab at Heilbronn University of Applied Sciences. The setup of the classroom was originally designed for public speaking anxiety therapy.

real-world behavior in a classroom. Eye contact with the speaker was simulated because most virtual characters were programmed to look toward the direction of the desk where the speaker was standing. This simulation added to the impression of a real-life audience. Background noises consisted of distant quiet talking, which was intended to make the situation more authentic.

The researcher controlled the visual, auditory, and haptic sensory input that the participants received. The researcher could interact through a selected avatar by speaking via microphone. A motion-tracking camera (Microsoft Kinect v2) could take over the avatar by projecting the researchers' movements onto the avatar.

In the Zoom setting, the participants had their web cameras activated, allowing to simulate face-to-face interactions. During the presentations, the interlocutors used body movements such as nodding to give non-verbal feedback.

Data collection and instruments

The data collection lasted for over three months during the 2019 Spring semester. The scope of this article is narrowed down to the quantitative analysis, using Statistical Analysis Software (SAS). The study used two instruments: the demographic questionnaire and an operationalized FLA questionnaire. The demographic questionnaire consisted of 21 items and solicited information about the participants such as gender, age, native language, linguistic background, and language learning experience.

The FLA questionnaire was based on a validated instrument (Cronbach Alpha coefficient = 0.93) measuring foreign language classroom anxiety (Horwitz et al., 1986). We operationalized the Horwitz et al. (1986) questionnaire to fit the context of the study (see Appendixes A and B). Because foreign language speaking anxiety was the main focus of our intervention, we ensured that our instrument covered items relevant to speaking. We also omitted irrelevant statements (e.g., "I often feel like not going to my language class") and made adjustments to fit the VR or Zoom settings. The questionnaire was further operationalized by replacing all mentions to "FL" with "English".

One of the researchers, a native speaker of German, translated the operationalized questionnaire into German and that translation was verified with another German language speaker. The operationalized scale had a high level of internal consistency, as determined by Cronbach Alpha of 0.96.

The modified instrument required the face and construct validity. As recommended by Ary et al., (2010), we formed a panel of experts to help us with evaluating the face and construct validity of our modified instrument. The evaluation was conducted independently by two second language acquisition (SLA) experts, two educational technology professors, and one neuropsychologist. Each expert held a doctoral degree from renowned universities and were actively engaged in research within their respective fields. To gather feedback on the first draft of our FLA questionnaire, we started by engaging two experts in SLA. We shared the draft as a Word document and requested them to evaluate each questionnaire item, specifically focusing on the appropriateness of the FLA concept. The experts tracked changes and provided their feedback, which we subsequently combined and thoroughly discussed. Through this iterative process, we actively sought consensus on the questionnaire items, ensuring that they accurately captured the essence of FLA. The process of gathering feedback from the two educational

technology professors and the neuropsychologist followed a similar approach. However, in this instance, these three panel members were specifically requested to evaluate the questionnaire items from the lenses of educational technology and the psychological aspects of VR-based learning.

The feedback received from the panel allowed us to fine-tune our instrument, consequently, the face and construct validity was confirmed.

We generated four versions of the questionnaire to reflect the intervention type (i.e., VR/Zoom) and to reflect the intervention timing (i.e., pre-/post-). The four versions were:

(1) Pre-intervention VR questionnaire (Appendix A),
(2) Post-intervention VR questionnaire (Appendix B),
(3) Pre-intervention Zoom questionnaire,
(4) Post-intervention Zoom questionnaire.

All the versions were identical except for two minor differences. First, because the pre-intervention questionnaires were administered before the intervention, they used the present tense. Meanwhile, the post-intervention questionnaires used the past tense because they were administered after the intervention. Second, the VR questionnaires used relevant mentions of VR, while the Zoom questionnaires had relevant mentions of Zoom.

Results

Our data are constructed from double-repeated measures for each subject. That is, each subject's FLA was measured three times in each session, and sessions were conducted four times. To appropriately correct for repeated measurements of each subject, we estimated a fixed effects regression model (Wooldridge, 2002), with time fixed effects for both tests and sessions. The regression model is given in Eq. (1):

$$\begin{aligned} FLA_{i,t,s} = \beta_0 + \beta_1(test_2) + \beta_2(test_3) + \beta_3(session_2) + \beta_4(session_3) \\ + \beta_5(session_4) + \beta_6\left(VR_{i.t,s}\right) + e_{i.t,s} \end{aligned} \tag{1}$$

where the *FLA* measure was defined as the sum of the scores from the FLA instrument for subject i in session s and test t, minus the score for subject i on the initial session 1 pretest. Because each subject is compared to their own pretest, the measure automatically accounts for across-subject variation, such as from previous language experience, baseline individual anxiety levels, demographics, age, gender, and personality. This approach is referred to as a difference-in-differences methodology in the wider social sciences and is considered a reliable method of inference when subjects are evaluated before and after a treatment effect (Donald & Lang, 2007).

