reconnect
Reconnecting relationships through technology

‘It’s not so scary anymore. It’s actually exhilarating’: A proof-of-concept study using virtual reality technology for music performance training under pressure.

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Extended lockdowns associated with the COVID-19 pandemic severely ruptured the capacity of performing artists to connect with peers and colleagues in professional and educational contexts. In this study we test a protocol for the use of immersive performance technologies in tertiary institutions to provide developing and early career musicians to connect with pedagogues and access safe, realistic spaces within which to practice performing under varying degrees of pressure. We investigated the affordances of a VR environment to trigger performance anxiety, and the effectiveness of a synchronous digitally mediated environment for tertiary educators to train a key performance psychology skill. Heart rate, self-reported anxiety and confidence measurements were taken over four levels of situational stress and performance demands. Results revealed that the technology enabled a pre-performance routine to be effectively taught online by an instructor to a musician wearing a VR headset. Notably, this was achieved by both participants being in separate locations without detriment to the teacher-student relationship. This study provides encouraging insight into the capacity for immersive technologies to help students effectively manage the stresses of live performance in both virtual and real worlds.

Keywords: Musicians, Immersive Environments, Performance Anxiety, Educational Technology

Introduction

Simulation training is used to develop performance skills in various disciplines, particularly where in-situ training is either impossible or unsafe to implement (Renganayagalu et al., 2021). Such training enables learners to acclimatise to real-life stressors and anxiety-inducing scenarios in physically and/or psychologically safe environments, to protect against performance decrements which reveal themselves in high pressure contexts rather than low-stress practice sessions. Recent work using virtual reality (VR) provides preliminary evidence of the capacity of this technology to evoke the intense anxiety which accompanies music performance (Fadeev et al., 2020; Fanger et al., 2020). In this proof-of-concept study, we explore the capacity of VR to assist music students to develop technical and psychological competence to perform at their best under pressure, implemented within tertiary music institution settings.

In early 2020 the COVID-19 global pandemic led to an almost overnight shift in the work and practices of the performing arts sector. The pandemic has had a profound and ongoing effect on performing arts professionals who have faced a substantial reduction in work and income, coinciding with increased anxiety, loneliness, and financial hardship (Spiro et al., 2021). This shift has equally been felt in the education sector, where the pivot to digital learning brought about by social distancing and lockdowns, has resulted in fractured relationships impacting students, staff, and the practices of research collaborations (Spreadborough et al., 2022). While the pandemic was not the catalyst for research and development in the use of immersive technologies for music performance (among other artistic practices), it did engender a deep sense of urgency to investigate how to reconnect with students and colleagues in meaningful ways. Indeed, our preparedness to embrace and harness immersive technologies will have enduring ramifications for performer wellbeing, accessibility, and readiness to perform.

Immersive technologies such as VR may play an important role for musicians to develop their performance techniques and performance skills under pressure. Performance stress and anxiety is a significant health and performance issue for musicians, with approximately 20% of professional musicians reporting that it adversely affects their career (Osborne & Kirsner, 2022). Pre-performance routines substantially reduce the likelihood of

choking under pressure, particularly in tasks which combine psychological and behavioural components such as music performance (Hanton et al., 2004; Mesagno & Mullane-Grant, 2010). Such routines attempt to down-regulate the performer's autonomic nervous system fight-flight-freeze response which results in excessive muscle tension and negatively impacts the execution of highly refined fine motor skills. The centering[1] technique is one such strategy that has proven efficacy for reducing debilitating performance anxiety whilst simultaneously improving performance preparation, confidence, courage, focus, concentration, and performance resilience in conservatorium music students (Osborne et al., 2014). This self-regulating technique can be used pre- and mid-performance to control overactive autonomic activity and refocus attention towards performance cues which assist the execution of the musical piece in high pressure performance situations. In this technique the performer begins by quieting their eye gaze before verbalising a clear intention of what is to be accomplished in the task, e.g., "I'm going to play the opening phrase with confidence". A breathing technique is then employed which is initially focused on taking deep breaths in and out of the abdominal area, before changing to tension release in key muscle groups common in anxiety (e.g., jaw and shoulder tension), as well as those required to play their instrument. The performer then visualises an optimal execution of their stated intention - feeling, hearing and seeing themselves performing well. When this is clear in their minds, the performer starts to play. This process takes approximately 90 seconds to complete and can be shortened with practice (see Osborne et al., 2014, for more detail on the steps). Centering has been taught effectively in a tertiary education context to university students in face to face (Osborne et al., 2014) and dual-delivery simultaneous face-to-face and online delivery mode (Osborne, 2020), but not in a hybrid online-immersive VR environment.

