TAM reveals AI negativity bias in VR music performances

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***Abstract*— Virtual reality concerts are gaining traction, yet very little is known about its experience. The present study employs the Technological Acceptance Model (TAM) to assess user perception and enjoyment of virtual reality (VR) concerts. More specifically, it aims to investigate the so-called AI negativity bias in the context of VR concert adoption. An experiment was conducted in which one group of participants believed the concerts were generated by artificial intelligence (AI), while another group believed the musical performances were live recordings translated into VR environments. Afterwards, participants evaluated their stance towards VR concerts. Results showed that the TAM measures of Perceived Enjoyment, Perceived Ease of Use, and Perceived Usefulness significantly differed across conditions, with higher scores for the live recording condition. Moreover, general attitude towards VR, as well as immersive tendencies, correlated with technological acceptance. Differences between participant groups could not be explained by familiarity or liking of the artists and songs, strengthening the theory of an AI negativity bias. As such, this study adds to the literature on perceptions of AI usage, extending it into the domain of virtual concert experiences.**

Keywords*— music, virtual reality (VR), artificial intelligence (AI), technological acceptance model (TAM), concert experience

I. Introduction

The possibilities to attend concerts in virtually mediated environments are steadily increasing. The appeal resides in a multitude of factors. For example, audiences might not be able to attend physically due to an artist not touring near their geographical location, people might simply not have the funds for concert tickets, transport, beverages, and other expenses that often accompany physical attendance, or people might have mental and/or physical disabilities that prohibit them from attending. Moreover, virtual concerts provide experiences that are not possible in real-life, and allow people to experience new and enhanced forms of musical expression and interaction [1], [2]. Nevertheless, technologically mediated concerts such as those in virtual reality (VR), remain to be widely adopted by the general public, and the question remains to what extent people are willing to accept such technologies for concert attendance.

Previously, Deng and Pan [3] found that factors of player experience (i.e., autonomy, relatedness, and engagement) positively influenced technological acceptance of virtual concerts in game settings. Yet, very little is known about the adoption of VR for concert experiences specifically. Forced to look beyond VR, we find that a wide range of virtually mediated concerts exists. Previous research has, for example, examined livestreams [4], avatar concerts [5], and the usage of holograms [6]. Here we find that while such formats are already utilized by large groups of people, they are often simultaneously met with reluctance. For example, Matthews and Nairn [6] found a divide in reactions to the announcement of ABBA's holographic concert series, with some people calling the concerts "economically exploitative" due to the physical absence of the members of ABBA. In such instances, the technological mediation applied to the musical performances were seen as "a cop out". Nevertheless, more than a million people have attended the tour with reviews being overwhelmingly positive.

Aversive reactions to technological mediation are nothing new. A well-known example is the AI negativity bias. A large body of research shows that peoples' perceptions are negatively impacted when evaluating (what they believe to be) AI-generated art (e.g., [7], [8], [9], [10], [11]). However, studies also show that such a bias is context-dependent. For example, one study [10] found that the AI negativity bias affects perceptions of quality and liking of music, however, this was influenced by its genre. With the interest of the current paper residing on VR concerts, which is still a largely underexplored field [12], the question arises whether the AI negativity bias persists in the context of concerts in VR environments.

Hence, the present study wishes to examine a possible AI negativity bias in the context of virtual reality concert adoption. In order to shed light on contributing factors of VR concert acceptance, we opted for the usage of the Technological Acceptance Model (TAM). Originally developed by Davis [13], the TAM predicts the acceptance or adoption of information technology by users. Its two key determinants are Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) [14]. Perceived Ease of Use (PEOU) refers to the amount of effort the system demands, while PU refers to the perception of a technology being useful for intended purposes. However, a distinction is made between hedonic and utilitarian systems [15]. As a result, hedonic systems (e.g., leisure, entertainment) are often evaluated with the additional measure of Perceived Enjoyment (PE), which refers to the extent the technology provides enjoyment in its own right (i.e., regardless of system performance qualities).