Our coefficient estimate on the VR variable provides a measure of the effect size and can then be interpreted as the marginal impact of VR on FLA relative to other subjects in the same test and the same session. The use of fixed effects has the added benefit of correcting for learning, adaptation, and novelty effects over time. The fixed effects are indicated in Eq. (1) by the terms $session_s$ and $test_t$, which indicate dummy variables for tests two through four and sessions two and three. Fixed effects are not indicated for the first test and first session, as this is captured by the model's intercept term, β_0.

Table 1 Regression results

Variable	Coefficient estimate	Standard error	*t* value	Pr >|*t*|
Intercept	−0.18	1.57	−0.11	0.91
Virtual reality (VR)	−1.81*	0.91	−2.00	0.05
Session 2	0.69	1.40	0.49	0.62
Session 3	0.69	1.40	0.49	0.62
Session 4	0.41	1.40	0.29	0.77
Test 2	0.23	1.17	0.19	0.85
Test 3	−1.30	1.17	−1.11	0.27

*Indicates significance at the 5% level

Table 1 reports the multivariate regression results for the estimation of Eq. (1). The intercept term, β_0, can be interpreted as the impact of the Zoom control condition on FLA and was not significantly different from zero. The VR treatment was significantly and negatively associated with FLA ($t = -2.00$; $p = 0.0468$). The coefficient estimate of -1.81 for β_6 indicates that FLA was 1.81 points lower following the VR treatment, after correcting for the session and test sequence. To interpret the effect size, the coefficient estimate of the VR treatment was consistent with a reduction in FLA about ten times greater than the in the control condition (-1.81 coefficient estimate on β_6 compared to model intercept, β_0, of -0.18). The statistical strength of the VR effect is evident from the significance of the coefficient estimate for β_6 (t-statistic of -2.00, p value of 5%) on VR despite the small number of subjects and the multiple fixed effects terms included in the model. Dummy variables, or fixed effects, for the session and test sequence were all insignificant, indicating that FLA was not significantly different on later sessions or tests, relative to the initial pretest. The model R^2 was 3.3%.

Discussion

The main finding of the study is that practicing speaking in VR is associated with significantly lower anxiety scores, compared with practicing speaking on Zoom. While this finding is mostly aligned with the existing literature (Gruber & Kaplan-Rakowski, 2020; Thrasher, 2022), our contribution differs from previous studies. This previously lacking quantitative evidence (Parmaxi, 2023) was founded on repeated VR and Zoom interventions and contributes to the literature in several meaningful ways. First, our findings enrich research by confirming the qualitative findings by Gruber and Kaplan-Rakowski (2020) in which, based on semi-structured interviews, the researchers concluded that speaking practice in VR could serve as a useful setting in terms of FLA. Our finding adds to their evidence in that we used statistical calculations and a control group of students speaking on Zoom.

Second, York et al. (2021) found that practicing in VR lowered FLA, but the rate was insignificantly different compared with other media, such as voice or video. Our study provides support for the growing body of evidence that, compared with video format, VR-based public speaking can be more effective with regard to reducing FLA. One reason could be that our participants performed in front of programmed virtual humans, whereas participants in York et al. (2021) interacted with real classmates, who were represented by avatars.

Third, our participants had eight occasions to speak, increasing the chance for VR to be effective. According to the systematic review by Dhimolea et al. (2022), VR interventions are more likely to be statistically significant when subjects are exposed to VR interventions multiple times.

The interview data in (Gruber & Kaplan-Rakowski, 2020) support the quantitative finding in this study. During the semi-structured interviews, some participants who exhibited signs of public speaking anxiety employed different strategies to deal with their anxiety within the VR environment. For instance, one student expressed the belief that VR had the potential to replicate a classroom setting, thereby enabling him to conquer stage fright. Another student remarked that thanks to the repeated public speaking practice sessions, he developed a routine that made him feel less anxious. Yet, a participant who experienced high anxiety during real-life presentations reported that he wanted to use VR as a means to practice for an upcoming foreign language class presentation (Gruber & Kaplan-Rakowski, 2020). Participants cited the ability to move and talk in a classroom environment in a realistic setting as a benefit of practicing in VR as opposed to practicing speaking, for example, in front of a mirror (Gruber & Kaplan-Rakowski, 2020). Such iterations seem to reveal that subjects felt comfortable in the VR setting, which goes along with our study finding.

Implications

This study finding has several pedagogical implications and is useful to educators and curriculum designers who should consider recommending speaking practice sessions in VR to their learners. Speaking simulations in VR can be particularly useful for students who are prone to anxiety when giving presentations or individuals preparing for inherently stressful situations such as a job interview or an elevator pitch. The reason is that repeatedly practicing in front of a virtual audience in VR is potentially nonthreatening.

