The Pleasurable Stress of the VRAVG Beat Saber: A Mixed-Methods Study

Leland Masek
Tampere University
Kalevantie 4
Tampere, FI, 33100
Leland.masek@tuni.fi

Mun Kuan Chan, Jukka Särkijarvi
Tampere University
Kalevantie 4
Tampere, FI, 33100
munkuan.chan@tuni.fi, jukka.sarkijarvi@tuni.fi

ABSTRACT

Playfulness is an important component of wellbeing both in theory and a growing empirical body of literature. Past studies of games and wellbeing are valuable but often lack the use of contemporary positive psychological tools or reinforcing theory on playfulness. This study aims to contribute to game studies by integrating a positive psychological toolset and playfulness as a theoretical approach to studying the wellbeing effects of the virtual reality active video game *Beat Saber*. A non-clinical mixed-methods intervention was conducted where 34 participants came in to play 60 minutes of *Beat Saber*, reporting their Positive and Negative Affect before and after the study, their playfulness as a personality trait, and perceived exertion. A reinforcing semi-structured interview was conducted on perception of playfulness, stress and experience in the game. In conclusion we find evidence that Beat Saber raised positive affect, lowered negative affect and increased participant sense of playfulness.

Keywords

Beat Saber, Positive Psychology Intervention, PANAS, Playfulness

INTRODUCTION

Physical exertion in a variety of forms is fundamental for both physical and mental health (Martín-Rodríguez et al. 2024). Previous studies have shown a host of benefits for regular physical activity including enhanced brain functioning (Dishman et al. 2006), improves general life expectancy (Mahindru et al. 2023), and mental health across age groups (Rodriguez-Ayllon et al. 2019) increasing resiliency to stress (Lin et al. 2024) and lowering anxiety (Anderson & Shivakumar 2013).

Active video gaming (AVG) is a promising way for some individuals to increase their physical activity in an enjoyable way. As opposed to traditional video games which usually involve

Proceedings of DiGRA 2026

minimal or sedentary digital interaction, exergames are specifically designed to promote physical exertion by requiring players to perform larger movements as a core part of its gameplay (Moller et al. 2023). One major AVG that is understudied for its possible physical and especially mental health impacts is *Beat Saber* (Beat Games 2019). *Beat Saber* holds the promise of encouraging individuals to exercise based on its enjoyable and active gameplay but there are still large gaps in the literature. *Beat Saber* has been studied for how it is generally not causing of long-term VR sickness (Szpak et al. 2020). It has shown to cause light to moderate exertion in users while being rated as highly enjoyable (Boots et al. 2025). Finally, the multi-angle, and 360° modes of play have been studied as causing higher cognitive and exertional demands than the single angle mode (Tammy Lin et al. 2023). No past study has investigated how *Beat Saber*, as an AVG, may affect the mental health of users, either as a playful experience in a game or as an exertional exercise.

Playful experiences in game-based mental health interventions is a promising lens of inquiry to be applied to *Beat Saber*. A past literature analysis argued that game-based playfulness specifically may be an effective manner by which individuals are encouraged to participate more extensively in mental health interventions (Masek 2023). This article specifically postulated two general claims on how playfulness in game-based interventions may be presented: increasing *participation* in the study and inducing changes in playfulness as a *personality trait*.

The current study thus contributes to scholarly research on *Beat Saber* by investigating how playfulness, exertion, and stress interact for users. It applies a within subjects, exploratory, uncontrolled, before and after, mixed methods intervention design. Young adult university students (N=34) were brought in to play 60-minutes of *Beat Saber*. Their emotional responses to the game were investigated through self-reports of the Positive and Negative Affect Schedule (PANAS, Crawford 2004). Their perceived exertion through the OMNI exertion chart (Robertson et al. 2003). Their playfulness was investigated by using the OLIW instrument (Proyer 2017). Finally, participants were qualitatively interviewed on how they perceived playfulness, exertion, and stress within their play session.

Our findings are that *Beat Saber* was generally seen as playful, moderately physical, and causing increases in positive affect and reductions in negative affect. The two pathways of playful participation and playful personality trait effects are generally supported, though with strong limitations due to the design of the study. Participants quantitatively reported a significant increase in two forms of playfulness, Lightheartedness and Whimsical after the study than before, with no effect on the Other-Directedness and Intellectual forms of playfulness. Qualitatively they described several manners in which stress, playfulness and exertion interact. They viewed certain forms of stress as inducing playful experience and non-playful experiences, and finally playful experience as lowering general life stress. Playful stress was analyzed as *Achievement-based stress*, and *learning-based stress*. Non-playful stressors were analyzed as: *Study-based anxiety/stress* and *VR stress/strain*. Finally Stress-relief themes were *focus-based stress relief*, *exertion-based stress relief* and *music-based stress relief*. Bringing these two data forms together we conclude that Beat Saber seemed to most often be seen as a playful and pleasurable form stress that lowered participants larger sense of life stress through demanding cognitive focus and causing stress-relieving exertion in the game. The playful experiences in the game then seemed to have a stimulating effect on the components of playfulness as a personality trait but only those relevant to the gameplay.

This study is thusly an exploratory approach opening the door for future larger controlled studies to study how playful stress, active games and playfulness may be an important component of health and stress regulation.