The TAM is a well-established theoretical framework and has previously been applied successfully in the context of virtual concerts [3]. Thus, we extend this approach to assess whether there is an AI-negativity bias in the context of VR concerts. Here, we expose participants to pre-recorded VR concerts under two narrative conditions: an AI condition, in which participants believe the performances are AI-generated, and a Live condition, in which participants believe a real-life performance has been translated into a VR environment. At the end of the experiment, participants evaluated their general stance towards VR concerts using the TAM. Based on previous research on the AI negativity bias, we hypothesized

that all components of TAM are negatively affected in the AI condition compared to the Live condition.

II. Methods

A. Participants

Forty-nine people consented and completed participation. One participant was excluded due to visual impairments. The remaining forty-eight participants were pseudo-randomized (balancing age and gender) over the two conditions. The Live condition (n = 24) consisted of 12 women, 10 men, 1 non-binary person and one person preferred not to say. Ages ranged from 20 to 66 years (M = 37.2; SD = 14.9). Due to technical difficulties, one person did not complete the third trial. Nevertheless they provided answers to the final questions (including the TAM) and are included for analysis here. The AI condition (n = 24) consisted of 15 women and 9 men. Ages ranged from 19 to 70 years old (M = 37.7; SD = 14.4). Both conditions had 11 participants at Location 1 and 13 participants at Location 2. Participants took part completely voluntarily (no compensation was provided).

Looking at prior VR experience, 14 participants indicated to have no experience with VR at all, 23 had used it once or twice, 9 had used it 3-15 times, 1 person had used it 15-40 times, and 1 person had used VR technology more than 40 times. Regarding attitude towards VR, no person was extremely negative towards VR technology, 2 people were somewhat negative, 22 people indicated to have neither a positive or negative stance, 17 people were somewhat positive, and 7 people had an extremely positive attitude towards VR in general. The bulk of participants (n = 46) indicated to have never attended a concert in VR. Two participants indicated to have attended a VR concert once or twice. These did not include the concerts used in this experiment.

B. Materials

A Meta Quest Pro VR headset was used with noise-cancelling headphones (Bose QuietComfort 15). Volume levels were set at 8/15. Participants watched three songs from concerts in the AmazeVR app (Version January, 2024): Lush Life by Zara Larsson, Into My Body by UPSAHL, and Bartender by T-Pain. These particular artists and songs were chosen as there were only four available artists at the time, and these songs had the cleanest cuts between transitions, making it the most self-contained performances within their respective concerts (each concert generally consists of 4 songs). A music and neighbouring rights license was acquired.

The performances in the AmazeVR app are live recordings captured by high-quality volumetric cameras, making the experience of seeing the artist in front of you highly realistic. These recordings are then mixed with computer-generated elements (e.g., virtual background environments). To the best of our knowledge, the audio used are studio recordings, with occasional live voice overlays. The performances are on-demand and can be accessed at people's own leisure. The artists often play towards the viewer (e.g., eye contact, coming closer/moving away). The viewer itself does not have any control over their position in the virtual space, but position changes slightly throughout the performance (e.g., moving up and down/left to right). The viewer has two controllers that are represented as hands within the VR environment. There are no other audience members during the performance. All optional features (e.g., haptic feedback) of the app were turned off. As with many VR experiences, we believe mere description does not fully suffice. Therefore, we encourage readers to take a look at the AmazeVR app. People can experience one free song per artist.

C. Procedure

All protocols, including procedure and data management, were approved by the ethics committee of the researchers' university. Authors declare no conflict of interests.

