

# Music Performance Science with Virtual Reality: Artistic, Acoustic and Psychological Aspects and Troubles

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## Background

For years, technology enthusiasts have been fascinated by the prospect of using virtual reality headsets to "play" games or music performance apps. However, playing musical instruments within immersive environments is still a relatively new area of research, and is typically only performed under lab conditions. This paper provides an overview of previous and recent research experiments conducted by various teams.

In addition, we present new insights from our current VR project at the Motion-Emotion-Lab in Vienna, where photorealistic immersive visuals are combined with augmented audio and linked with psychophysiological measurements. Like previous anxiety studies, we show that stress levels of performers can be stimulated using VR and measured with several sensors (EMG, SCL, etc.).

While there are fantastic possibilities for using VR in a lab setting, exploring the concerted results and discussions of all approaches, there are still more problems than solutions for a broad and simple usage of this new technology. Identifying the challenges in the development process and comparing different approaches and interfaces for Virtual Reality Exposure Therapy (VRET) may be a constructive way to gain cooperative momentum.

## Stage Fright and VRET

The prevalence of Music Performance Anxiety (MPA) in professional musicians varies within studies between 16.5% and 60% [1], with reported disorders estimated between 15% and 25% [2]. Internal questionnaires at the University of Music and Performing Arts in Vienna indicate similar prevalence rates reported for extreme stress levels (stage fright) of 30% at a concert or 20% at an internal class audition [3]. Today, most institutions responsible for the education of young musicians know the demand and necessity to teach different coping strategies [4] [5].

Successful methods for coping with MPA include Mental Training, Stage Fright Training, or Performance Coaching by Experts. Exposure Therapy is also a proven concept to deal with any kind of anxiety. Many studies have demonstrated that for many phobias, Virtual Reality Exposure Therapy (VRET) is similar or even more efficacious than in vivo exposure therapy [6] [7].

VRET Pioneers: Projection Viewing VRET in the context of Music Performance has also been studied within the last decade. Williamon and his group developed a "Performance Simulator Room" at the Royal College of Music in London in 2014, where the scenery of a concert or an audition was presented with a beamer on a large display [9].

Rappaz and his colleagues developed VCOOL, an "Immersive Virtual Environments" Stage Fright Training at the Haute École de Musique de Genève in 2015. The performer played within a 4 Screen Virtual Cave, while psychophysiological Measurements and Motion Tracking of the musicians were made. They studied and demonstrated the impact of social factors by varying reactions on gestures by manipulating the body and facial expressions of a simulated audience [9] [10].

Bissonnette and colleagues at the Laval University Québec, showed a positive Effect of VRET on Performance Anxiety and Quality, especially for musicians with high trait anxiety and suffer from MPA. As method they used a computer automatic virtual environment presented in a four 10 × 10-ft screens CAVE display [11].