BACKGROUND

To properly contextualize our approach, we will briefly overview the key concepts of our work and how they define our research questions. Firstly, Virtual Reality (VR) AVGs, and *Beat Saber* (2019). We will also briefly go over past research on exertion-based activity, playfulness and stress

Physical exertion games, exergames or AVG's, are a type of video game that makes physical exercise core to gameplay (Gao et al. 2011, 37). Classic examples include the dance game *Dance Dance Revolution* (1998), where the game's controller is a dance mat the player must step on in time with the music, and *Wii Fit* (2007), which is a suite of minigames for strength training and aerobics. More recent games, such as *Beat Saber* (2019), *Synth Riders* (2019), and *OhShape* (2019), have included VR headsets into their designs for a more immersive, yet still active, experience. *Beat Saber* is also quite popular, being reported as one of the first VR games to cross 100 million dollars of revenue (Tammy Lin et al. 2023).

Beat Saber is a virtual reality rhythm game that has been released for several platforms. It has downloadable original music and licensed hit songs from artists and bands such as Billie Eilish or Queen. In the game, the player's objective is to use a pair of glowing sabers to strike an oncoming stream of blocks. When the player strikes a block, it is destroyed, and points are awarded. There are also walls, which the player must step aside or dodge to avoid, and bombs, which reduce the player's Battery, or health bar, if hit. The blocks, walls, and bombs are laid out in synchronicity with a piece of music.

Beat Saber holds the promise of encouraging individuals to exercise based on its enjoyable and active gameplay (Szpak et al. 2020). While it holds this promise, the studies addressing this are still generally limited. It has shown to cause light to moderate exertion in users while being rated as highly enjoyable (Boots et al. 2025). It has several unique features such as a single angle, multi angle, and 360° mode, which have differing cognitive and exertional demands on the player (Tammy Lin et al. 2023). It was also seen as more enjoyable, yet also less physically intense than a traditional exercise regime (Rubio-Arias et al. 2024). Individuals' motivation to play *Beat Saber* is also theorized to possibly have different outcomes for their exertion (Mikac & Bernik 2022). In this way, past studies have meaningfully demonstrated that Beat Saber is a widely enjoyable game, that also has a variance of physical exertional demands, generally light to moderate. In this way we seek to replicate these findings and form the basis of our first research question:

RQ1: Do participants experience *Beat Saber* as causing exertion?

Past studies have argued that *Beat Saber* induces exertional demands but have not investigated how it may interact with mental health for users. This is a promising line of inquiry as physical exercise in general has been shown to have positive effects not only on physical but also mental health (Steptoe & Bolton 1989; Shosha 2020; Xu et al. 2021). Mental health, especially for games or play, is often analyzed within the domain of positive psychology (see Oades & Mossman 2017). One frequently used tool for studying affect in positive psychology is the Positive and Negative Affect Schedule (Crawford 2004). This instrument measures "dispositional dimensions, with high-NA epitomized by subjective distress and unpleasurable engagement, and low NA by the absence of these feelings. By

contrast, PA represents the extent to which an individual experiences pleasurable engagement with the environment." (Ibid p. 246). Considering past studies on *Beat Saber* found it was widely considered enjoyable (Boots et al. 2025); we frame our next research question in this study as the following:

> **RQ2:** Do participants report higher levels of Positive Affect (PA) after playing *Beat Saber* than before?

A past systemic literature review found that off the shelf video games, including exergames, helped reduce stress and anxiety (Pallavicini et al. 2021). Past studies on *Beat Saber* have mostly discussed enjoyment (Tammy Lin et al. 2023; Boots et al. 2025) or no affect at all (Szpak et al. 2020). No past study on *Beat Saber* has used an open-ended approach to investigate player-perceived negative affect during their play session. In this way we frame our next research question:

> **RQ3:** Do participants perceive lower levels of Negative Affect (NA) after playing *Beat Saber*?

A recent theoretical literature review on games and mental health found that "Considering how playfulness predicts desire to engage in an intervention, it is valuable for game-based interventions to measure ongoing playful experience" (Masek 2023, p. 10). This finding aligns with past studies on *Beat Saber* as enjoyable and opens the door for greater investigation on how playfulness in *Beat Saber* may interact with the exertional and emotional effects. Playfulness as a personality trait has been theorized as possibly being a mediator, moderator, or outcome variable for health interventions (Shen and Masek 2024). The *OLIW* measure of playfulness as a personality trait is a promising tool for investigating playfulness in a wellbeing context. It has been studied in the context of wellbeing, with evidence of playful experiences causing a change in self-reported personality (Proyer et al. 2021). The OLIW theorizes "Playfulness is an individual differences variable that allows people to frame or reframe everyday situations in a way such that they experience them as entertaining, and/or intellectually stimulating, and/or personally interesting." (Proyer 2017, p. 5). Given its growing application for psychological wellbeing, it is a promising theory to bring into game-based health interventions. In this way we justify our next point of inquiry:

> **RQ4:** Does playfulness as a personality trait (as measured by the OLIW) act as a moderator or mediator of positive/negative affect (as measured by PANAS) or as an outcome variable of study participation?

Brought together, there is a value behind additional research attention being brought to *Beat Saber* as an off the shelf VRAVG and how it interacts with positive and negative affect, exertion, and playful experience. The current research is thusly exploratory in nature (Jaeger and Halliday 1998). This distinction refers to different scientific goals where "research that mainly seeks to explore patterns in the data (hereafter exploratory research)" is contrasted to "research that tests scientific hypotheses that are clearly stated before the study is conducted (hereafter confirmatory research)." (Nilsen et al. 2020, p. 843). In this way, the goal of this work is to explore the patterns present between player perceived stress, perceived playfulness in a 60-minute play session of *Beat Saber*.

