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Hooked on the metaverse? Exploring the prevalence of addiction to virtual reality applications

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Similar to debates about other new media technologies in the past, with the popularization of virtual reality (VR) technologies, concerns are raised about their potential to breed media addiction. In response to these concerns, the aim of this research was to provide a first examination of the prevalence of addiction to VR application use. An online survey was conducted among frequent VR users (N = 754), and measures of the different components of addiction were obtained, as well as demographics, hours of weekly use, type of apps used, and feelings of spatial presence and embodiment during VR app use. The results indicate that between 2% and 20% of users reveal compulsive VR use, depending on the classification criteria used. These prevalence estimates are similar to those of other activities such as the use of (non-VR) video games or the use of social networking sites. Therefore, the results suggest that VR applications do not have a higher addictive potential than other more traditional technologies. However, feelings of embodiment when using VR positively predict addiction. This may suggest that future developments of VR technology could, perhaps, also increase its addictive potential compared to other technologies.

KEYWORDS

addiction, compulsive use, video games, social virtual reality, spatial presence, embodiment

1 Introduction

Recurrently, whenever a new media technology becomes popular in society, concerns arise about its possible negative consequences (Orben, 2020). Virtual reality (VR) is no exception. In parallel to the increasing penetration of VR, the debate about its hypothetical detrimental effects on users is beginning to gain momentum among academics, healthcare practitioners, and users (e.g., Huddleston, 2022; Kaimara et al., 2022; Noone, 2022). The expectation raised by the idea of the Metaverse as a future spatialized internet with a widespread presence in our lives (Ball, 2022) will probably contribute to accentuating this debate in the coming years.

Among the often presumed risks of VR use is its potential to offer compelling experiences that might turn VR use into a behavioral addiction (Madary and Metzinger, 2016; Kaimara et al., 2022). Some authors have speculated that immersive VR experiences

may provide intense psychological rewards (e.g., Sternlicht and Sternlicht, 2022) that could eventually lead to problematic compulsive use by users. However, to date (and to the best of our knowledge), the prevalence of addictive use of VR applications has not been empirically investigated. Therefore, current claims about this question are not based in empirical evidence. Moreover, although previous research with other media shows that psychological outcomes such as spatial presence (which play a central role in many VR experiences; e.g., Slater and Sánchez-Vives, 2016) may facilitate the development of addiction to other media (e.g., Park et al., 2009), their actual impact on the risk of developing addiction to VR applications has not been examined. This article aims at start filling this research gap and provide evidence for a better informed assessment of the actual risk of addiction to VR, that can also help guide future research on this question.

1.1 Online behavioral addictions

Since the 1990s, research has suggested the addictive potential of various online activities. The dominant view seems to be that certain online experiences, such as gaming, gambling, pornography use, online shopping, or the use of social networking sites, may trigger behavioral addictions in certain users (Griffiths et al., 2016). These behavioral addictions are characterized by symptoms such as excessive stimulus salience (i.e., recurrent thinking about the activity), mood modification (e.g., alleviating negative emotional states), tolerance (i.e., needing increasingly greater amounts of the activity), withdrawal symptoms (e.g., unpleasant feelings when the activity is discontinued), conflict (e.g., in interpersonal relationships), and relapse after discontinuation of the activity (Griffiths, 2005).

One online activity that is currently recognized by the Psychiatric Association (APA) and the World Health Organization (WHO) as a potential cause of addictive behavioral disorder is online gaming ("Internet gaming disorder"; APA, 2013; "Gaming disorder"; World Health Organization (WHO), 2018). Recent meta-analyses indicate that the prevalence of gaming disorder in the general population is in the range of 2–3% (Pan et al., 2020; Stevens et al., 2021; Kim et al., 2022).

