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An Overview of Immersive Virtual Reality Music Experiences in Online Platforms

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Abstract

As the field of Virtual Reality (VR) continues to mature, so too does the potential for creative and immersive musical experiences in the medium. However, of the thousands of applications now available across the major VR platforms, only a small number of titles focus on the ability to create or explore musical content. This article outlines the current state of music games, experiences, and creative applications across the current VR ecosystem. Firstly, it surveys the quantity of commercial titles currently available across the major VR platforms with a music-related focus. Secondly, the article classifies music applications into the following subcategories: music creation and creative arranging, rhythm games, music video experiences, and music performance activities. Finally, it provides an overview of the key musical applications in each category that can assist and inspire musicians, technicians, and educators in their creative musical endeavors.

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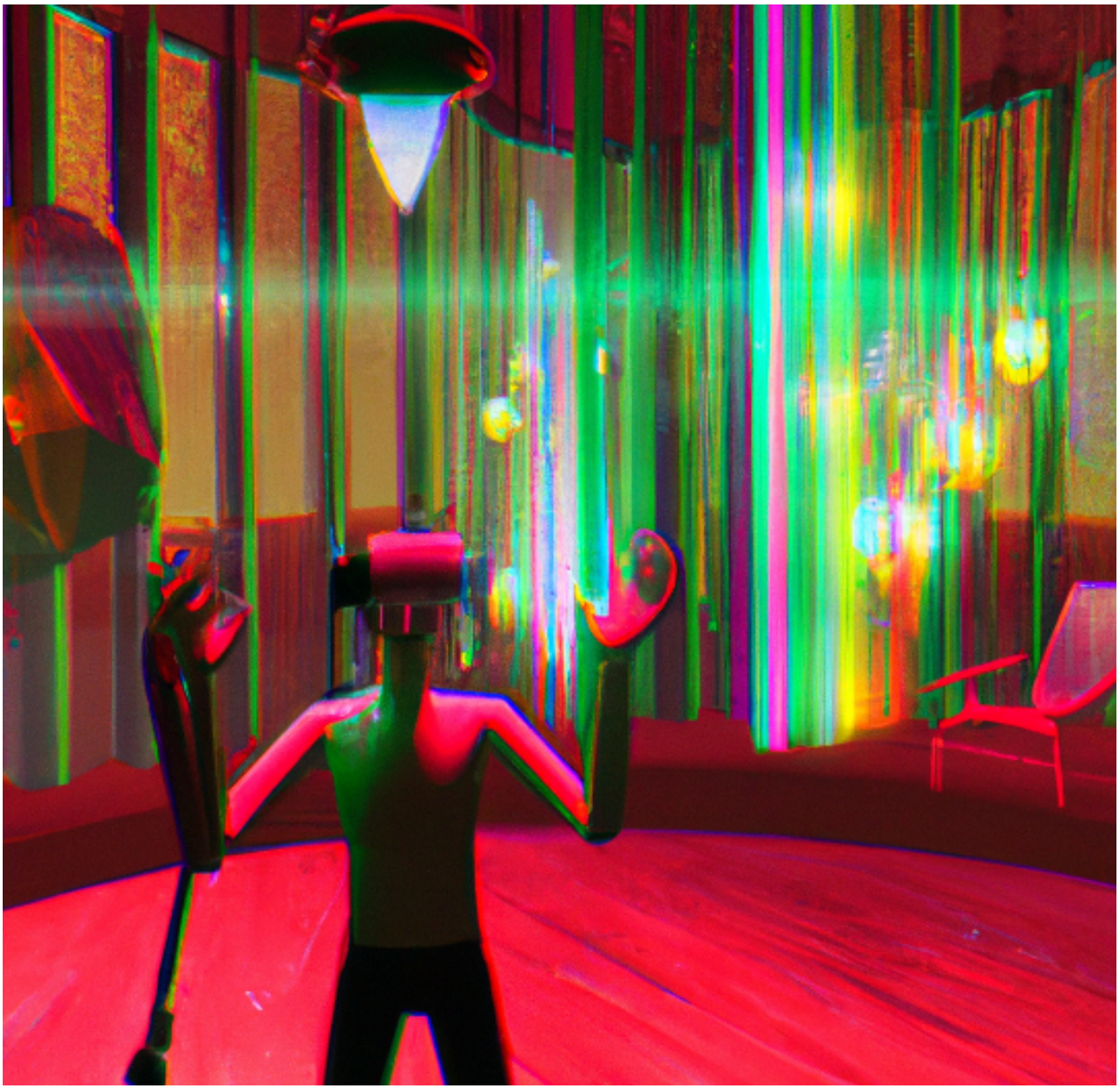