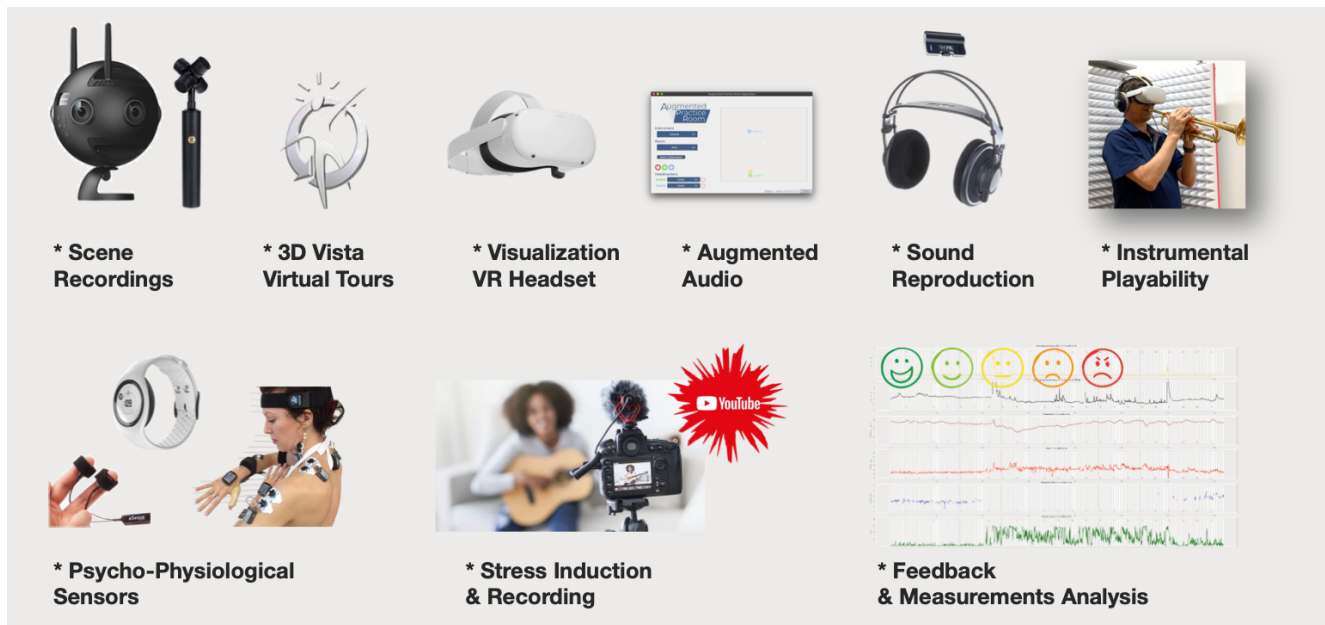
## Recent VRET Using Head-Mounted Displays

Using VR headsets is an emerging field that has the potential to affect people's minds with a superlative 3D experience. The tools to create 3D VR visual assets are VR Rendering Editors, such as Unity or Unreal Engine.

Fanger from the LMU Munich created a VRET application and rendered sceneries for mixed reality of a piano player in 2020. Stereotypical performance settings were designed, including a place to practice piano in a relaxing living room and piano performance locations in front of a large concert hall or in front of a small jury. The musicians had real haptic feedback by playing a MIDI stage piano, and different approaches were studied on how to represent and visualize the fingers, which are crucial to playing a piano [12].

PPali, Lalioti, and a team at the University of the Arts London and the University of Kent built a VR Venue Simulation to investigate how Virtual Reality can support creative musical practice [13]. They simulate accurate recreations, both visual and acoustical, of iconic concert venues and modifiable visual sceneries with simulation software. The app also allows changing the music settings, such as accompaniment tempo, or modifying room acoustics with adjustments of the reverberation time.

Much other research is being done in related areas requiring high skill training, such as sports. For example, Markwell and Jared M. Porter's Lab have shown the positive effects of virtual reality practice on motivation and performance. [14] [15] [16] In other fields, the usage of Head-Mounted Displays has been a focus for a longer time. For instance, it has been demonstrated that when real-world contexts are blended with virtual environments, drastic improvements in performance can be found [17].



**Figure 1:** Methodological challenges developing photorealistic 'Virtual Reality Exposure Therapy' (VRET) linked with psychophysiological measurements.

## About our photorealistic VRET method

In our approach to a virtual reality training program at the University of Music and Performing Arts in Vienna, we focus on photorealistic sceneries. In recent years, we have conducted several experiments with the technical infrastructure presented at the DAGA 2022 conference. [18] [19]. The goal is to provide the opportunity to immerse in performance stress situations relying on specific rooms and persons. Young musicians can train to perform an entrance audition at our university in front of the professor whom they will meet when playing the audition, and to become comfortable being around one of the world's leading academic palaces for music education. Students at the university should have the option to get a realistic impression of playing on famous stages, such as the Musikverein Vienna.

### Scene Recordings

Professional equipment makes it easy to record 360° 3D images and videos in 8k with Ambisonic Audio 1st order [21]. However, the editing, stitching, and rendering process is time-consuming and handling huge file sizes (terabytes of raw data) is very challenging. The real issue is to find uncompensated but famous individuals and well-known venues to make recordings available for non-profit educational materials. Interestingly, curiosity in new opportunities has helped to find support, and recordings have been made.