Thusly, to provide the clearest elucidation of the understudied phenomenon of playfulness, exertion, negative affect, in *Beat Saber* we take a mixed methods approach that not only statistically studies the questions at hand but also reinforces these findings through a

qualitative interview to triangulate (Heale & Forbes 2013) clarity in the answer. In this way, these research questions are not just approached statistically, but also as qualitative questions posed to participants with analysis of their answers being used to help frame our research result. In this way we merge our four research questions, for the purpose of a qualitative triangulation:

> **RQ5:** In what manner do participants find playfulness, stress/negative affect, and exertion interacting within a play session of the VRAVG *Beat Saber*?

METHODS

The current study reports on a within subjects, uncontrolled, before and after mixed methods intervention design. The design has two frameworks of data gathering and reporting, used to reinforce each other's findings: Quantitative statistical analysis and Qualitative Thematic Analysis. This choice was made to provide as much context as possible, as described in methodological research "Mixing two methods might be superior to a single method as it is likely to provide rich insights into the research phenomena that cannot be fully understood by using only qualitative or quantitative methods." (Dawadi et al. 2021, p. 27). We approach quantitative findings as useful in establishing an interaction occurred, and our qualitative findings for how this type of event was felt to occur by participants.

Study Design

The study had 34 participants. It was advertised at a publicly known coworking space at a mid-sized university in Finland. It also recruited participants through a mailing list for research volunteers called the DMlab Pool (Greiner 2015).

In the study, a participant was first asked to fill out a quantitative questionnaire of the PANAS (Crawford 2004) based on their day so far and the OLIW measure of playfulness as a personality trait (Proyer 2017) asking how they have felt. After filling out the questionnaire, the participant played *Beat Saber* for up to one hour. Every fifteen minutes, the researcher would ask if the participant wished to take a break. Water was made available. The participant was asked to first play the game's Campaign mode to teach them the game. Then, at the 30-minute mark, the participant was asked to switch from the Campaign mode to the Solo mode, firstly trying the 360° mode and then playing in any way they wished.

The participant had the option to quit playing at any time, and they were informed that performing well in the game or attaining a high score were not a consideration in the study. After one hour at the latest, the game session was ended. The participant then filled out the same questionnaire for the second time, reflecting how they were feeling in the time immediately after the play session. Participants were then interviewed about their experiences playing *Beat Saber* as discussed below.

Quantitative and Qualitative Approaches

We tested three statistical relationships between playfulness as a personality trait, the intervention, and participants positive and negative affect scores. Firstly, we tested the intervention as having a direct effect increasing both all forms of playfulness and positive affect while decreasing negative affect as visualized by Figure 1:

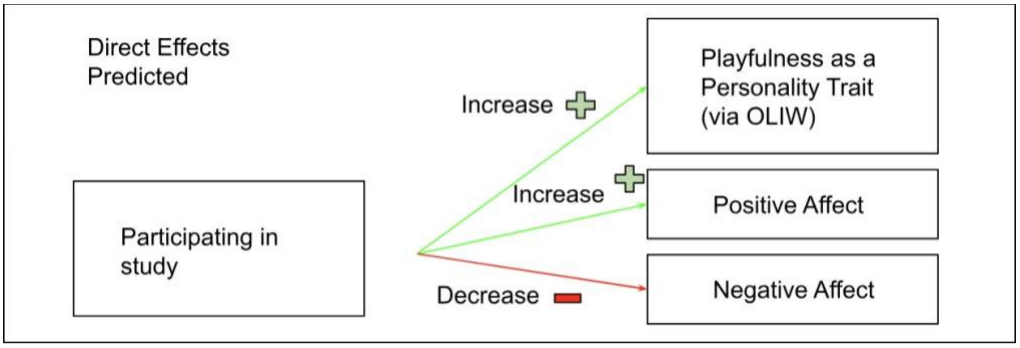

Figure 1: Direct Relationship between study and Playfulness

Secondly, we measured whether playfulness as a personality trait acted as a moderator or as a mediator of any relationship between *Beat Saber* and any effects on Positive or Negative Affect as can be visualized in Figure 2:

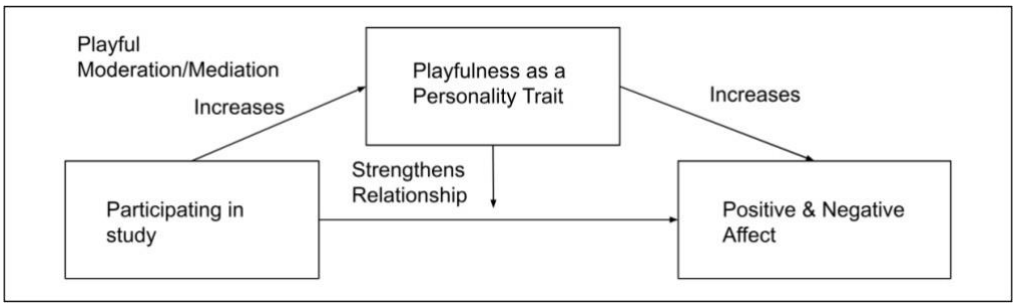

Figure 2: Mediation and Moderation Pathways

Finally, Participants were interviewed for an average of 12.24 minutes (6.08-22.05) through a semi-structured protocol asking them about their experiences playing *Beat Saber*, perceived exertion, engagement/playfulness, and perceptions of stress. Interviews were recorded, transcribed, and the qualitative data was compiled, disassembled, coded, and reassembled by the research team as based upon a five-phase analytic technique proposed by Yin (2015). In this phase of the process, each individual interview was handled by at least two researchers, and the work was discussed and reviewed in weekly meetings. The current text will focus upon the qualitative analysis on how participants described playful engagement, exertion, and reductions in negative affect.