Figure 1: A computer-generated human figure with arms outstretched wears a head-mounted display inside an abstract room. This image was created with the assistance of *DALL·E 2*[2] using the prompt "Getting started with immersive VR music experiences."

Introduction

Advances in recording technology during the latter half of the twentieth century saw a widespread shift in music production from tape-based studios to digital audio workstations (DAW) at home. Computer applications such as Pro Tools and Logic Pro, designed around an analogue tape-based setup, provided familiarity for users coming from a traditional recording studio (see

[2] *DALL·E 2*, accessed March 16, 2023, https://openai.com/product/dall-e-2.

Figures 2 and 3). Although gains were ultimately made transitioning to computer-based recording in terms of operational efficiency and cost, this was often at the loss of a traditional hands-on approach in a physical studio setting. Beginners unfamiliar with traditional ways of working in a recording studio were thus required to familiarize themselves with complex 2D user interfaces based on unfamiliar workflows.

Figure 2: Logic Pro application interface displaying track layout. This type of system is also known as a linear sequencer. Screenshot taken from https://www.apple.com/au/logic-pro/ on November 2, 2022.

VR technology allows for immersive and embodied control through the use of a head-mounted display (HMD) and motion-tracked hand input, consisting of "a computer-generated environment that can be experienced and interacted with as if that environment were real."[3] For musicians, this allows for the recreation of physical instruments and devices, as well as enabling immersive and collaborative music experiences in networked music performance (NMP).[4] A recent study has shown that the use of VR in NMP offers a viable alternative to video conferencing for leader-follower style duo singing, although musical performance is challenged by the lack of current avatar expression fidelity.[5] Overall,

[3] Jason Jerald, *The VR Book: Human-Centered Design for Virtual Reality* (Association for Computing Machinery and Morgan & Claypool, 2015), 9.

[4] Ben Loveridge, "Networked Music Performance in Virtual Reality: Current Perspectives," *Journal of Network Music and Arts* 2, no. 1 (August 29, 2020), https://commons.library.stonybrook.edu/jonma/vol2/iss1/2.

[5] Ben Loveridge, "An Exploration of Duo Singing in Virtual Reality and Videoconferencing" (Masters Thesis, The University of Melbourne, 2023), http://hdl.handle.net/11343/326090.

the widespread commercial availability of VR devices now provides the opportunity for physically embodied music creation within a fully digital workflow.

Figure 3: Two-inch tape machine at Eastern Bloc Studios, Melbourne, Victoria, March 28, 2006. DAW interfaces were initially designed around the functionality of physical machines using the analogy of tape transport controls. In some studios, DAW systems are still used alongside tape machines, although modern workflows often contain production completely within the digital realm. Photo by author.

The Current State of VR

The technical prowess of VR headsets has improved rapidly over recent years. Considerable investment has been led by Meta (formally Facebook), who have spent $36 billion dollars on research and development since 2019.[6] Advances such as untethered six-degrees-of-freedom movement, increased visual fidelity, eye and face tracking, as well as the acquisition of numerous gaming studios have all contributed to the growth of the platform. As of early 2023, combined sales of the Oculus Quest 1 and 2 have reached almost 20 million headsets,[7] resulting in a market share of 85% for the Oculus

[6] Grace Dean, "Meta Has Pumped $36 Billion into Its Metaverse and VR Businesses since 2019. These 4 Charts Show the Scale of Its Extreme Spending — and Huge Losses," *Business Insider*, October 29, 2022, https://www.businessinsider.com/charts-meta-metaverse-spending-losses-reality-labs-vr-mark-zuckerberg-2022-10.