### Creating Virtual Tours

3D Vista is a user-friendly software for creating virtual tours, but it is also time-consuming. All types of multimedia, including 2D, 3D, panoramas, or videos, can be arranged in several ways, with audible or text information. Hotspots are defined to navigate by gazing, and the app renders media resolutions for all devices with different streaming

bandwidths. Experiments have shown that it is essential for the eye height to be on par with the camera height, with a tolerance of only 10 cm. Otherwise, musicians may feel uneasy, and smaller people may feel as though they are floating in the room. This must be considered when recording images or videos, and it is one of the drawbacks when the visualization is not a simulation with avatars rendered individually, or when musicians play in a CAVE.

### Visualization VR Headset

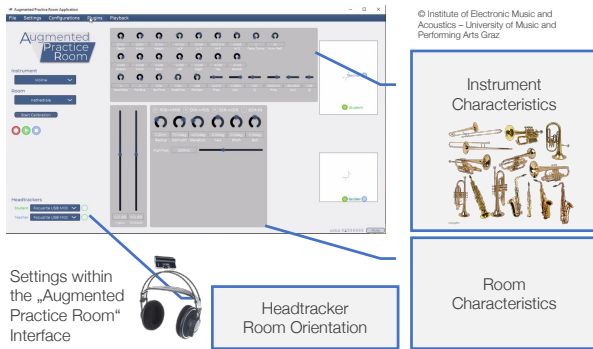
When it comes to headsets, we are all waiting for the next generation to be lighter, faster, and smaller. Although the visual quality of the Meta Quest 2 (1,832 x 1,920 px resolution, 96° field of view, 503-gram weight) or Pico 4 (2,160 x 2,160 px resolution, 105° field of view, 295-gram weight) is reasonable, discomfort and fatigue can arise after prolonged use of the VR headset. To prevent motion sickness, it is advantageous to use fixed motion-free panoramic views for immersion, and sickness is rarely evoked. Some people do not like wearing a headset due to personal reasons, such as hair, but about 90% of the students are very open and interested in experimenting with VR. Despite everything is working fine, study interruptions may occur due to sudden update requests or changes in login policies by Meta or Facebook.

### Acoustic Room Simulation

As our pilot studies have shown, matching visual and auditory impressions of the room size and characteristics is a key aspect for musicians. To simulate the room, we use the "Augmented Practice Room" audio app developed by the Institute of Electronic Music and Acoustics at the University of Music and Performing Arts Graz [22]. While the handling is easy, the operation itself requires manual adjustments and therefore at least a second person in the lab.

## Sound Playback

Since a near-field microphone is used as input for the app to calculate reverberation and sound directivity, there is a need for a low-latency headset, and therefore a cable to the otherwise standalone head-mounted displays used for visual input. To include sound directivity, a head tracker is engaged, even though VR headsets have head tracking included. Up to now, there is no interface from the Meta Quest head tracker back to the computer. The head tracker also needs a USB cable and connects the player to the cable distance.



**Figure 2:** Settings within the IEM 'Augmented Practice Room' - Interface

## Playability of Instruments in VR

Performing an instrument while wearing a VR headset is a challenge for musicians, and they handle it in various ways depending on the instrument. Pilot studies have shown that most singers have no or minor difficulties, but some do not like the weight on their head. Brass wind instrument players, such as trumpeters and tubists, only have a 3-4 valve interface that they do not need to see. Since the fingers and hands do not move their position while playing, eye contact is not crucial to play. Most brass and wind players get accustomed to the unfamiliar situation rather quickly. For string players, guitarists, and pianists, it is in most cases strange. Some students like the challenge and play guitar and piano without seeing the instruments (well, there are also blind musicians who master instruments). For the majority of those view-demanding instruments, virtual reality is not a recommended tool, and applications in augmented reality (AR) or mixed reality have to be taken into account. Regarding augmented reality, many technical approaches are in progress, and a bunch of AR apps for pianists are already available. But AR does not allow full immersion into virtual sceneries.

## Psycho-Physiological Sensors

Measuring non-invasive biopsychological data while wearing a headset can be done using a huge variety of different sensors, several of which have been successfully tested. Pulse, Galvanic Skin Response (SCL), Skin Temperature, Breathing Pattern, Motility, Motion-Capture, and Muscles Activation (EMG) can be informative indicators for stress detection, but everyone reacts differently. Increasing SCL seems to be the most reliable indicator for sympathetic nervous system (stress) and decreasing skin temperature for parasympathetic nervous system (relaxation). These findings from pilot studies

need to be further tested when the VRET method is standardized.