RESULTS

In order to report the preliminary findings of this study in the most approachable way it will be split into two sections. The first four research questions will be handled separately, using quantitative statistical measures to identify the presence of any effects. Then secondly, the qualitative interview will be presented in a wholistic form addressing RQ5. In the discussion the meaning of these in tandem will be addressed.

Statistical Results

RQ1: Do participants experience Beat Saber as causing exertion?

In addressing RQ1, participants rated their level of perceived exertion using the OMNI perceived exertion scale from 0-10 (Robertson et al. 2003). Participants rated it on average

as a 4.23 (95% CI of 3.71-4.75) This means, on average participants found *Beat Saber* to be "fairly easy" in terms of physical exertion, with participants rating it anywhere from "easy", i.e. 2/10, to "hard" i.e. 8/10. In this way, our data generally confirms past studies that *Beat Saber* is usually perceived as causing a light to moderate exertional demand on its players.

> *RQ 2-3: Do participants perceive higher levels of positive affect (PA)? Lower levels of Negative Affect (NA) after playing Beat Saber?*

According to the Shapiro-Wilk test for normality Positive Affect was normally distributed ($W(34) = .96$, $p = .289$) while Negative Affect ($W(34) = .93$, $p = .030$) was not. Paired samples correlations between the levels, pretest and posttest, for all measures were significant. A paired samples *t*-test demonstrated there was a significant effect from *Beat Saber* on PA, $t(33) = -2.09$, $p = .045$, 95% CI [-8.77, -0.11], with participants reporting significantly greater PA at posttest ($M = 66.24$, $SD = 13.55$) as compared to pretest ($M = 61.79$, $SD = 11.43$). Because the normality assumption was violated for NA a Wilcoxon signed-rank tests were used as the non-parametric correction test. Participants' NA significantly decreased at posttest ($Mdn = 7.00$) than at pretest ($Mdn = 19.50$), $Z = -4.26$, $p < .001$.). In this way we generally confirm that participants reported higher positive affect and lower negative affect after the study than before.

> ***RQ4:*** *Does playfulness as a personality trait (as measured by the OLIW) act as a moderator or mediator of positive/negative affect (as measured by PANAS) or as an outcome variable of study participation?*

Firstly, we analyzed the direct effect of participating in the study on playfulness as measured by the OLIW instrument. According to Shapiro-Wilk test Lighthearted playfulness was normally distributed ($W(34) = .97$, $p = .391$), whereas Other-directed playfulness ($W(34) = .78$, $p < .001$), Intellectual playfulness ($W(34) = .84$, $p < .001$), and Whimsical playfulness ($W(34) = .88$, $p = .001$) were not normally distributed.

Thusly a paired samples *t*-test was conducted for Lighthearted playfulness pre-vs-post study participation. It showed a statistically higher reported level after than before, $t(33) = -3.25$, $p = .003$, 95% CI [-2.34, -0.54], thus participants reported significantly greater Lighthearted playfulness trait at posttest ($M = 19.59$, $SD = 5.69$) as compared to pretest ($M = 18.15$, $SD = 5.25$).

As Other-Directed, Intellectual, and Whimsical forms of playfulness were not normally distributed in our sample, we conducted a Wilcoxon signed-rank test as the non-parametric correction test. Results indicated that participants' reported Whimsical playfulness trait significantly increasing from pretest ($Mdn = 19.00$) to posttest ($Mdn = 20.50$), $Z = -2.41$, $p = .016$. In contrast, Other-Directed playfulness did not significantly change at pretest ($Mdn = 23.00$) and posttest ($Mdn = 23.00$), $Z = -1.42$, $p = .155$. Intellectual playfulness also did not significantly change at pretest ($Mdn = 18.00$) to posttest ($Mdn = 19.50$), $Z = -1.85$, $p = .064$.

Taken together we see a relationship between participating in the study and certain components of playfulness as a personality trait. Lighthearted ($p = .003$) and Whimsical ($p = .016$) forms of playfulness acted as an outcome variable with significant increases, while Other-directed and Intellectual playfulness did not have a significant reported change.

Mediation-Moderation

Mediation analysis for repeated measures was conducted using MEMORE macro (Mediation and Moderation for Repeated measures designs) (Montoya & Hayes 2017) in SPSS to examine whether changes in playfulness traits (Other-directed, Lighthearted, Intellectual, and Whimsical) mediate the relationship between *Beat Saber* and PA and NA. MEMORE Model 1 was used to test simple mediation within two timepoints (pretest and posttest).

Homoscedasticity of the main effect models was assessed using scatterplot of the standardized residuals against the standardized predicted values and visual inspection. For PA, NA, and OLIW, visual inspection of the scatterplots indicated that the residuals appeared to be randomly distributed with consistent variance across the range of predicted values, suggesting that the assumption of homoscedasticity has been met. The absence of curvilinear pattern also suggests that the assumption of linearity of the model was met.