From a practical point of view, the equipment used in our study was high-end and therefore not accessible to everybody. However, low-cost devices exist which allow students to insert their mobile phones into a VR viewer (e.g., Google Cardboard) that can provide similar speaking simulations as described in this study. The number of higher education institutions with VR laboratories is growing, and VR devices are increasingly affordable. Therefore, the augmenting affordability and accessibility of VR devices increasingly allow students to practice speaking in a foreign language on their own, which fosters autonomy.

While certain benefits of practicing public speaking in VR exist, acknowledging its drawbacks is necessary. Typical issues include the risk of cybersickness, potential technical difficulties, and the limited ability of VR to accurately replicate and effectively practice body language and mimicry. However, this last limitation is being addressed with the newest VR systems, such as Oculus Pro (Gruber & Kaplan-Rakowski, 2022). Presenting in a foreign language in front of real humans using a videoconferencing tool (e.g., Zoom) is likely to make presenters more anxious due to features such as the heightened amount of eye gaze at a close distance, or the real-time camera feed (Bailenson, 2021). In contrast, speakers in VR are shielded through an avatar, which may have a positive effect on their anxiety levels.

Regarding the conduct of VR-based public speaking research, although it offers numerous benefits, it also presents several challenges and risks. For instance, potential emotional distress when simulating anxiety-inducing situations like public speaking might occur. Moreover, there is limited prior research to draw upon, making it necessary for researchers to navigate this underexplored research territory.

Limitations and future studies

A recognition of certain limitations within this study should be noted. A limitation in FLA studies is often the sole use of self-reported questionnaires which are prone to bias. In our study, we administered self-reported questionnaires, and a wearable *Empatica E4* collected objective data (e.g., heartrate and electrodermal activity), but reporting these data extends the scope of this paper. To collect objective data to detect emotional states, future studies should use eye-trackers, wearable devices, or automatic emotion recognition tools. Alternatively, salivary cortisol samples could also provide alternative measures of FLA, as reported by Thrasher (2022).

Future endeavors should extend this type of study to more participants, subjects from different age groups, learners with different proficiency levels, various task complexities, and different presenting conditions (e.g., small or large audiences, with or without an activated camera). Future studies could explore the effect of diverse virtual environments. For instance, a comparative analysis could be conducted between presenting in VR using computer-generated content and realistic content using 360-degree videos. Alternatively, a comparison between the effectiveness of using VR as opposed to mixed-reality devices can constitute another future research endeavor.

Future research endeavors could study other factors that influence FLA including contextual factors (e.g., speaking task complexity, time constraints) or cultural factors in which learners' backgrounds and experiences may play a role. Moreover, coping with FLA could be done using emotional regulation strategies such as relaxation techniques or mindfulness because such approaches have the potential to regulate anxiety (e.g., Kaplan-Rakowski et al., 2021) in high-stress situations.

Conclusions

Speaking in public, and especially in a foreign language, is associated with increased levels of anxiety. Given the foundations of VR-based theories and the related literature on the topic of public speaking, our study answered the research question: "Is practicing speaking in high-immersion VR associated with lower FLA scores, as compared with practicing speaking using a videoconferencing tool, Zoom?" Learners of English practiced speaking in public on eight occasions either in VR or on Zoom. We explored how VR and Zoom settings impacted the participants' FLA levels. The quantitative analysis revealed that practicing speaking in VR was associated with significantly lower anxiety scores, compared with practicing speaking on Zoom. This research contributes to understanding the potential of VR technology to support students when practicing for public speaking in a foreign language, including presentations in an academic or corporate context.

Appendix A

The German and English versions of the operationalized pre-intervention FLA questionnaire.

The German version

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zustimmen (stimme voll und ganz zu, stimme zu, weder noch, stimme nicht zu, stimme überhaupt nicht zu)

1. Ich fühle mich nie ganz sicher, wenn ich Englisch spreche.
2. Ich mache mir keine Sorgen, wenn ich Fehler im Englischen mache.
3. Ich zittere, wenn ich weiß, dass ich aufgefordert werde, Englisch zu sprechen.
4. Es macht mir große Angst, wenn ich Englisch sprechen muss, ohne vorbereitet zu sein.
5. Im Fremdsprachenunterricht werde ich so nervös, dass ich Dinge vergesse, die ich eigentlich weiß.
6. Auch wenn ich gut auf das Sprechen in Englisch vorbereitet bin, mache ich mir Sorgen.
7. Ich bin selbstbewusst, wenn ich Englisch rede.
8. Ich fühle, wie mein Herz bis zum Hals schlägt, wenn ich Englisch sprechen muss.
9. Ich fühle mich unsicher, wenn ich vor anderen Leuten Englisch sprechen soll.
10. Ich denke, ich bin angespannter und nervöser, wenn ich nicht meine Muttersprache, sondern Englisch sprechen soll.
11. Ich werde nervös und verunsichert, wenn ich Englisch spreche.
12. Wenn ich weiß, dass ich Englisch sprechen werde, fühle ich mich sehr sicher und entspannt.
13. Ich fühle mich von der Zahl der Regeln, die man in Englisch lernen muss, überfordert.
14. Ich habe Angst, dass andere Studierende über mich lachen werden, wenn ich Englisch spreche.
15. Ich würde mich unter Englisch-Muttersprachlern:innen wahrscheinlich wohl fühlen.

