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Would you rather come to a tango concert in theater or in VR? Aesthetic emotions & social presence in musical experiences, either live, 2D or 3D

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ABSTRACT

This work shows the preliminary results of a pioneering project aimed at comparing the aesthetic experience of a musical concert experienced in different contexts for which the audience's perceived presence is modulated in a continuum ranging from a live concert to a music video, passing through immersive artificial environments.

In contrast to previous qualitative investigations of various immersive contexts, our study is unique in both the use of validated scales and the structured comparison of four experimental conditions: 1.*live concert (LC)*, 2.the same concert through a traditional non-immersive *music video (MV*, analogous to fruition on YouTube), and finally in a virtual reality environment *(VR)*, provided by two different devices, *3.* a *google cardboard (CVR)* and 4. an *HTC vive (HVR)*, allowing respectively for a basic and easily accessible experience, or for a less affordable but more immersive one.

Through these manipulations we presumably affected not just the subjective aesthetic experience, but also the perceived presence of the Other/s. Consistently we measured both through the administration of the Aesthetic Emotions Scale (Aesthemos) and the Networked Minds Measure of Social Presence (NMMSP).

The NMMSP showed no notable differences between conditions, which instead emerged from the analyses on the Aesthemos. The most liked experience was the Live one. Results also showed that LC experience had a stronger emotional impact only when compared to MV and CVR, but not to HTC since this last manipulation was the one eliciting the greatest interest.

Theoretical implications are critically discussed, suggesting novel applications of the proposed approach.

1. Introduction

The present work shows the preliminary results of a pioneering project aimed at comparing the aesthetic experience of a musical concert lived in-presence with the same concert experienced in not-shared spatial and temporal dimensions. There are currently several alternatives to the live event experience: we encountered them on a massive scale during the pandemic. In our homes we familiarized ourselves with both traditional streaming (e.g., a movie on Netflix or other digital platforms) and "live streaming" (e.g., a concert on YouTube or Twitch). From the perspective of the user, live streaming has the advantage of reaching the audience in the shortest time, favoring the sense of presence; from the perspective of IT developers, it is challenging for the large amount of data and information to be created in a few seconds and sent immediately to users. The sense of presence is even stronger in a virtual world, which is symmetrically much more complex to implement – the ultimate exponent of it being the "metaverse". This product combining physical and virtual reality can provide enhanced immersive experiences in a space-time structure identical to our physical universe.

Psychologists and philosophers are familiarizing themselves with these new experiences, reasoning on their possible implications and new research questions. Intriguing in this regard is the proposal by Atherton and Wang (2020) of a practical philosophy oriented toward developing design principles of artful musical VR. Computer scientists are chasing each other in the realizations of "digital twins" that are increasingly effective in replacing both objects and real agents, adapting to different contexts. Artists, unencumbered by research objectives, are variously directing their creative thrust. In the musical field, which we are most

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interested in here, consider the recent experimentation by Travis Scott (2020): his musical concert in Fortnite has been one of the most attended live events in VR.

Beyond the daring artistic endeavors, which range across different fields, the present project moves from a collaboration among scholars who, from different perspectives (i.e., psychology, philosophy, computer science), have been questioning how to clearly structure research work on immersive experiences in virtual environments. We decided to proceed incrementally: starting from a well-circumscribed field of investigation and bounding the theoretical questions accordingly. For different reasons, the field we have chosen is that of virtual environments recreating aesthetic experiences, circumscribing (for now) the analysis to the musical ones.

To understand whether and how these aesthetic (and social) experiences are systematically modulated (i.e., not just because of the temporary 'novelty effect') by differently immersive settings, we must select physical and social environments for which the degree of immersiveness is incrementally increased. Consistently, we contrasted the classic experience of a live concert (LC, in presence) with three "remote" conditions, not simultaneous with respect to the event: the experience with audiovisual musical files (MV, the classic viewing of a concert on YouTube) and two experiences lived thanks to a less or more sophisticated eye-mounted apparatus for virtual reality (VR), i.e., google cardboard (CVR) and an HTC Vive (HVR). The CVR and the HVR allow respectively for a basic and easily accessible experience vs. a less affordable but more immersive experience. Both the devices permitted a three-dimensional vision: by moving the head or the whole body, participants could have a 360° view, therefore an overall vision of the concert venue, including musicians and audience – together with their possible reactions to a virtuosity or a false note played by the performers.

For this novel field of research, there is not yet substantial empirical literature. It took shape from hands-on needs arising in the context of the COVID-19 pandemic (Vardomatski, 2021), but it is of considerable interest also from a theoretical point of view. The aesthetic social experience strongly influences the shaping of identity: it allows bodily effects-affects to re-emerge, consistently with psychological approaches enabling the re-enactment of the bodily self (Scorolli, 2019). In this sense, it could be considered as a novel and privileged means for approaching the acting-sentient bodily self in a dynamic-social and affective environment. The emergence of a coherent identity not only affects the well-being of the individual but is also fundamental in the development of the self – particularly during adolescence. In aesthetic experience (in the broad definition of which we can include, for instance, reading a book or listening to a piece of music) we are immersed in an interaction in which we participate without controlling what happens. The contents of the environment become an integral part of the same (extended) mind to which we feel we belong (Matteucci, 2019). In perceptual and emotional interaction, expressive artifices concur to aesthetically construct our bio-cultural niche (Matteucci, 2021).

The aesthetic experience *in everyday contexts* is still little investigated by cognitive science: among the reasons there is the difficulty in collecting data and creating equally controllable and comparable experimental conditions. Another issue can be ascribed to the challenge in converging on a 'good' definition of aesthetic experience. In this regard a recent and inspiring work is the special issue by Mastandrea, Tinio, and Smith (2021) on aesthetic experiences addressed in different contexts: we endorse the authors' definition as "people's interactions with, and reactions to, objects, places, but also to the environment" (see also Tinio & Smith, 2014).

This novel area of investigation does have the merit of taking empirical research out of the laboratory and re-thinking the places of art as possible experimental labs and places of contact, interaction, and inclusion. Moreover, it fits well with the new institutional mission of the Academia. Alongside the traditional missions of teaching and research, nowadays the Academia must be engaged in fostering the scientific, technological, and cultural transfer of knowledge, through processes of direct interaction with society: the goal is to promote the social growth of the territory, so that knowledge becomes instrumental in obtaining benefits of social, cultural, and economic nature.

A further value of the perspective proposed lies in its interdisciplinarity. Psychologists, philosophers, virtual environment developers, and artists are engaged in the jointly effort to explore the relationship between the aesthetic experience and the individual's self-awareness but also innate needs (Yu, 2016; Yu & Wang, 2018), consistently with the hierarchy proposed by Maslow, in which aesthetic needs even precede personal self-realization (Maslow, 1954, 1992; Ward & Lasen, 2009).

Finally, among the innovative features of this research, we point to the emphasis on new technologies. Throughout our evolutionary history, our cognitive systems have been profoundly changed with the advent of technological inventions such as primitive tools, writing, and arithmetic systems. Immediately following the advent of the Internet, the progressive development and spread of Virtual Reality environments are profoundly reshaping the human mind, our feelings, our interactions, and our way of life.

Despite the usefulness of VR paradigms, only 1.24% of the worldwide population is using it: any further data providing contexts and insights regarding its use in different application domains may provide data suitable to support the design and implementation of novel immersive experiences (Richter, 2023). This becomes even more evident when taking as reference the country which has the largest amount of VR users, i.e., USA, where 15.96% of the population has experienced VR: a large portion of these users focus on the gaming sector (43%), while a very small percentage (6%) have exploited VR to visualize artistic performances, including concerts (Security.org Team, 2022). To this evidence we must add the general reluctance to produce this type of content, driven by the lower perceived authenticity for digital content related to these experiences (Bossey, 2022). Yet, the major research contributions on the use of VR are restricted to the area of gaming and education (Bowman, Rieger, & Lin, 2022; Kamińska et al., 2019; Psotka, 2013; Shelstad, Smith, & Chaparro, 2017; Virvou & Katsionis, 2008). Although in recent years there has been a continuous production of new VR devices, with increasingly complex and novel capabilities, the literature still lacks evidence on how consumers respond to VR experiences in the realm of aesthetic perception, for example, in the music domain. Therefore, we still know little about how these technologies impact the enjoyment of the artistic performance.

Nowadays an analysis of aesthetic experience cannot neglect updated technologies as they convey art and transform it (Marfia & Matteucci, 2018; Weber-Sabil & Han, 2021). New 'machineries' not only facilitate the creation of art but also connects us to the world. Not surprisingly, even artists are now sensitive to the role of technology to such an extent of describing the laptop as "the most intimate instrument that we've ever seen" – as stated by the experimental artist Holly Herndon (2019), who collaborated with an artificial neural network trained to sing for her album "Proto".

From an *experimental* perspective, we intend to exploit the potential of VR technologies as a *methodological* boost to empirical aesthetics: virtual environments provide an excellent compromise between ecological validity and experimental control. Here, we want to compare different devices able to convey an aesthetic-musical experience, including VR devices with varying degrees of immersiveness, in order to investigate their ability to engage, more or less powerfully, the participant with respect to that experience, typically enjoyed in a theater. New generations are certainly more inclined to the use of VR technologies, at the same time they are not accustomed to a context such as the theater and do not autonomously seek "classical" aesthetic-musical experiences, such as the tango concert proposed for our study. That kind of experience, typically enjoyed in the traditional context of a theater, is closer to an adult-senior audience. We therefore decided to bring the tango concert into virtual reality, to understand whether this new fruition

could introduce even a young audience to tango. In this perspective, the adult participants in the Live condition, who are manifestly interested in that type of performance, serve as a baseline for the comparison.

To investigate human aesthetic experience, we need a rethinking of classic laboratory experiments, especially if we consider that "The most enigmatic components of aesthetic experience include inclination to cry, aesthetic rapture, a sense of the sublime, and intense fascination. However, we cannot evoke these 'hot' aesthetic emotions in the lab" (Makin, 2017, p. 184). Although empirical aesthetics is often focused on cold evaluation of parts, aesthetic experience is essentially about warm emotional reactions to wholes (Makin, 2017): by capitalizing on emerging technologies, we can overcome traditional reductive approaches. Furthermore, VR would also allow to address inter-individual peculiarities in sensitiveness to a specific modality conveying the aesthetic experience at hand: e.g., some individuals could be more likely involved with exhibitions (visual modality), while others with concerts (acoustic modality). The convergence of empirical studies in attesting the effectiveness of VR as a medium for eliciting empathy (Ventura et al., 2020) further encourages us to proceed in this direction.

From a *theoretical* perspective, we are interested in both the emotional and the social dimensions. Thus, in the present work, we addressed the aesthetic emotions evoked in the four conditions (LC, MV, CVR, HVR) through the administration of a validate questionnaire: the Aesthetic Emotions Scale (Aesthemos: Schindler et al., 2017), structured in 21 subscales covering prototypical aesthetic emotions, epistemic emotions, and emotions indicative of amusement. As far as the social dimension is pertained, we investigated the effectiveness of our scenarios in conveying the human interactions at hand. Even if social interactions do have a crucial role in aesthetic appreciation, they are frequently neglected when addressing VR aesthetic experiences. Paradoxically, one of the most significant contributions of VR is in its potential to create a sense of "social presence", that is, the feeling of being and interacting socially within a new environment. Consistently we aimed at detecting the possible feeling of the other people's presence in our scenarios. To assess the feeling of social presence, we administered a revised version of the Networked Minds Measure of Social Presence (Biocca, Harms, & Gregg, 2001), composed of items focusing on both co-presence and psychological involvement.

These experimental and theoretical perspectives were adopted and applied for a particular use case: evaluating how virtual experiences could be put to good use within a musical aesthetic experience. Specifically, in our case we used VR technologies to increase the interest and engagement of a specific population (i.e. young students) which is typically not interested in attending a certain kind of cultural experience, namely a tango music concert in a theater, but that is prone to use virtual experience technologies (de la Fuente Prieto, Lacasa, & Martínez-Borda, 2022; Geng et al., 2022; Dwivedi et al., 2022); then we compared scores of interest and of social involvement so obtained for young adults with those of a solid baseline: passionate adult people, who are usually the target audience for this kind of cultural activities (Meeks et al., 2018). To clarify, we used the scores of participants in the Live Concert condition (i.e., adults enthusiastic for tango concerts) as a benchmark to assess the extent of involvement of young people who experienced the same concert through different Virtual Experiences (MV, CVR, HVR). It is worth noting that a similar approach, with appropriate adjustments, can be adopted with other types of aesthetic experiences characterized by age-specific targets (e.g., ballet, tourist tours, etc.).

2. The experiment

2.1. The tango live concert at the Teatro Comunale Pavarotti-Freni

The project has been realized thanks to the collaboration with the Teatro Comunale Pavarotti-Freni, the Opera House of Modena (https://teatrocomunalemodena.it/en/). Importantly, the Italian city of Modena has recently been awarded the title of UNESCO Creative City for Media Arts. The UNESCO Creative Cities Network has been created in 2004 to promote cooperation with and among cities that have identified creativity as a strategic factor for sustainable urban development: the city of Modena has excelled for its social and cultural projects exploiting artificial intelligence applied to the fields of art and education. The Teatro Comunale Pavarotti-Freni, the most important cultural center of the city, stands out for its inclusion-oriented projects (e.g., CrossOpera, a lyrical opera dedicated to the theme of transcultural integration); consistently, it is trying to initiate immersive concert experiences, taking inspiration from the experimentation led abroad. In Germany, for instance, the Staatstheater Augsburg is working on the vr-theatre @home project to transform the conventional passive role of spectator into a participative position (Weber-Sabil & Han, 2021). For further VR experimentations in the areas of spatial music (acoustic quartet), contemporary opera, rave and rock music, see respectively Bates and Boland (2016); Kallionpää, Chamberlain, and Gasselseder (2018); Weinel (2021); Slater et al. (2022).