There were no significant indirect effects from playing *Beat Saber* on PA through each of the playfulness traits, as the Monte Carlo confidence intervals contained zero (Other-directed playfulness, 95% MC-CI [-3.03, 1.30]; Lighthearted playfulness, 95% MC-CI [-5.25, 1.83]; Intellectual playfulness, 95% MC-CI [-2.42, 2.56]; Whimsical playfulness, 95% MC-CI [-2.33, 3.01]), suggesting that mediation did not occur.

There were no significant indirect effects of *Beat Saber* on NA through each of the playfulness traits, as the Monte Carlo confidence intervals contained zero (Other-directed playfulness, 95% MC-CI [-0.84, 3.84]; Lighthearted playfulness, 95% MC-CI [-1.57, 6.11]; Intellectual playfulness, 95% MC-CI [-0.96, 4.17]; Whimsical playfulness, 95% MC-CI [-2.75, 3.54]), suggesting that mediation did not occur.

Moderation analysis was conducted using linear mixed-effects models (LMM, see Brown 2021) to test whether playfulness traits moderated the effect of *Beat Saber* on PA and NA over time. Having completed the 60-minute play session of *Beat Saber* was operationalized as within-subjects fixed factor and dummy-coded (0 = pretest, 1 = posttest), while playfulness traits (Other-directed, Lighthearted, Intellectual, and Whimsical) were included as between-subjects fixed factors. All playfulness traits' scores were main centered prior to the analysis. Participants (ID) were included as random intercept in the model to account for the dependency among repeated measures. Notably, this approach allowed controlling for individual differences among participants while focusing on the interaction of fixed effects (*Study participation* and playfulness traits).

In testing the normality of residuals for PA, we used a Shapiro-Wilk test (Lilliefors 1967) which indicated that the assumption had been violated, $W(68) = .96$, $p = .046$. Visual inspection of the histogram and Q-Q plots indicated that the residual distribution was approximately normal overall, with violation stemming primarily from outliers. For the assumption of homoscedasticity, visual inspection of the scatterplot demonstrated that the residuals were randomly scattered across the predicted values, suggesting that the assumption was met. The assumption of linearity was also met, where the scatterplot did not show any curvilinear pattern.

In testing the normality of residuals assumption for NA, we used a Shapiro-Wilk test, and it revealed that the assumption was violated, $W(68) = .96$, $p = .015$. A visual inspection of the histogram and Q-Q plots indicated that there were several outliers likely causing this. The assumption of linearity was met with no significant curvilinear pattern in the scatterplot.

The assumption of homoscedasticity was violated as the scatterplot showed a clear "funnel" shape where residuals clustered at lower predicted values became increasingly spread out as the predicted values increased. This indicated that the residual variance was not constant across the range of predicted scores.

When testing for PA, the interaction between *Beat Saber* and Other-directed playfulness ($F(1,30.03) = 0.04$, $p = .837$; $\beta = -0.10$, $SE = 0.49$, $t(30.03) = -0.21$, $p = .837$), Lighthearted playfulness ($F(1,31.15) = 0.63$, $p = .432$; $\beta = 0.37$, $SE = 0.47$, $t(31.15) = 0.80$, $p = .432$), Intellectual playfulness ($F(1,31.56) = 0.11$, $p = .744$; $\beta = 0.14$, $SE = 0.44$, $t(31.56) = 0.33$, $p = .744$), and Whimsical playfulness ($F(1,31.42) = 3.04$, $p = .091$; $\beta = -0.80$, $SE = 0.46$, $t(31.42) = -1.75$, $p = .091$) were not statistically significant. These results indicate that the effect of *Beat Saber* on PA did not vary based on playfulness traits, hence, moderation did not occur.

When testing for NA, the interaction between *Beat Saber* and Lighthearted playfulness ($F(1,29.10) = 5.40$, $p = .027$; $\beta = -1.29$, $SE = 0.56$, $t(29.10) = -2.33$, $p = .027$) and Intellectual playfulness $F(1,29.52) = 4.21$, $p = .049$; $\beta = 1.07$, $SE = 0.52$, $t(29.52) = 2.05$, $p = .049$) were significant. This suggests that participants' levels of Lighthearted playfulness and Intellectual playfulness moderated the change in NA following their play session. Specifically, participants with lower levels of Lighthearted playfulness ($\beta = -1.29$) experienced less reduction in their NA from playing *Beat Saber* compared to those with higher levels. In contrast, participants with lower levels of Intellectual playfulness ($\beta = 1.07$) experienced greater decrease in NA after *Beat Saber* compared to those with higher levels. Conversely, the interaction between *Beat Saber* and Other-directed playfulness ($F(1,27.95) = 0.27$, $p = .609$; $\beta = -0.30$, $SE = 0.58$, $t(27.95) = -.52$, $p = .609$) and Whimsical playfulness ($F(1,29.37) = 1.25$, $p = .272$; $\beta = 0.61$, $SE = 0.54$, $t(29.37) = 1.12$, $p = .272$) were not significant, hence, moderation did not occur.