The mechanism by which the use of online games can lead to addictive behaviors has been explained using the Hedonic Management model of addiction by Brown (1997) (e.g., Hussain et al., 2012; Lee et al., 2021). According to this model, activities that help achieve a positive hedonic tone may lead the individual to want to maintain this positive hedonic tone over time. This could distort the person's long-term goal-planning functions, which could eventually lead to addictive behavior. Other theoretical accounts stress the role of flow in online addictions (e.g., Chou and Ting, 2003). Flow is an intrinsically motivated experience involving states of intense and focused attention, enjoyment of the activity and a positive emotional tone, a distorted sense of time, and low self-consciousness (Nakamura and Csikszentmihalyi, 2014). Users (e.g. of video games) may feel motivated to repeat such positive experience over time, which may ultimately derive in addiction (Chou and Ting, 2003; Hull et al., 2013). The literature on the subject has analyzed various aspects of video games that can provide increasing such psychological rewards to users. These include, among others, a sense of mastery of the game (Ryan et al., 2006), escapism from real-life (Yee, 2006), or social rewards obtained in multiplayer games (e.g., social recognition from other players; King et al., 2010). As of today, the main activity for which VR devices are used by final users is to play games (Security.org Team, 2022). Games in VR can, in principle, provide the same type of psychological gratifications and flow experiences as those mentioned above, suggesting that they could also breed addiction among users.

On the other hand, other online activities can also offer intense psychological rewards, thus potentially breeding behavioral addiction. Typical examples are social networking sites (Kuss and Griffiths, 2017) or online pornography (Love et al., 2015). VR applications that allow for social networking among users (e.g., VRChat, Horizon Worlds) as well as VR sites for pornography consumption (e.g., VRPorn) could therefore foster more compulsive use among some users, too. However, the unique characteristics of VR might lead to a higher addictive potential of games and other online activities in VR, compared to similar activities carried out using more traditional technologies, as discussed below.

1.2 Spatial presence, embodiment, and the potential of VR applications to trigger addictive use

One of the factors that makes VR unique compared to other media technologies is its ability to provide users with a sense of presence, understood, in a broad sense, as the feeling of *being there* in the virtual environment (Skarbez et al., 2017). A influential conceptualization of presence was provided by Slater (2009). According to this view, presence has two components: place illusion (also called *spatial* presence; Wirth et al., 2007), which refers to the feeling of being physically located in the virtual environment, and plausibility illusion, which refers to the illusion that the represented events are actually happening (Slater, 2009; Slater and Sánchez-Vives, 2016). Previous research has addressed spatial presence much more than the plausibility illusion, and has provided evidence that it may facilitate addictive behaviors in other contexts (e.g., Park et al., 2009; Stavropoulos et al., 2019).

Feelings of spatial presence are fostered by the immersive features of VR systems, such as user-tracking, stereoscopic images, and a wide field of view (Cummings and Bailenson, 2016). Previous research suggests that feelings of spatial presence in VR are associated with stronger emotional arousal (e.g., Riva

et al., 2007; Elsey et al., 2019; Barreda-Ángeles et al., 2021) and users' enjoyment (e.g., Shafer et al., 2018; Barreda-Ángeles et al., 2020; Barreda-Ángeles and Hartmann, 2022). Thus, by inducing feelings of spatial presence, activities such as video games and other VR activities may be comparatively more rewarding for the user, which may contribute to their addictive potential. Indeed, previous research suggests that feelings of spatial presence may facilitate the development of addiction in the context of video games (e.g., Park et al., 2009; Stavropoulos et al., 2019). However, it is important to note that, although individuals can feel spatially presence when interacting with technologies like video or traditional video games, the immersive technical features of VR systems (Cummings and Bailenson, 2016) contribute to make feelings of spatial presence much stronger in VR, compared to less immersive media (e.g., Barreda-Ángeles et al., 2021; Lemmens et al., 2022). Therefore, spatial presence in VR could play a particularly relevant role in facilitating addictive behaviors.

In turn, the sense of embodiment (or *self-presence*) refers to the experience in VR that the user's avatar is his or her own physical body (Lee, 2004; Kilteni et al., 2012). In several VR applications, the user controls an avatar, which often represents the users' hands and head or upper body, responding to the user's movements in real time. This can enhance the sense of embodiment (Kilteni et al., 2012), and research suggests that embodiment favors intense emotional responses to media experiences (Gall et al., 2021). Thus, by increasing the emotional reward experienced by the user, feelings of embodiment may contribute to making VR applications addictive (at least, in the case where interactive avatars are available). Moreover, embodiment can facilitate identification of users with their avatar (Van Looy et al., 2012; Gonzalez-Franco et al., 2020), and, in online video games, this is a factor that can increase the risk of addiction (Mancini et al., 2019). This may be because, by interacting with others using an idealized avatar, users can escape a potential negative view of their physical body (e.g., physical unattractiveness) or self in real life (King et al., 2020).