[7] Alex Heath, "This Is Meta's AR / VR Hardware Roadmap for the next Four Years," *The Verge*, March 1, 2023, https://www.theverge.com/2023/2/28/23619730/meta-vr-oculus-ar-glasses-smartwatch-plans.

Quest 2.[8] Other major VR devices aimed at the general population include the HTC Vive, Sony Playstation VR (PSVR), Valve Index and Pico.

Figure 4: Two musicians perform while wearing HMDs. This image was created with the assistance of *DALL·E 2* using the prompt "Duo singing in virtual reality."

However, not all headsets are designed for mainstream adoption. The HP Reverb Omnicept Edition, released in 2021, includes features such as a heart rate monitor, face and eye tracking, and a pupillometer. Designed for research-oriented activities, these tracking capabilities allow for the

[8] "AR & VR Headsets Market Share," IDC, accessed March 5, 2023, https://www.idc.com/promo/arvr.

measurement of a user's cognitive load while in a VR setting.[9] Although the addition of these technologies provide exciting and creative opportunities for musical research and software development, questions around the privacy and ethical implications of biometric capture need to be considered across all platforms.

Immersive virtual reality

The use of the word immersion (and immersive) as it relates to VR technology has been the subject of debate for a number of years.[10] This article uses the term *immersive virtual reality* to denote experiences that involve the use of an HMD to "fully immerse a number of senses in computer generated stimuli."[11] Although the recent introduction of higher quality color passthrough modes on VR HMD's places them closer to augmented reality (AR) devices, the examination of AR musical applications is not within the scope of this article.

Musical Applications available in VR stores

What is the current availability of immersive VR musical experiences? To explore this question, a number of searches were conducted across several websites with the subsequent results presented below (Table 1). On March 12, 2023, a search for music-related content was conducted via the VRDB.app website,[12] an enthusiast-run database of collated VR titles covering the Meta Quest, Oculus Rift, App Lab and SteamVR stores. A manual search and categorization was then run on the Sony PSVR[13] and Viveport[14] (HTC Vive) stores for relevant applications. At the time of writing, the Pico[15] had no ability to search for games and applications on its website. Overall, these results highlight the relatively low number of music titles compared to total applications. It does need to be considered that a limitation of this type of search is that it misses music experiences that may be available within another application or web-based experience.

[9] E. Siegel et al., "HP Omnicept Cognitive Load Database (HPO-CLD)–Developing a Multimodal Inference Engine for Detecting Real-Time Mental Workload in VR" (Technical report, HP Labs, Palo Alto, 2021).

[10] Mehmet Ilker Berkman and Ecehan Akan, "Presence and Immersion in Virtual Reality," in *Encyclopedia of Computer Graphics and Games*, ed. Newton Lee (Cham: Springer International Publishing, 2019), 1–10, https://doi.org/10.1007/978-3-319-08234-9_162-1.

[11] Frank Biocca and Mark R. Levy, eds., *Communication in the Age of Virtual Reality* (New York: Routledge, 1995), https://doi.org/10.4324/9781410603128.

[12] "VR Store Statistics," VRDB.App, accessed March 12, 2023, https://vrdb.app/.

[13] "PlayStation Store Australia," accessed March 6, 2023, https://store.playstation.com/en-au/.

[14] "VIVEPORT," accessed March 6, 2023, https://www.viveport.com/.

[15] "PICO Virtual Reality," accessed March 12, 2023, https://www.picoxr.com/.

VR HMD / platform	Music Applications	Total Applications	Relative %
Meta Quest	26	472	5.5
Oculus Rift	193	1995	9.7
App Lab	116	1669	7.0
Steam VR	61	2955	2.1
Viveport	82	2440	3.3
PSVR	28	546	5.1

Table 1: A list of music-related results, total available applications and the relative percentage across VR platforms as searched on March 12, 2023. Meta Quest, Oculus Rift, App Lab and Steam VR data were drawn from the VRDB.app website. Viveport and PSVR data were drawn from their respective platform storefronts.