1) Pre-questionnaire

Participants were recruited through personal networks of the researchers, as well as through advertising on social media and campus grounds. Before partaking in the experimental session, participants filled out a pre-questionnaire. Qualtrics (Version January 2024) was used for data collection throughout the study. The first page of the pre-questionnaire consisted of informed consent. If consent was not provided, the survey was terminated. The pre-questionnaire assessed general demographic information and contained a set of standardized tests. As the purpose of these tests is beyond the scope of the current paper, the full contents and results will be presented elsewhere. Of interest for the current paper is that we asked participants about prior experience, and attitudes towards VR using five-point Likert scales. The questions read: "How often have you used virtual reality (VR) technology? (1=not at all, 2=once or twice, 3=3-15 times, 4=15-40 times, 5=40+times)" and "To what extent do you feel positive or negative towards VR? (1=extremely negative, 2=somewhat negative, 3=neither positive nor negative, 4=somewhat positive, 5=extremely positive)". At the end of the pre-questionnaire, participants provided an email address to arrange the experimental session. Contact information was deleted after this was no longer required. The full registration survey was aimed to take approximately 30 minutes.

2) Experimental Session

Participants either took part at Location 1 (a local library) or Location 2 (university campus). This was the result of efforts to diversify our subject sample, as a large body of research is often solely performed on university students (e.g., [16], [17], [18]). Experimental spaces were highly similar in setup (i.e., a small conference room). Upon arrival participants received explanation on the procedure of the day and filled out an initial survey. This contained the Immersive Tendencies Questionnaire (ITQ [19]) and measures for purposes outside of the current scope (i.e., stress and connectedness). Subsequently, participants were informed that they were going to watch three songs from VR concerts and that we would be asking them to fill out a short survey on their experience after each viewing/trial. They were then given instructions on placing of the virtual headset, usage of the controllers, and how to interact within the virtual environment (e.g., how to select a performance to start). The instructions were accompanied by either of two narratives. The Live condition was accompanied by the following narrative:

"As you know, you are going to watch a couple of VR concerts. These performances are produced by a new company that is experimenting with providing musical performances in virtual reality. The artist performs live in their studio, which is captured with high-quality cameras. The live performance is then merged with a virtual world. We would like to know a bit more about your concert experience in such a setting."

The AI condition was accompanied by the following:

"As you know, you are going to watch a couple of VR concerts. These performances are produced by a new company that is experimenting with providing musical performances in virtual reality. For this, they use a hyper-realistic AI model of the artist. They are able to create these AI models based on past interviews, music videos and performances, with the goal of creating a life-like concert. We would like to know a bit more about your concert experience in such a setting."

Participants then watched three songs from the VR concerts in randomized order. After each song, they filled out a questionnaire on their experience using a laptop. Again, of interest here is that we assessed familiarity and liking of the artist and the song on a five-point Likert scale, ranging from not familiar at all/dislike a great deal (1) to extremely familiar/like a great deal (5). After the three trials, the researcher verbally checked whether participants believed their conditional manipulation, and were subsequently fully debriefed about the intentions of the experiment. That is, they were told all performances were live recordings translated into virtual reality environments and that we were looking at differences in concert experience based on a Live-recorded versus AI narrative. Subsequently, in a systematic manner, we discussed other forms of VR concerts, namely, the possibility of personalized avatars for both artists and audience members as a form of expression, the possibility of walking around virtual spaces and interacting with other audience members in such concerts, and the possibility of receiving haptic feedback via controllers or full-body suits, in order to feel the vibrations of the music. Participants were then asked to fill out a final questionnaire on their views of VR concerts based on the concert experiences and subsequent conversation. For this, we used the Technological Acceptance Model adapted from [14], containing the components used in [3]. As such, participants were asked to answer on a seven-point Likert scale, ranging from highly disagree (1) to highly agree (7), to what extent they agreed with the following statements (subcategories added here):

Perceived Enjoyment (PE)

Using VR to attend a musical performance is really fun.

VR concerts and its elements are a nice gimmick.

It is fun to discover VR concerts and its elements.

VR concerts invite you to discover more performances.

Perceived Ease of Use (PEOU)

I found the VR concerts easy to attend.

The VR concerts were intuitive to attend.

It was easy to learn how to attend VR concerts.

Attending VR concerts was easy.

Perceived Usefulness (PU)

For me, VR concerts have great value.

VR concerts provide beautiful performances.

VR concerts are very inspiring.

VR concerts are perfect for attending performances.