Simulation training involving VR is used to develop performance skills in various disciplines such as surgery and sport where performance failures may have devastating consequences (Akbaş et al., 2019; Renganayagalu et al., 2021). Following the acclimatization principle, training under mild levels of anxiety can prevent choking when people are required to perform with higher levels of anxiety (Oudejans & Pijpers, 2010). To prepare to move from spending hours practicing alone in practice rooms and into dynamic and high stress live performance contexts such as an audition panel or concert hall, musicians can simulate the physical space of their upcoming performances. Interventions of this nature in tertiary education settings include the fit-out of physical rooms with adjoining backstage and stage area, ceiling mounted projectors to project life-sized audiences or audition panels onto walls, spotlights, and speakers (Bissonnette et al., 2016; Williamon et al., 2014). In these semi-immersive spaces musicians can practice walking from the green room and side of stage to the concert stage, before commencing their performance. The expressions and responses of the pre-recorded audience members can vary from responding very favourably to becoming more aggressive. These simulated performance environments provide a bridge between imaginal and in-vivo exposure, with equivalent state anxiety and physiological patterns of heart rate variability being recorded across simulated and actual auditions in front of live judges, and decreased anxiety across sessions accompanied by improved performance quality within sessions (Bissonnette et al., 2016; Williamon et al., 2014). These in-situ interventions raise questions of resource accessibility. Currently, and prior to COVID-19 restrictions, the opportunity for students to perform in concert halls, and to experience the associated pressure of a live audience, were - and remain - limited. The extensive lockdowns and restrictions in place during the COVID-19 pandemic has resulted in a reduction of opportunities to access physical spaces to practice and perform, including the on-site simulation facilities in place in certain tertiary institutions. Long-term questions also exist regarding access for students of diverse backgrounds, levels of competency, ableness, and career and/or life stage. VR may provide a unique platform to address these issues while providing realistic and ecologically valid performance situations for musicians.

One early adopter of the use of VR to assist musicians to alleviate music performance anxiety is the PIANX platform (Fanger et al., 2020). Designed specifically for pianists, the PIANX platform is a Mixed Reality platform consisting of a MIDI (Musical Instrument Digital Interface) stage piano and an HTC Vive Pro VR headset. The platform enabled a comparison of a virtual representation of hand tracking and a real representation using see-through VR, as well as three different performance settings in which to practice: home, audition, and concert hall. Unfortunately, despite the promise as a fully immersive VR performance experience in these three settings, due to COVID-19 constraints the researchers were unable to place musicians directly into the apparatus. Instead, 23 participants took part in an online study in which they watched a series of videos demonstrating features of the system and provided feedback ratings on what they *expected* they would feel. Ratings reflected real life comparisons of lower to higher stress contexts, with no significant differences in anxiety ratings between the audition and concert hall, and lower anxiety ratings between each of those conditions to the living room condition. These results are promising and lend support to the notion that VR can

[1] The American spelling is intentionally used when referencing the centering technique in this article for consistency with extant research and instructional literature.

stimulate performance anxiety. However, a major limitation is that participants did not participate in the actual VR simulation. The design of this study potentially underestimates the impact of VR on physiological responses and evocation of music performance anxiety. Further studies in controlled experimental conditions including physiological sensors to measure participant stress and anxiety levels more accurately in a fully immersive VR environment were recommended.

The current study
This proof-of-concept study was designed to address two elements. First, we extend the work of Fanger and colleagues (2020), by investigating the affordance of a VR environment to trigger the physiological fight-flight response that accompanies performance anxiety in a non-pianist. Second, we assess the affordance of a digitally mediated environment to enable tertiary educators to form productive teaching and learning relationships with students when training performance psychology skills online and virtually.

Method

Participants

The musician participant (second author, Glasser) in this study is a highly trained violinist (30+ years' experience) with early professional experience as a member of a state symphony orchestra. Professional performance in recent years is, however, minimal; Glasser's professional involvement is currently in teaching and research activities with music performance students. Glasser therefore has an acute awareness of the needs and perceptions of this population. A registered psychologist and performance psychology lecturer (first author) guided the musician through the procedure. The technical setup, recording and video post-production was facilitated by a support technician (third author). All three members were located in their respective homes due to state-issued lockdown laws preventing onsite gatherings arising from the COVID-19 pandemic.

