Virtual Reality (2024) 28:20
https://doi.org/10.1007/s10055-023-00925-6

ORIGINAL ARTICLE

Not just a game: the effect of active versus passive virtual reality experiences on anxiety and sadness

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Received: 19 February 2023 / Accepted: 7 December 2023 / Published online: 16 January 2024
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Abstract
The use of virtual reality (VR) technology is becoming more common and can be harnessed as a tool to improve various emotional and psychological aspects. The present research explored whether different kinds of VR experience (i.e., active versus passive) would differently affect people's mood, anxiety and sadness. Undergraduate students ($n = 133$) were randomly assigned to three study conditions: active game VR experience, passive VR experience and control 2D passive viewing and filled out a battery of questionnaires before and after manipulation. The results show that following both VR exposures (but not following the control condition), participants' moods improved, and the degree of anxiety was reduced. The degree of sadness was reduced only following the active game VR experience. Regarding self-efficacy, it was higher in the passive VR experience but lower following the active game VR experience (and not affected by the control condition). In conclusion, the results indicate that short VR experiences could provide a suitable alternative for the lack of accessible treatments to improve mood and to alleviate levels of anxiety and sadness, although further research is needed to tailor and refine the exact VR experience that would best improve each specific psychological aspect.

Keywords Virtual reality · Anxiety · Depression · Self-efficacy · Active VR experience · Passive VR experience

1 Introduction

Modern life consists of an intense life pace and mounting working hours, both taking their toll by the continuous increase of physical and mental stress symptoms (Lee et al. 2017). The combination of the constant needs to achieve goals, an everlasting race against time, and a sedentary lifestyle has become a real threat to people's physical health and well-being (Müller et al. 2018), as well as to their levels of self-efficacy (Wiencierz and Williams 2017). Indeed, the prevalence of anxiety and depression disorders has increased during the recent decades, and became a truly distressing issue (Brody et al. 2018; Hasin et al. 2018). One of the main symptoms in depression is feeling sadness. While some percentage of the people who suffer from anxiety or depression-like symptoms are treated by either psychological (Li et al. 2018) or medical (Prado et al. 2018) means, many people remained untreated, due to various reasons; First, people who suffer from depression-like symptoms often lack the motivation to seek help, or to engage in any activity, let alone one that demands them to leave their home (Givens and Tjia 2002; Moir et al. 2018; Achttien et al. 2019). Second, even once people do seek help, the traditional treatments are not suitable for everyone (Munkholm et al. 2020). Last, due to the consistent growing demand which overloads the health care systems, those systems are unable to provide immediate help for every patient in need, and many patients are left without a solution. With the outbreak of COVID-19, this already existing problem of untreated patients was significantly escalated, as both the number of people who suffer from anxiety and depression and the burden on the health care system skyrocketed (Shah et al. 2021; Vahratian et al. 2021; Ettman et al. 2022). Thus, the necessity to find new alternative treatments, that might provide an attractive solution for some of these untreated patients, became crucial. We suggest that innovative VR technology could be a

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convenient and applicable tool that can offer a solution for this stressful issue.

Innovative VR technology provides its users with an immediate shift from their current surroundings to an alternative virtual and immersive arena. In this alternative reality, people can experience and interact with objects and situations, among a multi-dimensional virtual space which they experience and control via headsets and joystick controllers. The synch between user's eyes and body movements to the events in the virtual arena, with the edition of compatible sound effects, enables a live and powerful experience of active interaction within the virtual situation and an illusion of actual presence in the occurring events (Miloff et al. 2019). As this technology keeps evolving, it becomes more common, affordable and accessible (Hartl and Berger 2017; Dyer et al. 2018; Bradley and Newbutt 2018).

The increasing availability, high mobility and immediate impact of VR technology enable to adapt it as an efficient tool for creating initiated refreshment breaks during a stressful day or to encourage people to engage in short physical activity (PA) sessions, without the necessity to leave their room. Indeed, recent findings have shown that VR technology-based treatments among the general population were positively correlated with good mood, positive affect and increased engagement (Yeo et al. 2020; Mazgelytė et al. 2021; Kalantari et al. 2022), while negatively correlated with negative affect (Chan et al. 2021). Similar pattern of results was found among clinical populations as well. For example, it was found that VR technology-based treatment led to improvement in measurements of mood and well-being (Habak et al. 2020), as well as measurements of mood, positive emotions, self-efficacy, and motivation (Herrero et al. 2014).