The musical event under our investigation has been "Amarcord d'un Tango," an open-air concert held on July 14, 2022, at 9 p.m., at the "Cortile del Melograno" in Modena, as part of the "Musiche sotto il Cielo" festival. The concert took shape from the artistic encounter of two Italian virtuosi, playing instruments of mid-19th century: Marco Albonetti (soprano sax) and Daniele Di Bonaventura (bandoneon), accompanied by the "Ensemble dell'Orchestra Filarmonica Italiana." The concert presented a new recording project created for the English label Chandos Records. Sacred and secular music, folk and tango coexist together in this work, characterized also by Mediterranean inspirations. The melancholy sound of the *bandoneon* blends with modern harmonies and timbres achieved by the strings and soprano saxophone. The bandoneon, named by the German instrument trader Heinrich Band (1821–1860), was originally intended as an instrument for religious and popular music of the time, in contrast to its predecessor (i.e., the German concertina, which had been predominantly used in popular music). Around 1870, German and Italian emigrants and sailors brought the bandoneon to Argentina, where it was adopted into the emerging genre of tango music, a descendant of the earlier milonga.

2.2. Experimental conditions: LC, MV, CVR, HVR

The experimental condition *live concert (LC)* consisted of participation in the whole concert. From the video recording of the concert, nine significant minutes were extracted, including the introduction of the artists and the musical performance.

From this recording, we extracted a music video *(music video condition, MV)*, and a three-dimensional scenario, to be experienced through an app on a smartphone, integrated with adaptive VR glasses (average cost, 20 euros: *google cardboard VR condition, CVR*), or through a professional visor, i.e., a VR headset (average cost, 300 euros: *HTC vive condition, HVR*). The immersive VR interfaces have been developed by the VARLab (https://site.unibo.it/varlab/en) by applying protocols that have been already successfully adopted (Morotti et al., 2021). For MV, CVR and HVR conditions, participants watched and listened to nine minutes of the concert; all three pieces of equipment allowed the choice of interface language (Italian or English) and the performance to be paused, re-started, and speeded up or slowed down – even if these actions were not allowed for the experiment.

Below we specify why we chose a 9-min experience length for the video, referring both to the literature and to a questionnaire administered to participants online in days following the experimental session. Unlike the sample of young adults, who experienced the "not-in-presence" conditions (MV, CVR and HVR conditions), the sample of participants who chose to attend the concert (Live condition) were accustomed to attending this type of event for a period of time of an hour or more (Meeks, S. et al., 2018). Young people are used to enjoying music videos on screen: several studies testify that the average time of

such experiences is usually less than 9 minutes (Nielsen, 2020; Loh et al., 2022; Yang et al., 2022). Therefore, we considered the 9-min video of the concert to be a fair trade-off for the youngsters to stay focused and, at the same time, to provide them with a music video slightly longer than the ones they are used to. This choice made their experience during the experiment more realistic and closer to their habits, similarly to the theater experience for live audiences. Consistent with the literature evidence are the scores of our follow-up questionnaire "TAMIG" (Appendix c. Follow-up questionnaire TAMIG), which, by means of several questions, provides an overview of students' habits in relation to multimedia and video viewing time. In the TAMIG, we also included a question about whether they would be interested in watching additional minutes of the experience - after the 9 minutes planned for the experiment. Questions directly related to these points are F5, F7, F8, F9, F10 (see Appendix c.). The results of the TAMIG questionnaire show that 96% of the subjects had seen a video of a concert (item F5: "Have you ever seen the video of a concert?"). For these subjects, we examined the responses to item F7 ("In your estimation, how many minutes would you spend watching the video of a concert?") obtaining an average estimate of 19.6 minutes. Examining also the categorical item F8 ("What are the minimum minutes that would make you consider a video to be long?"), the trend of the distribution is on 10 minutes (Fig. 1). This is general in line with the results obtained in literature (Nielsen, 2020; Loh et al., 2022; Yang et al., 2022). Furthermore, the scores for item F9 ("Following the previous question, would you be predisposed to watch a concert video that exceeds 10 minutes?", 5-points likert scale) suggested uncertainty about watching a video concert longer than 10 min, with a mean of 3.2/5 (1.30 SD). Finally, the scores for item F10 ("After the experiment, would you have continued watching the video beyond the proposed 9 minutes?") revealed little interest in watching the video for a time longer than 9 minutes (68% of the sample answered "No"). These results support the chosen duration for the video during the experiment, consistently with the aforementioned literature.

After all the experiences (conditions LC, MV, CVR, HVR), two questionnaires (see Section 2.3 Method) were filled out. The Live conditions were then compared with all other conditions. We point out the main limitations of this comparison. In the live condition, participants attended the entire concert; moreover, they were the spectators: they had chosen to attend that specific concert, paying for a ticket, and thus evidently appreciating that kind of music. In the other three conditions, participants experienced only part of the concert; furthermore, they were college students, with a lower average age (see subsection 2.3.3 Ethics and Participants for details), and with (predictably) different musical preferences: their level of motivation for participating in that experience was therefore not the same as the spectators. Students received one college credit for participating in the experiment; spectators received a theater gadget (a pencil).

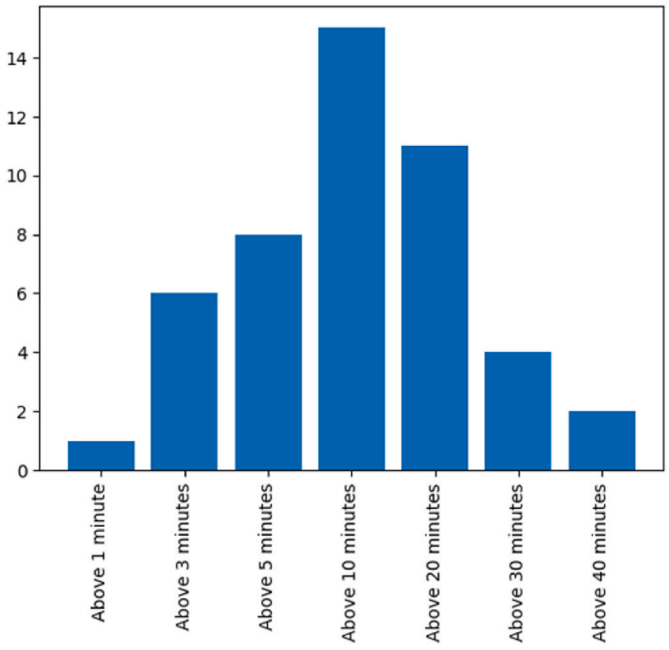

Fig. 1. Histograms of F8 question item answers.

In interpreting the results, we will take into account these differences between conditions, still maintaining that they are inevitable in ecological studies. For this kind of study, the point is to find the best compromise solution, and to interpret the results cautiously. We believe that methodological difficulties should not inhibit frontier research in relatively unexplored areas.

2.3. Method

2.3.1. Aesthetic Emotions Scale and Networked Minds Measure of Social Presence

To answer to our research questions, we needed validated scales able to catch (i) the *aesthetic emotional experience*, to understand whether it was equally effective for MV and VR (considering both the cardboard and HTC Vive devices) compared to LC, and (ii) the *social presence*, to investigate whether the effectiveness in VR was comparable to that in LC, and significantly higher than that in MV.

(i) Cognitive scientists have tried to implement direct and indirect measures for the variable "*aesthetic emotional experience*". Recent evidence has shown that the capacity to experience aesthetics, and thus to make appropriate aesthetic judgments, is modulated by daily behavioral habits, as adequate sleep duration, improving also empathic skills (Peretti et al., 2018). Indeed, aesthetic perception and aesthetic judgment are not solely "cognitive" processes, but they involve the affective-emotional sphere. Mastandrea, Fagioli, and Biasi (2019) have provided a stimulating account of the relationship between aesthetic emotions and physical-psychological well-being: they propose psycho-physiological measures of stress to index aesthetic appreciation. From another side, the behavioral-qualitative investigation of aesthetic experiences focuses on the conceptualization and measurement of aesthetic self-reported emotions. Schindler et al. (2017) have proposed a review of different aesthetic experiences highlighting possible "elicitors" of aesthetic emotions (i.e., arts in the strict sense, but also nature; regarding nature see also Løvoll, Sæther, & Graves, 2020), and have suggested an analysis of existing measures for aesthetic emotions within specific domains (music, literature, film, painting, advertisements, design, and architecture). They finally developed a questionnaire, the Aesthetic Emotions Scale (Aesthemos), structured in 21 subscales covering prototypical aesthetic emotions (e.g., the feeling of beauty, being moved, fascination, and awe), epistemic emotions (e.g., interest and insight), and emotions indicative of amusement (humor and joy), differentiating between the activating (energy and vitality) and the calming (relaxation) effects of aesthetic experiences, and capturing negative emotions that may contribute to aesthetic displeasure. The original version, and the Italian translation, of the Aesthemos-specific scale (Schindler et al., 2017, p. 42 items in total, 2 for each subscale) is reported in Appendix a. Aesthemos. (For a semantic profile analysis of aesthetic emotion terms used in the Aesthemos scale see Beermann et al., 2021).

(ii) As stated above, another major factor leading to an effective social VR simulation is the feeling of Social Presence, that is the sense of being with another (Biocca et al., 2001). It refers to the ability of the VR system to create the illusion that the user is inhabiting the virtual environment with someone else. Social presence research, however, suffers from two main flaws: a) the disagreement (and frequent inconsistency) in terminology among researchers, which transfers both into different operationalizations of the construct (Oh, Bailenson, & Welch, 2018) and difficulties in measuring and comparing results; b) the use of different (behavioral or psychophysiological) markers, not adequately

validated. Indirect measures of social presence include those focused on unconscious physiological changes or conscious volitional actions (Slater, Lotto, Arnold, & Sanchez-Vives, 2009); a widely used behavioral measure is proximity (e.g., Bailenson et al., 2005). Regarding direct measures, validated questionnaires are often not appropriate for the specific experimental scenario (Biocca, Harms, & Burgoon, 2003): consistently, there are not scales perfectly suitable to measure "social presence" in our four scenarios. In keeping with the suggestions of Sterna and Zibreck (2021), we finally opted to use an adapted version of the validated questionnaire Networked Minds Measure of Social Presence (Biocca et al., 2001). We translated the questionnaire in Italian and slightly re-adapted it by eliminating items not pertinent to the experience of a concert (namely the ones related to behavioral interdependence and mutual assistance; see subsection 2.3.5 Assessment model). The original version, and the Italian translation and adaptation, of the questionnaire is reported in Appendix b. Social Presence.

Thus, we exploited both the Aesthetic Emotions Scale and the Networked Minds Measure of Social Presence to investigate the aesthetic experience for the examined continuum *music video (MV) – google cardboard VR (CVR) – HTC vive VR (HVR) – live concert (LC)*. For this *continuum* we advance the general predictions that both the feeling of aesthetic emotions and the felt presence of the Other(s) are progressively more powerful. That is, for both questionnaires, the predictions are of the highest scores for LC, gradually lower for VR (as VR allows for the vision of the virtual Other(s) close to the participant: their facial expressions, their possible yawns, etc.); LC should significantly differ from MV (as MV allows for the vision of other spectators only in peripheral vision). MV should result in the poorest aesthetic experience and less social involvement.

The differences between the addressed conditions will necessarily be affected by the differences in the tested samples, i.e., for LC we consider the greater motivation and interest respect to MV-CVR-HVR. Thus, the effects will be interpreted also considering this confounding effect.

2.3.2. Follow-up questionnaire TAMIG: Theater Attendance, Media Habits, Immersiveness and Interest Gain

To further validate our hypothesis on the selected samples (MV, CVR, HVR), and to disambiguate whether the results from the previous scales could be due also to the different interest in the specific kind of music genre (in additoin to the immersive effect of the virtual experiences), we needed a new custom methodological questionnaire), i.e., the above introduced TAMIG.

This questionnaire had to be able to catch (i) the participants' attendance at the theater, if any and (ii) the use of video media, (iii) the level of immersivity of the different Virtual Experiences (HVR, MV, CVR) and (iii) the Interest Gain towards Tango Concert differentiated by the type of experiences.

To measure such constructs, we designed the custom questionnaire composed of 4 sub-groups of itmes: Theater Attendance, Media Habits, Immersiveness and Interest Gain (Appendix c. Follow-up questionnaire TAMIG). Theater Attendance aims at evaluating the attendance of subjects at the theater, while Media Habits aims at measuring how long our subjects are used to watch musical videos. Then Immersiveness and Interest Gain aim at evaluating the immersive level of the interface, extrapolating the most meaningful question from the Igroup Presence Questionnaire (IPQ) scale (Schubert, 2003), and at measuring the increase in the interest towards Tango Music before/after the experiment-experience.

This custom questionnaire (TAMIG) was administered only to student participants (i.e., the sample which is not usually interested in attending Theater).

2.3.3. Ethics, Participants and specificities of the selected samples

The experiment has been conducted in accordance with the ethical standards laid down in the Declaration of Helsinki and fulfilled the ethical standard procedure recommended by the Italian Association of Psychology (AIP). All procedures were approved by the Ethics Committee of the University of Bologna (Approval number 0159749). For the MV, CVR, and HVR conditions, before starting the experiment, all participants were briefly explained the general objectives of the project and the procedure; then they signed the written informed consent to participate. For the LC condition, a flyer about the research was distributed before the beginning of the performance. At the end of the concert, volunteers were recruited at the venue; before filling out the questionnaires, they received a verbal explanation and then signed the informed consent. For all the conditions, participants were aware of the time needed to participate in the experience and the time needed to fill out the questionnaires (i.e., about 15 min).

We tested 70 participants, 10 for the live concert condition (LC: age Mean 56.44; SD 9.03; Females 70%) (see Radbourne et al., 2009); 20 for the music video condition (MV: age Mean 19.6; SD 1.47; Females 65%); 20 for the immersive condition with the Cardboard (CVR: age Mean 25; SD 6.83; Females 70%); 20 for the immersive condition with the HTC-VIVE (HVR: age Mean 20; SD 1.88; Females 65%). For each virtual experience condition, 20 was considered a sufficient large number of participants consistent with similar work (He et al., 2018): evidence demonstrates that 10 is the minimum number of participants to discover 80% of existing interface design problems and so to validate it (Salomoni et al., 2017; Hwang & Salvendy, 2010; Morotti et al., 2021).