## Individual Choice of Sensor & Method

Stress can affect musicians in different ways. Some are handicapped by muscle tension or modified breathing patterns. The performance suffers due to reduced ease of playing, or by playing differently than trained and intended. Sound quality, notes, or musically projected interpretation (such as tempo) are not meeting expectations. In these cases, expert ratings or analysis of recordings are objective criteria. In other cases, the musical output is less affected, but the subjective mental experience of the player may lead to early fatigue syndromes.

## On-Site & New Off-Site Sensor Options

Until now, measurements of stress have only been conducted on-site in the lab. New tools, such as the EmbracePlus Smartwatch, allow for the development of new off-site monitoring of stress levels and for the comparison of real-life situations (such as auditions or concerts) with performances in virtual reality [23]. Our pilot studies indicate that this is a promising new approach, and further studies are planned.

## Stress Induction & Recording

Several options are available to easily induce stress in musicians. Recordings, expert ratings, or streaming performances over an online platform usually have a large impact on the mental state of the player. In some cases, professional musicians state that the stress level is not as high as when real-life-changing auditions are at stake for them.

## Feedback & Measurement Analysis

Measuring a different state of mind, stress level, or sound output is scientifically interesting documentation. To support musicians, further studies must investigate whether VRET really supports musicians as expected by some previous studies [8][11]. Feedback such as "We can show your stress level here in the data" or "you performed definitely worse under stress" is not the target of VRET. Improving the setup and developing good personal feedback VRET requires interdisciplinary coaching experts and many more studies with different target groups.

## Conclusion

Virtual reality (VR) simulations utilizing 360-degree photos and videos provide an immersive and lifelike experience for users. This technology presents opportunities for scientists to study emotions and behaviors and offers exciting prospects for musicians to improve their skills and conquer performance anxiety. As technology and procedures continue to improve, the potential for VR education and performance enhancement in the future is promising.

While recent studies have shown the potential of VR in this field, it is important to overcome obstacles to make it more accessible and enjoyable for everyone. The integration of realistic elements may further enhance the effectiveness of VR in helping people overcome stage fright, and it will be interesting to see how this technology is utilized in the future.