Hence, there are several reasons that may fuel concerns about the addictive potential of VR applications, and, in this regard, there is also evidence, albeit limited, that some users perceive certain applications as potentially addictive (Merkx and Nawijn, 2021). However, despite this, the prevalence of problematic or addictive use of these apps has not yet been explored. Therefore, our first research question (RQ) is as follows:

RQ_1: What is the prevalence of addiction to VR applications?

Previous research shows that several factors, both individual, technology-related and contextual, are related to the addictive use of technology. Internet Gaming Disorder is more prevalent among male users, and among adolescents and young adults, and, not surprisingly, the number of hours spent gaming also appears to be a risk factor (Rho et al., 2018; Carlisle, 2021; Stevens et al., 2021). Structural aspects (e.g., the type of reward and punishment system in the game) and game genre have also been associated with an increased risk of addiction (Rehbein et al., 2021).

However, the incidence of these factors in the problematic use of VR applications has not been explored to date. In addition to aspects such as the gender and age of the user, the time of use, or the type of application used (which may involve different types of rewards), users' intensity of feeling spatially present and embodied might pose an unexplored additional factor. Given that, as mentioned above, spatial presence and embodiment seem to increase the psychological rewards that VR users obtain (Acena and Freeman, 2021; Freeman and Acena, 2021; Barreda-Ángeles and Hartmann, 2022), it could be associated with an increased risk of addiction. Thus, our second research question is as follows:

RQ_2: What is the relationship between user gender and age, time of use, type of application used, and feelings of spatial presence and embodiment, with addictive use of VR applications?

2 Methods

This research was a part of a larger online survey on other aspects of the impact of VR use on users. English-speaking participants were recruited *via* posts in VR-related Facebook groups and Reddit subreddits during the months of February and March 2022. To incentivize participation, participants who completed the survey could take part in a raffle of three $50.- Amazon gift cards.

2.1 Participants

A total of 1,164 participants took part in the survey. Incomplete or invalid responses (e.g., those failing to answer the attention check questions, or reporting an unrealistic age, for instance, older than 100 years) were removed, leaving a final sample of 754 VR users (aged between 18 and 86, $M = 30.12$; $SD = 9.89$; 82% male, 12% female, 6% other gender or no gender information provided). The majority of participants came from the United States (60%), followed by Canada (9%) and the United Kingdom (7%). The remaining participants came from a wide variety of countries spread across several continents.

2.2 Measurements

2.2.1 Addiction

An adapted version of the 7-item Game Addiction Scale (GAS-7; Lemmens et al., 2009) was used to measure addiction to VR applications. The items were modified to refer specifically to

the use of VR applications (e.g., *How often during the last 6 months have you felt bad when you were unable to use VR?*). Participants responded on a 5-point Likert-type scale, from 1 to 5. As in the original scale, labels (*Never*; *Rarely*; *Sometimes*; *Often*; *Very often*) were included for each step. The scale showed acceptable reliability (McDonald's $\omega_t = 0.78$).

2.2.2 Time spent using VR

Participants reported the days per week that they use VR (*On average, how many days per week do you use VR?*), and the hours per day on a typical day in which they use VR (*On a typical day in which you use VR, about how many hours do you spend using VR?*). The responses to these two items were multiplied to obtain an estimate of hours of use per week.

2.2.3 Type of VR application

Participants were asked to report, in an open-ended question, the VR application that they have used the most over the last 6 months. The responses were coded by two researchers. Each of them coded 60% of the sample (20% overlap, Krippendorff's $\alpha = 0.90$), and three main categories of applications emerged: VR games (64% of the responses), social VR platforms (29%), and other (7%).

2.2.4 Spatial presence and embodiment

We collected measures of spatial presence and embodiment using one item adapted from the SPES (*Usually, when I use VR, I feel like I am actually there in the virtual environment*; Hartmann et al., 2016) and one item adapted from the Avatar Embodiment questionnaire (*Usually, when I use VR, I feel as if my virtual body is my body*; Peck and Gonzalez-Franco, 2021), respectively. These measures were collected using a five-point Likert-type scale (from 0 - *I do not agree at all*; 4 - *I totally agree*). These variables were measured using only one item to keep the survey short and maximize chances that the participants complete it.