This was followed by three open-ended questions on what they liked and disliked about the performances. Finally, participants were thanked for their participation.

III. Results

A. Data analysis

Data was analysed using R (RStudio version 2023.12.1.402, release name: Ocean Storm; R version 4.3.3). The following packages were used: ggplot2 [16], ggpubr [17], and car [18].

B. Live versus AI

We examined whether the components of the TAM were significantly different across the two narrative conditions. As the components are averages of Likert answers, we first investigated the assumptions of normality (Shapiro-Wilk) and homogeneity (Levene's) for the usage of the t-test. Assumptions were met, with the exception of normality for PEOU in the Live condition. For uniformity we proceed with the t-test for all TAM measures.

Results reveal that Perceived Enjoyment (PE) was higher for those that watched concerts in the Live condition (M = 5.58, SD = 1.06) compared to those in the AI condition (M = 4.84, SD = 1.21), $t(45.19) = 2.249$, $p = 0.029$, d = -0.65, 95% CI [-1.25, -0.05]. Similarly, Perceived Ease of Use (PEOU) is higher in the Live condition (M = 6.06, SD = 0.88) compared to the AI condition (M = 5.46, SD = 1.05), $t(44.62) = 2.168$, $p = 0.036$, d = -0.63, 95% CI [-1.22, -0.03][1]. Lastly, Perceived Usefulness (PU) is higher in the Live condition (M = 4.72, SD = 1.42) compared to the AI condition (M = 3.76, SD = 1.19), $t(44.64) = 2.526$, $p = 0.015$, d = -0.73, 95% CI [-1.33, -0.13]. Results are visualized in Figure 1. Overall, evaluations lean towards the positive side (i.e., >4) of the scales, with the exception of PU in the AI condition.

C. Familiarity and liking

Subsequently, we examined whether the significant differences could simply be attributed to higher familiarity or liking of artists and songs by participants in the Live condition. As these were ordinal Likert scales, we opted for the Wilcoxon rank sum test. Familiarity with the artist (W= 2511.5, p = 0.838, r = 0.02), familiarity with the song (W= 2247, p = 0.113, r = 0.19), liking of the artist (W= 2353, p = 0.389, r = 0.10), and liking of the song (W= 2680, p = 0.603, r = 0.06), all yielded non-significant results, indicating no differences between participant groups. Figure 2 visualizes the results per artist. Participants were (rather) unfamiliar with the artists/songs (i.e., scoring below 4). Additionally, liking scored mediocre overall (i.e., < 4).

D. Correlations

We examined possible correlations of the TAM measures with Immersive Tendencies (continuous), previous VR experience (ordinal), and attitude towards VR (ordinal). Results are found in Table 1. Continuous variables were assessed using the Pearson correlation coefficient, while ordinal variables were assessed using the Kendall rank coefficient. Note that the correlations reported here are exploratory and are not corrected for multiple comparisons. Interpretation should be done with this in mind. Results show significant moderate correlations for immersive tendencies (with PE and PU), as well as VR attitude (all components).

[1] A non-parametric equivalent (Wilcoxon rank sum test) reveals similar results: Live Mdn = 6, AI Mdn = 5.75, W = 389, p = 0.037, r = 0.43.