Materials

Richie's Plank Experience (Toast VR, 2016) was used as the VR application to approximate the physiological symptoms of high-stress performance for the musician. This application has been used previously for VR studies such as exposure therapy (Hu et al., 2018; Ramdhani et al., 2019). An Oculus Quest 2 headset (rebranded as the Meta Quest 2 in November 2021) owned by the musician was used for running the plank experience. One-second intervallic heart rate data was captured using a Polar OH1 optical sensor secured to the musician's forearm.

Communication between the psychologist, musician and technician was co-ordinated using the Zoom video conference platform. The psychologist guided the participant remotely through the routine via Zoom, whilst the participant was immersed in the VR environment. Audio and video recording of the participant and psychologist was captured by the technician on a MacBook Pro using the Zoom recording function. The first-person perspective view from the Oculus Quest 2 was captured using the in-built recording function of the headset. The heart rate information was generated by converting intervallic heart rate data from a .CSV file into a visual display ticker and saved as an mp4 file. The heart rate video, Zoom recording and captured plank experience was then edited together and exported as an mp4 file using DaVinci Resolve v17 editing software. The images depicted in the figures were taken from screenshots of the composited mp4 file.

Procedure

This study was designed as a researcher-as-participant paradigm (Probst, 2016). As per the Declaration of Helsinki (World Medical Association, 2013) and the National Statement on Ethical Conduct in Human Research (National Health and Medical Research Council, 2007), ethics committee review is not explicitly referenced as being required for self-experimenters, and therefore formal ethics approval was not sought. The lead author, as a registered psychologist with the Australian Health Practitioner Regulation Authority, was operating under the professional code of ethics. Verbal informed consent was obtained from the participating researcher (second author) prior to commencing the intervention. Two weeks prior to the exposure session, a performance psychologist (first author) taught the participant the centering pre-performance routine which has demonstrated efficacy to reduce performance anxiety in musicians (Osborne et al., 2014).

During the session the psychologist guided the participant remotely through the routine via Zoom, whilst the participant was immersed in the VR environment. Heart rate, subjective units of distress, and confidence measurements were taken across levels of exposure which varied the integration of instrument and intervention

listed in Table 1. The session included baseline measurements and all four exposure levels and took 1 hour 22 minutes to complete.

Table 1: Description of tasks for each level of exposure

Condition	Task description
Baseline	Recording heart rate and self-reported anxiety rating when standing. No centering intervention, plank exposure or instrument play.
Level 1	Walk the plank, no intervention, no instrument.
Level 2	Center and walk the plank, no instrument. Centering intention "Now I'm going to walk confidently and safely to my previous position on the plank".
Level 3	Walk the plank and play instrument, no intervention.
Level 4	Center, walk the plank and play instrument. Centering intention "Now I am going to perform confidently and safely".

Results

Heart rate (HR), subjective units of distress and confidence measurements across the levels of exposure in Richie's Plank Experience are summarised in Table 2. Figures demonstrating levels 1 to 4 can be accessed at https://doi.org/10.26188/20280321.v3.

Table 2: Heart rate, subjective units of distress and confidence measurements across exposure levels

	Baseline	Level 1	Level 2	Level 3	Level 4
Heart rate					
Mean	99.98	141.88	120.055	124.84	122.29
SD	2.63	7.01	6.26	9.61	7.33
Min	97	129	109	113	106
Max	105	158	133	135	135
Range	8	27	24	22	29
Anxiety /100	65	99	80	70	72
Confidence /100	--	70	80	60	90

Baseline measurements were taken at the start of session whilst the musician had the VR headset on but had not yet opened the Plank Experience application. The relatively high baseline self-reported anxiety of 65/100 was explained by the musician thus:

> At the moment I'm feeling pretty calm, it's peaceful, I'm in an open white space. Knowing I'm on a film in front of you two, and knowing what I'm about to do, the unknown, is making me feel a bit nervous. So I know my heart rate is higher than it should be.

The musician then opened the Plank application, entered the elevator and took it up to the plank floor before commencing the level 1 exposure task.

In level 1 we saw a dramatic elevation in HR from baseline to the first plank walk. The musician reported extreme distress during the task, which took 11 seconds from the edge of the plank in the lift to reach the end before racing back into the lift. Figure 1 shows their position within the lift looking out to the plank on the right-hand side, and their recovery position crouched on the floor in the lop left corner after they had completed the first level 1 task, as the psychologist watches and provides instructions.