As discussed above, the mean age in the live condition (LV) was higher than the mean age in the laboratory-tested conditions (MV, CVR, HVR). Our protocol allows to test whether virtual (not in presence) experiences can be put to good use to increase the interest and engagement of a population (young students) which is not interested in attending a certain cultural experience, namely a Tango music concert, but instead is prone to use virtual experience technologies (de la Fuente Prieto et al., 2022; Geng et al., 2022; Dwivedi et al., 2022).

As clarified above, in the TAMIG follow-up questionnaire (administered to student participants: conditions MV, CVR, HVR) we included questions related to the Theater Attendance and Media Habits. 47/60 participants filled out the questionnaire. The experimental mortality for this follow-up questionnaire was not of particular concern (13/60); importantly, participants' dropout for the different experimental conditions was comparable, thus the treatment itself could not be the cause for the noncompliance of research participants (see Ciuk & Yost, 2019).

Focusing on the first items (Theater Attendance: F1, F2; Media Habits: F3, F5, F6, F11, F12, F13), we found that 68% of young participants were not used to attend theaters; for the remaining 32%, most of the attendees (80%) were used to go to the theater just once every 6 months (item F1–F2) and a greater percentage (87%) had never attended a live Tango Concert (item F3). Moreover 96% of our sample had previously seen a video of a concert, while just 28% a video of a tango concert. Finally, around half of the participants had previous experiences with immersive tools (47%); from this sub-sample, 41% and 64% had previous experiences with respectively Smartphone-based devices and HTC-vive tools (F12–F13).

As additional clarification, we asked to subjects who responded negatively to question F1 why they do not ususally attend theater (F4). Most of the responses concern a general lack of interest. Moreover, this disinterest seems mainly related to a general distance with respect to the type of offered performances: university students seem not accustomed to certain kinds of entertainment (e.g. tango concert; ballet) This finding further supports our choice to test VR technology to experience a Tango concert. Below we report some answers provided by participants at the final debriefing:

1. I am not interested in this kind of entertainment;
2. I don't find it a fun activity;
3. I prefer the movies;
4. By taste and personal passion, I prefer cinema;

5. The theater shows generally offered in the theater nearest to me are not usually of interest to me or I do not learn about shows that are interesting to me;
6. I have never felt the curiosity;
7. It is not something that has never particularly piqued my interest;
8. I don't attend it because my acquaintances are not passionate about it;
9. I am not used to going theater;
10. I am not interested in it;
11. Because it doesn't fit my cultural tastes and habits;
12. Probably because of lack of information about it and unfortunately also because of habit;
13. There are no shows that generally interest me;
14. I don't like it;
15. I don't attend the theater because I'm not passionate about it;
16. I simply don't feel involved in many performances, and this causes me boredom;
17. I am not passionate about;

These comments are consistent with findings in literature showing that young student population has little experience attending theater and even less experience attending Tango concerts (de la Fuente Prieto et al., 2022; Geng et al., 2022; Dwivedi et al., 2022): this further supports the relevance of our study.

2.3.4. Materials and apparatus

For the google cardboard and HTC vive, the 360° video was recorded using the Insta360 Pro2 and post-processed with the Insta360 STITCHER that produced a 2 K video. We recorded the concert placing the camera between the stage and the audience, to capture as much detail as possible, without losing focus on the main content, i.e., the musicians on the stage.

Two VR experiences were developed to present such video in both the CVR and HVR conditions. The Game Engine used for developing those experiences was Unity (version 2019.4.39f1). In particular, the CVR application was developed using the GoogleVR SDK, while the HVR one using the SteamVR SDK. Both the applications allow to render and reproduce a 360° video on the target devices.

The CVR and HVR settings (3D), differently from the MV (2D), allowed participants to move their head and explore the space around them while enjoying the show. This is possible considering that both CVR and HVR have the human head rotation 3-degree of freedom devices (i.e., pitch, roll, and yaw). In any of the virtual conditions, no interaction was possible.

The developed CVR application was executed on a Samsung S22 equipped with a Qualcomm SM8450 Snapdragon 8 Gen, 8 GB of RAM and 1080 × 2340 pixels. The HVR one was instead executed on an HTC-VIVE Pro (1440 × 1600 resolution) connected to an Alienware Area 51 model. These devices were chosen based on their high-performance to achieve the smoothest video reproduction along with the highest possible resolution.

2.3.5. Assessment model for Aesthemos and Social Presence

The Aesthemos questionnaire presented forty-two statements referring to twenty-one emotion subscales (Schindler et al., 2017): Feeling of beauty; Fascination; Being moved; Awe; Enchantment; Nostalgia; Joy; Humor; Vitality; Energy; Relaxation; Surprise; Interest; Intellectual challenge; Insight; Feeling of ugliness; Boredom; Confusion; Anger; Uneasiness; Sadness.

For the Networked Mind Measure of Social Presence (Biocca et al., 2001), we proposed a shorter version with thirty statements out of the thirty-eight of the original one. We eliminated the items on Mutual assistance and Dependent action as inadequate to assess social presence during a concert in a theater, where spectators are not interacting in collaborative actions. The remaining thirty statements can be divided in two groups: Co-presence and Psychological Involvement. The Co-presence group is composed by six statements about Mutual Acquaintance. The Psychological involvement group can be divided in four sub-groups: eight statements on Mutual Attention, six on Behavioral Involvement, four on Mutual Understanding, and six on Empathy.

The subgroups (i.e., constructs) for both the Aesthemos and the Networked Mind Measure of Social Presence are detailed in Table 1 (see also section 3 Data Analysis and Results). For both questionnaires, participants had to rate all the statements on a 5-point Likert scale (1 = not at all agree, 5 = very much agree); they could write comments or suggestions at the end of the questionnaire.

2.3.6. Assessment model for TAMIG

The TAMIG presented 19 questions referring to 4 constructs (2 for Theater Attendance, 11 for Media Habits and 6 for Immersiveness and Interest Gain). For evaluating the immersiveness, we proposed a shorter version of the original IPQ scale (Schubert, 2003), with three statements of the fourteen out. All the other questions were custom-made; however, they follow the best-known practices for designing questionnaires (Krosnick, 2018). We adopted a different kind of scales, based on the question item and the sub-group: 5-point Likert scale, Categorical Scale, Ordinal Scale, Open Question and Yes/No questions (see Appendix c. Follow-up questionnaire TAMIG for details).

2.3.7. Procedure

Below we detail the procedures for the four experimental conditions.

2.3.7.1. Live concert. The LC condition was executed at the Teatro Comunale "Pavarotti-Freni" in Modena, on the concert "Amarcord d'un Tango" (on July 14th, 2022, at 9 p.m.). The event took place outdoors, in the theater courtyard. At the end of the concert, we asked volunteers to fill in a hard copy of both the questionnaires, while sitting at the station we placed in the theater foyer. As it was late at night (about 11 p.m.), most spectators were in a hurry to get back home, therefore not available to participate.

For the other three conditions we used a 9-min video of the concerts. Participants were tested at the Virtual and Augmented Reality Lab (VARLAB) of the University of Bologna. All the tests took place in a silent room with no other person present but the experimenter and the participant. After each of the three experiences, participants filled out both questionnaires presented on mobile phone through the Qualtrics platform (https://www.qualtrics.com/eng/).

2.3.7.2. HTC vive. The HVR condition consented participants a full immersive virtual reality experience by giving the opportunity to have a 360° visual perspective of the concert context by wearing the HTC-Vive. This kind of headset was a professional device, the use of which requires specific IT expertise. None of the participants had any previous experience with this device. Before the test, they were instructed about the kind of experience: a 9-min video-concert in a VR immersive environment in which they could turn themselves around and move their head up and down, left or right, as they preferred, changing the scenario accordingly.

2.3.7.3. Google cardboard. In case of the CVR setting, we used a Samsung S22 device, chosen for the high quality of the display; the smartphone was inserted into the simplest version of a cardboard (box paper with two lenses). Unlike the HTC-Vive, this device was not provided with custom headphones to listen the music in an immersive way. We provided participants with Bluetooth wireless headphones. Despite the need for external headphones, cardboard is a cheap device, quite easy to afford, thorough which anyone can try a first basic VR experience at home. Also, for this condition, none of the participants reported previous experience with the device at hand. Before starting, participants were informed about the kind of experience.

Table 1
Cronbach's alpha index for all the considered sub-groups (i.e., constructs) of the three questionnaires. Twelve out of twenty-one constructs of the Aesthemos (in bold) passed the internal consistency test (in bold); one out of five constructs of the Social Presence scale (in bold) passed the same test; The Immersiveness and Interest Gain in TAMIG passed the same test.

Scale	Sub-groups	Questions	Cronbach Alpha	Acceptable
Aesthemos	**1 Feeling of beauty - liking**	E1-E6	0.87	Yes
	2 Fascination	E7-E34	0.81	Yes
	3 Being moved	E14-E36	0.57	No
	4 Awe	E31-E40	−0.13	No
	5 Enchantment	E8-E18	0.81	Yes
	6 Nostalgia	E26-E28	0.59	No
	7 Joy	E3-E39	0.79	Yes
	8 Humor	E22-E42	0.92	Yes
	9 Vitality	E9-E32	0.76	Yes
	10 Energy	E16-E41	0.59	No
	11 Relaxation	E4-E20	0.86	Yes
	12 Surprise	E11-E29	0.21	No
	13 Interest	E5-E38	0.8	Yes
	14 Intellectual challenge	E2-E10	0.01	No
	15 Insight	E13-E21	0.73	Yes
	16 Feeling of ugliness	E12-E35	0.65	No
	17 Boredom	E19-E33	0.76	Yes
	18 Confusion	E24-E37	0.54	No
	19 Anger	E17-E25	0.87	Yes
	20 Uneasiness	E27-E30	0.68	No
	21 Sadness	E15-E23	0.78	Yes
Social Presence	a Co-Presence: Mutual Acquaintance	P1–P2–P3–P4–P5–P6	0.43	No
	b Psychological Involvement: Mutual Attention	P7–P8–P9–P10–P11–P12–P13–P14	0.45	No
	c **Psychological Involvement: Behavioral Engagement**	P25–P26–P27–P28–P29–P30	0.81	Yes
	d Psychological Involvement: Mutual Understanding	P15–P16–P17–P18	0.58	No
	c Psychological Involvement: Empathy	P19–P20–P21–P22–P23–P24	0.01	No
TAMIG	Interest Gain	F14–F15	0.87	Yes
	Immersiveness	F17–F18– F19	0.77	Yes

2.3.7.4. Music video. For the MV condition, participants watched the concert while sitting in front of a 4 k PC screen, wearing the same headphones used for the CVR condition. This condition was conceived as to replicate the well-known experience of watching a concert at home on YouTube, well known to all our participants. Due to the features of the 360° camera, the video was shown by an unusual perspective: each participant had a between-the-audience point of view, allowing for a simultaneous watching of both the musicians (i.e., the concert, at the middle of the screen) and part of audience (on the sides), as if she was sitting in the middle of the scene. We introduced this novelty (i.e., making visible part of the audience) to make the 2D condition comparable to the other ones, and thus to make meaningful our questions on social presence. Participants were instructed about the 2D condition, for which they could only watch the video: any head movements were not followed by any change in the scenario.

3. Data Analysis and Results

In this section we describe the analyses carried out on the data collected for the questionnaires. Please note that all the analyses were performed using out-of-the-box and adjusted functions provided in the Python libraries 'Pingouin, Statsmodels, Scipy'. Overall, there were only ten empty cells (due to non-response of participants in the first experimental session). To avoid both discarding the questionnaire questions and affecting the distribution of the data, in the pre-processing for each subject we replaced the missing value with the means of the distribution for the related item.

3.1. Reliability test

The collected data has undergone a reliability check to test for internal consistency and validate our research. For Aesthemos and Social Presence questionnaires, we computed the widely accepted Cronbach's alpha index for each sub-group (i.e., construct). Each sub-group was considered consistent if the Cronbach's alpha index was $\geq$0.70 (as indicated by Taber, 2018). Results are reported in Table 1. In the assessment model for TAMIG, we analyzed only Immersiveness and Interest Gain, because they were the only subgroups measuring a construct.

While twelve out of twenty-one constructs of the Aesthemos passed the internal consistency test (in bold in Table 1), the Social Presence scale presented only one out of five consistent subgroups of answers (Psychological Involvement: Behavioral engagement, in bold in Table 1). In the following analyses, for each questionnaire we will consider only those subgroups with acceptable Cronbach's alpha index.

3.2. Data visualization and description of the trends

In this section we report the overall results only for acceptable constructs, plotting them in five different figures. Each figure shows mean scores (Likert scale) and standard deviation reported as error bars.

Participants' scores for the Aesthemos, aggregated for each subgroup, are reported in Fig. 2 (first six subgroups) and Fig. 3 (last six subgroups). For the constructs shown in Fig. 2 (Feeling of beauty – liking; Fascination; Enchantment; Joy; Humor; Vitality) there is a general agreement on the superiority of the Live condition over all others (MV, CVR, HVR). However, HVR seems to be preferred to CVR and MV for the constructs Fascination, Enchantment, and Joy. For the constructs shown in Fig. 3 (Relaxation; Interest; Insight; Boredom; Anger; Sadness), the advantage of the LC condition over all the others is no longer evident. In particular, the plot shows that Interest is similar for LC and HVR, and greater than CVR and MV; Boredom is more pronounced for the MV condition than for the other three scenarios, especially when compared to LC. For the constructs Anger and Sadness, the values are relatively consistent and similar for the different experimental conditions.

Fig. 4 shows the mean scores, and associated error bars, for the only construct of the Social Presence scale that passed the internal consistency test, i.e., c Psychological Involvement: Behavioral engagement. The graph shows high variability for all conditions: it is not possible to detect any advantage of one condition over the others in relation to the perceived behavioral involvement in the four experiences.