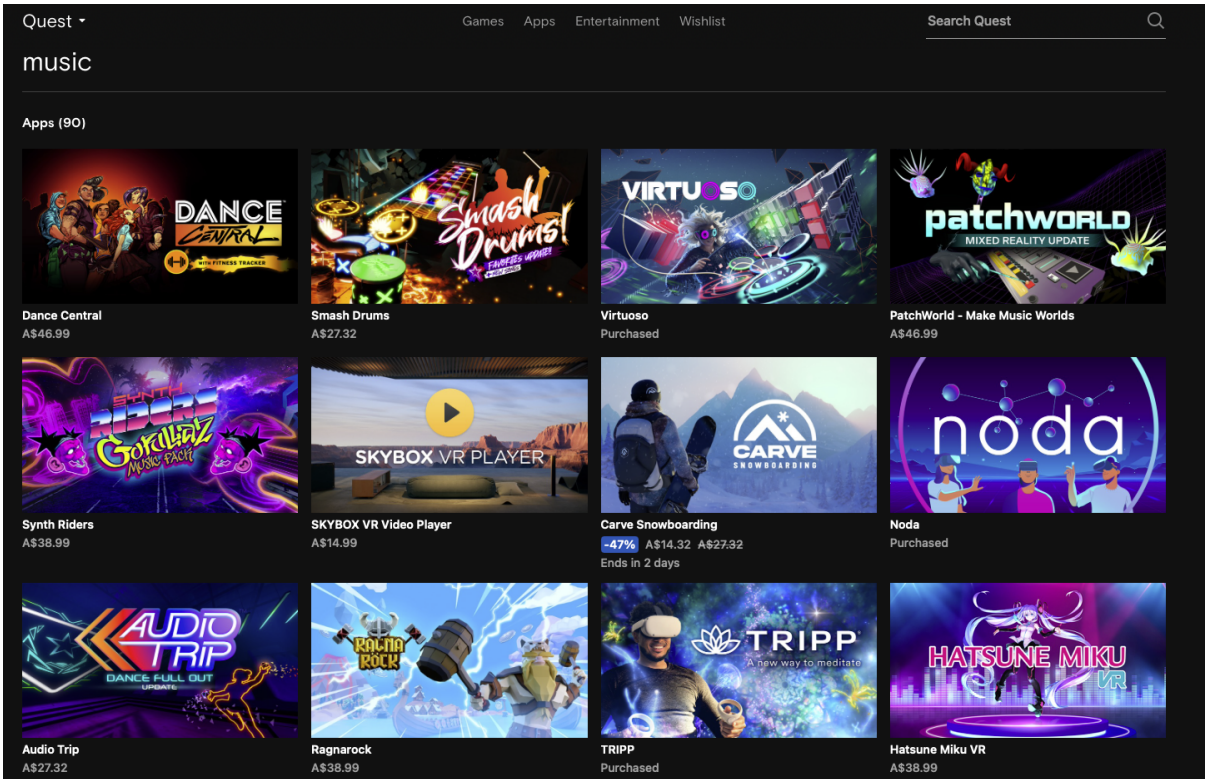

Figure 5: A screenshot of a search for "music" on the Oculus Quest store displaying several non-music related applications such as Carve Snowboarding, Noda, and Skybox VR Player alongside music experiences. This result highlights the lack of keyword accuracy in the website search functionality, as well the lack of ability to filter through different types of music applications on the store.

VR Music Categories

Categorizing all music VR applications across each VR platform beyond what is already listed would be a large undertaking and not within the scope of this current article. However, taking a closer look at the 29 music specific applications on the official Oculus Quest store, we can use this to define the

following categories: music creation and creative arranging (4), rhythm games (20), music video or narrative experiences (3), and music performance (2). It should be noted that most VR music-related applications are single player experiences and very few offer synchronous networked musical collaboration. One reason for this is likely due to the high technical demands of combining visuals and audio in a seamless, low-latency NMP experience.[16] That being said, the popularity of rhythm games cannot be understated with (at the time of writing), the category occupying nine out of the top 10 listed Quest music applications according to VRDB.[17]