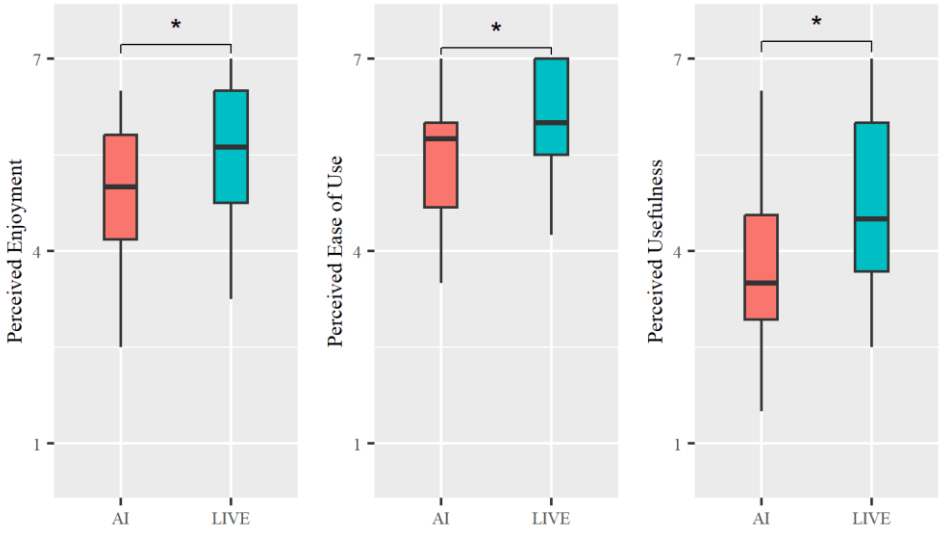

Fig. 1. TAM scores over conditions. Asterisk indicates a significant difference. PE, PEOU and PU are significantly lower in the AI condition compared to the Live condition.

