SURVEY

Dancing in virtual reality as an inclusive platform for social and physical fitness activities: a survey

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Abstract

Virtual reality (VR) has recently seen significant development in interaction with computers and the visualization of information. More and more people are using virtual and immersive technologies in their daily lives, especially for entertainment, fitness, and socializing purposes. This paper presents a qualitative evaluation of a large sample of users using a VR platform for dancing ($N = 292$); we study the users' motivations, experiences, and requirements for using VR as an inclusive platform for dancing, mainly as a social or physical activity. We used an artificial intelligence platform (OpenAI) to extract categories or clusters of responses automatically. We organized the data into six user motivation categories: fun, fitness, social activity, pandemic, escape from reality, and professional activities. Our results indicate that dancing in virtual reality is a different experience than in the real world, and there is a clear distinction in the user's motivations for using VR platforms for dancing. Our survey results suggest that VR is a tool that can positively impact physical and mental well-being through dancing. These findings complement the related work, help in identifying the use cases, and can be used to assist future improvements of VR dance applications.

Keywords Human-centered computing · Virtual reality · Dancing · Social platforms · OpenAI

1 Introduction

With the rapidly growing demand for interactive VR consoles and the introduction of Metaverse—Metaverse is a digital environment that exists in a physically persistent virtual world with virtual avatars represented by humans—there has also been an increase in the number of people using VR for entertainment, fitness, and socializing. In this context, dancing in VR for fun and fitness has recently gained popularity. To better understand dancing in VR, we look at some relevant definitions of dance.

Dance is "a performing-art form consisting of purposefully selected and controlled rhythmic sequences of human movements" for aesthetic purposes [7, 68]. Similarly, Sikora and Burleson [58] define dance as "a discipline that has deep expertise in the expression and interpretation of human movement and emotion." As a scientific study topic, dance is ultimately about action and conscious human intentions [11]. In this paper, we define *dancing in VR* as a conscious way of purposeful rhythmic movements of the body in a space with clearly defined boundaries that take place in a virtual environment using a VR console. The type of movement and the space in which users dance depends on the user's motivation, which could be to learn a specific set of movements, e.g., traditional dance, to dance in a social event, or as an exercise.

Currently, there are two main categories for gamified dance VR applications: (a) those that are for single-players, such as BeatSaber, SynthRiders, and AudioShield (rhythm games) or DanceCentral and OhShape (teach dance moves), which primarily aim at the user's entertainment and fitness training; and (b) those that are for multiple-players, like the VRChat, Sansar, Second Life, and AltspaceVR, that allow users from all over the world to join multi-user sessions.

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The latter category is mostly built for social VR platforms and focuses on the user's entertainment, socializing, attending dance performances, dancing together in clubs and live DJs, attending dance classes, teaching dance classes, and performing dance in virtual clubs [63]. Recently, the increased need for social interaction conceived due to the COVID-19 pandemic, followed by the state restrictions on traveling and mass gatherings, has prompted users to use social VR platforms to get together, interact, and support similar dance interests. Indeed, social VR activities can provide people with a sense of connection and community, and help people to connect with others who share their interests, even if they live in different parts of the world or have different backgrounds and experiences.

Despite the increase in the use of VR applications, it is still unclear what kind of values VR dancing offers for most users. A series of recent qualitative studies provide a user-focused perspective on specific topics related to social VR [57, 63]. They demonstrate that VR provides a superior social experience compared to traditional digital social spaces, like games or social media [63]. In particular, they concluded that dancing or training in a VR environment is cost-effective, it provides adequate feedback, removes unnecessary risks, increases users' engagement, and reminds users of the task at hand [8, 15, 32]. By providing an immersive experience, VR successfully increases learning retention and makes remote training accessible. However, despite the advances in the learning process, dancing in VR involves addressing several specific technological challenges. An ideal dance application should allow people to carry out their performance freely and have, at the same time, coherent feedback in the virtual world. Such a dance application requires perfect tracking facilities, avatar simulation, and embodiment. But it remains to be seen which of these challenging requirements corresponds to an actual expectation of the current dance VR users. Understanding the VR systems' current functionalities and limitations will enable the development of user-friendly, efficient, and safe VR spaces for dancing. Another aspect of further research is whether the users dancing in VR consist of a representative sample of people dancing in the real world, and we need to understand the relationship and the differences between the two groups.

To better understand these aspects, we need information on the dance activity of the participants in the real-world scenario, dance activity in VR, preference for avatars, motivations for using VR for dancing, and usability factors such as likes and dislikes and the future requirements. Based on this statement, we conducted an online survey to reach out to VR users and answer the following research questions:

1. What are the motivations for using VR for dancing?
2. What features do users like and dislike in current VR dancing platforms?

3. What are the guidelines for designing and developing user-centered dance VR applications?

Our survey found that dancing in VR platforms is a different experience from real life, addressing particular needs or expectations: we found that, several insecurities and social pressures present in the real world do not apply to the virtual world. A large sample of data ($N = 292$) was received from users with experience in dancing in various VR platforms, with various experiences and motivations. Based on the responses, we categorized the data based on six users-motivations: fun, fitness, social activity, pandemic, escape from reality, and professional activities. Using recent advances in OpenAI data analysis, and more specifically the Open AI's GPT3 language model [13], we analyzed the data to understand the user requirements and expectations. We concluded that, even though further improvements could be applied to overcome the current hardware, tracking, and technical limitations (including better and more affordable full-body tracking capabilities, lighter hardware, safe spaces in Social VR platforms, better avatars, etc.), VR is still an inclusive platform that helps with mental and physical well-being, especially in the current pandemic. Note that, in this work, we used an unsupervised classification model to remove any bottlenecks of human labeling of the data, such as bias [49].

There have been similar recent surveys on SocialVR adoption, but they have not explicitly dealt with dance in VR. We contribute to the field of dance in VR by understanding the profiles of many different dance VR users. This precise understanding will help build a segue between the research community and the VR users, leading to the building of more target-oriented and user-friendly applications for dancing in VR. This online survey led to the acquisition of a large, freely available data set (https://forms.gle/q9VHe9sUkoeEzDcf9), aiming to provide the research community and companies with relevant information about the expectations and future developments required to satisfy the expectations of such a large audience. Even though we do not address all the details from the survey in this paper, it gives an overall picture of WHY and HOW people use VR for dancing.