The beneficial effects of VR technology-based treatments can be explained by two mechanisms. The first explanation derives from the immediate severance from one's current reality, and the abrupt shift to an alternative immersive reality, which VR technology offers. This technology is distinguished from other medias by its ability to produce an immersive experience, characterized by a powerful sense of presence in the situation, a feature that disconnects its users from their current surroundings and reality at once (Riva et al. 2015; Lindner 2021). That way, VR provides a unique gateway to "escape" one's demanding reality and commitments (Hartl and Berger 2017; Van Kerrebroeck et al. 2017) and an instant disruption of their current mental state. At the same time, it provides them with alternative reality, which is immersive, rich and exciting. Because this media has such an immediate and powerful impact, even a brief VR experience which lasts for only a few minutes could have a significant effect on the user and could enable a genuine shift of their state of mind (Furman et al. 2009; Gerber et al. 2017; Lindner 2021). For example, recent research has indicated that a short VR exposure immediately decreased levels of anxiety within anxious dental patients (Lahti et al. 2020), successively distracted anxious children during blood-draw (Özalp Gerçeker et al. 2020) and even alleviated pain among people who endures chronic pain, by distracting them from the painful stimuli (Pourmand et al. 2018). Thus, VR experiences are a potent tool, which has the power to alter negative emotions and to diminish fatigue within a period of few minutes.

VR technology-based treatments vary in the type of environment they expose to, and the amount of engagement and activity they require from the user. Previous studies show that exposing VR users to natural environment (e.g., forest, ocean) yields better psychological outcomes and decreases the level of negative emotions compared to exposure to an urban environment (Yu et al. 2018; Mostajeran et al. 2021). Furthermore, VR technology-based treatments can either be applied in a passive setting, where the user merely watches the virtual scenery or in an active setting where the user interacts with the virtual surroundings. Several studies demonstrated that while both passive and active VR treatments were beneficial in providing distraction from painful situation and reduce anxiety levels, active VR had greater impact (Xiang et al. 2021; Saquib et al. 2022; Ferraz-Torres et al. 2022). However, a recent clinical study comparing interactive VR to passive VR (watching nature pictures) found that while users of the active VR reported higher enjoyment from the treatment, both types of VR were similarly helpfully in distraction from pain (Patterson et al. 2022). Furthermore, active VR technologies may require practice, as thus at first it can cause a negative effect (Weerdmeester et al. 2021).

While most of the research indicates that VR technology-based treatments may be beneficial for mood disorders, there is ongoing debate about the effectiveness of the various types of VR. Additionally, there is a lack in research that distinguish between methods that may help anxiety vs. depression-like symptoms. Thus, the current research aims to explore whether different kinds of short VR experiences, specifically passive vs. active VR, could alleviate levels of anxiety and depression-like symptoms and modify mood and self-efficacy levels in the general population, compared to a control group.

2 Materials and methods

2.1 Participants

In order to determine the required number of subjects, an a-priori power analysis test was calculated using G*power software (Faul et al. 2009) following these parameters: A conservative effect size (effect size $f = 0.15$ which equals Cohen's $d = 0.3$), an alpha error of $\alpha = 0.05$ and a correlation of 0.6 among repeated measures. The minimum total sample size required to produce an effect with 80% power was calculated as $N = 90$. This is in accordance with past studies with similar conditions (Browning et al. 2020; Yeo et al. 2020). Our initial sample included 143 healthy participants, all Israeli undergraduate students at the Open University of Israel, taking part in the study for course credit, with ages ranging from 19 to 58. Four participants were not native Hebrew speakers, three participants were uncomfortable with the equipment, and three additional participants were familiar with our VR experience. Thus, the data of all these participants were excluded from the analyses, and the final sample consisted of 133 participants (67.7% females, *M*age = 29.98, *SD*age = 9.31). Participants were randomly assigned to one of three experimental conditions: active game VR condition ($N = 44$), passive VR condition ($N = 43$) and 2D passive viewing (YouTube) condition ($N = 46$).