Music Creation and Creative Arranging

Although the exploration of commercial VR games has not been well represented in academic literature, there is a growing need for more musically creative and exploratory VR audio design tools.[18] These types of applications provide users with the ability to create original musical patterns or manipulate existing patterns and can be categorized within the existing DAW framework as sample and loop triggers.[19]

Examples of these types of applications from early tethered PC-based VR systems include *Exa Music*, *The Music Room*, and *Sound Stage*. Unfortunately, as is the case with many of the first-generation of VR titles, not all of these applications have been ported to recent untethered HMDs. To play these requires the use of an additional PC, creating an extra level of friction and cost to the user. More recent experiences released for the Meta Quest, such as *Virtuoso*, *Patch World*, and *Electronauts*, allow users to create music in a virtual environment using built-in virtual instruments as well as the ability to record their output in a sequencer style. Virtuoso offers users a range of virtual instruments and environmental settings while providing the ability to quantize audio to improve beat synchronization during performance. The use of VR for music creation and arrangement has the ability to provide users with a more intuitive way to create music in a fully online environment.

[16] Ben Loveridge, "Networked Music Performance in Virtual Reality: Current Perspectives," *Journal of Network Music and Arts* 2, no. 1 (2020): https://commons.library.stonybrook.edu/jonma/vol2/iss1/2.

[17] VRDB.App, "VR Store Statistics," accessed March 12, 2023, https://vrdb.app/.

[18] Luca Turchet, Rob Hamilton, and Anil Çamci, "Music in Extended Realities," *IEEE Access* 9 (2021): 15810–32, https://doi.org/10.1109/ACCESS.2021.3052931.

[19] Matthew Duignan, James Noble, and Robert Biddle, "A Taxonomy of Sequencer User-Interfaces," *International Computer Music Conference Proceedings* (2005), http://hdl.handle.net/2027/spo.bbp2372.2005.158.

Figure 6: Examples of music creation applications. In clockwise order: *Virtuoso*, *EXA VR Music*, *Electronauts*, and *Tribe DJ School*. Images from store thumbnails.

An example of a linear sequencer, similar to Pro Tools and Logic, can be seen in *The Retro Recording Studio*, a PC-based VR recording studio currently in development (Figure 7).[20] This faithful recreation has been designed to give the user a virtual hands-on mixing experience within a traditional studio environment. While this type of tool has great potential for familiarization and aspects of music training, interaction design challenges are based around the current limitations of hand controllers and haptic feedback.

[20] Marald Bes, "Retro Recording Studio Development Vlog 1," YouTube, August 29, 2022, https://youtu.be/IXg5GrUqPJ4.

Figure 7: Screenshot from the *Retro Recording Studio VR* application, currently in development. Accessed on March 14, 2023.

Rhythm Games

By far the most common genre of VR music games are rhythm games. Although the association of music with fitness is not uncommon,[21] playing VR games while getting fit has been a surprising success to the industry.[22] The benefits of VR fitness games are further highlighted by how the technology is promoted to new users as a way to "exercise by accident."[23] One of the first examples to capture the attention of the VR community was the game *Beat Saber*,[24] which has become one of the most successful VR games to date.[25] By combining engaging gaming mechanics alongside rhythmically musical actions, users are able to engage through both physical and cognitive elements. The success of *Beat Saber* has led

[21] See, e.g., Kelly Brooks and Kristal Brooks, "Enhancing Sports Performance through the Use of Music," *Journal of Exercise Physiology Online* 13, no. 2 (April 2010): 52-57.

[22] Andrew Bosworth, "Why We Still Believe in the Future," *Tech at Meta*, December 19, 2022, https://tech.facebook.com/reality-labs/2022/12/boz-look-back-2023-look-ahead/.

[23] Hayden Dingman, "Exercise by Accident: VR Games To Help You Work Out at Home," *Meta Quest Blog*, January 12, 2022, https://www.oculus.com/blog/exercise-by-accident-vr-games-to-help-you-work-out-at-home/.

[24] *Beat Saber*, V. 1.29.0, Oculus, accessed March 5, 2023, https://www.oculus.com/experiences/quest/2448060205267927/.