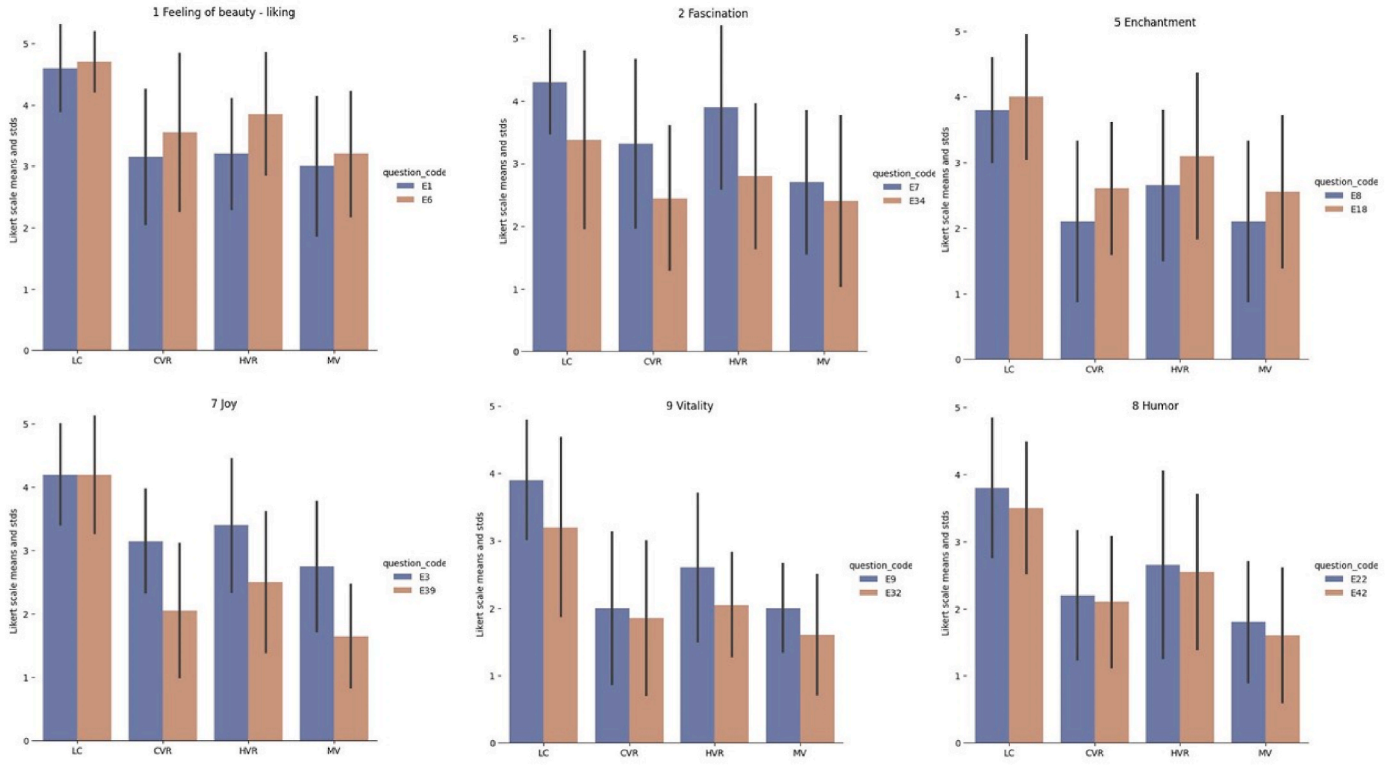

Fig. 2. Histograms of first six sub-groups of the Emotional Scale: 1 Feeling of beauty – liking; 2 Fascination; 5 Enchantment; 7 Joy; 8 Humor; 9 Vitality. Error bars represent the standard deviation.

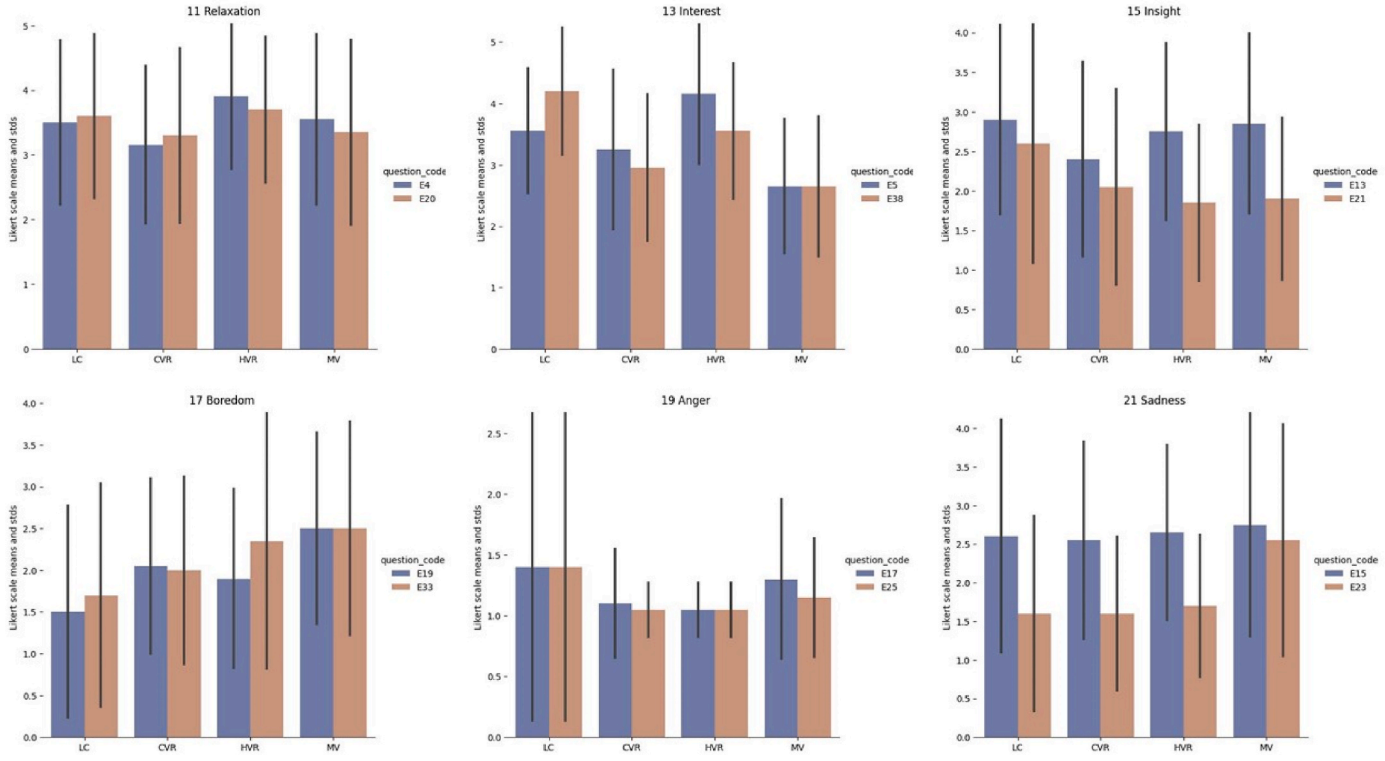

Fig. 3. Histograms of the second six sub-groups of the Emotional Scale: 11 Relaxation; 13 Interest; 15 Insight; 17 Boredom; 19 Anger; 21 Sadness. Error bars represent the standard deviation.

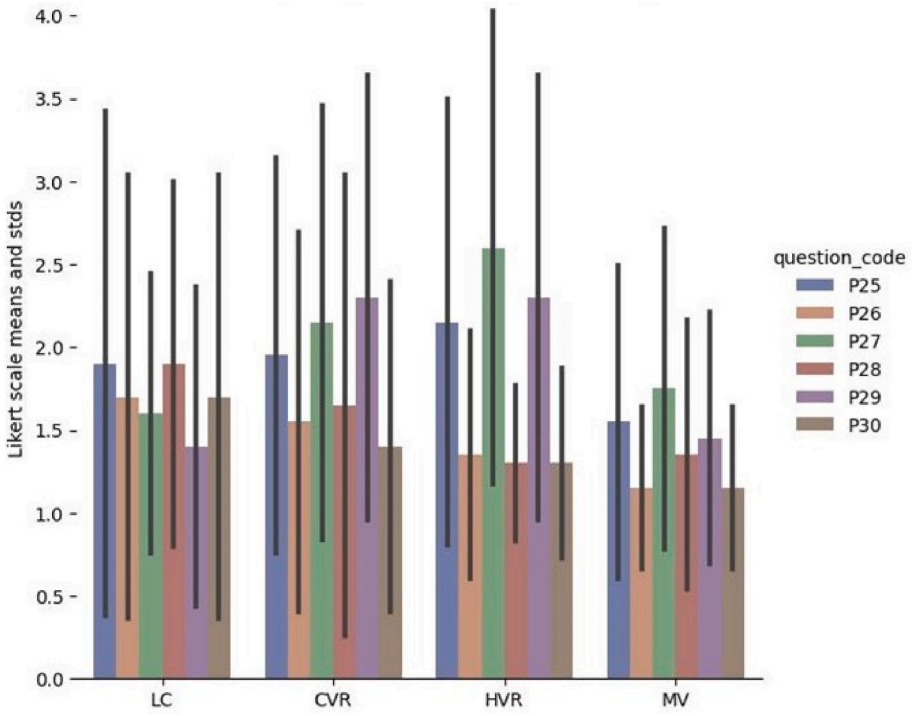

Fig. 4. Histograms of the consistent sub-group for the Social Presence Scale: c Psychological Involvement: Behavioral engagement. Error bars represent the standard deviation.

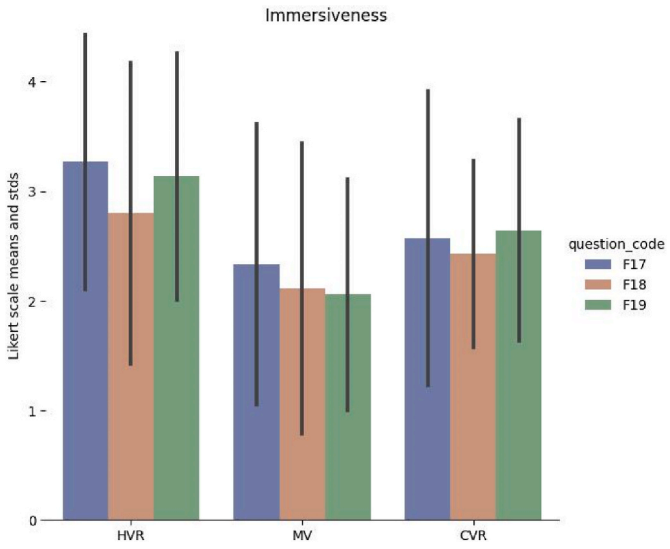

Fig. 5. Histograms of the consistent sub-group for the TAMIG: Immersiveness. Error bars represent the standard deviation.

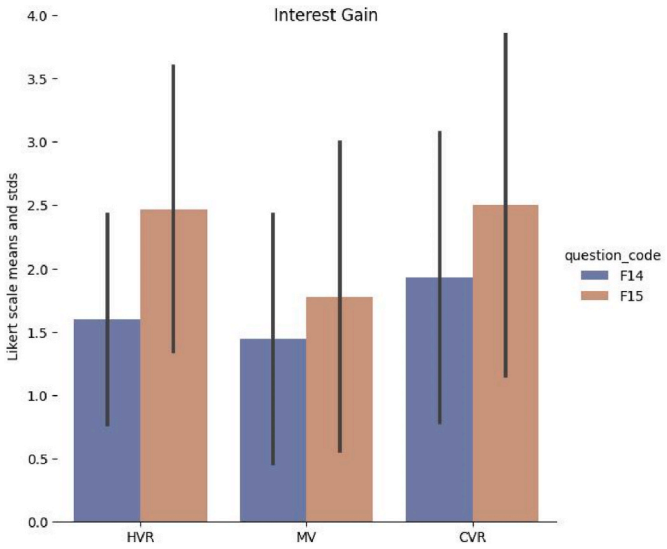

Fig. 6. Histograms of the consistent sub-group for the TAMIG: Interest Gain. Error bars represent the standard deviation.

The mean scores, and associated error bars, for Immersiveness (TAMIG) are reported in Fig. 5. The graph shows a clear tendency of Immersiveness for the HVR with respect to the other devices (He et al., 2018), even considering the variability. Finally, Fig. 6 depicts the same statistics for the Interest Gain. It is interesting to note that in each condition an interest gain (F15 - F14) was verified, but HVR was the experience for which the interest gain was higher with respect to the other not in presence conditions.

3.3. Adjusted Wald-Confidence Interval test & Wilcoxon signed-rank test

In this section we perform statistical analyses on the obtained scores to verify (only for the constructs that passed the internal consistency test) any significant differences among the four conditions, namely LC, MV, CVR and HVR.

Following the guidelines of Agresti and Caffo (2000), we performed an Adjusted Wald-Confidence Interval test: this statistical test allows to check if the difference between two proportions is significant and how large the difference is. We selected this specific statistical test as we had four conditions and a low number of samples for each of them (Sauro & Lewis, 2016).

We considered a confidence level of 95%, thus the two-sided z critical value for the test corresponded to 1.96. To adapt our data for the specific test, we binarize the Likert-scale answers with a threshold of 4:

≥4 Likert scale answers were converted to 1, the lower to 0. Considering that the Adjusted-Wald Confidence Interval test compares two proportions, we proceeded comparing, two by two, all the scores got in the different conditions for each subgroup of questions of the questionnaires.

Thus, as an example, for the construct "X", composed by questions Ey – Ez, we run a comparison test between each possible pairing of our four conditions (LC, CVR, HCV, MV). Then we accumulated, for each question in each construct (subgroup), just the pairings that provided positive Wald Adjusted Difference and a lower confidence interval greater than zero – meaning that the considered condition (e.g., LC) does have a higher score than the others (e.g., MC, CVR, HVR) for the question under examination (e.g., Ez). In this way we could find a difference in proportions valid for the entire construct (instead of for a single question within the construct-subgroup).