2.2 Materials and procedure

The study was conducted in two phases, completed by each participant individually on the same day. The participants were undergraduate students at the university, who took part for a few hours in various psychology research as part of their studies. The first study phase took place upon their arrival and was the first study they attended that day. Each participant was approached by an experimenter who instructed them to complete a battery of self-reporting questionnaires via "Qualtrics" software. This battery consisted of the following four questionnaires: mood, anxiety, depression and self-efficacy. After completing this battery, participants proceeded with their laboratory experience by taking part in different and unrelated studies at the laboratory for approximately two hours. Then, participants proceeded to the second phase which was introduced to them by a different experimenter and presented as a new study, entirely unrelated to the previous part. Participants were randomly assigned to one of three study conditions. They experienced either an active game VR experience, using an "Oculus quest" device; a passive relaxation VR experience (using the same device); or watched a 2D passive viewing relaxation video. Each activity lasted 8.5 min. After completing this activity, participants repeated the same battery of self-reporting questionnaires as in first phase, in addition to a short demographic survey and a few questions regarding their previous VR experience and the research goals. Participants were thanked and debriefed at the end of their laboratory participation duty.

2.3 Mood

This variable was measured by a visual mood scale which presented five drawings of faces expressing emotions on a range from sad to happy (based on Reynolds-Keefer (2009)). Participants were asked to choose the drawing that reflected their current mood in the best way. Each choice was coded to a single mood score on a range from 1 (the sad face) to 5 (the happy face); hence, higher scores represented a more positive mood.

2.4 Anxiety

We used the generalized anxiety disorder (GAD7; (Spitzer et al. 2006)), a self-reporting questionnaire consisting of seven items (e.g., "feeling nervous, anxious or on edge"). Participants were asked to rate the degree of their agreement or disagreement with each item based on their feelings in the previous two weeks. Responses were recorded on a four-point Likert scale, ranging from 0 (not at all) to 3 (almost every day), with higher scores representing a higher anxiety degree. Responses were averaged to create a composite anxiety score. (Cronbach's α of the first and second measurements was 0.86 and 0.88, respectively.)

2.5 Sadness

We used the Patient Health Questionnaire (PHQ9; (Kroenke and Spitzer 2002)), a self-reporting questionnaire consisting of nine items (e.g., "little interest or pleasure in doing things") to measure various depression-like symptoms such as sadness, anodynia, troubles in concentration and self-confidence.

Participants were asked to rate the degree of their agreement or disagreement with each item based on their feelings in the previous two weeks. Responses were recorded on a four-point Likert scale, ranging from 0 (not at all) to 3 (almost every day responses were averaged to create a composite sadness score. (Cronbach's α of the first and second measurements was 0.79 and 0.80, respectively.)

2.6 Self-efficacy

We used the Generalized Self-Efficacy Scale (GSES; (Chen et al. 2001)), a self-reporting questionnaire consisting of eight items (e.g., "I can succeed in every task when I am determined"). Participants were asked to rate the degree of their agreement or disagreement with each item based on how they know themselves generally. Responses were recorded on a five-point Likert scale, ranging from 1 (hardly agree) to 5 (entirely agree), with higher scores representing a higher self-efficacy score. Responses were averaged to create a composite self-efficacy degree. (Cronbach's α of the first and second measurements was 0.96 and 0.97, respectively.)

2.7 Manipulation

In the active game VR condition, participants experienced three rounds of the Beat-Cyber demo VR experience, using both the Oculus headset and the joystick controllers. During that game, obstacles came flying at participants which they had to avoid and hit before they were hit by them. These obstacles included blue and red cubes and included arrow marks pointing in various directions. Participants had to slice each cube following the corresponding direction of the arrow with a matching color sword, using both joystick controllers, each serving as either a blue or a red sword. Additionally, participants were approached by walls which they had to avoid by ducking or moving slightly aside with their whole body. The game also included rhythmic music (for illustration, see Beat-Cyber: https://www.youtube.com/watch?v=BUXPOqt4O2E).