[25] Scott Hayden, "'Beat Saber' Earned Nearly $100M in Revenue Last Year Alone," *Road to VR*, July 1, 2022, https://www.roadtovr.com/beat-saber-100m-revenue-2021/.

to the creation of similar applications in the rhythm games category such as *Smash Drums*, *Audio Trip*, *Pistol Whip* and many more. Other games, like *Tetris Effect: Connected*, have incorporated more traditional gameplay alongside musical rhythmic elements.

Figure 8: Examples of rhythm games in clockwise order: *Beat Saber*, *Smash Drums*, *Audio Trip*, and *Tetris Effect: Connected*. Images from store thumbnails.

Music Video Experiences

The ability for VR technology to provide what can feel like a first-person experience to the user, allows for what can be classified as an immersive music video. One such example is "Pearl," a short film produced by Google Spotlight Stories that utilizes a 360-degree viewpoint to create an emotionally driven narrative experience for the viewer.[26] Another notable VR music video experience is the *Together* EP by synthwave producer Sheaf.[27] The journey guides the viewer as a participant through a stylised digital landscape while listening to music in the driver's seat of a car. Importantly, the straight-line, constant velocity design of the experience creates no acceleration for the user and reduces the potential for motion sickness. Other music video experiences such as ARTAAL and SURGE, available only on tethered-PC based systems, showcase abstract graphics along a musical journey that provide the user with an engaging and immersive experience.

[26] "Pearl," directed by Patrick Osborne, *Google Spotlight Stories* (Google, 2017), VR film, https://store.steampowered.com/app/476540/Google_Spotlight_Stories_Pearl/.

[27] Sheaf, *Together* (Stryde Games, 2019), VR EP, https://store.steampowered.com/app/1072530/Sheaf__Together_EP/.