2 Dancing in virtual reality

Virtual reality has been used over the years for learning and training purposes, aiming to make monotonous indoor workouts more fun, e.g., in sports workouts and exertion games [8, 15, 32, 45, 48], or martial arts [10, 64]. More recently, it has also been explored on how it enhances dance performance by bringing in immersion, visualization, and interactivity [16, 28, 29, 69]. In that manner, the term *dance technology* usually refers to emerging technological appli-

cations in activities related to dance, with an emphasis in education, performance, gamification, and research [19, 25, 27, 44]. Indeed, VR is becoming an increasingly intriguing space for dancers and choreographers since it offers unique and compelling possibilities, an ideal technological medium that enhances fundamental elements of the dancing experience, e.g., visual spectacle, imaginary worlds, transformative space, interactive virtual agents, but most importantly, audience immersion [3, 6]. Therefore, many commercial applications have been developed, e.g., "Ballet Pixelle,"[1] the first company to perform dance in full virtual reality, or "Virtual Dance," a theater dance application in a virtual global community platform called Second Life [36]. These applications use VR to explore physical and virtual dance, as well as blended realities.

Although social dance learning via VR is an emerging topic with numerous applications, the current literature in the evaluation of these systems, including empirical studies, is limited. Previous research suggests that virtual reality, as part of collaborative virtual environments [9], offers great benefits in social dancing and interaction, e.g., in between the users or the public and the performers [65, 69]; it improves health for the elderly, e.g., brain reconditioning [20], the balance and cognition [41, 42]; collaboration techniques and/or collaborative learning [17, 60], etc. So far, several studies have been conducted to evaluate how the user can learn and improve dance skills through repetitive training [53, 55] or to evaluate the performance of a user that performs alongside a virtual teacher while being monitored by a motion capture system [1, 5]. However, in contrast to other social VR environments [26, 39, 40, 52, 54, 63], little effort has so far been devoted to the evaluation of the VR design practices [71], or certain pedagogical strategies [18], that are dance-specific.

The use of immersive VR in dance training and education indeed offers great advantages. The best design practices related to VR education and social—VR are still forming, and thus a more profound understanding of the motivation, requirements, and limitations of the user is required. These practices refer to the aesthetics and architecture of the virtual environment, social mechanics, methods for shaping social norms and mitigating harassment, and communicative affordances related to the avatars [31, 38]. Previous research showed that there is a strong illusion of virtual body ownership and a feeling of actually being present in the shared virtual worlds [37, 59], while other researchers support that the use of high-quality social VR avatars changes the way users perceive and understand their avatars, making them feel more engaged for self-expression and identity exploration [21]. Only a little work has been done in terms of the satisfaction of the VR users, their familiarization and confidence in the virtual environment, as well

as their motivations, experiences, and requirements, especially for dance application where the visual feedback of the performance is so important. In relation to the above, Zacharatos et al. [70] introduced a set of body features to detect significant emotional states of the user (concentration, meditation, excitement, and frustration) in computer gaming, aiming to intelligently adapt the game to offer a better user experience for the players. It has also been observed that users were more engaged when they played in groups against their friends rather than in single plays or competing with an unknown user. In another example that is part of the danceDB project [4, 61], the dancers explained that they were more confident in showing their virtual avatar dancing instead of being watched by others in the real world.

The recent emerging growth of social dance VR applications, and the future Metaverse, though, requires to design of a deeper strategy evaluation to define what it means to be social dancing in VR, to identify design trends, best practices, unique features, harassment, interactions, taking into account the user's motivation, expectation, and satisfaction. For that, Smith [60] introduced new types of creative content and explained how the audience could provide tools for analyzing and understanding VR dance performance as part of an interdisciplinary creative team. The interaction between dance performers has also been studied in the psychological domain [47, 67]. In general, it has been observed that social VR users envision and reflect the design of social VR technologies by evaluating the following five types of meaningful activities: (a) the full-body tracking capacity of the VR technology; (b) everyday activities; (c) mental self-improvement; (d) cultural appreciation and educational activities; and (e) participation in immersive events [33]. Social VR seems to support socializing, self-expression, identity exploration, self-improvement, mental health, and learning skills. However, despite the few studies available in other social VR domains that sometimes are based only on a small number of participants, there are still many open questions and challenges for the optimal design of dance-specific social VR platforms, such as usability, safety, and ethical implications [12, 33, 34]. Thus, this work aims to unveil and understand, via an online survey, the VR user motivation, requirements, and satisfaction as an inclusive platform for social and physical fitness activities.

3 Method

We conducted the online study between May and June 2021. We posted the call for participation in several subreddits, Facebook pages, and Twitter relevant to virtual reality in order to recruit participants. In order to gain more visibility on the platforms, an update call was posted every week. No compensation was provided to the participants. Before

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[1] http://balletpixelle.org/.

conducting the online survey, we ensured that participants provided their consent to participate. Hence, they had to click on an "accept" button after reading the information linked to the survey. Furthermore, we want to emphasize that no personal data that could identify the participants was collected during the survey process. As there was no personal data collected in this survey, and the participants accepted the informed consent, there was no need to apply for an ethical committee in our institution.

3.1 Research framework and measures

To assess the motivation for using VR for dancing, we applied the Uses and Gratifications Theory (UGT) framework [66] while designing the questionnaire similar to the survey conducted by [63]. VR users have different motivations and expectations in using VR for dancing. Hence, the survey questionnaire included open-ended questions to give participants the freedom to share their experiences instead of being limited by the choices we provide.

The questionnaire includes demographics, questions about the user's real-world dancing experience, their VR dancing, the VR platforms used for dancing, etc. We used open-ended questionnaires on their perceived confidence, mental fatigue, physical fatigue, motivations for dancing, likes, dislikes, and desired features. To understand the user's personality, we recorded ten items Big-Five Inventory [51]. The Big-Five model represents five major personality traits: Conscientiousness, Agreeableness, Neuroticism, Openness, and Extraversion.

3.2 Content analysis

Responses to each of the questions included a vast spectrum of themes. We used the Open AI framework with the DaVinci engine to analyze the content and extract the major themes from the participant's responses.[2] As motivation was one of the major topic to understand of this work, we categorized the participants based on their primary motivation to dance in VR, as a starting point to understand their experiences and requirements better.

3.2.1 OpenAI for analysis

As the number of VR users is growing rapidly, there is a gradual increase in the amount of survey data that VR researchers have access to. It is, therefore, very costly, and time-consuming to label these large amounts of survey data manually. For that reason, we follow the current trends in machine learning analysis using the Open AI tool to categorize and label user data. The AI tool highlights information
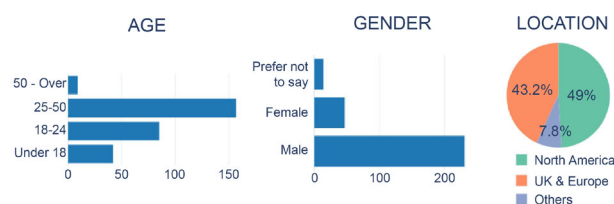

Fig. 1 Demographic data

that traditional expert-based approaches may miss because of predetermined categories or hypotheses. The Open AI uses GPT3 (Third-generation Generative Pre-trained Transformer) and a qualitative data analysis software package called NVivo to analyze and group the themes recurring in the user's responses [2]. Among many others, this method has been successfully used for classifying social media texts [14, 24, 43]. In our case, the responses of the participant were used as input to the OpenAI playground interface, and the query for the classifier was: "List the top themes from the comments above." In this method, no predetermined theme is suggested, hence allowing the AI system to explore any theme, arising from the data. After extracting the top themes, we coded each of the responses to quantify them for further analysis. By using OpenAI for content analysis, we intend to remove any bias or error arising due to the researchers' background.