Conversely, for the Interest Gain (TAMIG) we considered a different test since this construct aims at evaluating the relative gain in interest towards Tango Music in a pre-post experimental scenario. Considering that our sample population is less than 30 and that we are dealing with Likert Scale scores, we decided to adopt a non-parametric text, namely the Wilcoxon signed-rank test (Woolson, 2007, pp. 1–3). In practice, this test verifies the null hypothesis that two related paired samples come from the same distribution, and also whether the distribution of the differences between two paired sequences is symmetric about zero. This test is appropriate for a repeated measure design where the same subjects are evaluated under two different conditions, and it is the non-parametric equivalent of the parametric paired *t*-test. In our case, the two different conditions are "before" and "after" the virtual experience. We had a one-sided test with a confidence level of 95%, where the null hypothesis indicated whether the distribution underlying the difference between the before and after interest in Tango Music Concert was stochastically greater than a distribution symmetric about zero.

3.4. Significant results for Aesthemos and Social Presence

3.4.1. Aesthemos

Concerning the Aesthemos Emotional Scale, twelve constructs passed the Cronbach's Internal Consistency Test: 4 of these 12 subgroups (namely: Relaxation, Insight, Boredom, Anger) did not show any significant results for the Adjusted-Wald Confidence Interval test. Instead, for the constructs Fascination and Sadness we found significant results but not the agreement between the two items, thus we will discuss the results only briefly. More interestingly, the constructs for which we found significant results and agreement between the items are the following (6/12): Feeling of beauty, Enchantment, Joy, Humor, Vitality, Interest.

All significant comparisons for the Aesthemos (including Fascination and Sadness, in italics) are shown in Table 2, organized by construct and question-item, and reporting the Wald inferior bound, Wald difference, Wald max bound and Mixed representation.

Live Concert (LC) was found to be the most effective condition in activating aesthetic emotions since this condition resulted to be superior for 5 of the 7 constructs (acceptable Wald-difference) in at least one comparison with all the other three conditions (all of the above

Table 2
The Table reports all significant comparisons for the Aesthemos (including Fascination and Sadness, in italics), organized by construct and question, and reporting the Wald inferior bound, Wald difference, Wald max bound and Mixed representation. The conditions of advantage for HVR (for Humor and Interest constructs) are underlined.

Construct	Quest.	Comparisons	Wald inferior bound	Wald difference	Wald max bound	Mixed representation
1 Feeling of beauty – liking	**E1**	**LC > CVR**	0.18121	0.47243	0.76365	0.18| 0.47| 0.76
		LC > HVR	0.18121	0.47243	0.76365	0.18| 0.47| 0.76
		LC > MV	0.23125	0.51805	0.80485	0.23| 0.52| 0.8
	E6	**LC > CVR**	0.15931	0.41946	0.67961	0.16| 0.42| 0.68
		LC > HVR	0.02884	0.2826	0.53636	0.03| 0.28| 0.54
		LC > MV	0.20563	0.46508	0.72453	0.21| 0.47| 0.72
5 Enchantment	**E8**	**LC > CVR**	0.08037	0.40324	0.72611	0.08| 0.4| 0.73
		LC > HVR	0.08037	0.40324	0.72611	0.08| 0.4| 0.73
		LC > MV	0.13458	0.44886	0.76314	0.13| 0.45| 0.76
	E18	***LC > CVR***	0.02749	0.35762	0.68775	0.03| 0.36| 0.69
		LC > MV	0.02749	0.35762	0.68775	0.03| 0.36| 0.69
7 Joy	**E3**	***LC > CVR***	0.1718	0.47978	0.78776	0.17| 0.48| 0.79
		LC > MV	0.1718	0.47978	0.78776	0.17| 0.48| 0.79
	E39	**LC > CVR**	0.22949	0.53275	0.83601	0.23| 0.53| 0.84
		LC > HVR	0.12185	0.44151	0.76117	0.12| 0.44| 0.76
		LC > MV	0.28551	0.57837	0.87123	0.29| 0.58| 0.87
8 Humor	**E22**	**LC > CVR**	0.13458	0.44886	0.76314	0.13| 0.45| 0.76
		LC > MV	0.19022	0.49448	0.79874	0.19| 0.49| 0.8
		HVR > MV	0.03962	0.27372	0.50782	0.04| 0.27| 0.51
	E42	***LC > CVR***	0.13458	0.44886	0.76314	0.13| 0.45| 0.76
		LC > MV	0.13458	0.44886	0.76314	0.13| 0.45| 0.76
9 Vitality	**E9**	**LC > CVR**	0.33269	0.61664	0.90059	0.33| 0.62| 0.9
		LC > HVR	0.224	0.5254	0.8268	0.22| 0.53| 0.83
		LC > MV	0.44808	0.70788	0.96768	0.45| 0.71| 0.97
	E32	***LC > HVR***	0.02243	0.32669	0.63095	0.02| 0.33| 0.63
		LC > HVR	0.02243	0.32669	0.63095	0.02| 0.33| 0.63
13 Interest	**E5**	**CVR > MV**	0.05523	0.31934	0.58345	0.06| 0.32| 0.58
		HVR > LC	0.02749	0.35762	0.68775	0.03| 0.36| 0.69
		HVR > CVR	0.00078	0.27372	0.54666	0.0| 0.27| 0.55
		HVR > MV	0.35511	0.59307	0.83103	0.36| 0.59| 0.83
	E38	**LC > CVR**	0.07123	0.38854	0.70585	0.07| 0.39| 0.71
		LC > MV	0.224	0.5254	0.8268	0.22| 0.53| 0.83
		HVR > MV	0.04707	0.31934	0.59161	0.05| 0.32| 0.59
2 Fascination	**E31**	**LC > CVR**	0.02275	0.34292	0.66309	0.02| 0.34| 0.66
		LC > MV	0.224	0.5254	0.8268	0.22| 0.53| 0.83
		HVR > CVR	0.04176	0.31934	0.59692	0.04| 0.32| 0.6
		HVR > MV	0.24613	0.50182	0.75751	0.25| 0.5| 0.76
21 Sadness	**E23**	***MV > CVR***	0.08138	0.31934	0.5573	0.08| 0.32| 0.56
		MV > HVR	0.08138	0.31934	0.5573	0.08| 0.32| 0.56

Table 3
The Table reports the significant results obtained by subjecting TAMIG items F14 and F15 to the Wilcoxon signed-rank test. Even if the measured differences were all statistically significant, the HVR condition provided the strongest effect.

Construct	Comparisons	Wilcoxon Stats	Wilcoxon P-Value
Interest Gain	HVR	45	0.003
	MV	24.5	0.029
	CVR	21	0.012

mentioned except Interest and Sadness).

More specifically, LC was found to be significantly more activating (i.e., more enchanting, joyous, and amusing) when compared to Music Video (MV) and VR experience with google cardboard (CVR), but not when compared to VR experience with the HTC-Vive (HRV). Thus, even if the live condition remains the best way to enjoy a music concert, the difference with the same experience lived through the HCT-Vive headset is not meaningful. This suggests that the HVR is the "artificial experience" that can offer the spectator an experience more like the "real-live one".

The only construct for which LC significantly differed from all the other conditions (thus also from HVR) is the Feeling of beauty: the LC was the most liked experience. Notably, looking at the construct Interest, the HVR condition resulted significantly more interesting than MV (underlined in Table 2). At the best of our knowledge, this is the first empirical evidence of a major interest for *musical* aesthetic experiences (i.e., experiences for which the acoustic component, and not the visual or social ones, should be predominant) when experienced in VR (HVR) than on a computer screen (e.g., on YouTube or Twitch). Moreover, for one of the items of the construct Interest (namely the E5: "It made me curious"), the HVR condition was found to be superior not only to MV, but also to CVR and even to LC. (This item is also the only one for which LC resulted significantly lower with respect to another of the three tested conditions).

Overall, our results are consistent in supporting a clear advantage for the Live Concert; nevertheless, they also emphasize that the experience with the HTC-vive device is, immediately following, the most powerful in evoking aesthetic emotions, thus better than those generated with a device such as a computer (MV) or a google cardboard (CVR).

This advantage is further confirmed if we look also at the scores for the item E31, "I found it sublime", of the Fascination construct (for the complementary item, E34, no acceptable wald differences were found) and at the scores for the item E23, "It made me sad", of the Sadness construct (for the complementary item, E15, no acceptable wald differences were found). From this more comprehensive outlook HVR emerges as significantly "more sublime" than MV and CVR, and MV appears as an experience significantly "sadder" than both HVR and CVR.

3.4.2. Social presence

Concerning the Networked Minds Measure of Social Presence, as stated above, only one construct (i.e., sub-group of items) passed the Cronbach's internal consistency test, namely the *Psychological Involvement: Behavioral Engagement* one. However, no significant difference between the four conditions has been found for this construct.

3.5. Significant results for TAMIG

3.5.1. Immersiveness

Concerning the Immersiveness as measured by the TAMIG questionnaire, by applying the Agresti-Caffo test no significant difference between the tested conditions was found.

3.5.2. Interest Gain

As mentioned above, the Interest Gain question items (F14, F15) of TAMIG were subjected to the Wilcoxon signed-rank test for the different virtual experiences. In all the tested conditions, the test rejects the null hypothesis: it seems that interest in tango music concerts has increased for each condition examined. The statistical effect was higher for HVR with respect to the other two conditions (Table 3).

3.6. Qualitative analysis

To further understand our results, we integrate them with a qualitative analysis based on an open question (see Lewis, 1982) for the Aesthemos, the Social Presence and the TAMIG. We here report some of the answers provided by the participants (see also the Appendix). The answers to open questions at the end of the Aesthemos and the Social Presence can be summarized in the following two arguments:

(a) The specific music genre (i.e., Tango) was disliked by the youth audience. Despite a general interest in music concerts, participants stated that they did not like the video's music genre, thus presumably they were less involved or less affected by the experience itself. For example, participant #62 stated: "*I really enjoy music and the experience of live concerts, however, the genre played is not among my favorites. As a result, it did not particularly stimulate or impress me. If it had been another genre, and if there had been a person singing, it would not have left me so indifferent, and I would have been more involved. I do not consider it an unpleasant experience though; I could never consider the music as such*".
(b) The weaker immersive effect and lower usability of the cardboard compared with the HTC condition. Indeed, sometimes the intensity of the experience was affected by some of the google cardboard's characteristics, being a less immersive and comfortable tool compared with the HTC. For example, participant #15 stated: "It was a fairly intense experience, partly adversely affected (at the level of physical stress) by the way the concert was enjoyed, which I found very heavy on the eyes".

The answers to the open question of the TAMIG, in relation to the reasons why participants usually do not attend the theater (F4), can be summarized in the following three arguments:

a) Lack of interest in theater: most of the participants explained that their choice is related to a general disinterest toward this kind of entertainment which is not fun for them. Here are some answers: "*I don't find it a fun activity*"; "*I am not passionate about it*"; "*There are no shows that generally interest me*"; "*I have never felt the curiosity*"; "*It is not something that has ever particularly piqued my interest*".
b) Absence of habit in going to the theater: several participants stated that they just never had this kind of habit. Some responses show that this is due to the distance from their cultural interest, and to the fact that none of their acquaintances usually attend the theater, as for example in this answer: "*I don't attend it because my acquaintances are not fond of it and I wouldn't know who to go with*".
c) Financial reasons: some participants said they cannot afford to pay to go to the theater.

Undoubtedly, all the arguments discussed above give strength to some of the choices we made to pursue our goal of inquiry. Indeed, to test the immersive tools' potential with our lab participants (namely, university students) we needed to propose a musical genre far from their standards. Moreover, the effect that we were looking for (i.e., to augment the interest toward a musical aesthetic experience such as a Tango concert) can be more easily found with a kind of audience that lacks any initial interest for the chosen experience. The responses we collected from all questionnaires (Aesthemos, Social Presence, TAMIG) converge in suggesting that the differences between LC participants and lab participants should not to be considered as a limit of the study but rather as a methodological choice, since LC participants' survey scores can be used as a benchmark for the magnitude of interest.

Finally, the qualitative findings support the quantitative ones in

highlighting the role of virtual devices in increasing engagement towards musical aesthetic experiences to which we are not accustomed

4. Discussion

4.1. Aesthemos

For the Aesthemos, analyses showed that the only construct for which LC significantly differed from all the other conditions is the Feeling of beauty. However, the greater fascination we found for LC than for HVR may be biased by the important difference between the samples in LC vs. HVR conditions. As highlighted above, participants in LC condition were people who had purposely chosen to attend the specific show at the theater, meaning that they were already motivated to participate at such kind of concert. Differently, students who came to the lab for the experiment had not autonomously taken such a choice: even though the experience for them lasted only 9-min, it was not greatly appreciated. Additionally, the difference in the mean age of the two samples (LC: 56 vs. HVR: 20 years old) lets us to predict discrepancies in the musical preferences of the two groups (theater's audience for the LC condition vs. college students for the other lab-conditions). Final comments reported by the HVR participants attested that tango is not particularly liked as music genre by younger generations. We reasonably suppose that this confound partially obscures far more important effects of the HVR condition: the integration of the results of the statistical analysis with the debriefing comments and the open answers made by the participants led us to speculate that the experience in the virtual environment (particularly HVR) is actually powerful in evoking aesthetic emotions (or at least, more than attested by the analysis of the collected scores), much like the live condition. A counterevidence would consist in the (future) replication of this study for which we would choose a musical genre, and thus a concert, that young people could appreciate (considering the greater simplicity to test young college students than older participants in the laboratory setting).

4.2. Social presence

We questioned the absence of significant results. The Networked Minds Measure of Social Presence questionnaire (Biocca et al., 2001) is aimed at providing a metric to measure the degree to which individuals feel interconnected to each other through networked telecommunication interfaces. Even in the conditions with a digital interface (MV, CVR, HVR), for which high and relatively consistent scores might be expected, the experimenter never provided any explicit reference to the Other(s): nor a conceivable interconnection with the Other(s), nor a possible enrichment of the aesthetic experience through the integration of the social component.