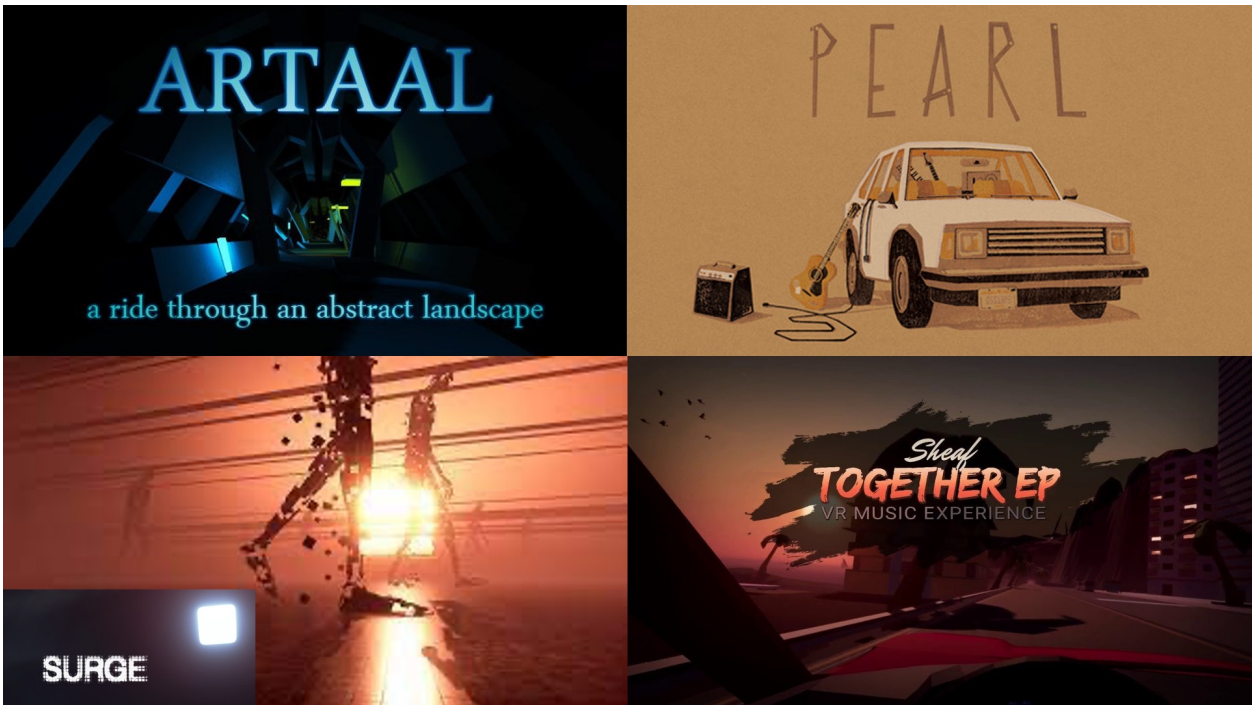

Figure 9: Examples of music video experiences in clockwise order: "ARTAAL," "Pearl," "Surge," and Sheaf's *Together* EP. Images from store thumbnails.

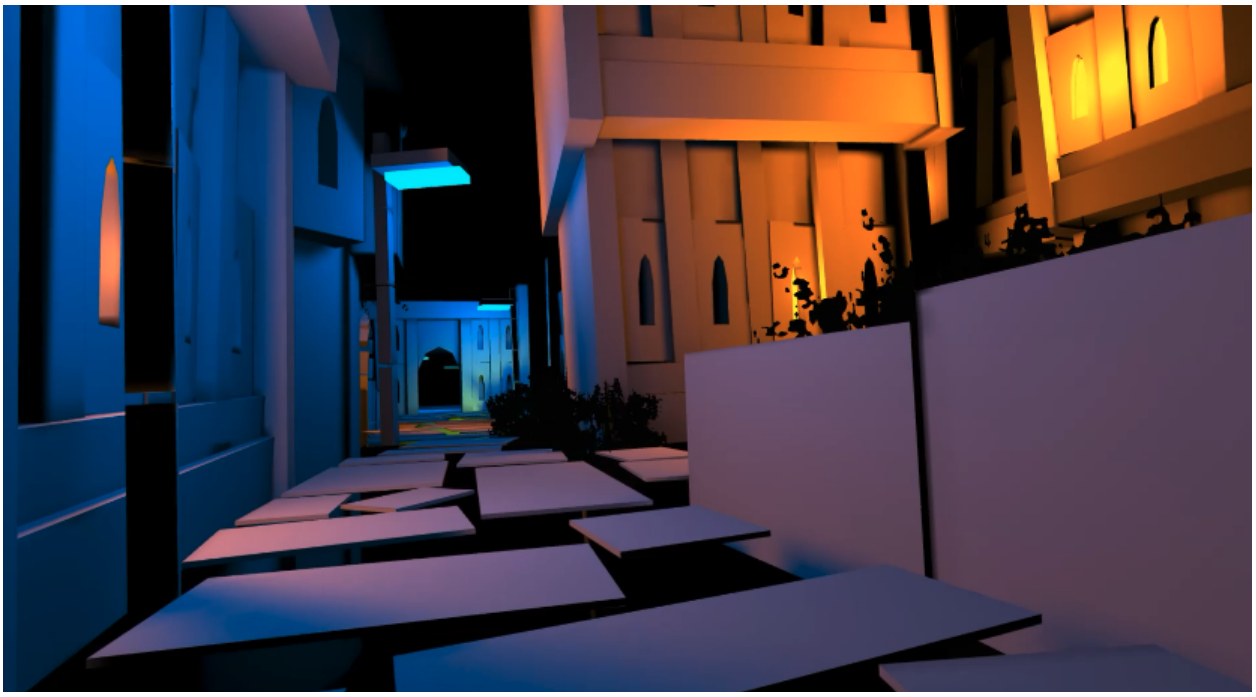

Figure 10: A screenshot from "ARTAAL" available via the Steam VR and Oculus Rift platforms. Unfortunately, many titles created for early VR systems are not available on current devices without an accompanying PC.

Music Performance Experiences

VR music performance applications offer opportunities for users to improve their stagecraft and performance skills, even if they do not always feel comfortable doing so in a physical setting. The technology has the ability to put the user in the shoes of the performer, potentially alleviating what is known as performance anxiety.[28] Examples of these types of applications include *Stage Presence* and *OnStage*, offering the user the experience of performing on stage in front of a computer-generated audience. In a related manner, the ability to dynamically conduct an orchestra can be experienced in *Maestro VR*, an application that also guides the user through a narrative learning journey.