4 Results

This section presents the results to better understand the population that uses VR for dancing. Firstly, we present the participants' demographic information, including their experience with dancing in the real world and VR. As avatar visualization is common in dance VR applications, we present results from a questionnaire regarding the participant's experience with the avatars. Consequently, we present the survey results according to the main motivations reported by the participants. Finally, we present the overall participant's feedback on the usability of current dance VR applications and their future recommendations.

A total of 307 participants completed the survey. Fifteen responses were removed from the analysis since the answers indicated that the participants had not used VR for dancing and just attempted the survey. In summary, most of the participants were male (79%) and were mainly from North America (49%) and Europe & UK (43%), as shown in Fig. 1. Among 292 participants, 42 (14%) were under 18 years old, 86 (29%) were between 18 and 24 years old, 156 (54%) were between 25 to 50 years old, and 9 (3%) were above 50. The participants used Oculus rift/Quest (44.9%), Valve Index (29.8%), HTC Vive (20.5%), Windows Mixed Real-

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ity (3.4%), PSVR (2.7%), HP Reverb (1.4%), Pimax 5K (1.4%), and Vive Cosmos (0.6%). Most participants used partial tracking with HMD and hand controllers (61.6%), and the rest used full-body tracking (38.4%). One participant mentioned using full-body tracking with a haptic vest. We have not included the results from the Big5 inventory since we could not derive any meaningful significance from the data.

4.1 Experience

The participants answered questions regarding their dance experience in the real world, dance experience in VR, and their experience with avatars in VR.

4.1.1 Real-world dancing

From 292 participants, 43% indicated that they do not or never danced in the real world. Out of those who answered positively about whether they dance in the real world, 50% stated that they dance for fun, and only 5% dance for fitness. Note that six participants were professional dancers in the real world. From 167 participants who have dance experience in the real world, the frequency of dancing is daily (10%), weekly (22%), monthly (28%), and very rare (40%). Almost half of the participants who practice dance in the real world spend less than 30 min every time they attend a VR session, 25% spend more than 30 min, and 25% spend more than an hour. Participants practice on different dance genres, including Freestyle (22), Hip-hop (18), Pole dance (5), Ballet (5), Breakdance (5), Contemporary (4), Tango (3), Bharatha Natyam (2), and Zumba (1).

4.1.2 Virtual-world dancing

In contrast, the majority of the participants use VR as a dance platform for fun (79%), and only 17% of the participants use it for fitness, while twelve participants use VR for professional purposes. The frequency of participants using VR for dancing is: Daily (18%), a couple of times a week (46%), a couple of times a month (24%), and very rare (12%). Approximately one-third of the participants spend less than 30 min dancing in VR, another one-third spend between 30 min and one hour, and the rest of the population (35%) spend more than an hour dancing in VR. It can be observed that participants spend more time, and dance more frequently in VR compared to the real world.

Out of 292 participants, 189 (65%) use SocialVR applications for dancing. They use applications such as VRChat (168), AltspaceVR (24), Neos VR (5), Recroom (8), Sansar (3), Bigscreen (2), Onward (1), Chillout VR (1), and Pythoran (1). A total of 126 participants (43%) use VR games for dancing. They use applications such as Beat Saber (79),

Synth Riders (24), Dance Central (19), Audio trip (6), Audica (5), Dance collider (3), OhShape (2), Audio shield (2), fitxr (2), song beaters (1), just dance (1), Pistolwhip (1), Sound boxing (1), Payday2 (1), and airtone (1). In general, participants responded that they use VR to imitate/recreate a dance (168), for fitness (155), to attend virtual dance battles, DJ, and social events (87), to learn dance (62), and to attend dance performances (41).

4.1.3 Avatars

One important aspect to discuss is the use and choice of the avatars, to understand their importance and impact on the overall experience of dancing in VR. When exposed to this immersive environment, 66% ($n = 193$) of the participants feel that the avatar's body represents their own, while 28% ($n = 83$) of the participants answered that they do not feel that the avatar is highly associated with their body. This question, of course, does not apply to all participants as there are applications that track users' limbs and do not include avatars. A deeper analysis on the participant's preferences regarding avatars can be found in the following sections.

4.2 Motivation

This section examines the reasons WHY people dance in VR. We asked participants about their main motivation, and based on their responses, we divided the total participants into six groups: Fun (139), Fitness (61), Social Activity (45), Pandemic (19), Escape (17), and Professional (11). By categorizing the participants based on motivation, we aim to present a comprehensive picture of the different user based experiences, needs, and expectations. Analyzing each category can help researchers and designers build future applications for the target population. To portray our results in more detail for future analysis, we illustrate the responses and observations on graph-based visualizations.

4.2.1 Fun

The *Fun* group participants ($n = 139$) choose to dance in VR for entertainment purposes, such as playing fun games, attending virtual concerts, parties, or just exploring the VR worlds: *"It is fun and I get to see myself as my avatar doing cool dances (P44)"*. The participants prefer their avatars to be a different person (45), a fictional character (43), an identical version of themselves (32), or an ideal version of themselves (5). Figure 2 lists the questionnaire responses.