## References

- [1] Fernholz Isabel, Mumm JLM, Plag J, Noeres K, Rotter G, Willich SN, et al. Performance anxiety in professional musicians: a systematic review on prevalence, risk factors and clinical treatment effects. *Psychological Medicine*. Cambridge University Press (CUP); 2019. p. 2287–2306. DOI: 10.1017/s0033291719001910
- [2] Spahn, Claudia, Richter, B. & Altenmüller, E. (2011). *MusikerMedizin: Diagnostik, Therapie und Prävention von musikerspezifischen Erkrankungen*. Schattauer Verlag. p. 153.
- [3] Bertsch, Matthias. (2011) Beschwerden & Copingstrategien von Musikstudierenden in Wien *ÖGfMM Newsletter Journal Vol 4* (ISSN-2218-2780) Wien: OeGfMM.at p. 17-22
- [4] Kenny, Dianna (2011). *The Psychology of Music Performance Anxiety*. OUP Oxford.
- [5] Osborne, Margaret S., & Kirsner, J. (2022). Music Performance Anxiety. In G. E. McPherson (Hrsg.), *The Oxford Handbook of Music Performance, Volume 2* (S. 0). Oxford University Press. DOI:10.1093/oxfordhb/9780190058869.013.11
- [6] Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., Asmundson, G. J. G., Carlbring, P., & Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders*, 61, 27–36. DOI:10.1016/j.janxdis.2018.08.003
- [7] Wechsler, T. F., Kümpers, F., & Mühlberger, A. (2019). Inferiority or Even Superiority of Virtual Reality Exposure Therapy in Phobias? A Systematic Review and Quantitative Meta-Analysis on Randomized Controlled Trials Specifically Comparing the Efficacy of Virtual Reality Exposure to Gold Standard in vivo Exposure in Agoraphobia, Specific Phobia, and Social Phobia. *Frontiers in Psychology*, 10. DOI:10.3389/fpsyg.2019.01758
- [8] Williamon A, Aufegger L, & Eiholzer H (2014), Simulating and stimulating performance: introducing distributed simulation to enhance musical learning and performance, *Frontiers in Psychology*, 5 (25), 1-9.
- [9] Glowinski, D., Baron, N., Shirole, K., Coll, S., Chaabi, L., Ott, T., Rappaz, M.-A., & Grandjean, D. (2015). Evaluating music performance and context-sensitivity with Immersive Virtual Environments. *EAI Endorsed Transactions on Creative Technologies*, 2. DOI:10.4108/ct.2.2e3
- [10] Schaerlaeken, S., Grandjean, D. M., & Glowinski, D. (2017). Playing for a Virtual Audience: The Impact of a Social Factor on Gestures, Sounds and Expressive Intentions. *Applied Sciences*, 7(12), 1321. DOI:10.3390/app7121321
- [11] Bissonnette, Josiane, Francis Dubé, Martin Provencher, und Maria Teresa (Maite) Moreno Sala. „Virtual Reality Exposure Training for Musicians: Its Effect on Performance Anxiety and Quality“. *Medical problems of performing artists* 30 (23. September 2015): 169–77. DOI:10.21091/mppa.2015.3032
- [12] Fanger, Y., Pfeuffer, K., Helmbrecht, U., & Alt, F. (2020). PIANX – A Platform for Piano Players to Alleviate Music Performance Anxiety Using Mixed Reality. *19th International Conference on Mobile and Ubiquitous Multimedia*, 267–276. DOI:10.1145/3428361.3428394
- [13] Ppali, Sophia, Lalioc, Vali, Branch, Boyd, Ang, Chee Siang, Thomas, Andrew, Wohl, Bea, Covaci, Alexandra (2022) Keep the VRhythm going: A musician-centred study investigating how Virtual Reality can support creative musical practice. In: *CHI '22: Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. pp. 1-19. ACM. DOI:10.1145/3491102.3501922
- [14] Markwell, L., Velten, J., Partridge, J., & Porter, J. (2022). Virtual motivation: The psychological and transfer of learning effects of immersive virtual reality practice. DOI:10.1101/2022.12.29.522235
- [15] Kothgassner, Oswald D., Sophie-Antonia Utermöhlen, und Anna Felnhofer. „Virtual Reality Therapy: Die Zukunft klinisch-psychologischer Behandlung?“, 323–31, 2017.
- [16] Pereira, Julie S., Leonardo M. Faêda, und Alessandra M. Coelho. „Evolution of VRET to Assist in the Treatment of Phobias: a systematic review“. In *2020 22nd Symposium on Virtual and Augmented Reality (SVR)*, 386–90, 2020. DOI:10.1109/SVR51698.2020.00064
- [17] McGill, M., Boland, D., Murray-Smith, R., & Brewster, S. (2015). A Dose of Reality: Overcoming Usability Challenges in VR Head-Mounted Displays. DOI:10.1145/2702123.2702382
- [18] Frank, M., Rudrich, D., & Brandner, M. (2020). *Augmented Practice-Room—Augmented Acoustics in Music Education*. DAGA Fortschritte der Akustik, Hannover. Deutsche Ges. f. Akustik (DEGA), 2020
- [19] Bertsch Matthias & Matthias Frank (2022). *Stage-Fright Training with EMG- or Biofeedback for Musicians by means of Virtual and Augmented Reality*. Fortschritte der Akustik - DAGA 2022 Tagungsband,. Berlin: Deutsche Ges. f. Akustik (DEGA), 2022
- [21] Bertsch Matthias (2023) *Virtual Performance Training Project Website* <https://mdw.ac.at/mrm/iasbs/virtual-performance>
- [22] Klanjscek, N., David, L., & Frank, M. (2021). Evaluation of an E-Learning Tool for Augmented Acoustics in Music Education. *Music & Science*, 4. DOI:10.1177/20592043211037511
- [23] Empatica.com. (2023) *EmbracePlus | The world's most advanced smartwatch for continuous health monitoring*. URL: <https://www.empatica.com/embraceplus>

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