At the end of each round, participants were exposed to their own score as well as to a table of the top ten scores of previous players. Participants in the current study were never included in these top scores, as they had little experience with the game and high scores necessitate training: the ten top scores were attained by more experienced players who had used this device prior to our study. In the *passive relaxation VR condition*, participants used only the headset device. Participants sat on a chair and were located in a specific spot in a snowy environment of the *Nature Treks* experience. Participants were surrounded by trees, flowers, and various animals in a snowy wood, listening to the sounds of nature, alongside soothing music in the background (for illustration, see: Nature-Treks-Snow: https://www.greenergames.net/nature-treks). Participants could move on their chairs to look around but could not move the chair or make any changes to their surroundings. In the *2D passive viewing condition,* participants sat on a chair in the middle of a dark room and watched a video scene of a snowy wood, pond, and a few animals on a big television screen hung on the wall in front of them. The video included sounds of nature, alongside soothing background music (for illustration, see https://www.youtube.com/watch?v=nHSawp_TyoE&t=39s).

2.8 Statistics

Repeated measures analysis or mixed model (for variables with missing values) of variance (ANOVA) was used for comparing the within and between groups difference, followed by an LSD post hoc test when applicable. Significance was considered at $p < 0.05$, two-tailed. Outliers were excluded using the ROUT method, with Q = 1%, according to the convention (Motulsky and Brown 2006). All statistical analyses were executed via GraphPad Prism 8 software.

3 Results

3.1 Effect of VR manipulation on mood

A 2 (before and after measurements) X 3 (study conditions: VR active game versus passive VR versus 2D passive viewing) mixed design ANOVA on the mean mood scores yielded a significant interaction between time of measurement and study condition [F (2, 126) = 7.011, $p = 0.0013$, $\eta^2 p = 0.171$]. To probe the interaction, we used an LSD post hoc analysis; in the active game VR condition, the analysis revealed that the mean mood score of the first measurement was significantly lower than the mean mood score of the second measurement ($p = 0.0013$).

In the passive VR condition, the analysis revealed that the mean mood score of the first measurement was significantly lower than the mean mood score of the second measurement ($p = 0.0006$), indicating a positive effect in both VR conditions. However, in the 2D passive viewing condition, the mean mood score of the first measurement was not significantly different from the mean mood score of the second measurement. Moreover, while there was no difference between the conditions in the mean mood score in the first measurement, in the second measurement both the passive VR and active VR conditions were significantly different compared to the 2D passive viewing condition ($p = 0.0002$ and $p = 0.0007$, respectively) (Fig. 1). Overall, the results indicate that both VR conditions enhanced the participants' mood to more positive, whereas the 2D passive viewing condition had no significant influence on the participants' mood.

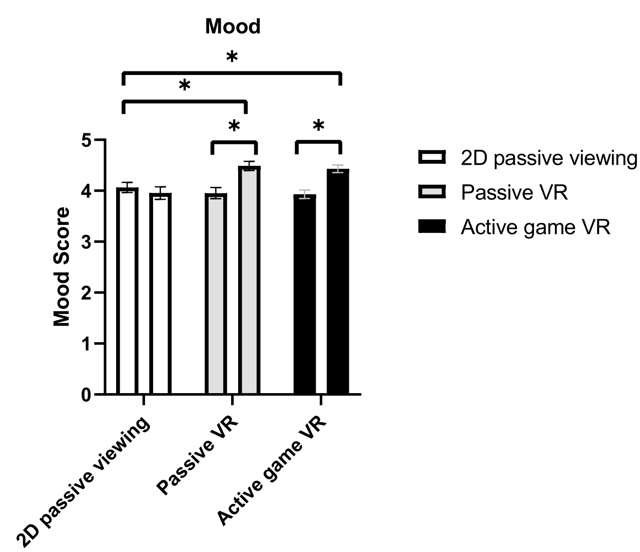

Fig. 1 Mean mood scores as a function of time of measurement and the study condition. Higher scores represent a more positive mood. Data represented as mean +/− SEM, *indicates $p < 0.05$

3.2 Effect of VR manipulation on anxiety and depression-like symptoms

A 2 (before and after measurements) X 3 (study conditions) mixed design analysis of variance (ANOVA) yielded a significant effect of time of measurement [F (1, 123) = 9.771; $p = 0.0022$, $\eta^2 p = 0.074$]. The mean score of the anxiety score was lower on the second measurement compared to the first measurement (Fig. 2A). An LSD post hoc analysis revealed that, as expected, in the active game VR condition the anxiety score of the first measurement (before) was significantly higher than the anxiety score of the second measurement (after) ($p = 0.0378$). Surprisingly, although the active game VR condition has an added value of PA, there was no difference between the active game VR condition and the passive VR condition. Similar to the active game VR condition, in the passive VR condition, the anxiety score of the first measurement (before) was significantly higher than the anxiety score of the second measurement ($p = 0.0462$, respectively). In the 2D passive viewing condition, the mean anxiety score of the first measurement was not significantly different from the mean anxiety score of the second measurement.