3 Results

3.1 Measurement model for addiction

To test our measurement model, a Confirmatory Factor Analysis (CFA), considering a single underlying factor, was carried out using the responses to the items of the GAS-7. The *lavaan* package (Rosseel, 2012) in *R* was used for this purpose. Since a Henze-Zirkler test showed that the multivariate normality assumption did not held in the data, the diagonally weighted least squares (DWLS) estimator was applied in the CFA (Bandalos, 2014). The results suggest that the model fits well the data, χ^2 (14) = 57.72, $p < .001$, CFI = 0.96, RMSEA = 0.06, SRMR = 0.10 (Hu and Bentler, 1999) (see Supplementary Materials for more details).

TABLE 1 Means, standard deviations, and Pearson zero-order correlations between the quantitative variables collected in the survey.

	M	*SD*	1	2	3
1 GAS-7 score	13.44	4.41			
2 Hours per week	13.37	12.34	0.49***		
3 Spatial presence	2.56	1.03	0.27***	0.15***	
4 Embodiment	1.71	1.22	0.32***	0.20***	0.54***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

3.2 Descriptive statistics

Table 1 provides the means, standard deviations, and Pearson zero-order correlations between the quantitative variables included in the survey: time spent using VR per week, the sum of scores in the GAS-7 questionnaire, and the feelings of spatial presence and embodiment when using VR. The table shows that these four variables were significantly correlated.

Participants spent, on average, 13.37 h per week using VR applications. The most used type of application were games (for 64% of the participants), followed by social VR platforms (29% of the participants) and other types of applications (7%). Figure 1 shows the average score per each of the individual symptoms included in the GAS-7.

3.3 Prevalence of addiction

Our RQ_1 inquired about the prevalence of addictive use of VR applications among users. To explore this question, we calculated an addiction score for each participant, following both the monothetic and the (regular and strict) polythetic classification schemes specified by Lemmens et al. (2009). In the monothetic format, to be considered addicted, a participant has to score at least 3 (*Sometimes*) in all seven items. In the polythetic format, a participant needs to score at least 3 (*Sometimes*) in at least four out of the seven items. In the polythetic strict format, participants are considered addicted if they score at least 4 (*Often*) in at least four out of the seven items.

Using the monothetic criterion, only 13 out of the 754 participants (i.e. 1.72% of the sample) scored above the threshold for addiction. When the polythetic and strict polythetic criteria were applied, 153 participants (20.29%) and 31 participants (4.11%), respectively, scored above the threshold.

3.4 Factors associated with addiction

Our second research question (RQ_2) inquired about the relationship between users' gender and age, time of use, type of application used, and feelings of presence and embodiment,

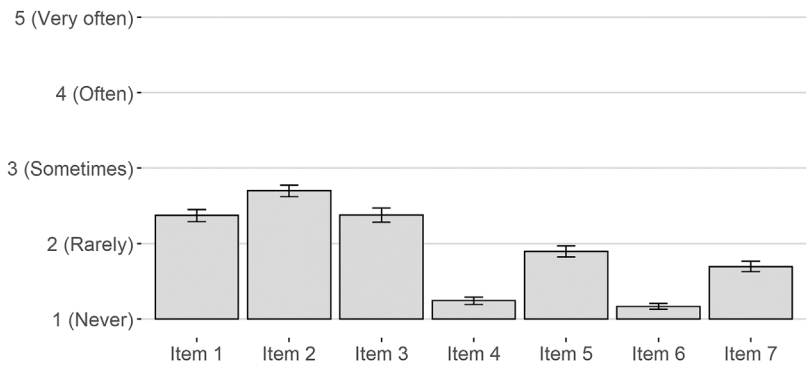

FIGURE 1
Means of the individual items in the GAS-7. Notes. The wording of the items (and the symptoms they refer to, in brackets) were as follows: Item 1—Did you think about using VR all day long? [Salience]; Item 2—Did you spend increasing amounts of time in VR? [Tolerance]; Item 3—Did you use VR to forget about real life? [Mood modification]; Item 4—Have others unsuccessfully tried to reduce your VR use? [Relapse]; Item 5—Have you felt bad when you were unable to use VR? [Withdrawal]; Item 6—Did you have fights with others (e.g., family, friends) over your time spent in VR? [Conflict]; Item 7—Have you neglected other important activities (e.g., school, work, sports) to use VRs? [Problems]. Error bars represent the 95% confidence interval.

TABLE 2 Summary of the binomial logistic regression models (log odds ratios).