The social enrichment of the musical experience could be a factor that comes into play only at a later stage, that is, after the subject has acquired a complete knowledge of the event-scenario, and of the device, on her own. Moreover, for the concert experience, for which the presence of the Other(s) is not "necessary," it is possible that the administered questionnaire (originally designed for other contexts) is less sensitive.

Another possible explanation for the lack of significant results for the social presence may be sought in the choices for audio-video recording of the concert – to build the MV, CVR and HVR experiences. One of the concerns in the recording was the camera position: the concert was outdoors, the stage where the musicians played was not close to the audience (as is generally the case in theaters, indoors). To get a good view of the stage, the camera had to be placed in the space between the stage and the front row of the audience. Participants in VR conditions by turning their heads could have a full view of the other spectators, but they could not have spectators' perspective (i.e., the perspective participants would have as sat audience). This confounding perspective might have negatively affected the perception of the Other(s) in the CV, MVR and HVR conditions.

For the future adaptations of this experimental protocol, we will critically take into consideration all the weaknesses discussed above; we will also consider the possibility of selecting a different validated questionnaire, i.e. more sensitive to social aspects in the specific examined context, and of supplementing these surveys with psychophysiological measurements.

4.3. TAMIG: Immersiveness and Interest Gain

The analyses on TAMIG, for MV, CVR and HVR conditions, showed that, the Interest Gain was stronger in HVR with respect to the other virtual conditions, even if all the conditions passed the test. This result supports the hypothesis that the HTC-vive is the best device to increase the interest and engagement for the target music genre.

On the other hand, analyses on Immersiveness did not show any significant difference. However, the 'first' experience with the virtual devices could have biased our results. Indeed, less than half of our sample had had any virtual experiences before the experiment.

5. Conclusions

The present work shows the preliminary results of a pioneering project aimed at comparing the aesthetic experience of a musical concert lived in different contexts for which the audience's perceived presence is modulated in a continuum ranging from a live concert to a music video, passing through immersive artificial environments. The project has been inspired by the recent experimentation by Staatstheater Augsburg (in Germany, Weber-Sabil & Han, 2021) aimed at rethinking art and its places; it has been conducted thanks to the collaboration with the Opera House of Modena (Teatro Comunale Pavarotti-Freni, Italy). This new line of research involves psychologists, computer scientists, philosophers, and artists.

From an *experimental* perspective, we exploited the potential of VR technologies as *methodological* boost to empirical aesthetics; from a *theoretical* perspective, we addressed the aesthetic emotions aroused by VR experiences, through the Aesthetic Emotions Scale (Aesthemos, Schindler et al., 2017). In addition to the more traditional investigation of VR pleasantness, we wanted to address also the VR effectiveness in rendering the social aspects of immersive (musical) experiences. To measure the social presence, we used a revised version of the Networked Minds Measure of Social Presence (Biocca et al., 2001), composed by items focusing on both co-presence and psychological involvement.

Thus, we assessed both the *Aesthetic Emotions* and the *Social Presence* in contexts with different levels of immersivity distributed in the proposed continuum: at one extreme the live concert, at the other extreme the traditional music video, in between the experience in an immersive virtual reality environment (CVR and HVR); while in the live condition both performers and audience were present, in the other conditions their presence was only evoked.

Live Concert was the most liked experience, as attested by the analysis of the Aesthemos' construct *Feeling of beauty – liking*. Interestingly, it was found to be also the most enchanting, joyous, and amusing experience, but only if compared to Music Video and VR experience with google cardboard, not when compared to the VR intensely immersive experience with the HTC vive. This last finding suggests that, at least for the constructs of Enchantment, Joy, and Humor, the proposed "artificial" HVR experience is analogous to the "real" one.

Crucially, for the *Interest* construct we no longer find the superiority of the Live condition, but a clear preference for the HTC live one. At the best of our knowledge, this is the first empirical evidence of a major interest for musical aesthetic experiences (i.e., experiences for which the acoustic component, and not the visual or social ones, should be predominant) when experienced in VR (HVR) than on a computer screen (e.g., on YouTube or Twitch).

These findings are even more relevant when taking into account

some of the confounds of our work, which we could not avoid in order to keep the study ecological: the Live condition sample consisted of participants who were highly motivated toward that concert – they paid for a ticket to participate that specific show. The scores they gave to the items of the various constructs of the Aesthemos were necessarily biased toward high values. Conversely, the samples for the MV, CVR, and HVR conditions were composed of college students who were much younger, had different preferences in music, and had been recruited from class to participate in the laboratory experiment. The hypothesis that this confounding obscured possible more important effects of the non-live conditions is further supported by the analysis of the final comments left by the participants (i.e., students expressed their limited appreciation toward that genre of music, and thus for that type of experience) as well as by the TAMIG questionnaire.

Concerning the Social Presence, no significant findings were found. Therefore, we reasoned on the adopted scale, the Networked Minds Measure of Social Presence, actually developed to measure the degree to which individuals feel interconnected to each other through networked telecommunication interfaces. The presence of the Other(s) may have been poorly felt in these different experiences; another (plausible) explanation for the lack of significant effects may lie in the low sensitivity of the chosen questionnaire in detecting the feeling of social presence in the specific scenario we investigated, namely a musical experience of a tango concert. Consistently for future developments of this project we would consider the possibility of selecting a different validated questionnaire and of supplementing the surveys with psychophysiological measurements indexing the feeling of being social immersed in such a context.

As for the questionnaire we designed, the TAMIG (Theater Attendance, Media Habits, Immersiveness and Interest Gain), administered for the MV, CVR and HVR conditions , significant differences were found in the increase of interest (Interest Gain) for Tango Music in all the examined conditions. This result was somewhat expected since most of the sample had no previous experience with a tango concert. However, the HTC-vive has had the greatest effect with respect to the classical computer display and smartphone-based virtual experiences. This finding is in line with evidence in literature, confirming that, despite possible problems with VR devices (related to their weight, range, and possible dizziness) virtual immersive experiences are a feasible means to make people 'more' interested in musical genres toward which they are not used to. Considering that our approach could be generalized also to other activities, in future works we would like to consider other music genres but also other aesthetic experiences typically enjoyed in the theater (e.g., ballet).

To summarize: in contrast to previous qualitative investigations of various immersive scenarios, our study is unique in both the use of validated scales and the structured comparison of four experimental conditions: a live concert, a concert through a traditional non-immersive music video, and a concert in a virtual reality environment (VR), provided by a basic and easily accessible device or a less affordable but very immersive VR viewer. As emphasized in the Introduction, the present project has the ambition to contribute not only empirically but also theoretically to the current literature by framing a coherent and well-defined scaffolding for the relationship between aesthetic experience, social self, and VR environments. In our view, this goal can only be achieved through the integration of philosophical, psychological, artistic, and technological competences, through the (badly needed, but often just advocated) dialogue between these disciplines.

In this first attempt, this study, so far, emphasizes how important is the selection of suitable psychological tools to measure the effectiveness and immersiveness of the *VR* aesthetic experience, which obviously depend on the scenario and on the processes to be scrutinized. Further interesting investigation would pertain the eventual activation of *simulation processes* when looking at vs. taking the role of an embodied artist (i.e., digital twin) that "co-creatively" performs in the play (e.g., theater performance, dance, or concert), within the physical, social, and affective experience on stage (Scorolli, 2019). The shift in perspective (provided by VR) allows the subject-agent with the opportunity to slip into the role and perspective of the Other (Gianelli, Scorolli, & Borghi, 2013), experiencing her interactions with the external environment, thus directly perceiving both physical and affective affordances (Caravà & Scorolli, 2020).

Pertaining the possible *therapeutic applications*, several studies have shown the potential of the arts for mental health (e.g., in older adults: Thomson, Lockyer, Camic, & Chatterjee, 2018); recently scholars are specifically addressing the effectiveness of therapies founded on VR and music in promoting psychological well-being (Alexanian, Foxman, & Pimentel, 2022) as well as in supporting traditional palliative care (Brungardt et al., 2021) and distraction interventions during chemotherapy (Chirico et al., 2020).

In relation to the *social* dimension of the *musical VR experience*, instead, there is not much literature yet, but the effect of different levels of social presence has recently been explored in virtual real-time interactions between pianists by exploiting embodied avatars (Van Kerrebroeck, Caruso, & Maes, 2021). In our work we do not introduce avatars nor digital twins, but in a complementary manner to the work by Van Kerrebroeck and colleagues, we put emphasis on the exploration of the (dynamic) intersubjective relationship between the spectator and the object, which in case of musical performances necessarily includes the artists-musicians. Our attempt was oriented at a first framing of the relationship between aesthetic (musical) experience, empathy, and VR environments by accounting for it also in relation with the *affective motivation* (Stamatopoulou, 2004, 2018). "In art, given the non-reciprocity of the beholder and the beheld and the within, the self's roles and rules become emergent throughout the unfolding action, forming anticipatory action patterns of the morphology of the event and setting the poles that take on signification" (Stamatopoulou, 2018, p. 184).

Consistent with the affective-motivational frame hypothesis, future work developments should focus the analysis of aesthetic experience on the engagement within the *unfolding of the action*; secondly, empirical work should further address the complex interrelationships between art and *extended mind*, both from an aesthetic (Iannilli, 2022; Matteucci, 2021) and a cognitive perspective (Borghi, Scorolli, Caligiore, Baldassarre, & Tummolini, 2013). Of particular interest would be converting the passive participation into an active one: we are planning to improve our virtual experiences to create an all-in-one platform to investigate perceptual and motor processes during action perception and action execution-motor learning (e.g., observing ballet; learning ballet). Finally, future research should explore the implication of aesthetic appreciation for the effectance motivation (Furby, 1991; White, 1959) and *psychological ownership*, pointing to the interplay between individuals and those special objects (often intangible in nature) that convey aesthetic emotions, thus in a privileged position to become part of the extended self (Pierce, Kostova, & Dirks, 2003).

From a grounded perspective of cognition, this interdisciplinary work will bring new light to the circular relationship between *aesthetic experience and creative practice*, pushing toward new forms of participatory art. Artificial, immersive, and interactive environments can be exploited to simulate the experience of enjoying/designing the creative product (see the PNRR Project FAIR, Future Artificial Intelligence Research, https://future-ai-research.it/, specifically the Spoke 8). In line with the intriguing evidence supporting the coupling of perceptual and motor processes during motor learning (Bayani et al., 2021), these new environments would allow the investigation of perceptual changes associated with improvements in motor skills (real or simulated). These technological and societal challenges are consistent, and timely, with respect to the Italian National Recovery and Resilience Plan (PNRR) presented to the European Commission in 2021.

Credit author statement

Claudia Scorolli: Conceptualization, Methodology, Resources, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration, Funding acquisition; **Eduardo Naddei Grasso:** Methodology, Investigation, Data Curation, Writing - Review & Editing; **Lorenzo Stacchio:** Methodology, Formal analysis, Data Curation, Writing - Review & Editing, Visualization; Vincenzo Armando: Software, Investigation; **Giovanni Matteucci:** Conceptualization; **Gustavo Marfia:** Conceptualization, Methodology, Resources, Writing - Review & Editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix. Aesthemos, Networked Minds Measure of Social Presence and TAMIG

a. Aesthemos

"What 'emotional effect' did the concert have on you?

For each emotion described in the list below, we kindly ask you to indicate with a cross answer (from 1, "not at all agree," to 5, "very much agree") that best corresponds to your experience during the concert "Amarcord d'un tango". There are no right or wrong answers. The emotional experience of a concert (e.g., intensity and type of emotions felt) is indeed absolutely personal: it is therefore important that in your answers you indicate only how you actually felt (e.g., you may choose 'not at all' for all items on the list that refer to emotions that do not correspond to what you personally felt). Please indicate with a check mark how much the following statements describe your emotional experience during the concert.

Emotional feelings 1 (not at all agree) 2 3 4 5 (very much agree)"

1 I found it beautiful	22 It amused me
2 It stimulated me intellectually	23 It saddened me
3 It delighted/cheered me up 4 It calmed me down 5 It made me curious	24 I felt confused
6 I enjoyed it	25 It made me aggressive
7 It fascinated me	26 It made me feel emotionally involved
8 I experienced something wonderful	27 It worried me
9 It invigorated me	28 It made me feel nostalgic
10 I was mentally engaged	29 It surprised me
11 It baffled me	30 It made me feel oppressed
12 I found it ugly	31 I found it sublime
13 I sensed a deeper meaning	32 It motivated me
14 I felt deeply moved	33 I felt indifference
15 It made me feel melancholy	34 I was impressed
16 It gave me energy	35 I found it unpleasant/unpleasant
17 It made me angry	36 It affected me
18 I was enchanted	37 It was disturbing to me
19 It bored me	38 It piqued my interest
20 It relaxed me	39 It made me happy
21 I felt a sudden insight	40 I felt awe
	41 It moved me to action
	42 It was fun for me

COMMENTS/SUGGESTIONS:

Please enter here any comments and suggestions you have about the questionnaire, and/or about your overall experience of the concert and participation in the research.