Participants in this category expressed different opinions about their increased self-confidence when dancing in VR. Multiple users ($n = 19$) agree that they feel more confident when dancing in VR because they are anonymous: *"I don't see it, I just see my motions being applied to an avatar I just*
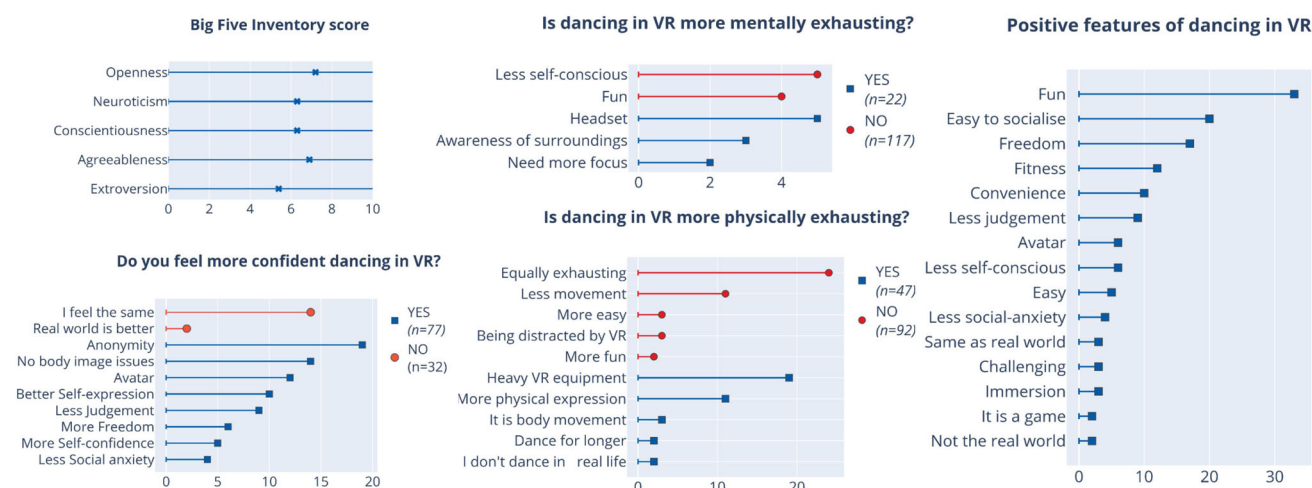
Fig. 2 Summary of Fun category data: The figure shows the top themes extracted by OpenAI from the responses to some survey questionnaires regarding confidence, physical exhaustion, mental exhaustion, and positive features of using VR perceived by the participants in the Fun category. The horizontal axis represents the number of participants having similar responses

became (P86)". They can be themselves without judgment ($n = 9$): *"I am transgender and do not like the current form of my IRL body. VR lets me look how I want (P232)"*. It also helps people who are self-conscious ($n = 14$) about their body image because they can choose their appearance in VR, and it is a separate world with no limitations: *"I dislike my IRL appearance and don't really know how to dance IRL. I don't feel comfortable on an IRL dance floor, but in VR, I can choose my appearance (P108)"*. Two participants feel that even though they have a good body in the real world, they do not look very good while dancing: *"I feel about the same, though in VR, I am more conscious about my lack of dancing skills than my appearance of course. In real life, MOST people don't know how to dance, so it feels more forgiving (P187)"*.

The survey results indicate that VR dancers experience the same fatigue and exhaustion as real-life dancers: *"I only dance in VRChat. But I go super hard, from like 10 pm–6 am, which is exhausting but it feels amazing. I would imagine it would feel the same IRL too (P110)"*. Eight participants feel that VR is less tiring than real-life dancing because they cannot move around in VR as freely as they could in real life, resulting in overall less movement: *"Most people have to limit their movements to accommodate a small VR space, and there are several tricks people use on their avatars to make it seem like they're moving more than they really are (P152)"*. Being distracted ($n = 5$) in VR is mentioned as another reason for less physical fatigue in VR: *"It's easy to let loose and to let your mind take the high of enjoyment and fun, and allowing you to go further (P188)"*. The heavy headset was observed by many participants ($n = 19$) to be the cause of higher physical exhaustion: *"Compare it to dancing*

with a microwave taped to your head (P7)". Eleven participants mentioned that they are more physically expressive in VR compared to the real world and hence danced longer than usual: *"It frees up your inhibitions, so you make bolder movements (P227)"*. Nevertheless, five participants responded that they do not feel more mentally exhausted in VR, and declared less self-consciousness as the reason: *"Your mind is concentrating on the game so there is a psychological disconnect with what you're doing with your body (P156)."*

Many participants ($n = 33$) indicated that they like dancing in VR because it is a fun way to enjoy the freedom of moving to the music and seeing their characters mimic every move. Also, socializing in such an environment is considered easier, as it provides a feeling of safety and confidence: *"I have met a lot of great friends through dance communities and been to an incredible amount of amazing live events (P152)"*. A VR dancing platform also allows its users to express themselves more freely: *"I get to be a different gender, and I can do/act in ways that fit that properly (P110)"*.

Dancing in VR, for some participants ($n = 12$), is considered as a fun way of exercising and improving physical fitness. Being able to dance from the comfort of your home is another factor favor in favor ($n = 10$) *"I don't have a car, I can go to parties, artist tours, and raves without leaving home. I don't have to worry about crowds (P232)"*. A few participants indicated that they are in favor of VR dancing platforms due to their nonjudgmental nature ($n = 9$), and they feel less self-conscious ($n = 6$) and less social anxiety ($n = 4$) than in the real world: *"absolutely nobody judges you (P263)"*. Six people like to dance in VR because they can be anyone or anything using avatars: *"I can be more weird as a cartoon character or creature (P178)"*. Three participants
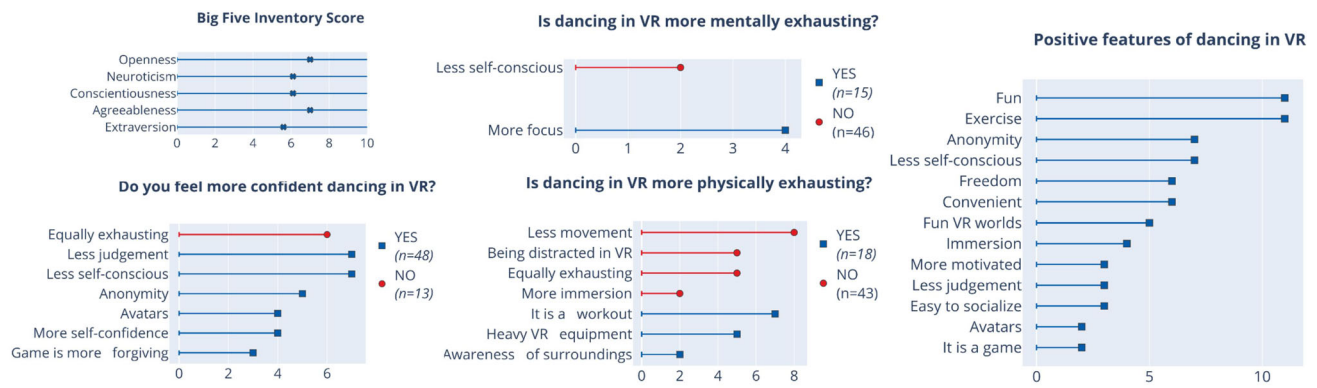
Fig. 3 Summary of Fitness category data: The figure shows the top themes extracted by OpenAI from the responses to some survey questionnaires regarding confidence, physical exhaustion, mental exhaustion, and positive features of using VR perceived by the participants in the Fitness category. The horizontal axis represents the number of participants having similar responses

described dancing in VR as challenging, and it encourages them to dance more: *"that it motivates me to dance, that it is challenging, that it can teach me (P218)"*.