	Model 1 (monothetic)	Model 2 (polythetic)	Model 3 (polythetic, strict)
Intercept	−6.30***	−2.42***	−4.23***
Age	−0.01	−0.03**	−0.07**
Gender: Female	1.03	0.18	0.21
Gender: Other	−15.24	0.34	0.00
Hours per week	0.05**	0.06***	0.05***
Application: Social VR	−3.04**	0.18	0.42
Application: Other	−1.93	−0.17	1.17
Spatial presence	−0.01	0.09	0.35
Embodiment	0.92**	0.44***	0.40*
Null deviance (df)	131.35 (753)	760.67 (753)	258.57 (753)
Residual deviance (df)	92.09 (745)	677.65 (745)	221.28 (745)
AIC	110.09	691.65	235.28

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

with addictive use of VR applications. To examine this question, we fitted a series of three binomial logistic regression models. In Model 1, the outcome variable was whether the participant scored above the addiction threshold or not according to the monothetic approach, whereas participants' age and gender, hours spent per week using VR, type of VR applications used, and feelings of spatial presence and embodiment were included as predictors. For gender and type of application, the most common values of the variables in our sample (male and VR games, respectively), were used as baseline values. Models 2 and 3 were similar to Model 1, but included as outcomes participants' addiction scores according to the polythetic and strict polythetic criteria, respectively.

The results (Table 2) show that hours per week spent using VR, and feelings of embodiment experienced are the only significant predictors across the three models. When the monothetic approach is considered (Model 1), using social VR applications (as compared to using VR games) as the preferred type of app is associated with a lower risk of addiction. However, when a polythetic approach is considered, the type of application is not significantly associated anymore with the risk of addiction. According with the polythetic models (Models 2 and 3), younger users are more likely to become addicted, but this association is not apparent in the monothetic model (Model 1). According to the guidelines provided by Chen, Cohen, and Chen (2010), the effect sizes (see Table 3) of age and of using social VR can be

TABLE 3 Odd rations (effect sizes) for the significant predictors in the three binomial logistic regression models.

	Model 1 (monothetic)	Model 2 (polythetic)	Model 3 (polythetic, strict)
Age	—	0.71	0.48
Hours per week	1.89	1.99	1.78
Application: Social VR	0.05	—	—
Embodiment	3.04	1.70	1.63

Notes: The values in the table represent the odd ratios (OR), as a measure of effect size (Ialongo, 2016), for each significant predictor in each model. They have been calculated based on standardized (z-score) predictors (Chen et al., 2010).

considered very small, whereas the effect sizes of time of use and embodiment fall in the small or small-to-medium range.

4 Discussion

4.1 Prevalence of addiction to VR applications

Our results show a large variability of prevalence of addiction to VR applications, depending on the classification scheme used: around 2% when a monothetic approach is used, and around 20% and 4% for the polythetic and strict polythetic approaches, respectively. These values are similar to (or lower than) those of studies on Internet Gaming Disorder. For example, a study by Hussain, Griffiths and Baguley (2012) among 1,420 gamers shows an addiction prevalence of between 3.6% for the monothetic approach, and 44.5% for the polythetic approach. Studies on other types of online addictive behavior, in particular social media addiction, also show great variability depending on the classification scheme used. A meta-analysis conducted by Chen and colleagues (Cheng et al., 2021) indicates that the prevalence of social media addiction is around 5%, 25%, or 13%, depending on whether a monothematic, polythetic, or strict polythetic approach is applied.

It has been previously stressed that the polythetic classification may lead to an overestimation of the prevalence of addiction (which can, in turn, have negative consequences both for research and policy-making) (e.g., Hussain et al., 2012), suggesting that more restrictive classification criteria may be more adequate. The values of prevalence obtained using the most restrictive criteria in our study (values of 2% and 4%) are very similar to those reported by existing meta-analyses on Internet gaming disorder (Pan et al., 2020; Stevens et al., 2021; Kim et al., 2022). This suggests that, contrary to the voices warning about an increased addictive potential of VR experiences (e.g., Madary and Metzinger, 2016), to date the share of users addicted to VR applications is comparable to those of other technologies (Cheng et al., 2021).