Figure 1: Level 1 - Walk the plank, no intervention, no instrument

*N*ote. This figure demonstrates the musician recovering in the virtual elevator after their first time walking the plank. The HR bpm value shown corresponds to the moment the screenshot was taken.

In level 2 we saw a marked reduction in HR after the psychologist took the musician through the centering exercise in the lift prior to walking on the plank. The musician commented that they needed to reduce the sound of the city a little so they could hear and concentrate on the instructions, because the sound of the city was heightening their anxiety. Anxiety and confidence ratings were given after centering and prior to commencing the walk. Anxiety had reduced by 19 points and confidence increased by 10 from level 1. The increased confidence could be seen clearly in their body language through a more upright posture, and after shuffling along the plank and reaching the end of the plank they exclaimed with a smile, 'Woo hoo! It's not so scary anymore. It's actually exhilarating'. They then looked down, lost their balance and fell to the ground at the front of the elevator on the street below. After this exposure, the musician reported that prior to the fall they felt an intense fight-flight reaction which reminded them of the anxiety prior to giving a talk or music performance, despite their improved confidence. Physiological responses were also evidenced in increased sweating and shaking which were uncharacteristic for the musician:

> My hands don't normally get sweaty but they were wet. And my whole body shaking, sweating on my face…I remember this type of feeling when you're about to perform or give a speech, such a quick physiological response….You know, when you're waiting to go on, especially a solo performance, and your whole body starts to shut down. I couldn't concentrate on what I was meant to do.

In level 3 we saw an increase in HR once again as the musician walked the plank for the first time with their instrument and played whilst on the plank. Surprisingly, despite not centering beforehand, mean HR increased only slightly, and minimum and maximum HR was comparable to level 2. The subjective difference in the difficulty of this task was evidenced by both anxiety and confidence ratings reducing by 10. The level of immersion the musician was experiencing in that moment was described by their concern for the instrument being damaged by the virtual environment:

> It's weird because I don't feel like…I've got one foot on the plank, and I don't feel like I can put my arms out because I think I'm going to hit my violin against the wall of the elevator. I'm actually more concerned for the instrument than I am for myself at the moment.

Yet immersion was not absolute, as the musician also described that the ongoing communication to the psychologist over Zoom enabled them to feel tethered to the real world.

In level 4, we saw a minor drop in HR after centering in the lift before the musician walks the plank with their instrument and plays for a second time (see Figure 2). Interestingly, the inclusion of centering had the most impact on confidence levels which improved by 30 points from level 3. Anxiety remained steady.

After completing the final exposure task, the value of the Plank Experience application and guided practice to downregulate the physiological symptoms and subjective anxiety that can accompany music performance was encapsulated by the musician's comments:

Well it did (help me focus). And I think one of things that it did, is that it actually allowed a habituation of the sights and sounds as well. So in a really calm way, to just look around and feel safer…' (when in the elevator) '…made it feel less menacing or less dangerous'… 'I think after doing this, playing in a concert hall would be a piece of cake.

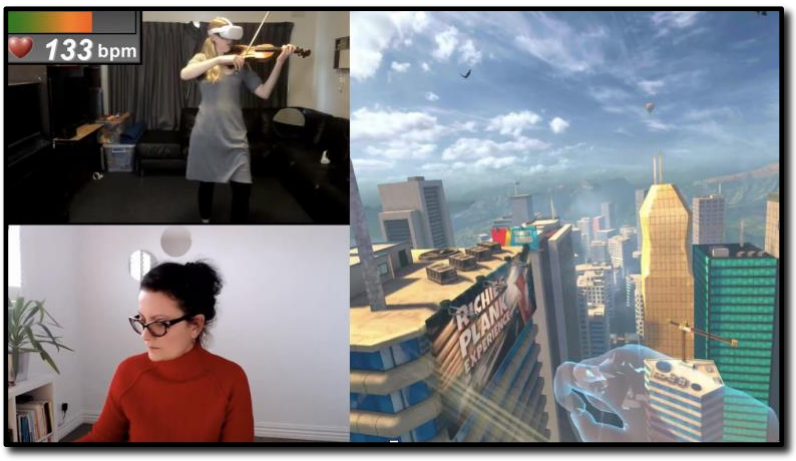

Figure 2: Level 4 - Center, walk the plank and play instrument.
Note. This figure demonstrates the musician playing the violin on the edge of the plank after a guided centering in the lift. The HR bpm value corresponds to moment the screenshot was taken.