4.2.2 Fitness

The *Fitness* group participants ($n = 61$) are more motivated in order to use VR for exercising, to lose weight or stay fit while having fun: *"It helped me to lose a lot of weight, and I just love VR in general (P181)"*. The participants prefer avatars identical to themselves (19), a fictional character (15), or a different person (14). Figure 3 presents the responses of the participants to various questionnaires.

Seven participants reported that they feel more confident in VR because they do not have to worry about the judgment of other people: *"I never danced until I had access to VR, and now it's something I love and looks forward to doing (P181)"*. Five participants feel more confident because they believe that avatars hide their identity and human imperfections. Hence, it is easier for them to let loose and be themselves while dancing in VR: *"Since I am dancing for fitness, my intent is to be actively changing my physical body. By necessity, there are things about my physical body I do not feel very confident about (P102)"*.

Four participants answered that they feel mentally more exhausted because of a higher level of cognitive focus: *"While dancing in VR, I am often also engaging with game mechanics (e.g., hitting notes in Beat Saber). This adds a level of mental engagement that is not present in physical dance P(102)"*. Two participants who felt that dancing in VR is less mentally exhausting listed a lack of self-consciousness as a reason.

Five participants feel less physically exhausted in VR because they are focusing less on the physical exertion of the dance and more on the challenge of the VR environment: *"I am distracted from my fatigue (P18)"*. Another eight users

explained that in VR less movement is required, hence it is less tiring. Perspiration seems to be one of the recurring reasons participants feel more physically exhausted when dancing for fitness on VR platforms. Seven participants feel more physically exhausted because the VR games require more than just dance moves: *"Because when I dance in VR I have a heart rate monitor on and I'm trying to keep my heart rate high (P140".)*

People motivated by fitness like to dance in VR because it is a fun way to get some exercise without having to travel. Dancing in VR could be motivating: *"Without it, I would have never started dancing (P181)"*. It is a convenient and safer option to learn dance or have some fun: *"I have multiple dance instructors so I can learn all sorts of different styles without leaving my living room (P259)"*.

4.2.3 Social activity

The *Social Activity* group participants ($n = 45$) are motivated by the scope of the VR platform for making friends and socializing: *"VR allows me to meet friends that also love dancing, and it allows me to go to digital music venues and put those dancing skills to use, it's helping me to be more fit, and I just enjoy doing it (P261)"*. The participants prefer their avatars to be a fictional character (20), an identical version of themselves (12), or a different person (11). Figure 4 shows the corresponding questionnaires responses.

Being anonymous in VR seems to be the main reason for using VR platforms for social activity. *"I don't like the way I look in real life, and VR allows me to present myself, however, I want to be seen. Also, being in VR feels like starting over. My friends in real life already know how shy and quiet I really am, and it would feel impossible to do something like dancing with them. In VR, I have a chance to make a different first impression on people and a chance to meet new people that are interested in the same things I am. That was how I started*
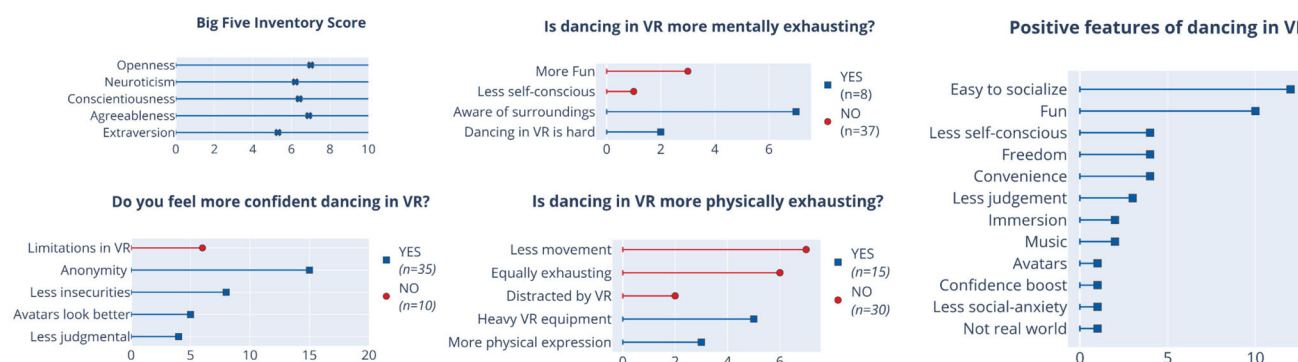
Fig. 4 Summary of Social Activity data: The figure shows the top themes extracted by OpenAI from the responses to some survey questionnaires regarding confidence, physical exhaustion, mental exhaustion, and positive features of using VR perceived by the participants in the Social Activity category. The horizontal axis represents the number of participants having similar responses

dancing in the first place, and I met a friend who learned to dance with a VR group and that offered to teach me the ropes. It's like building another identity that I can really do whatever I want without worrying about what other people think of me—after all, it's just VR. I can take off the headset and never see someone again if I want to."*. One participant felt confident because he could blame the tracking and hardware limitations of VR for his poor performance: *"When I know I've messed up my form, I have this fallback to just blame the tracking or the IK, which gives me a sort of mental security"* as if *"oh I didn't actually mess up"* or *"people can't see how bad I actually am (P179)"*. Six participants feel that dancing in VR is limiting and not realistic or graceful.

Three participants mentioned fun as the reason for being less mentally exhausted: *"My friends and I are constantly having fun, able to change locations and look at will. This allows serious variance and makes it less mentally exhausting (P87)"*. Participants feel that they are distracted in VR, resulting in less physical fatigue: *"I believe it's because you're less focused on things than in the real world. Your head treats real-world problems differently than the world of VR (P160)"*.

Social activity participants are excited about dancing in VR because it is a fun, social, and freeing experience, without being concerned about the judgment of other people. For two participants, the aspect of socializing was perceived as much stronger in VR than in reality: *"Dancing in VR is a much more social experience than I could get in real life right now. It's exciting seeing experienced dancers push the limits of what can be done in VR (P261)"*. One participant remarked how dancing in VR makes him less self-anxious: *"Being an anxious person, being in VR seemed to remove most of my social anxiety, so I'm way more likely to dance in VR (P160)"*.

4.2.4 Pandemic

The *Pandemic* group participants ($n = 19$) chose to use VR since they see it as the only option to have fun, exercise, socialize or attend events confined to their homes during this pandemic: *"The pandemic has pretty much killed any real-life events, so this is an excellent substitute (P213)"*. Again, the participants showed a preference to be presented by a fictional character (10), an identical version of themselves (4), or a different person (3). Figure 5 shows the questionnaires responses.