Original questionnaire administered to Italian participants:

Sensazione emotiva	Indichi con una crocetta quanto le seguenti affermazioni descrivono il suo vissuto emotivo durante il concerto. 1 per nulla d'accordo	2	3	4	5 molto d'accordo
1 L'ho trovato bellissimo	□1	□2	□3	□4	□5
2 Mi ha stimolato intellettualmente	□1	□2	□3	□4	□5
3 Mi ha deliziato/rallegrato	□1	□2	□3	□4	□5
4 Mi ha calmato	□1	□2	□3	□4	□5
5 Mi ha fatto incuriosire	□1	□2	□3	□4	□5
6 Mi è piaciuto	□1	□2	□3	□4	□5
7 Mi ha affascinato	□1	□2	□3	□4	□5
8 Ho provato qualcosa di meraviglioso	□1	□2	□3	□4	□5
9 Mi ha rinvigorito	□1	□2	□3	□4	□5
10 Ero mentalmente impegnato/a	□1	□2	□3	□4	□5
11 Mi ha sconcertato	□1	□2	□3	□4	□5
12 L'ho trovato brutto	□1	□2	□3	□4	□5
13 Ho percepito un significato più profondo	□1	□2	□3	□4	□5
14 Mi sono sentito/a profondamente commosso/a	□1	□2	□3	□4	□5
15 Mi ha fatto sentire malinconico/a	□1	□2	□3	□4	□5
16 Mi ha dato energia	□1	□2	□3	□4	□5
17 Mi ha fatto arrabbiare	□1	□2	□3	□4	□5
18 Sono rimasto/a incantato/a	□1	□2	□3	□4	□5
19 Mi ha annoiato	□1	□2	□3	□4	□5
20 Mi ha rilassato	□1	□2	□3	□4	□5
21 Ho sentito un'improvvisa intuizione	□1	□2	□3	□4	□5
22 Mi ha divertito	□1	□2	□3	□4	□5
23 Mi ha rattristato	□1	□2	□3	□4	□5
24 Mi sono sentito/a confuso/a	□1	□2	□3	□4	□5
25 Mi ha reso/a aggressivo/a	□1	□2	□3	□4	□5
26 Mi ha fatto sentire emotivamente coinvolto/a	□1	□2	□3	□4	□5
27 Mi ha preoccupato	□1	□2	□3	□4	□5
28 Mi ha fatto sentire nostalgico/a	□1	□2	□3	□4	□5
29 Mi ha sorpreso	□1	□2	□3	□4	□5
30 Mi sono sentito/a oppresso/a	□1	□2	□3	□4	□5
31 L'ho trovato sublime	□1	□2	□3	□4	□5
32 Mi ha motivato	□1	□2	□3	□4	□5
33 Ho provato indifferenza	□1	□2	□3	□4	□5
34 Ero impressionato/a	□1	□2	□3	□4	□5
35 L'ho trovato sgradevole/spiacevole	□1	□2	□3	□4	□5
36 Mi ha colpito	□1	□2	□3	□4	□5
37 Era inquietante per me	□1	□2	□3	□4	□5
38 Ha suscitato il mio interesse	□1	□2	□3	□4	□5
39 Mi ha reso felice	□1	□2	□3	□4	□5
40 Ho provato soggezione	□1	□2	□3	□4	□5
41 Mi ha spinto ad agire	□1	□2	□3	□4	□5
42 Era divertente per me	□1	□2	□3	□4	□5

b. Social Presence

Note: With respect to the original questionnaire Networked Minds Measure of Social Presence (Biocca et al., 2001), we eliminated the items on Mutual assistance and Dependent action as inadequate to assess social presence during a concert in a theater, where spectators are not interacting in collaborative actions.

"What was your social involvement during the concert?

We present below some statements that refer to your social experience referring to the other(s) Spectators during the concert "Amarcord d'un tango". For each statement, we kindly ask you to indicate with a cross if/how much you agree (from 1, "not at all agree," to 5, "very much agree"). In answering, keep in mind that there are no right or wrong answers: it is important to answer spontaneously. Please indicate with a cross how much the following statements describe your 'social experience' during the concert.

My social experience 1 (not at all agree) 2 3 4 5 (very much agree)"

1 During the concert, I just noticed the presence of another person (more or less close to me)	16 Other people's reactions were clear to me
2 Other people noticed me	17 My thoughts were intuitable to other people
3 I was often aware of the presence of other people in the surrounding space	18 Other people's thoughts were intuitable to me
4 Other people were often aware of my presence in the surrounding space	19 When I was happy, other people were happy too
5 I think other people often felt like they were alone	20 When other people were happy, I was also happy
6 I often felt like I was alone	21 Other people were influenced by my mood
7 I sometimes pretended to pay attention to other people	22 I was influenced by other people's moods
8 Other people sometimes pretended to pay attention to me	23 Other people's mood did not affect me
9 Other people paid a lot of attention to me	24 My mood did not affect other people's moods
10 I paid a lot of attention to other people	25 My actions were dependent on other people's actions
11 The person next to me was easily distracted when "other things" (than the concert) were happening	26 Other people's actions were dependent on mine

(*continued on next page*)

(*continued*)

around us	27 My behavior sometimes occurred in reaction to other people's behavior
12 I was easily distracted when "other things" (than the concert) were happening around us	28 Other people's behavior sometimes happened in reaction to mine
13 Other people tended to ignore me	29 What other people did affect what I did
14 I tended to ignore other people	30 What I did affected what other people did
15 My reactions were clear to other people	

COMMENTS/SUGGESTIONS:

Please enter here any comments and suggestions you have about the questionnaire, and/or about your overall experience of the concert and participation in the research.

Original questionnaire administered to Italian participants:

	Indichi con una crocetta quanto le seguenti affermazioni descrivono la sua 'esperienza sociale' durante il concerto.				
Mia esperienza sociale	1 per nulla d'accordo	2	3	4	5 molto d'accordo
1 Durante il concerto, ho appena notato la presenza di un'altra persona (più o meno vicina a me)	□1	□2	□3	□4	□5
2 Le altre persone mi hanno notato	□1	□2	□3	□4	□5
3 Ero spesso consapevole della presenza di altre persone nello spazio circostante	□1	□2	□3	□4	□5
4 Le altre persone erano spesso consapevoli della mia presenza nello spazio circostante	□1	□2	□3	□4	□5
5 Penso che le altre persone si siano sentite spesso da sole	□1	□2	□3	□4	□5
6 Mi sono sentito spesso come se fossi da solo	□1	□2	□3	□4	□5
7 Qualche volta ho fatto finta di prestare attenzione alle altre persone	□1	□2	□3	□4	□5
8 Le altre persone qualche volta hanno fatto finta di prestare attenzione a me	□1	□2	□3	□4	□5
9 Le altre persone hanno prestato molta attenzione a me	□1	□2	□3	□4	□5
10 Ho prestato molta attenzione alle altre persone	□1	□2	□3	□4	□5
11 La persona accanto a me veniva facilmente distratta quando accadevano "altre cose" (rispetto al concerto) attorno a noi	□1	□2	□3	□4	□5
12 Io venivo facilmente distratto/a quando accadevano "altre cose" (rispetto al concerto) attorno a noi	□1	□2	□3	□4	□5
13 Le altre persone tendevano a ignorarmi	□1	□2	□3	□4	□5
14 Io tendevo ad ignorare le altre persone	□1	□2	□3	□4	□5
15 Le mie reazioni erano chiare alle altre persone	□1	□2	□3	□4	□5
16 Le reazioni delle altre persone mi erano chiare	□1	□2	□3	□4	□5
17 I miei pensieri erano intuibili per le altre persone	□1	□2	□3	□4	□5
18 I pensieri delle altre persone erano intuibili per me	□1	□2	□3	□4	□5
19 Quando ero felice, anche le altre persone erano felici	□1	□2	□3	□4	□5
20 Quando le altre persone erano felici, anche io ero felice	□1	□2	□3	□4	□5
21 Le altre persone erano influenzate dal mio umore	□1	□2	□3	□4	□5
22 Io ero influenzato dall'umore delle altre persone	□1	□2	□3	□4	□5
23 L'umore delle altre persone non mi ha condizionato	□1	□2	□3	□4	□5
24 Il mio umore non ha condizionato le altre persone	□1	□2	□3	□4	□5
25 Le mie azioni erano dipendenti da quelle delle altre persone	□1	□2	□3	□4	□5
26 Le azioni delle altre persone erano dipendenti dalle mie	□1	□2	□3	□4	□5
27 Il mio comportamento a volte avveniva in reazione a quello delle altre persone	□1	□2	□3	□4	□5
28 Il comportamento delle altre persone a volte avveniva in reazione al mio	□1	□2	□3	□4	□5
29 Quello che facevano le altre persone influiva su ciò che facevo io	□1	□2	□3	□4	□5
30 Quello che facevo io influiva su ciò che facevano le altre persone	□1	□2	□3	□4	□5

COMMENTI/SUGGERIMENTI:

Inserite qui eventuali commenti e suggerimenti sul questionario e/o sulla vostra esperienza complessiva del concerto e della partecipazione alla ricerca.

c. Follow-up questionnaire TAMIG: Theater Attendance, Media Habits, Immersiveness and Interest Gain

Question	Question Type	Possible Answers
Theater Attendance		
F1. Are you a theatergoer/frequent attendee?	Yes/No Question	• Yes • No
F2. How often do you go to the theater?	4-Points ordinal scale	• At least once a year; • At least once every six months; • At least one time per month; • More than one time per month)
Media Habits		
F3. Have you ever listened to a Tango concert in the theater?	Yes/No Question	• Yes • No
F4. Try to specify why you do or do not frequent the theater.	Open Question	Open Question
F5. Have you ever seen the video of a concert?	Yes/No Question	• Yes

(*continued on next page*)

(*continued*)

Question	Question Type	Possible Answers
F6. Have you ever watched a video of a Tango concert?	Yes/No Question	• No • Yes • No
F7. In your estimation, how many minutes would you spend watching the video of a concert? *	Open Question	Open Question
F8. What are the minimum minutes that would make you consider a video to be long?	7-Point ordinal scale	• 1 min; • 3 min; • 5 min; • 5 min; • 10 min; • 20 min; • 30 min; • 40 min
F9. Following the previous question, would you be predisposed to watch a concert video that exceeds 10 min?	5-Points Likert Scale	• 1; • 2; • 3; • 4; • 5;
F10. After the experiment, would you have continued watching the video beyond the proposed 9 min?	Yes/No Question	• Yes • No
F11. Before this experiment, have you ever had experiences with immersive virtual reality tools?	Yes/No Question	• Yes • No
F12. Before this experiment, have you ever had virtual reality experiences with a smartphone?	Yes/No Question	• Yes • No
F13. Before this experiment, have you ever had virtual reality experiences with HTC-Vive?	Yes/No Question	• Yes • No
Immersiveness and Interest Gain		
F14. Before the experiment, how interested were you in Tango music?	5-Points Likert Scale	• 1; • 2; • 3; • 4; • 5.
F15. After the experiment, how interested were you in Tango music?	5-Points Likert Scale	• 1; • 2; • 3; • 4; • 5.
F16. In which mode did you watch the video for the experiment?	3-Points Categorical Scale	• HVR • MV • CVR
F17. I felt present in the virtual environment.	5-Points Likert Scale	• 1; • 2; • 3; • 4; • 5.
F18. I was not aware of the real environment around me.	5-Points Likert Scale	• 1; • 2; • 3; • 4; • 5.
F19. I was completely captured by the virtual world.	5-Points Likert Scale	• 1; • 2; • 3; • 4; • 5.

* Item F7 is asked only if F5 had positive outcome.

Original questionnaire administered to Italian participants:

Domanda	Tipologia di domanda	Risposte possibili
Frequentazione Teatro		
F1. Sei un frequentatore/frequentatrice del teatro?	Domanda Sì/No	• Si • No
F2. Quanto spesso vai a teatro?	Scala 1-4	• Una volta all'anno; • Almeno una volta ogni sei mesi; • Almeno una volta al mese; • Più volte al mese
F3. Hai mai ascoltato un concerto di Tango a teatro?	Domanda Si/No	• Sì • No

(*continued on next page*)

(*continued*)

Domanda	Tipologia di domanda	Risposte possibili
F4. Prova a specificare per quale motivo frequenti o non frequenti il teatro.	Domanda aperta	Domanda aperta
Esperienza personale con media e strumenti immersivi		
F5. Hai mai visto il video di un concerto?	Domanda Sì/No	• Sì • No
F6. Hai mai visto il video di un concerto Tango?	Domanda Sì/No	• Sì • No
F7. Secondo una tua stima, quanti minuti passeresti a vedere il video di un concerto? *	Domanda aperta	Domanda aperta
F8. Qual è il minimo minutaggio che ti fa considerare che un video sia lungo?	Scala 1-7	• oltre 1 minuto; • oltre 3 minuti; • oltre 5 minuti; • oltre 10 minuti; • oltre 20 minuti; • oltre 30 minuti; • oltre 40 minuti
F9. Seguendo la domanda precedente, saresti predisposto a guardare un video di un concerto che superi i 10 minuti?	Scala 1-5	• 1; • 2; • 3; • 4; • 5.
F10. Dopo l'esperimento, Avresti continuato a guardare il video oltre i 9 minuti proposti??	Domanda Si/No	• Sì • No
F11. Prima di questo esperimento, hai mai avuto esperienze con strumenti immersivi per la realtà virtuale?	Domanda Si/No	• Sì • No
F12. Hai mai avuto prima delle esperienze di realtà virtuale con lo smartphone? (cardboard)	Domanda Si/No	• Sì • No
F13. Hai mai avuto prima delle esperienze di realtà virtuale col visore HTC? (casco di realtà virtuale immersivo)	Domanda Si/No	• Sì • No
Immersività e aumento d'interesse		
F14. Prima dell'esperimento, quanto eri interessato alla musica Tango?	Scala 1-5	• 1; • 2; • 3; • 4; • 5.
F15. Dopo l'esperimento, quanto eri interessato alla musica Tango?	Scala 1-5	• 1; • 2; • 3; • 4; • 5.
F16. In quale modalità hai guardato il video per l'esperimento?	Scala categoriale	• Col visore HTC-Vive (casco montato sulla testa) MV • Tramite Google Cardboard (smartphone) • Schermo del computer
F17. Mi sentivo presente nell'ambiente virtuale.	Scala 1-5	• 1; • 2; • 3; • 4; • 5.
F18. Non ero consapevole dell'ambiente reale che mi circondava.	Scala 1-5	• 1; • 2; • 3; • 4; • 5.
F19. Ero completamente catturato dal mondo virtuale	Scala 1-5	• 1; • 2; • 3; • 4; • 5.

* Item F7 era chiesto solo in caso di risposta positiva alla domanda F5.

References

Agresti, A., & Caffo, B. (2000). Simple and effective confidence intervals for proportions and difference of proportions result from adding two successes and two failures. *The American Statistician, 54*, 280–288.

Alexanian, S., Foxman, M., & Pimentel, D. (2022). Virtual reality and music's impact on psychological well-being. *Frontiers Rehabilitation Sciences, 11*(3), Article 864990. https://doi.org/10.3389/fresc.2022.864990

Atherton, J., & Wang, G. (2020). Doing vs. Being: A philosophy of design for artful VR. *Journal of New Music Research, 49*, 35–59.