In summary, we tested playfulness as a personality trait for both whether it mediated or moderated the affect changes caused by a 60-minute play session of *Beat Saber.* In colloquial language this provides data to answer whether the session caused a change in playfulness as a personality trait that subsequently causing its own effects on PA/NA (mediation) or whether differing playfulness in people saw different types of effects from the study (moderation). We found no significant mediation effects, and we found two moderation effects: those with higher lighthearted playfulness saw a less strong negative affect reduction from their session playing *Beat Saber*, whereas those with higher intellectual playfulness saw a stronger negative affect reduction from their session playing *Beat Saber*.

Qualitative Results

> *RQ5: In what manner do participants find playfulness, stress/negative affect, and exertion interacting within a play session of the VRAVG Beat Saber?*

Participants primarily reported certain forms of stress as playful: Achievement-based stress, and learning-based stress. Secondly, participants some nonplayful forms of stress which conflicted with their ability to participate in the study: Study-based anxiety/stress and VR stress/strain. Finally, participants reported *Beat Saber* as causing a sense of stress-relief with three sub-types: focus-based stress relief, exertion-based stress relief, music-based stress relief.

Playful Stress

The largest category for how playfulness, exertion and stress interacted was participants describing certain types of engaging game mechanics as inherently stressful, but in a non-negative way. This type of stress we term "playful stress" as it was generally contrasted to life stress, big stress, serious stress and negative stress. Participants described it sometimes as an inherent part of wanting to win in the game, as something they seek in game experiences in general and essential for other categories, such as focus-based stress relief. There were two commonly reported sources for this form of stress in *Beat Saber*: *achieving challenging goals* and *new/surprising mechanics*. This kind of stress was usually stated as explicitly "positive" (P5;P34) or not negative (P6), "playful" (P1) or easy to release (P9). This type of playful-exertion-stress relationship was reported by a majority of our participants (N=27).

Participants would describe overcoming challenges in *Beat Saber* as a source of *playful stress*. As one participant describes "if you're alarmed, your stress goes up. But not, like, in a negative way. I thought, like, in a playful way….I was having fun dodging it in, like, a mini-boss challenge" (P1). Similarly, participants described various challenging mechanics where especially losing or being close to losing may trigger this type of stress. Participants described missing notes as causing "playful anger" (P2), or the fear of breaking combos as causing the "sort of the stress that makes you do more or makes you do better." (P4) or harder levels as causing "Definitely higher [stress]… but also more fun because there was more challenge" (P16).

Other participants specifically brought up the first time they experienced a mechanic/challenge as unique type of positive, playful stress. As P3 describes their experience facing a new mechanic in the game as causing "this kind of good kind of stress, I'd say, where, where something new is trying to be learned" (P3). Others similarly described a playful stress from a "first time" they faced a new game challenge (P5;P32).

In conclusion one of the primary ways participants described a relationship between *Beat Saber*, stress and playful experience was:

> **Playful Stress:** Certain game mechanics, especially challenging and new mechanics, create a positive form of desirable stress in players.

VR Stress/Strain

Participants also reported the VR equipment as directly causing some degree of strain, stress, or negative affect. These negative experiences had two subtypes: eye strain from the VR display and physical discomfort from the VR headset, and spatial anxiety of how the VR interacted with the actual space. This category of negative experience was described as both limiting their playful and exertional experience with the game, though usually in a short-term or manageable way. Six of the 34 participants described one of the two types of VR stress/stress.

Several participants described the VR display as causing strain on their eyes. P2 exemplifies this when they reported "I mean the eye strain at some point was kind of distracting and I was like man, I wish my eyes weren't bothering me right now so I could concentrate better at the game". This example is useful at the participant describes how this form of stress and negative experience did not contribute but rather distracted them from the general game experience. Several other participants reported VR-based eye strain as causing more

fatigue than a regular screen (P1), causing a desire to take breaks (P34), and causing a general sense of tiredness (P11).

The VR headset was also described as causing non-ocular physical discomfort. For example, P11 reported "the pressure of the headset in the head" caused a feeling of "now I have to decompress". Similarly, P5 reported the headset was uncomfortable and conflicting with the play experience. Finally, one participant reported the VR experience as triggering a sense of anxiety which conflicted with their playful experience. As not being able to see the real room "made me more concerned about, okay, am I going to bump into something?" (P25).

Overall, we assess one form by which participants described an interaction between *Beat Saber*, stress and playful experience.

> **VR Induced Stress:** VR headsets may cause eye strain, physical discomfort or anxiety which is experienced as negative and conflicting with the playful experience of a game.

Study Anxiety

The second form of non-playful stress caused by the study was when participants described internal mental anxiety around attending or participating in a research study as a new and unknown experience in general. This reported stress/anxiety generally decreased rapidly as the study progressed and they realized they enjoyed playing the game. Participants reported initial stress for participating in the study for several reasons: unfamiliarity, concerns of physical fitness, and fear of being observed. Thirteen of the 34 participants reported some version of study anxiety.

Several participants reported feeling stressed or nervous before the gameplay due to being unfamiliar to VR and the study. As P24 describes "I have never been here before and I had no idea what to expect. So like, of course, I'm like a little stressed". Other participants similarly described a sense of anxiety at not fully understanding what will occur in the experiment (P18). Other participants described a sense of anxiety around their ability to engage in the experiment physically. P17 described this as "I was feeling stressed because I think I was going to [mess] it up and throw up or be out of shape and collapse". Others described this anxiety as fear of being dizzy or overwhelmed by VR (P1). Other participants described a sense of stress from being in a study and being observed. P7 noted feeling uneasy because "I was a little bit stressed about like someone observing me playing". Similarly, P34 reported a slight feeling of embarrassment at imagining being watched playing. One participant reported this study anxiety as also engaging or playful, calling it "curious stress" (P9) about the experiment.