Interestingly, when examining the sadness score, there was a marked difference between the two VR conditions. A repeated design analysis of variance (ANOVA) yielded a significant effect of time of measurement [F (1, 130) = 6.418, $p = 0.0125$, $\eta^2 p = 0.047$], with only the active game VR condition inducing a positive effect with the first measurement significantly higher than the second measurement ($p = 0.0169$) (Fig. 2B). There was no significant difference in the sadness scores between the first and the second measurements in the 2D passive viewing condition. This outcome provides support to our notion that PA is a significant factor that could contribute to alleviating people's level of sadness or depression-like symptoms. We would discuss the possible implications of this result in the discussion section.

3.3 Effect of VR manipulation on self-efficacy

Lastly, we examined the improvement in self-efficacy after the exposure to the different types of manipulations. A 2 (before and after measurements) X 3 (study conditions) mixed design analysis of variance (ANOVA) on self-efficacy means scores yielded a significant interaction between the time of measurement and study condition [F (2, 123) = 9.176, $p = 0.0002$, $\eta^2 p = 0.112$]. To probe the interaction, we used the LSD post hoc analysis. In the passive VR condition, the analysis revealed that the mean self-efficacy score of the second measurement was significantly higher than the mean self-efficacy score of the first measurement ($p = 0.0006$), indicating an improvement in subject self-efficacy after the exposure. In the active game VR condition, however, the analysis revealed a surprising outcome, as a significant decrease in self-efficacy emerged following our manipulation ($p = 0.0226$). Moreover, while there was no difference between the conditions in the mean self-efficacy score in the first measurement, in the second measurement both passive VR and 2D passive viewing conditions were significantly different compared to the active game VR condition ($p = 0.0001$ and $p = 0.0009$, respectively). As before, in the 2D passive viewing condition, the mean self-efficacy score was not significantly different in the two measurements (Fig. 3).

These results show that both VR conditions affected self-efficacy. The results of the passive VR condition are in line with the known literature, as self-efficacy is usually found as positively correlated with variables such as positive mood and affect. The results obtained in the active game