The English version

Please indicate your level of agreement with the following statements (strongly disagree, disagree, neutral, agree, strongly agree).

1. I never feel completely confident when I speak English.
2. I don't worry when I make mistakes in English.
3. I tremble when I know I am going to be asked to speak English.
4. It scares me a lot when I have to speak English without being prepared.
5. I get so nervous in foreign language classes that I forget things I actually know.
6. Even if I am well prepared for speaking in English, I am worried.
7. I feel self-confident when I speak English.
8. I feel my heart beating up to my throat when I have to speak English.
9. I feel insecure when I have to speak English in front of other people.
10. I think I am more tense and nervous when I have to speak English instead of my mother tongue.
11. I get nervous and insecure when I speak English.
12. When I know I am going to speak English, I feel very confident and relaxed.
13. I feel overwhelmed by the number of rules you need to learn in English.
14. I am afraid that other students will laugh at me when I speak English.
15. I would probably feel comfortable around native English speakers.

This version of the questionnaire was used for both the VR and Zoom groups

Appendix B

The German and English versions of the operationalized post-intervention FLA questionnaire.

The German version

Bitte beantworten Sie die Fragen in Hinblick auf das Thema, über das Sie gerade gesprochen haben (strongly disagree, disagree, neutral, agree, strongly agree).

1. Ich habe mich nie ganz sicher gefühlt, als ich gerade Englisch gesprochen habe.
2. Ich habe mir keine Sorgen gemacht, dass ich Fehler im Englischen mache.
3. Ich habe gezittert, als ich angefangen habe, Englisch zu sprechen.
4. Es hat mir große Angst gemacht, als ich Englisch sprechen musste, ohne vorbereitet zu sein.
5. Ich wurde so nervös, dass ich Dinge vergessen habe, die ich eigentlich weiß.
6. Auch wenn ich mich gut auf das Sprechen in Englisch vorbereitet fühlte, habe ich mir Sorgen gemacht.
7. Ich habe mich selbstbewusst gefühlt, als ich Englisch geredet habe.
8. Ich habe gefühlt, wie mein Herz bis zum Hals geschlagen hat, als ich Englisch sprechen musste.
9. Ich habe mich unsicher gefühlt, als ich vor anderen in VR Englisch sprechen sollte.
10. Ich denke, ich war angespannter und nervöser, da ich nicht meine Muttersprache, sondern Englisch sprechen sollte.
11. Ich war nervös und verunsichert, als ich Englisch spreche sollte.
12. Obwohl ich wusste, dass ich Englisch sprechen musste, fühlte ich mich sehr sicher und entspannt.
13. Ich hatte Angst, dass die andere Studierenden in VR über mich lachen werden, wenn ich Englisch spreche.
14. Ich wurde nervös, als ich auf Englisch in VR über dieses Thema sprechen musste, das ich nicht vorher vorbereitet hatte.

The English version

Please answer the questions with respect to the topic you just talked about (strongly disagree, disagree, neutral, agree, strongly agree).

1. I never felt completely confident when I spoke English just now.
2. I didn't worry about making mistakes in English.
3. I was shaking when I started speaking English.
4. It worried me a lot when I had to speak English without being prepared.
5. I got so nervous that I forgot things I actually know.
6. Even though I felt well prepared for speaking in English, I was worried.
7. I felt self-confident when I spoke English.
8. My heart was pounding when I had to speak English.
9. I felt insecure when I had to speak English in front of others in VR.
10. I think I was more tense and nervous because I had to speak English instead of my mother tongue.
11. I felt nervous and insecure when I was supposed to speak English.
12. Although I knew I had to speak English, I felt very confident and relaxed.
13. I was afraid that the other students in VR would laugh at me when I speak English.
14. I got nervous when I had to speak in English in VR about this topic that I had not prepared beforehand.

This version of the questionnaire was used for the VR group. The version for the Zoom group was identical with the difference that the notions of VR were replaced with the notions of Zoom

Abbreviations

VR	Virtual reality
FL	Foreign language
FLA	Foreign language anxiety

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