As gameplay proceeded, participants reported this form of stress and nervousness subsiding as they became more playfully engaged with the game and the environment became more familiar. Participants described becoming more relaxed after an adjustment period, such as P17 stated "As soon as the game started and I felt that I was not going to feel dizzy, yeah, amazing. Like stress went away". Other participants described stress going away after gameplay was seen as engaging and intuitive (P7), finding the game immersive (P24), or replaced by the playful stress of striving to achieve in-game goals (P34). Overall, we assess another form by which participants described an interaction between *Beat Saber*, stress and playful experience.

> **Study Anxiety:** Participating in a study caused anticipatory stress/anxiety around being in a scientific study. The playful experience with the game was seen to reduce this stress.

Focus-Related Stress Relief

The first way participants described playful experience in the game as causing stress-relief was *focus-related stress relief*. In this category, the immersive experience of *Beat Saber* as a game and the mental focus required for successful gameplay was reported as both engaging/playful and relieving of stress because it took the participant's away from out-of-game life-stressors. Fifteen of the 34 participants reported a focus-related stress relief experience.

One participant represents this effect when they reported "I really felt stressful before. And then, like I said, when I managed to get the headset on and just started playing, that just kind of evaporated almost instantly. And then during the game, I didn't really think about anything else except the game. So, it wasn't stressful at all" (P20). Other participants reported a similar effect as making them "zoom out" from their normal stressors (P15).

The challenge of the gameplay was seen as one of the things that demanded focus, replacing life stress with the playful stress of trying to do well in the game. In one participant's words, "the little beautiful stress of hitting the next box correctly" made their "big stress" go away (P17). Another one described it as a focus on just the next goal of finishing the song or passing the challenge (P2). One participant reported deliberately seeking this kind of effect by trying to "overload" it, saying "I would like it if I could only be thinking about the blocks flying towards me (P15). While temporary, the effect lasted beyond the play session. B15, P23, and P25 all described their stress levels as reduced after playing the game but also noting that they would rise back to their normally expected level with time.

> **Focus-Related Stress Relief:** The VR game environment is immersive, which makes it easier to focus fully on the game experience. Conversely, the challenging gameplay demands that focus. Focusing on the game took a person's attention away from real-life stressors.

Movement-Related Stress Relief

The second way participants described playful/engaging experience in the game as lowering their overall stress was exertion-based stress relief. In this form, participants described the active movement required by *Beat Saber* as lowering their larger sense of life stress, like working out, going to the gym or another physical activity. Movement-related stress relief was reported by 12 of the 34 participants.

Participants who reported this relationship between the study, engagement and stress reduction, often described the effect as analogous to other exercise experiences. For example, P12 reported their feeling about their experience playing as "it kind of like a little relaxes you, yeah, like going to the gym" (12). Which is like how P2 reported or "I do feel this post-workout like satisfaction now where I'm like oh nice I did something physical today" (2). Others commented that *Beat Saber* much like other physical activities "released stress" (P1), "physically relaxed" (P5), or let them "physically let go of stress" (P20). In this way we report another manner by which participants reported playful engagement with the VRAVG *Beat Saber* as interacting with their sense of stress:

Movement-Related Stress Relief: *Beat Saber* was perceived as a physically active game. This physical activity was then associated with lower levels of perceived life stress.

Music-Based Stress/Stress Relief

The final and smallest category of playfulness as causing a reduction in perceived stress was music-related stress relief. In this category, participants (N=3) reported the music within the game as engaging, encouraging active movement but also lowering stress.

One participant described this when answering how the gameplay interacted with their sense of stress as "Certainly helped, because I listen to music a lot on my free time, so that helps naturally for me." (P21). This was like how P32 reported how "music and stuff and everything else combined together… it's good for the relaxing stuff". One participant (P27) reported the music as either engaging or as stressful reporting "when there was nice music, I somehow felt like I would like to dance, but not all the time. Then when the music changed and it was like kind of irritating" (P27). This probably speaks to music importantly needing to be engaging or a preferred type of music, not just any type of music to be stress-relieving. In this way we construct our final qualitative category:

Music-Related Stress Relief: *Beat Saber's* music, but only when enjoyable, caused participants to feel a reduction in their perceived stress.

DISCUSSION

This mixed-methods study provides both quantitative and qualitative data reinforcing each other towards some significant findings. Participants described several relationships between perceived stress, perceived playfulness and their 60 minutes playing *Beat Saber*. Qualitatively, participants described the study as causing various types of stress that conflicted or contrasted with playful experience, that were playful in themselves, and where playful experience reduced their sense of larger stress in life.

The versions of stress caused by the study were often reported as temporary or easily resolved. Study-stress generally dissipated during the study, VR strain was usually handled described as minor and handled by a break, while playful stress was seen as equally temporary, ending when the play session ended. In contrast, the stress-relief caused by participating in the study was usually described as having a longer lasting meaning. This finding is furthermore reinforced by the quantitative findings that Negative Affect was statistically lower after the study than before, signaling that taken together the study reduced perceived negative affect and stress as an experience.