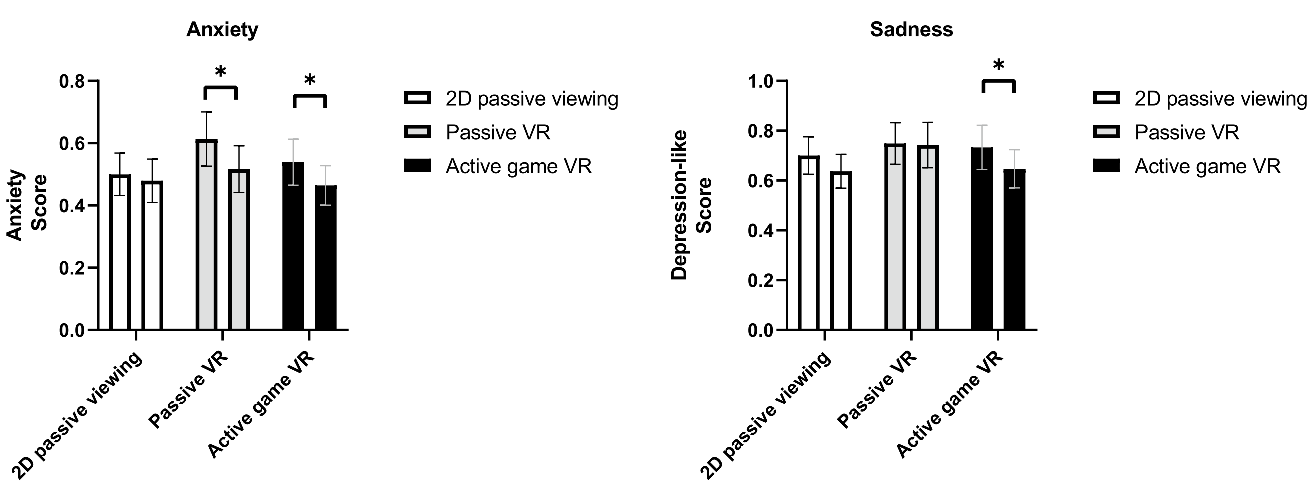

Fig. 2 Mean anxiety (**a**) and sadness (**b**) scores as a function of time of measurement and the study condition. Lower scores represent a more positive affect. Data represented as mean +/− SEM, *indicates $p < 0.05$

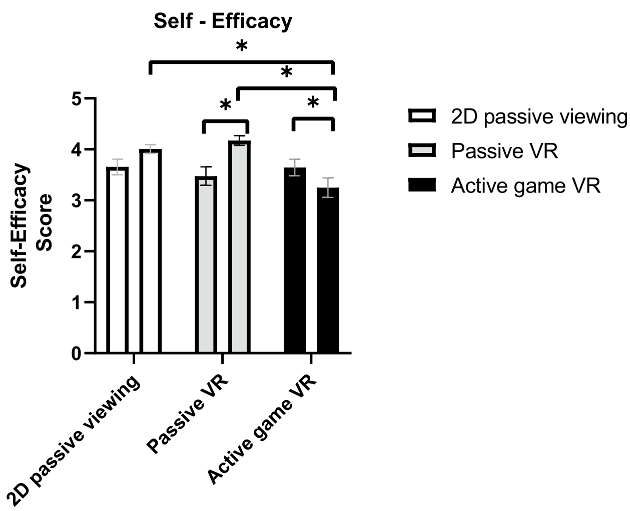

Fig. 3 Mean self-efficacy scores as a function of time of measurement and the study condition. A higher score represents a higher degree of self-efficacy. Data represented as mean + / − SEM, *indicates $p < 0.05$

VR condition, however, contradicted our prediction that the VR manipulation would improve all psychological variables. Furthermore, it seems that the difference in the second measurement between the 2D passive viewing condition and the active game VR condition is not due to a positive effect of the 2D passive viewing but rather to the negative effect of the active game VR condition. We will further discuss this surprising outcome in the discussion section.

3.4 Correlation between dependent variables

Table 1 displays means and standard deviations of all variables measured in this study, both before and after the manipulation as well the correlations between them.

Overall, these results show that VR-based experiences, either passive or active, were found as efficient tool to improve participants' mood, self-efficacy, anxiety and sadness (as opposed to the non-effective 2D passive viewing). Specific patterns of results regarding self-efficacy and sadness would be discussed in the following sections.

4 Discussion

The aim of the current study was to examine the potential of various kinds of short-term VR activities to become an effective and attractive substitute to existing "classic" treatments that induce relaxation and improve affect, among the general population.

While some studies have shown that different types of VR exposures have different psychological effects (Xiang et al. 2021; Saquib et al. 2022; Ferraz-Torres et al. 2022), in our study there was a significant improvement in the mood scores and a reduction in the levels of anxiety of the participants following both passive and active VR experiences, but not following the control 2D passive viewing (i.e., watching a short 2D relaxation nature movie). This is in agreement with a recent clinical study comparing interactive VR to passive VR (watching nature pictures), which found that while users of the active VR reported higher enjoyment from the treatment, both types of VR were similarly helpfully in distraction from pain (Patterson et al. 2022).

In regard to sadness and depression-like symptoms, only the active game VR experience had a significant effect. Our finding regarding the effect of an active game VR experience on the magnitude of depression-like symptoms could be linked to previous findings that examined the effect of physical activity on depression (Daley 2008; Eyre and Baune 2012; Cooney et al. 2013)). For example, North et al. (2008) indicate that different modes of exercise were effective antidepressants among a diverse and heterogeneous population, as it significantly decreased depression, and the antidepressant effect continued through follow-up measures. Moreover, in their research, subjects requiring medical or psychological care demonstrated the largest depression decreases. As our research was conducted among the general population, it is critical to replicate the current research among participants