According to the participants, the avatar's mask-like properties of VR help the users feel more confident and less self-conscious in the virtual world: *"due to the avatars not being very "expressive" I am hiding my awkwardness, and this makes me feel more confident (P50)"*. One participant mentioned that the headset is uncomfortable and causes nausea: *"Having a VR headset on can make me a bit nauseous if I have it on for long periods. The headset is clamped kinda tight onto my head which can make nauseous (P186)"*. Twelve participants did not feel mentally exhausted in VR because they have more freedom compared to real life, while one participant responded that dancing in VR is mentally relaxing.

Regarding physical fatigue, a participant mentioned that dancing in VR for a longer periods is easier at home: *"Very easy to dance for long periods. Less inclined to try to match people and you're able to set up climate control at home (AC and fans, cold drinks) (P250)"*.

Responses indicate that VR is a new tool for people to express their love for dance as it allows the users to dance anywhere in the world: *"any music possible, club feeling even if there's a pandemic (P33)"*. They can be social with people around the world, get a sense of presence, be in a
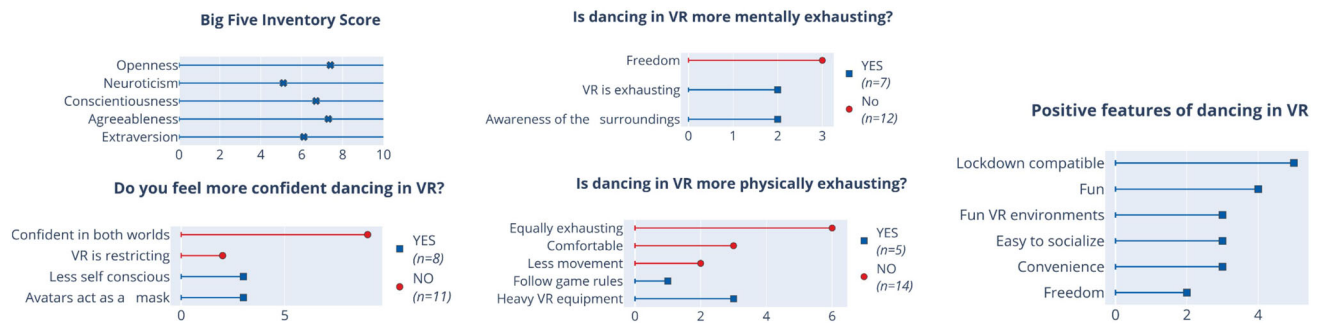
Fig. 5 Summary of Pandemic data: The figure shows the top themes extracted by OpenAI from the responses to some survey questionnaires regarding confidence, physical exhaustion, mental exhaustion, and positive features of using VR perceived by the participants in the Pandemic category. The horizontal axis represents the number of participants having similar responses

community, and be around people that share a similar taste in music: *"Sense of presence, community and being with people that like the same music as you. One of the best nightclub experiences have been this year in VR (P213)".*

4.2.5 Escape

The *Escape* group participants ($n = 17$) view dancing in VR as a platform to escape from the constraints of the real world (e.g., judgment, social anxiety, anonymity, etc.): *"As an autistic adult who is very uncomfortable around others, I've always wished for a way to start dancing, and VR gives that to me (P276)".* The participants prefer their avatars to be an identical version of themselves (5), a different person (4), a fictional character (3), or an ideal version of themselves (1). Figure 6 presents the questionnaire responses.

Fourteen participants have more confidence in VR because they can escape from their daily reality: *"I use VR as a tool to disassociate with my meat body as I suffer from chronic pain (P203)".* The body in VR is idealized and free from insecurities: *"I'm isolated in the headset. There may be family around, but I can't see them, and that helps me get past my self-consciousness. And as time passes, knowing that they're seeing me becomes less uncomfortable (P7)".*

The participants who are motivated to dance in order to escape reality like dancing in VR because they feel free from mental sabotage, freedom of self-expression, freedom to be immersed in music, being carefree and without judgment: *"Feeling free from mental sabotage, it doesn't exist for me in VR (P19)".* Some other reasons include convenience, being confident and dancing with friends: *"Can instantly leave and be safe at home (P193)".* One comment highlights the seriousness of social relations in VR: *"It is a form of self-expression and socializing. I have met great friends through dancing in VR, and have even started romantic relationships with people I have met while dancing in VR (P194)".*

4.2.6 Professional

Finally, the *Professional* group participants ($n = 11$) use the VR platform for learning dance, teaching dance, or giving dance performances in a professional capacity (e.g., virtual clubs and dance battles). In this group, the participants prefer their avatars to be a different person (5), a fictional character (3), an ideal version of themselves (1), or an identical version of themselves (1). Their responses to the questionnaire are presented in Fig. 7.

All participants of this category feel more confident when dancing in VR compared to the real world: *"The fact that I don't dance in IRL and only in VRC is pretty self-explanatory, but still I try, but when I learn more I would probably do more irl (P208)".* In addition, they claim being equally or less exhausted compared to the real world.

Dancing in VR can be a safe escape for people who enjoy dancing and share it with others: *"Easy to find a public group of people that love dancing (P242)".* VR can be a confidence booster or may also help people overcome stage fright: *"I love how people react to my performances, it's a huge confidence boost, and it's helped me get over my stage fright (P287)".*