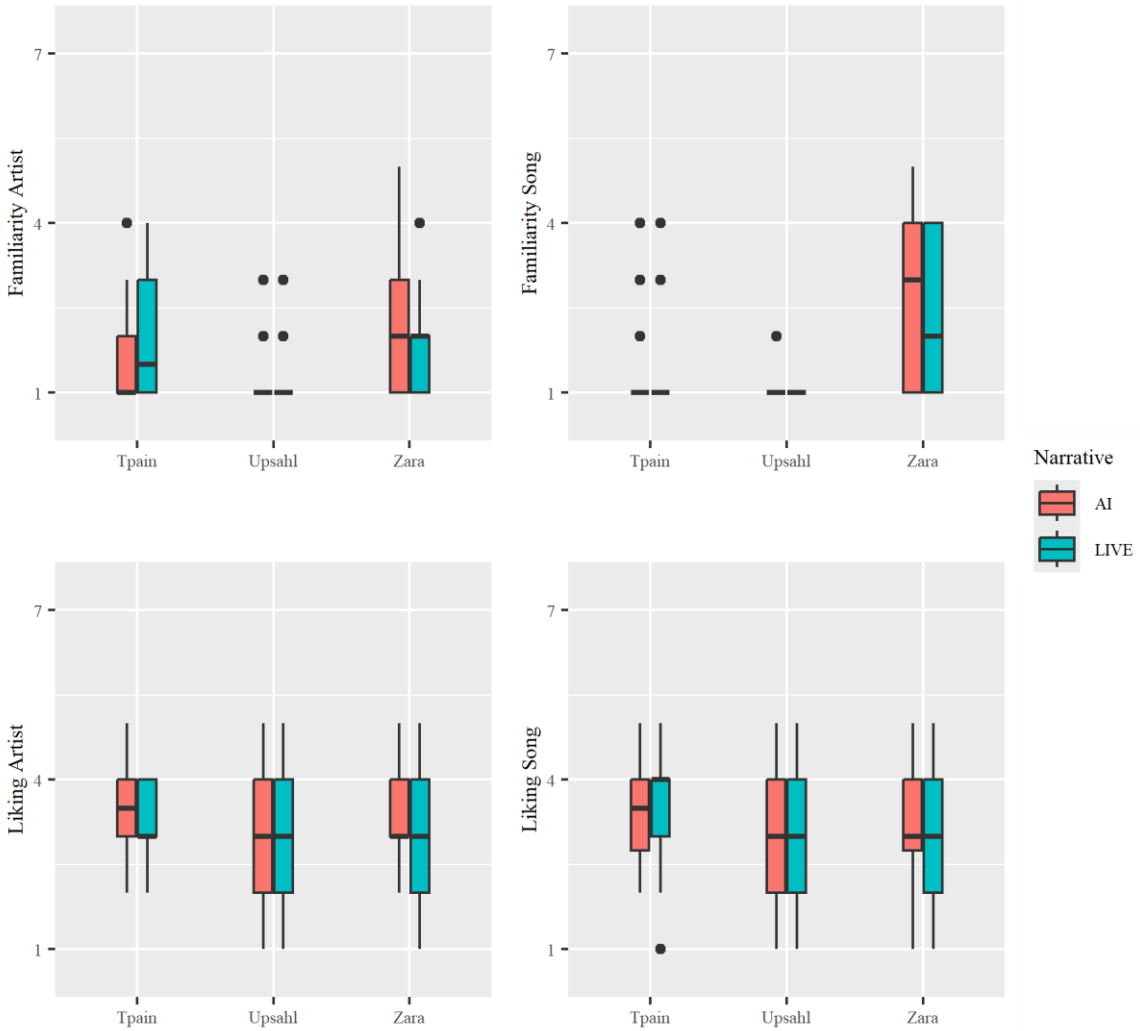

Fig. 2. Distributions of familiarity and liking of artists and songs. No significant differences were found between the Live and AI narrative conditions.

TABLE I. EXPLORATORY CORRELATION ANALYSIS

Variable	Component	Statistic
Immersive Tendencies	PE	**$r(46) = 0.37, p = 0.009$** [a.]
	PEOU	$r(46) = 0.21, p = 0.136$
	PU	**$r(46) = 0.33, p = 0.022$**
VR experience	PE	$r_\tau = 0.18, p = 0.115$
	PEOU	$r_\tau = 0.15, p = 0.204$
	PU	$r_\tau = 0.15, p = 0.203$
VR attitude	PE	**$r_\tau = 0.39, p < 0.001$**
	PEOU	**$r_\tau = 0.31, p = 0.008$**
	PU	**$r_\tau = 0.46, p < 0.001$**

[a.] Bold indicates significance

IV. DISCUSSION

In this study we examined whether the acceptance of VR for concert experiences is affected by an AI negativity bias. Using the TAM, our results indeed suggest a negative bias in the context of VR concerts. All TAM measures (i.e., Perceived Enjoyment, Perceived Ease of Use, and Perceived Usefulness) were negatively affected by the AI condition compared to the Live condition. This falls in line with previous research on this bias in arts research [7], [8], [9], [10], [11]. The negative impact of the AI bias is particularly of interest in the case of PU, where participants evaluate the usefulness of VR concerts negatively on average. Thus, our results suggest that VR concert adoption is more likely to succeed when accompanied by a narrative that assumes active human participation in the creative process. Otherwise, people might simply not see advantages to using such technologies.

As we were interested in a general stance towards VR concerts, the experimental trials were followed by a short conversation highlighting different possibilities of attendance. Here, participants were also informed about the experimental manipulation. While it can be argued that an exaggerated effect might have occurred if participants had not been informed, we find it of particular interest that the AI negativity bias persists even after our explanations. This intimates that such a first narrative can have lasting effects, even after new information has been provided. Nevertheless, our debriefing approach could be considered more indicative of reflective rather than intuitive responses.

Moreover, these results should be contextualized further to discuss the limits of its generalization. Firstly, although we were successful in diversifying our sample beyond university students through recruitment at a local library, the current study was done in The Netherlands with the bulk of participants having the Dutch nationality. Previous studies have shown that AI perceptions can differ based on nationality [19], [20]. Furthermore, the current study employed the AmazeVR app, which offers a specific kind of experience (i.e., they use volumetric recordings). Employing the same experiment with, for example, avatar concerts, might yield different results. Moreover, all songs in the current study can be considered pop songs. As [10] showed genre is of influence on the AI negativity bias (although showing a mitigated composer bias for pop music), further study is needed to examine how this result translates to different concert styles.

As stated, the TAM was used to gain insights into a general stance towards VR concert experiences. While participants did not particularly like the artists or songs on average, it stands out that PE scores positively, indicating that participants can see its potential beyond the concerts they were exposed to here. Anecdotally it can be added that participants indicated to be interested in watching more VR concerts if the performances were by their personal favourite artists, or if the VR concerts provided the possibility of virtually attending legendary concerts of the past (e.g., Live Aid). Additionally, some added to be interested in performances by artists that have deceased. The latter raises a number of interesting questions, including whether the usage of an AI model of an artist is more accepted in such cases. As such, the desire to relive/revive the past [6], [21] might mitigate the negative perceptions associated with AI.