Discussion

In this study we explored the affordance of a fully immersive VR environment to trigger the physiological and subjective fight-flight response that musicians can experience when they perform in high stress environments. We also assessed the effectiveness of a digitally mediated environment for tertiary educators to teach a pre-performance routine online to enable performers to practice the skills required to manage high levels of performance anxiety. Our findings confirm that Richie's Plank Experience VR application induces a notable stress response. We also show that a musician can be receptive to pre-performance routine instructions to downregulate their stress response when they are delivered online with the musician inhabiting an immersive virtual environment. The routine helped the musician feel poised and centred when walking the plank, and when playing their instrument. They were able to achieve a performance focus in the VR environment, demonstrated by decreased anxiety and increased confidence ratings across progressive performance tasks.

Examining the data we see evidence for the effectiveness of the centering technique, as well as habituation to stress over repeated walk-the-plank exposures. After centering, the musician demonstrated a dramatic reduction in HR from the first walk in level 1 to level 2, accompanied by their subjective experience changing from fear to exhilaration. Subsequent levels showed minor variation in HR. The increase in HR at level 3 was expected given it was the first time the musician had played their instrument on the plank. Interestingly, despite HR moving in expected directions given task requirements across the levels of exposure, the degree of HR variation was minimal. In level 3, the first play of the instrument on the plank *without* centering beforehand, the lower anxiety rating may be indicative of habituation to the task over repeated exposures in the same session. The lower confidence rating may also be a consequence of not having centered beforehand. By level 4, after four walks and centering with a clear performance intention, the musician's confidence rating had increased by a third, to almost 100% confidence in the task of playing their instrument confidently and safely on the plank. This is remarkable given that they had previously fallen off the plank and had experienced marked distress. It is also a testament to the capacity of the instructor and the musician to achieve an effective performance training outcome through a combination of video conferencing and VR technology.

One of the major affordances that VR can provide is the feeling of being in different place to the one that your body is physically located, referred to as *place illusion* (Slater, 2009; Slater et al., 2022). This phenomenon was seen in the actions of the musician on the plank based on two observed behaviours. Firstly, when carefully walking across the plank to avoid falling off and secondly, protecting the violin from hitting the virtual elevator doors when stepping back off the plank. The musician's sense of *self-embodiment*, i.e., having a body within a virtual environment (Jerald, 2015), was also observed during the session. In this case, the musician informing

the psychologist of intermittent hand tracking (due to instrument occlusion) as well as not being able to see their own instrument.

This study addressed a major shortfall in Fanger et al's (2020) PIANX study by fully immersing a musician in a stress-inducing VR environment whilst performing their instrument. We utilised Richie's Plank Experience to trigger the physiological response which accompanies stressful music performance in the absence of accessibility to a virtual stage. Since conducing this study, work is emerging on bespoke applications for performance practice such as "VR Rehearse & Perform" (Lalioti et al., 2021). Their proof-of-concept platform combines visual and acoustic features of a virtual auditorium to simulate performing on stage. Similar to our own observations, they also reported performance challenges with performers not being able to see their own instrument in VR. Future studies of this nature could be further enhanced using more extensive biometric data such as eye tracking, heart-rate variability, pupillometry and facial expressions. These types of measures in a performance and educational context are worthy of further investigations in their own right.

The use of immersive technology in both educational and performance contexts also raises ethical considerations. The IEEE Global Initiative on Ethics of Extended Reality (XR) has produced a set of recommendations for consideration in the educational context including areas related to data privacy, user consent, accessibility and others (Mangina, 2021). Further work is required in this area to assist ethics committees appropriately balance the risks with the potential benefits of this technology in training and research.

Conclusion

Our study provides initial evidence that VR can induce the situational stress required to trigger physical and psychological responses. This provides musicians with access to a safe, realistic space within which to practice psychological skills to downregulate music performance anxiety and focus on performance. This project has also identified the urgent need to develop a discourse and performance practice framework regarding ethical performance in virtual and augmented reality. The employment of a virtual environment to consider ethical questions relating to music performance outputs and practices provides a rare opportunity to instigate a transdisciplinary conversation in this timely and urgent domain and deliver creative and performance art opportunities that capture the intersectionality and confluence of the arts.

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