4.3 Dislikes

All the participants agree that dancing in VR, using the current technology, has the following three limitations: 1. *Hardware limitations*: include the VR gear being heavy, costly, unreliable, and uncomfortable. Three participants indicated that the lack of haptics makes the experience less convincing. 2. *Technical limitations*: include bad Inverse Kinematics (IK) implementation, reduced bandwidths, limited game mechanics, less technical customization, poor quality avatars, and lag that leads to nausea. 3. *Social limitations* include other people in VR who do not have optimal behavior, more challenging to bring friends, and less accessibility to communities with similar interests.
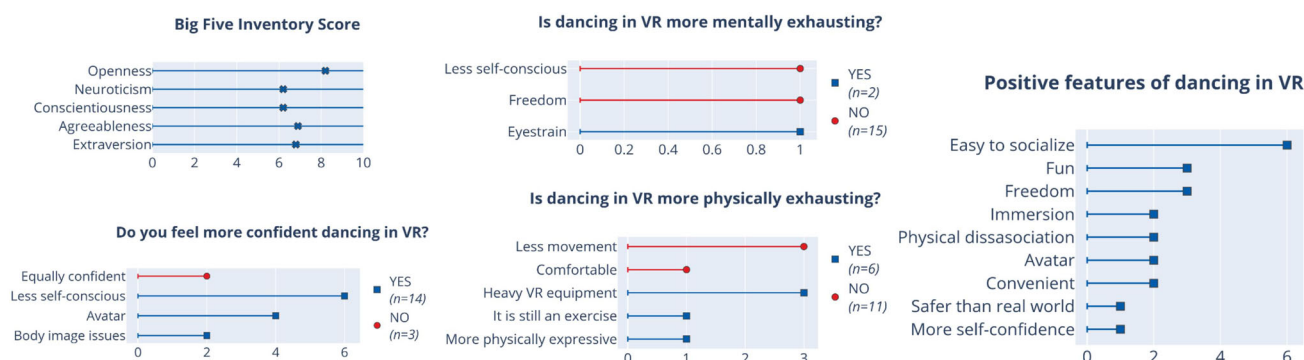
Fig. 6 Summary of Escape category data: The figure shows the top themes extracted by OpenAI from the responses to some survey questionnaires regarding confidence, physical exhaustion, mental exhaustion, and positive features of using VR perceived by the participants in the Escape category. The horizontal axis represents the number of participants having similar responses
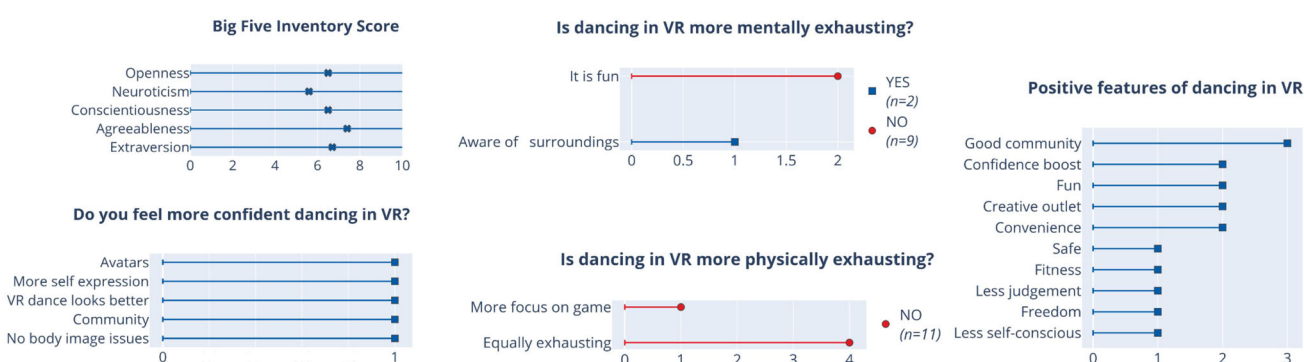

Fig. 7 Summary of Professional category data: The figure shows the top themes extracted by OpenAI from the responses to some survey questionnaires regarding confidence, physical exhaustion, mental exhaustion, and positive features of using VR perceived by the participants in the Professional category. The horizontal axis represents the number of participants having similar responses

4.4 Wanted features

Participants' recommendations for the future are closely related to the issues they have with the current systems, as explained in the previous section. Over 30% of the participants indicated that they prefer better tracking capabilities in VR. The participants would desire reliable, cheaper, and lighter VR hardware, and for a solution to the perspiration problem caused when wearing the headsets. In addition, participants indicated limited tracking space as one of their main concerns, and thus, they desire a better solution for the freedom of movement without fearing crashing into the surrounding objects. They also suggest that future VR systems must seamlessly include haptics, especially for experiences like dancing in a live concert.

In future, users expect to have more diverse social VR applications and games with better game mechanics and visualizations. Two participants show interest in dancing with partners as they would in the real world. Few participants indicated a need for more realistic dance applications that increase the presence and immersion of the users. In regard

to the avatars, participants desired to have more realistic and diverse models with varying design attributes. The participants also wish to have more robust customization features for their avatars. The access to community spaces in order to be in contact with like-minded people was another recommendation for the future.

4.5 Experience after dance

We have asked participants about how they feel after dancing in VR. Participants feel energized ($n = 164$), engaged ($n = 58$), inspired ($n = 31$), exhausted ($n = 16$), happy ($n = 5$), confused ($n = 4$), bored ($n = 2$), relaxed ($n = 2$), healthy ($n = 1$), and sad ($n = 1$). One participant felt sad after the experience because he could not perform to his best due to limitations in VR. One participant felt multiple emotions after the dance session. Another explained that his feelings were associated with the social situation rather than dancing itself: *"Dancing has little impact on how I feel after dancing. I am more likely to be tuned into social situations during and in between dancing sessions, and my feeling is more influenced*

by how those social situations develop (P194)". We asked participants if they would recommend dancing in VR to their friends and family. The responses from the participants are: Definitely yes (53%), Maybe (37%), and No (7%). Some participants could not choose one of these options.

5 Discussion

Previous research highlighted the benefits of dancing and the use of VR for improving both the user's physical and mental health. In that manner, we conducted an online survey to perform an in-depth investigation on (a) the motivations and (b) the experiences of users in using VR for dancing. Although we discovered a wide variety of motivations for dancing in VR, most users mainly use it for fun. Whereas social VR platforms are mainly used for social interactions [63], the primary motivation to dance in VR is not the professional orientation but mostly to have fun, fitness, or social activity (almost 84% of the participants voted for these three motivations). Interestingly, even though many users never (48%) dance in real life, they dance without any inhibitions in VR since they feel more confident, less exposed to criticism or mockery, and safer. Hence, even though users feel restricted from dancing due to physical, mental, or social factors in the real world, they could still dance in VR while reaping the many benefits of dancing for physical and mental well-being [46]. Dancing in VR also offers possibilities to change the appearance thanks to customizing various avatars. Controlling the avatar's movement makes the experience more fun, whatever the initial motivation is. In addition, similar to social VR [63], by being anonymous using avatars, users mainly experience a social closeness they cannot or do not want to experience in real life. Previous research also indicates that people are more comfortable expressing their emotions, personal information, and personal experience to strangers in social VR spaces compared to the real world [34]. However, participants also indicate that they cannot fully express themselves in VR due to hardware, tracking, and sensory limitations.

Many participants reported that they were equally or less exhausted in VR. Participants reported being distracted from physical fatigue and having fun immersed in VR as the reasons for their experience. In addition, previous research showed that regular exercise could reduce anxiety and improve body image perception [23]. Hence, with its capability to motivate users, dancing in VR could be a good alternative to conventional exercise for people who like home comfort, fear judgment from others in public spaces like gyms, and have body image issues. In the specific pandemic context, the survey results support the conclusions of previous research: VR is an efficient solution to escape the real world, relax, have fun, socialize and exercise, especially during the pandemic restrictions [57, 63]. With an uncertain future and prolonged social distancing being a possibility, dancing in VR could be a fun way to engage in some physical and social activity that is COVID-safe. Surprisingly, all the participants who dance in VR for professional purposes feel more confident in VR rather than in the real world. They prefer using VR to learn or teach dance because it is fun, and the community is more supportive. They also think of VR as their creative expression for their dance skills, while being in the presence of people with the same interests gives them a confidence boost.