Table 1 Means, standard deviations and correlations between both measurements of all dependent variables

Measurements (M, SD)	Mood1 (3.98, 0.65)	Anxiety1 (0.55, 0.50)	Sadness (0.73, 0.54)	Self-efficacy 1 (3.59, 1.09)
Mood 2 (4.29, 0.69)	0.414**	−0.132	−0.135	−0.004
Anxiety 2 (0.48, 0.45)	−0.301**	0.875**	0.650**	0.065
Sadness 2 (0.67, 0.52)	−0.340**	0.695**	0.902**	−0.065
Self-efficacy 2 (3.97, .097)	1	0.057	−0.037	314**

[#]1 stands for the first measurement of the variable, and #2 stands for the second measurement

Mood and self-efficacy were measured on a scale of 1–5, in which a higher score represents a better mood and improved self-efficacy. On the contrary, anxiety and sadness were measured on a scale of 1–4 in depression-like symptoms (sadness) with a higher score representing a higher level of anxiety or depression, respectively

** $p < 0.01$

with medical diagnoses of depression and examine whether these results would be replicated.

A possible explanation for the reasons why short active VR experiences improve a variety of psychological measurements, including mood, anxiety, and sadness, concerns the engagement in PA. A robust finding indicates that PA is positively correlated with measurements of optimism, happiness, life satisfaction and well-being (Pavey et al. 2015; McMahon et al. 2017; Kim et al. 2017; Wiese et al. 2018), associated with improved physical self-efficacy (Liu and Dai 2017; Cornelius et al. 2020) and could reduce symptoms of anxiety (McMahon et al. 2017; McDowell et al. 2019) and depression (Cooney et al. 2013; McMahon et al. 2017; McDowell et al. 2018; Dale et al. 2019; Kandola et al. 2019; Jemni et al. 2023). However, PA is strenuous and demanding, and modern lifestyle limits people's willingness, time and accessibility to engage in a significant PA routine.

Thus, for people who usually avoid PA, the impact of engaging in 8.5 min of enjoyable PA could indeed be significantly more effective than to people who are regularly active. We suggest that the use of advanced VR technologies could bridge between the necessity to engage in PA and the lack of time, motivation, or available physical conditions to do so. This assumption could be further tested in a future study that will involve a similar design in addition to inquiries about participants' regular PA routine. If participants that report higher levels of sadness or depression-like symptoms would also report less engagement in PA, it would provide support to this assumption, indicating that lack of engagement in PA is the key factor that need to be attended among depressive individuals.

A surprising outcome was obtained regarding levels of self-efficacy. We expected that self-efficacy would be affected positively by both VR-based experiences, as self-efficacy is generally associated with positive affect and well-being (Gull 2016; Martínez-Martí and Ruch 2017), as well as with PA (Li et al. 2022) and self-engagement (Vidić 2021). Unexpectedly, we found that self-efficacy scores were significantly higher after the passive VR manipulation but significantly lower after active game VR manipulation. In the 2D passive condition, there was no change. These surprising results might be explained by the unique condition of the active game VR experience. During the experience, in addition to enjoyable participation, subjects were also exposed to a chart of best previous scores at the end of each round of game. As our participants only had the opportunity to play three rounds of the game (which last 8.5 min, to match the other two study conditions), their achievements were rated significantly lower compared to previous online experienced participants. As a result, the active game VR condition included an experience of failure for most participants. According to Bandura (Bandura 1977, 2012), the most significant predictor for self-efficacy degree is previous performance in similar tasks. Namely, a previous success or failure in related tasks has a major effect on one's future self-efficacy level, a finding that was replicated in various studies (Smith et al. 2006; Hardy 2014). Hence, although unintentionally, our manipulation involved a failure experience to participants in the active game VR condition, which overshadowed the benefits that enjoyable PA or engagement might contribute to participant's levels of self-efficacy. In fact, our findings coincide with the results of Weerdmeester et al. (2021), which reported that participants that played a virtual reality biofeedback video game had a lower self-efficacy score on the first session, and an increase over time. Weerdmeester and his colleagues explained their results by arguing that self-efficacy is dependent on previous experienced of failures and successes. In order to further examine how VR-based experiences influence levels of self-efficacy, we suggest examining this influence by using an active VR condition that would include a sense of success instead of failure. Alternatively, this condition could include an active VR experience, with no sense of achievement or failure at all (i.e., no scoring during the activity). Such condition would help to further explore if VR-based experiences that do not include a sense of a failure could be efficient tool to enhance people's levels of self-efficacy.