Bailenson, J. N., Swinth, K., Hoyt, C., Persky, S., Dimov, A., & Blascovich, J. (2005). The independent and interactive effects of embodied-agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments. *Presence, 14*, 379–393. https://doi.org/10.1162/105474605774785235

Bates, E., & Boland, F. M. (2016). Spatial music, virtual reality, and 360 media. *Proceedings of the AES International Conference*.

Bayani, K. Y. T., Natraj, N., Khresdish, N., Pargeter, J., Stout, D., & Wheaton, L. A. (2021). Emergence of perceptuomotor relationships during paleolithic stone toolmaking learning: Intersections of observation and practice. *Communications Biology, 4*, 1278. https://doi.org/10.1038/s42003-021-02768-w

Beermann, U., Hosoya, G., Schindler, I., Scherer, K. R., Eid, M., Wagner, V., et al. (2021). Dimensions and clusters of aesthetic emotions: A semantic profile analysis. *Frontiers in Psyhcology, 12*, Article 667173. https://doi.org/10.3389/fpsyg.2021.667173

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and Virtual Environments, 12*, 456–480. https://doi.org/10.1162/105474603322761270

Biocca, F., Harms, C., & Gregg, J. (2001). The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. In *4th annual international workshop on presence (philadelphia, PA)* (pp. 1–9).

Borghi, A. M., Scorolli, C., Caligiore, D., Baldassarre, G., & Tummolini, L. (2013). The embodied mind extended: Using words as social tools. *Frontiers in Psychology, 4*, 214.

Bossey, A. (2022). Gatekeeper perceptions on adopting environmentally sound information and communication technology-enhanced live performances to improve the sustainability of music festivals. International Journal of Event and Festival Management, 13 No. 3, 307-325. https://doi.org/10.1108/IJEFM-07-2021-0060.

Bowman, N. D., Rieger, D., & Lin, J. H. T. (2022). Social video gaming and well-being. *Current Opinion in Psychology*, Article 101316.

Brungardt, A., Wibben, A., Tompkins, A. F., Shanbhag, P., Coats, H., LaGasse, A. B., et al. (2021). Virtual reality-based music therapy in palliative care: A pilot implementation trial. *Journal of Palliative Medicine, 24*(5), 736–742. https://doi.org/10.1089/jpm.2020.0403

Caravà, M., & Scorolli, C. (2020). When affective relation weighs more than the mug handle: Investigating affective affordances. *Frontiers in Psychology, 11*, 1928.

Chirico, A., Maiorano, P., Indovina, P., Milanese, C., Giordano, G. G., Alivernini, F., et al. (2020). Virtual reality and music therapy as distraction interventions to alleviate anxiety and improve mood states in breast cancer patients during chemotherapy. *Journal of Cellular Physiology, 235*(6), 5353–5362. https://doi.org/10.1002/jcp.29422

Ciuk, D. J., & Yost, B. A. (2019). Conflicting cues: Item nonresponse and experimental mortality. In P. Lavrakas, M. Traugott, C. Kennedy, A. Holbrook, E. de Leeuw, & B. West (Eds.), *Experimental methods in survey research*.

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., … Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 66*, Article 102542.

de la Fuente Prieto, J., Lacasa, P., & Martínez-Borda, R. (2022). *Approaching metaverses: Mixed reality interfaces in youth media platforms*. New Techno Humanities.

Furby, L. (1991). Understanding the psychology of possession and ownership: A personal memoir and an appraisal of our progress. In F. W. Rudmin (Ed.), *To have possession: A handbook on ownership and property. Journal of social behavior and personality* (Vol. 6, pp. 457–463), 6.

Geng, L., Li, Y., & Xue, Y. (2022). Will the interest triggered by virtual reality (VR) turn into intention to travel (VR vs. Corporeal)? The moderating effects of customer segmentation. *Sustainability, 14*(12), 7010.

Gianelli, C., Scorolli, C., & Borghi, A. M. (2013). Acting in perspective: The role of body and language as social tools. *Psychological Research, 77*, 40–52.

He, L., Li, H., Xue, T., Sun, D., Zhu, S., & Ding, G. (2018). Am I in the theater? Usability study of live performance based virtual reality. In *Proceedings of the 24th ACM symposium on virtual reality software and technology* (pp. 1–11).

Herndon, H. (2019). *Electronic pop for the surveillance era*. The New Yorker.

Hwang, W., & Salvendy, G. (2010). Number of people required for usability evaluation: The 10 +/- 2 rule. *Behavior Research Methods, Instruments, & Computers, 53* (130–133), 5.

Iannilli, G. L. (Ed.). (2022). *Co-Operative aesthetics: A quasi-manifesto for the 21st century*. Aesthetica edizioni [Sesto San Giovanni].

Kallionpää, M., Chamberlain, A., & Gasselseder, H. P. (2018). *Under construction: Contemporary opera in the crossroads between new aesthetics, techniques, and technologies*. ACM International Conference Proceeding Series.

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R. E., Avots, E., … Anbarjafari, G. (2019). Virtual reality and its applications in education: Survey. *Information, 10*(10), 318.

Krosnick, J. A. (2018). *Questionnaire design* (pp. 439–455). The Palgrave handbook of survey research.

Lewis, C. (1982). *Using the" thinking-aloud" method in cognitive interface design*. Yorktown Heights, NY: IBM TJ Watson Research Center.

Loh, F., Wamser, F., Poignée, F., Geißler, S., & Hoßfeld, T. (2022). Youtube dataset on mobile streaming for internet traffic modeling and streaming analysis. *Scientific Data, 9*(1), 293.

Løvoll, H. S., Sæther, K. W., & Graves, M. (2020). Feeling at home in the wilderness: Environmental conditions, well-being and aesthetic experience. *Frontiers in Psychology, 11*.

Makin, A. D. J. (2017). The gap between aesthetic science and aesthetic experience. *Journal of Consciousness Studies, 24*, 184–213. https://philpapers.org/rec/MAKTGB.

Marfia, G., & Matteucci, G. (2018). Some remarks on aesthetics and computer science. *Studi di estetica*, (12).

Maslow, A. H. (1954). *Motivation and personality*. New York, NY, USA: Harper & Row.

Mastandrea, S., Fagioli, S., & Biasi, V. (2019). Art and psychological wellbeing: Linking the brain to the aesthetic emotion. *Frontiers in Psychology, 10*, 739. https://doi.org/10.3389/fpsyg.2019.00739

Mastandrea, S., Tinio, P. P. L., & Smith, J. K. (2021). Editorial: Environment, art, and museums: The aesthetic experience in different contexts. *Frontiers in Psychology, 12*, Article 675165. https://doi.org/10.3389/fpsyg.2021.675165

Matteucci, G. (2019). *Estetica e natura umana. La mente estesa tra percezione* (emozione ed). Roma, Carocci: espressione.

Matteucci, G. (2021). Improvisation as resonance. In A. Bertinetto, & M. Ruta (Eds.), *The routledge handbook of philosophy and improvisation in the arts* (pp. 33–46). New York: Routledge, 2022.

Meeks, S., Shryock, S. K., & Vandenbroucke, R. J. (2018). Theater involvement and well-being, age differences, and lessons from long-time subscribers. *The Gerontologist, 58* (2), 278–289.

Morotti, E., Stacchio, L., Donatiello, L., Roccetti, M., Tarabelli, J., & Marfia, G. (2021). Exploiting fashion x-commerce through the empowerment of voice in the fashion virtual reality arena. *Virtual Reality*, 1–14.

Nielsen, K. L. (2020). Students' video viewing habits during a flipped classroom course in engineering mathematics. *Research in Learning Technology, 28*.

Oh, C. S., Bailenson, J. N., & Welch, G. F. (2018). A systematic review of social presence: Definition, antecedents, and implications. *Frontiers Robotics AI, 5*, 114. https://doi.org/10.3389/frobt.2018.00114

Peretti, S., Tempesta, D., Socci, V., Pino, M. C., Mazza, M., Valenti, M., et al. (2018). The role of sleep in aesthetic perception and empathy: A mediation analysis. *Journal of Sleep Research*. https://doi.org/10.1111/jsr.12664

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The state of psychological ownership: Integrating and extending a century of research. *Review of General Psychology, 7*(1), 84–107. https://doi.org/10.1037/1089-2680.7.1.84

Psotka, J. (2013). Educational games and virtual reality as disruptive technologies. *Journal of Educational Technology & Society, 16*(2), 69–80.

Radbourne, J., Johanson, K., Glow, H., & White, T. (2009). The audience experience: Measuring quality in the performing arts. *International Journal of Arts Management*, 16–29.

Richter. (2023). *AR & VR Adoption is Still in its Infancy*. https://www.statista.com/chart/28467/virtual-and-augmented-reality-adoption-forecast/.

Salomoni, P., Prandi, C., Roccetti, M., Casanova, L., Marchetti, L., & Marfia, G. (2017). Diegetic user interfaces for virtual environments with hmds: A user experience study with oculus rift. *Journal of Multimodal User Interfaces, 11*, 173–184. https://doi.org/10.1007/s12193-016-0236-5

Sauro, J., & Lewis, J. R. (2016). *Quantifying the user experience: Practical statistics for user research* (2 ed.). Elsevier.

Schindler, I., Hosoya, G., Menninghaus, W., Beermann, U., Wagner, V., Eid, M., et al. (2017). Measuring aesthetic emotions: A review of the literature and a new assessment tool. *PLoS One, 12*(6), Article e0178899. https://doi.org/10.1371/journal.pone.017889

Schubert, T. W. (2003). The sense of presence in virtual environments: A three-component scale measuring spatial presence, involvement, and realness. *Zeitschrift für Medienpsychologie, 15*(2), 69–71.

Scorolli, C. (2019). Re-Enacting the bodily self on stage: Embodied cognition meets psychoanalysis. *Frontiers in Psychology, 10*, 492. https://doi.org/10.3389/fpsyg.2019.00492

Security.org. (2022). *Virtual reality awareness and adoption: 2022 annual report*. https://www.security.org/digital-security/virtual-reality-annual-report/.

Shelstad, W. J., Smith, D. C., & Chaparro, B. S. (2017). Gaming on the rift: How virtual reality affects game user satisfaction. In *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 61, pp. 2072–2076). Sage CA: Los Angeles, CA: SAGE Publications. No. 1.

Slater, M., Cabriera, C., Senel, G., Banakou, D., Beacco, A., Oliva, R., et al. (2022). The sentiment of a virtual rock concert. *Virtual Reality, 23*, 1–25. https://doi.org/10.1007/s10055-022-00685-9

Slater, M., Lotto, B., Arnold, M. M., & Sanchez-Vives, M. V. (2009). How we experience immersive virtual environments: The concept of presence and its measurement. *Anuario de Psicol, 40*, 193–210.

Stamatopoulou, D. (2004). *Integrating the philosophy and psychology of aesthetic experience* (Vol. 95). Psychological Reports: Development of the Aesthetic Experience Scale.

Stamatopoulou, D. (2018). Empathy and the aesthetic: Why does art still move us? *Cognitive Processing, 19*, 169–186. https://doi.org/10.1007/s10339-017-0836-3

Sterna, R., & Zibreck, K. (2021). Psychology in virtual reality: Toward a validated measure of social presence. *Frontiers in Psychology, 12:705448. doi: 10.3389/fpsyg.2021.705448*.

Taber, K. T. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*, 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Thomson, L. J., Lockyer, B., Camic, P. M., & Chatterjee, H. J. (2018). Effects of a museum-based social prescription intervention on quantitative measures of psychological wellbeing in older adults. *Perspectives Public Health, 138*, 28–38. https://doi.org/10.1177/1757913917737563

Tinio, P. P. L., & Smith, J. K. (Eds.). (2014). *The cambridge handbook of the psychology of aesthetics and the arts* (p. 620). Cambridge: Cambridge University Press.

Van Kerrebroeck, B., Caruso, G., & Maes, P.-J. (2021). A methodological framework for assessing social presence in music interactions in virtual reality. *Frontiers in Psychology, 12*, Article 663725. https://doi.org/10.3389/fpsyg.2021.663725

Vardomatski, Sergei. "Augmented and virtual reality after COVID-19." *Forbes. Retrieved July* 6 (2021) https://www.forbes.com/sites/forbestechcouncil/2021/09/14/augmented-and-virtual-reality-after-covid-19/?sh=be6a8c82d97c: 2022.

Ventura, S., Badenes-Ribera, L., Herrero, R., Cebolla, A., Galiana, L., & Banos, R. (2020). Virtual reality as a medium to elicit empathy: A meta-analysis. *Cyberpsychology, Behavior, and Social Networking*. https://doi.org/10.1089/cyber.2019.0681

Virvou, M., & Katsionis, G. (2008). On the usability and likeability of virtual reality games for education: The case of VR-ENGAGE. *Computers & Education, 50*(1), 154–178.

Ward, D., & Lasen, M. (2009). An overview of needs theories behind Consumerism. *J. Appl. Econ. Sci., 4*, 137–155.

Weber-Sabil, J., & Han, D. I. D. (2021). *Immersive tourism-state of the art of immersive tourism realities through XR technology*. Breda University of Applied Science.

Weinel, J. (2021). Cyberdream: An interactive rave music visualization in virtual reality. In *Proceedings of SIGGRAPH asia 2021 XR, SA, 2021*.

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review, 66*, 297–330.

Woolson, R. F. (2007). *Wilcoxon signed-rank test*. Wiley encyclopedia of clinical trials.

Yang, S., Brossard, D., Scheufele, D. A., & Xenos, M. A. (2022). The science of YouTube: What factors influence user engagement with online science videos? *PLoS One, 17* (5), Article e0267697.

Yu, C.-Y. (2016). Aesthetic experience and its profound interaction with the self/ego. *Research in Arts Education, 32*, 103–132.

Yu, C.-Y., & Wang, P.-C. (2018). Aesthetic experience anchors ego identity formation. *Sustainability, 10*(8), 2596. https://doi.org/10.3390/su10082596