Furthermore, the adoption of VR concerts is likely to be led by people who already have a positive stance towards VR in general. Our exploratory correlational analyses show that moderate ($r_\tau > .3$) positive correlations exists between PE, PEOU, PU and VR attitude. Interestingly, no such effects were found for previous experience with VR, suggesting that preconceived notions play a greater role than actual experience with the technology. Moreover, the results on VR attitude might indicate that a positivity bias exists for those having a more positive attitude, that is, the positive experience might be driven by attitude rather than inherent technological affordances. This has interesting implications for the promotion of further adoption, as it seems general attitude needs to be targeted. Furthermore, our results showed a moderate ($r > .3$) positive correlation between immersive tendencies and PE, as well as PU, but not PEOU, suggesting that people who are more readily immersed get more enjoyment from immersive experiences such as VR concerts, and that they perceive greater usefulness for such technologies. The absence of a correlation with PEOU in this context might indicate that ease of use does not play a significant role in assessment of technologies for people that become more readily immersed in mediated environments, or alternatively that such people desire more complexity. These results highlight that subjective preferences play an important part in technological acceptance of virtual reality concerts. However, it should be noted that these correlational analyses were exploratory and future research should examine this more strictly.

Another aspect that cannot be ignored is that a substantial portion of participants mentioned, unprompted, that they felt the concerts they had watched were more akin to videoclips than to a concert experience. Possibly, this might be attributed to the audio used, which (to the best of our knowledge) were studio recordings with occasional live recorded voice overlays. Previous research has shown that auditory elements can play an important role in (virtual) concert experience [22], [23]. Therefore, it is possible that aural idiosyncrasies of the traditional concert format were not met.

Additionally, this might be attributed to the concept of temporal co-presence – the experience of sharing a specific time and (virtual) place – which is a crucial component of concert attendance [1], [24], [25]. Hence, the fact that participants were sole audience members stepping into an on-demand virtual environment might have influenced to what extent participants considered the performances as a concert. Nevertheless, while discussing this with one of the participants post-experiment, it became clear that, for example, a livestream of a traditional concert performance was still considered watching a concert, even though such a performance might be available on-demand on YouTube and

watched as a solitary activity at a later time. This raises interesting questions on what constitutes a concert for users and which contextual factors are of importance herein. Given the influence of previously held attitudes on TAM components, as discussed in previous paragraphs, preconceived notions and expectations related to the concept of "a concert" might influence technological acceptance of VR concerts as well. It should be noted, however, that such preconceptions and expectations surrounding concert experiences are not static [6], but are likely to change over time as more people are exposed to VR concerts.

All in all, this study adds to the literature on the AI negativity bias, as well as provides greater understanding of its role in the context of VR concerts. Additionally, the present study adds to the literature on virtual (reality) concert experiences in general, which is still an underexplored field of study. Future research could examine contextual factors and individual characteristics more closely in relation to the technological acceptance of VR as a means for concert experiences, as well as deepen understanding through supplementing self-report surveys with behavioural and physiological measures.

V. Conclusion

The Technological Acceptance Model (TAM) was used to investigate technological acceptance of virtual reality concerts. Our results convey that an AI negativity bias exists for all components of the TAM in the context of virtual reality concert experiences. Nevertheless, perceived enjoyment and perceived ease of use were positively evaluated on average in both the Live and AI condition (perceived usefulness solely in the Live condition), showing willingness to adopt VR concert technologies in general. Participants suggested increased interest under the assumption that subjective interests were met (e.g., favourite artists). Our results further suggest that personal attitudes and individual characteristics (e.g., immersive tendencies) might play an indicative role in technological acceptance of VR concerts. As such, this study provides new insights at the intersection of AI, VR and music research.

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