It is also relevant to note that, as shown in Figure 1, our participants presented, on average, higher scores for those symptoms that (according to some authors; e.g., Charlton and Danforth, 2007) have a more peripheral character in determining addiction (e.g., salience, tolerance, mood modification), while scores on more central symptoms of addiction (e.g., withdrawal, conflicts) were on average lower. High values on these peripheral symptoms may not be exclusive to addicted users, but may be common to users who have a high engagement with this technology, without necessarily resulting in addiction (Charlton and Danforth, 2007).

4.2 Predictors of addiction to VR applications

Time spent per week using VR and feelings of embodiment experienced while using VR emerged as two predictors of addictive VR usage in the present study. The first of these two factors is not surprising; time of use is a key predictor of addiction to online activities (e.g., Stevens et al., 2021). In contrast, the fact that feelings of embodiment may increase the risk of addiction to VR use appears more relevant, as embodiment represents a special affordance of VR applications. Although our results suggest that, at present, the prevalence of addiction to VR use is similar to that of Internet Gaming Disorder, it may be the case that further technological developments that intensify the feeling of embodiment will make VR more addictive in the future. Feelings of embodiment are determined by factors such as the appearance of the avatar, the system's response to user's actions, and the multisensory feedback that the VR device provides (Peck and Gonzalez-Franco, 2021). Recent technological advances may further enhance these aspects (e.g., photorealistic avatars, facial reactions integrated in the avatar, or haptic feedback; Oh et al., 2021; Jourabloo et al., 2022). Once these technological advances are incorporated in commonly used VR systems, they might not only increase users' embodiment experiences, but also increase the addictive potential of these experiences.

In our data gender was not a significant predictor of the prevalence of VR addiction. However, the number of women represented in our sample is much lower than that of men, which could perhaps explain these results. Future research on this topic should include a larger sample of women to overcome this limitation. Age was only a significant predictor of addiction in models based on a polythetic approach. This suggests that younger age increases the risk of some of the symptoms of

addiction (but not all of them at the same time). Finally, the use of social VR platforms as a preferred type of application appears to be associated with a lower risk of addiction compared to the use of video games, but only when a monothetic classification scheme is employed.

4.3 Limitations

As every study, our work was not free of limitations. First, the cross-sectional nature of our data does not allow us to demonstrate a causal relationship between addiction scores and the predictors considered. Therefore, the relationship between embodiment and risk of addiction should be interpreted with caution. Second, other factors that may predict addiction risk (e.g., cultural background; Stevens et al., 2021) were not included in our study. Our sample represents mainly participants from Western countries; research with more diverse samples is needed before we can extrapolate these results to users from other cultural backgrounds. Third, and relatedly, since the adoption of VR technology is still limited, it is possible that our sample contains mainly early-adopters, and might not provide an adequate representation of the population of VR users in the future (when VR may be extended to broader segments of the population). Thus, our results should be replicated and tested with larger samples in the future. Moreover, we also did not examine to what extent specific characteristics of the activities performed in VR may be predictors of addiction. Given that our dataset includes the specific applications used by the participants, future research could address this question, by classifying these applications according to their technical characteristics of interest. Finally, it is important to keep in mind that VR technology is only recently becoming commonplace for many users and that the supply of VR applications is currently evolving rapidly. It is possible that the reality reflected by our results could change in the short term, if applications with other functionalities not yet available become popular.

5 Conclusion

This is, to our knowledge, the first study to analyze the prevalence of addictive use of VR applications. Our results suggest that the addictive potential of VR apps, in their current state, is hardly different from that of other online activities based on more traditional media, such as video games or the use of social networking sites. However, the fact that feelings of embodiment are a predictor of addictive VR use suggests that future applications employing more immersive technologies might prove more addictive for users. Thus, as new immersive technologies develop and become popular, it will also be necessary to examine the extent to which they may contribute to compulsive use, and what measures (both in terms of design and in encouraging responsible use) will need to be implemented to ensure an optimal user experience.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: Open Science Framework (https://osf.io/u2pb3/).

Ethics statement

The studies involving human participants were reviewed and approved following the self-check procedure by the Research Ethics Review—Faculty of Social Sciences, VU Amsterdam. The participants provided their written informed consent to participate in this study.

Author contributions

MB-A and TH contributed to the ideation of this article and the conceptualization and development of the methodology. MB-A implemented the survey and was responsible for the data curation and analysis, and for writing the original draft. TH supervised the formal analysis and reviewed and edited the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frvir.2022.1031697/full#supplementary-material

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