4.1 Limitations and future research

Our results provide further support for earlier findings regarding the possible influence of VR experiences as an efficient tool to improve various components of affect (Yeo et al. 2020; Mazgelytė et al. 2021). Additionally, our results provide a novel and initial finding regarding the effect that VR experiences might have on levels of self-efficacy. Yet, a few possible methodological limitations should be taken into account. First, our research was conducted on a sample of undergraduate psychology students in Israel. Although samples of students are extremely common in Psychology research, they might not be a representative-enough sample of the global population, as students tend to share some homogeneous features as age range and phase in life. Hence, future research might benefit by replicating a similar design over a more general and diverse sample of the population. It should also be noted that results obtained for healthy participants should, of course, be validated in clinical settings. Thus, based on our initial results regarding the positive influence of the active game VR experience on depression-like symptoms, future research might focus on this specific population in order to further explore the possible contribution of VR gaming to clinical populations as well.

Another major limitation concerns the research period. Our research was conducted during the Covid-19 pandemic. As a result, we were only able to run it between one lockdown and the next, and the research stretched out for a long period. Moreover, this period was characterized by high general uncertainty and stress levels among the entire population. These factors might have influenced our results, both in the practical aspect and in the dependent variables which included various emotional measurements. It is crucial, then, to replicate this study in times of routine, when people are not experiencing any extreme life changes and studies can be conducted in more normal terms.

4.2 Implications and conclusions

VR provides its users with the opportunity to experience and interact with objects and situations in a multi-dimensional virtual arena, within an environment that is sensitive to and affected by their body movements. This experience is emphasized by a total severance from the actual reality and an illusion of real presence in the occurring events (Miloff et al. 2019). Not only that such experience offers people the opportunity to engage in an active, physical, powerful and exciting experience, but it also enables them to do so without the need to leave their current room. Therefore, VR technology might offer a unique and attractive way of encouraging people to engage in PA, even those who lack the appropriate conditions or the motivation to engage in a more "classic" PA.

Based on the findings of the present study indicating that active and passive VR experiences contribute to improving mood and reducing anxiety, we believe that this technique should be adopted especially in situations where there is difficulty in leaving the house (e.g., such as during a pandemic) or as an accessible method to improve the quality of life independently and flexibly.

While there was no preference for the type of VR experience regarding mood and anxiety, only the active gaming VR experience had a positive effect on depression levels and, for that reason, we believe that a VR experience that includes PA is preferable. Psychomotor difficulties of various kinds, including movement difficulties, are common among those suffering from depression (Sobin and Sackeim 1997). Fostering PA without leaving the house can be a unique opportunity for this population. The use of active VR experiences can be an encouraging first step in increasing participation and activity which, according to previous finding as well as the results of the current study, contributes to improving the feelings of reported depression-like symptoms.

To conclude, the current research explored the effect of different kinds of short VR experiences on mood, anxiety, sadness and self-efficacy levels among the general population. Our results imply that both passive and active VR-based experiences are indeed a potent tool that can offer a solution for the treatment of anxiety and sadness in the general population, with a preference to active VR in alleviating depression-like symptoms. Although further research is needed to tailor and refine the exact VR experience that would best improve each specific psychological aspect, the overall direction is promising.

Author contributions SS, GH and RD were involved in the conceptualization; SS, GH and RD contributed to the methodology; SS contributed to the software; SS and KN contributed to the formal analysis; SS contributed to the investigation; SS and GH assisted in writing—original draft preparation; KN, GH and RD were involved in writing—review and editing; KN was involved in the visualization; GH and RD contributed to the supervision. All authors have read and agreed to the published version of the manuscript.

Funding This research was supported by the Open University of Israel's Research Fund (grant no. 511527).

Data availability The data presented in this study are available on request from the corresponding author.

Declarations

Conflict of interest The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Ethical approval The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of the Open University of Israel (protocol code 3259, approved on January 2020).

Informed consent Informed consent was obtained from all subjects involved in the study.

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