In the years prior to its second shutdown in March 2023, the social VR platform Altspace provided individuals with opportunities to improve their singing skills through virtual open mic nights. Altspace provided users the ability to perform as a custom avatar in front of an audience within a supportive virtual environment. However, reports of trolling and harassment in social VR spaces have been reported, negatively impacting the experience for users.[29] As a result, moderation tools to allow banning or kicking out disruptive users are required features for such applications to address these issues.

Examples of other applications that facilitate socially interactive experiences between performers and audiences are VRChat[30] and Mozilla Hubs.[31] These have been popular with performing artists exploring the boundaries of musical expression alongside audiences within the virtual environment. At the 2022 NowNet Arts Conference, the work *Oscuterium*[32] was performed and involved musicians sending digital instrument data into an online scene which was played out of virtual synthesizers. The social VR application VRChat has been the platform for the *Loner Online*[33] series, which merges physical nightclub events with the online world playing out in the background of the performing DJs.

[28] Margaret Osborne, Solange Glasser, and Ben Loveridge, "'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," *ASCILITE Publications*, November 18, 2022, https://doi.org/10.14742/apubs.2022.116.

[29] Lindsay Blackwell et al., "Harassment in Social Virtual Reality: Challenges for Platform Governance," in "CSCW," special issue, *Proceedings of the ACM on Human-Computer Interaction* 3 (November 7, 2019): 1–25, https://doi.org/10.1145/3359202.

[30] *VRChat*, V. 2023.1.2 Build 1286, accessed March 10, 2023, https://hello.vrchat.com/.

31 Mozilla Hubs, V. 2023-02-07, accessed March 10, 2023, https://hubs.mozilla.com/.

[32] For more details see "The Society For Arts And Technology | SAT," interview by Matt Cool, *Creator Labs*, Mozilla Hubs, August 1, 2022, https://hubs.mozilla.com/labs/society-for-arts-and-technology/.

[33] "Loner_Online - Twitch," accessed March 15, 2023, https://www.twitch.tv/loner_online/.

Figure 11: Examples of music performance experiences in clockwise order: *Stage Presence*, *Maestro VR*, and *OnStage*. Images from store thumbnails.

Figure 12: A solo performer singing on stage at an Altspace Open Mic Night. Screenshot captured on July 16, 2020.

What is the future of music performance?

Is embodying an avatar in a virtual environment the future of music performance? This question was presented to a mainstream audience in the television programme *Alter Ego* which aired on American television during 2021. The show used face tracking and motion capture technology to represent performers as stylized avatars, performing on screens in front of a live audience and a judging panel. Despite its high production values, *Alter Ego* received generally negative reviews from critics including comments such as "like watching the end of humanity"[34] and was not renewed for a second season. The lack of emotional expression in the avatars was mentioned as one of the factors that detracted from the experience, in line with prior musical research on avatar appearances in VR.[35] The potential to use VR alongside biometric capture technology for virtual performance training is an emerging area for future research. This type of research is particularly valuable due to the cost and logistical challenges of conducting performance training in highly sought-after physical spaces within music institutions.

Conclusion

This article has provided an overview of the current state of immersive VR experiences for creative music-making and performance highlighting the capabilities of VR for enhancing musical creativity. As further advances in AI, graphical fidelity, and user experience are incorporated into creative music applications, it is likely that VR will continue to offer engaging alternatives to traditional computer interfaces. Further research will be needed to determine the most effective techniques in utilizing VR for collaboration and NMP, while also ensuring the technology remains engaging for users and audiences both online and in the physical world.

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[34] Stuart Heritage, "'Legitimately Nightmarish': Is Alter Ego the Worst TV Show of 2021?," *The Guardian*, September 22, 2021, https://www.theguardian.com/tv-and-radio/2021/sep/22/alter-ego-worst-tv-show-of-2021.

[35] Loveridge, "An Exploration of Duo Singing in Virtual Reality and Videoconferencing."

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