The perceived gender gap in using VR platforms for dancing is more significant than in real-world dancing [35]. Since VR platforms are predominantly used for gaming, we speculate that this technology attracts more males than females. One of the reasons could be that females prefer using social media over gaming for fun and social activity [30]. With the increase in VR usage for social activity, there might be an increase in the number of females adopting VR for dancing.

Many participants indicated that they could not fully express themselves in VR due to the hardware, tracking, and sensory limitations. Regardless of the motivation, the results show that users have some expectations about the provided technological facilities, such as customizing the avatar or its control via the body tracking systems. Interestingly, 38% of the participants have full-body tracking; this shows the motivation and interest of the users to improve their immersion and realism in dancing, even though the equipment costs are high. Nevertheless, with the recent advances of deep learning in computer vision, a number of methods have been proposed to offer light and accurate tracking facilities using a single vision camera [56].

The primary goal of our research is to draw the big picture and sketch the profiles of potential users, helping both researchers and developers who are interested in further developing the technology, or creating content in VR. By studying their objectives and expectations, and based on their primary motivation, we concluded the following summarized observations:

Fun: Dancing in VR for fun has not reached its full potential yet. There are only a few venues for entertainment in VR. Participants expressed a need for better content, a safe community, and custom avatars. Having the flexibility to attend a live concert or event (hybrid) in VR could help better adoption of VR for dance in the future.

Fitness: Participants mentioned that immersion in VR, as well as other challenges in VR games, distract them from physical fatigue. A variety of engaging and gamified fitness routines in VR will attract more users to move toward VR for fitness. Also, adding information from existing fitness trackers like Fitbit into the headset view will increase user awareness, regarding their actual physical perfor-

mance. Heavy VR equipment and limited play space are still significant issues for using VR for fitness.

Social activity: Based on the results of this survey, and in conjunction with previous research on social VR, we understand that participants tend to trust and share more intimate details with strangers when being in VR. With the rapid increase in VR users, there could be many ethical issues. Making VR platforms for social activity a safe space should be a priority for both the developer and research community.

Pandemic: Pandemic, in general, has deprived people of social activities. Though most participants responded that they use dancing in VR for fun, they also expressed concerns about the difficulty of including friends and family in the VR worlds. One solution could be to create spaces that gather friends or families together, allowing them to perform some dance activities to compensate for the adverse effects of social distancing. Dance applications that could boost physical and mental health from our home comfort are especially relevant to the pandemic times.

Escape: Participants in this category, in general, expressed their desire for more creative content that will immerse them in the virtual worlds within the boundaries of their limited play space. This could be done only by developing better tracking solutions and engaging other senses (such as haptics).

Professional: Even though there has been a good amount of research on using VR for teaching, learning, or visualizing dance, our survey results show that these applications are not adopted well by the users. We can deduct two conclusions from this survey: users are not much interested in using VR for professional dancing, or the professional dance applications are not accessible. Participants expressed a need for more communities, applications, and creative platforms that target professional dance activities.

6 Limitations and future work

The demographics indicate that participants are not diverse. This could be due to the platforms (Reddit, Facebook, and Twitter) we chose to survey, which cater mainly to American and European users. Though UGT open questionnaire model gave participants the independence to freely express themselves, we ended up with many incomplete answers; in addition, some participants could not clearly articulate their answers. The accuracy and limitations of the GPT3 engine used in the OpenAI platform also apply to the data analysis here.[3] The sample size for different categories is

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3 https://beta.openai.com/docs/api-reference/classifications.

widely varied, which is a limitation for fair statistical comparisons. Nevertheless, the extensive data set used in this work ($n = 292$) mitigates the effect of low-quality responses and supports the derived conclusions from the survey.

Our times' increased use of social media platforms gives researchers the required access to data from many VR users around the world, enabling in-depth analysis. The conventional method of processing and analyzing data for small sample sizes do not apply to the masses. Hence, it is crucial to find efficient ways to analyze and extract large data sets using context-oriented deep learning techniques, such as OpenAI. Automatic data processing, such as machine learning, can retrieve interesting complex relations between variables that traditional heuristic-based methods could miss. However, further research is needed to understand the limitations of such "black box" approaches, especially in interpreting some of the results.

OpenAI's text-based models like GPT3 offer advantages for natural language processing tasks, but they also have disadvantages for text labeling. The lack of control can lead to biased or inaccurate labels, reflecting the biases present in the training data [62]. These models may struggle with contextual understanding, resulting in ambiguous or incorrect labels [50]. Their influential outputs raise ethical concerns about responsibility and unintended consequences [22]. These disadvantages are not unique to OpenAI models and efforts are being made to address them for improved fairness, transparency, and control.

7 Conclusion

In conclusion, our survey is based on the need to understand WHY and HOW people use virtual reality platforms for dancing, to help design user-centered future applications. We collected responses from a large set of users ($n = 292$), across a wide spectrum of population (varied gender, age, geographical location, and physical and mental disabilities), with different motivations and experiences. The quality of the VR dancing experience may vary depending on the specific VR setup, the game app being used, and the physical condition of the user. The preliminary analysis of the data showed that the user experience, usage of the system, and the user's expectations of future VR systems are based on their motivations and scope for using VR as a platform for dancing, i.e., fun, fitness, social activity, escape, pandemic, and professional. Our results summarize current users' experiences and future expectations that could be used as research and design guidelines for future VR dance applications. The results indicate that dancing in VR has great potential, helping users with mental and physical health issues, and may open many more avenues of research. They also indicate that dancing, in general, helps to improve confidence and reduce

personal insecurities; in particular, some participants use VR to escape from health issues, such as chronic pain and autism. The majority of the users, though, claim that dancing in VR is a purely fun activity that entertains them. Based on the outcome of this extensive survey, we can safely conclude that dancing in VR is an inclusive activity for improving physical and mental fitness.

Our results also support that the experience of dancing in VR is very different from the real world. The physical and psychological limitations that apply to dancing in the real world are irrelevant in VR. As the future VR hardware gets more sophisticated and the social VR community grows larger, it is imperative that we need to study its negative effects in real life. The target audience for most of the current VR companies is the young generation, being vulnerable to mental manipulations similar to current social media networks. It is therefore essential to research the ethical issues raised due to VR overuse, both physical and psychological. Therefore, even though most of our users' feedback on using VR and SocialVR is positive, it is essential to conduct in the future more detailed and long-term research on the negative behavioral implications of using these VR platforms.

Data availability The data sets generated during and/or analyzed during the current study are available in the following repository: https://team.inria.fr/mimetic/files/2022/03/Dancing-in-Virtual-Reality.zip.

Declarations

Conflict of interest The authors declare that there is no conflict of interest related to the publication of this paper.

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