Participants described the *Beat Saber* experience usually as highly playful and only a light to moderate physical exertion experience. The playfulness of the experience may have caused the finding that participants reported a higher level to the Lighthearted and Whimsical playful personality traits after playing. While we did not find a significant mediation and only partial moderation effects between playfulness as a personality trait and positive and negative affect, that also could be due to a limited number of participants as moderation and mediation can require significantly more power to detect in studies (Xu et al. 2024). The moderation we did find may be interesting for future studies to investigate and confirm. Participants with higher lighthearted playfulness saw a less extreme reduction in their negative affect, possibly because they also had lower negative affect to begin with[1]. Secondly, the novelty of *Beat Saber* may have enabled those with higher intellectual

playfulness to be more focused learning a new game system, thusly improving their focus-based stress relief.

Taken together, this study has significant findings about the relationship between *Beat Saber*, exertion, playfulness, and wellbeing. Participants reported the game as improving their positive affect and lowering their negative affect, a common goal in positive psychological interventions. Playing this game also increased their general sense of playfulness as people. This confirms past theoretical claims that playfulness is a valuable concept for game-based mental health interventions. Importantly though, this specific game caused a specific result in both wellbeing and in playfulness as a personality trait. Where *light-hearted* and *whimsical* playfulness increased, *other-directed* and *intellectual* playfulness did not. This intuitively makes sense and *Beat Saber* is a one-player game, and thusly not the most obviously social form of playful experience, as measured in other-directed playfulness. This type of nuance is essential for understanding the complicated interactions of such larger categories of "playfulness" and "wellbeing". This specificity and nuance is essential for future studies that are mapping the full and specific effects that playing specific games have on specific types of wellbeing.

Limitations

The studies method has some serious limitations. Firstly, there was no control group, so many statistical tests conducted would be greatly benefited by a group of individuals attending a study but not engaging in a VRAVG. Participants discussed a certain type of stress coming from attending a study for the first time so especially Negative Affect as a before and after statistic should be confirmed in a controlled study. Various parameters in the moderation and mediation testing for the study had violations of those statistical tests' assumptions, mostly due to a few outliers which limit the value of these tests. Subsequent studies with additional participants would greatly improve the strength of these findings.

The study addresses these limitations through its triangulation of qualitative and quantitative data. Participants described their 60-minute play session of *Beat Saber* as creating many of the effects we found in our statistical results. In this way, we find our triangulation techniques improved the quality of the study and ensures it has still made significant contributions.

CONCLUSION

This study adds to the growing data for games as effective playful manipulations for future studies on health and wellbeing. This study confirms that games hold promising preliminary evidence for being effective, off the shelf, well-designed ways to generate certain forms of playful experiences which are psychologically relevant to wellbeing. The study adds qualitative pathways for how games, especially AVGs may effectuate wellbeing for players. Participants reported that *Beat Saber* as an AVG caused a light to moderate type of exertion, and a high level of engagement. They felt more positive affect and less negative affect after the study than before. Participants reported this same effect as gameplay being fundamentally stressful, but in a playful, pleasurable way. This pleasurable stress then generally lowered their larger sense of life stress through demanding cognitive focus and causing stress-relieving exertion in the game.

This study is relevant for those who wish to investigate playfulness, those who wish to study positive psychological interventions, and those who study games. Future studies should investigate this relationship further, doing larger studies, with control groups and with

various games. It is very possible that some types of affect manipulation are specific to *Beat Saber* and others are more general to "highly engaging" gameplay experiences that various games cause. Furthermore, the playful forms that this study affected may be specific to the game investigated. For example, other-directed playfulness may be significantly increased by a game that is, in its play, social rather than a 1-player experience.

Thusly this study opens the door for a wide range of studies. How do games cause playful experiences? How do these playful experiences vary or stay the same? In what way do these experiences thusly impact player wellbeing in the short term and long term? We warmly welcome future scholars to continue studying this exciting and rapidly expanding connection between playfulness, games, and specific forms of wellbeing.

REFERENCES

Abós, Á., Sevil-Serrano, J., Julián-Clemente, J. A., Generelo, E., & García-González, L. (2021). "Improving teachers' work-related outcomes through a group-based physical activity intervention during leisure-time." *The Journal of Experimental Education*. 89 (2), 306-325.

Anderson, E. and Shivakumar, G. 2013. "Effects of Exercise and Physical Activity on Anxiety." *Frontiers in Psychiatry.* 4 (27). https://doi.org/10.3389/fpsyt.2013.00027.

Beat Games. 2019. *Beat Saber*. VR game. Menlo Park, CA, USA: Oculus Studios.

Benzing, V., Heinks, T., Eggenberger, N., and Schmidt, M. 2016. "Acute Cognitively Engaging Exergame-Based Physical Activity Enhances Executive Functions in Adolescents." *PLOS ONE.* 11 (12): e0167501. https://doi.org/10.1371/journal.pone.0167501.

Boots, B., Berg, D., Hewitt, E., Naugle, K., & Naugle, K. 2025. "Physical Activity and Enjoyment in Active Virtual Reality Games in Youth: Comparative Analysis of Gorilla Tag and Beat Saber." *JMIR Serious Games*. 13 (1), e66593.

Brown, V. A. 2021. "An introduction to linear mixed-effects modeling in R." *Advances in Methods and Practices in Psychological Science*. 4 (1), 2515245920960351.

Crawford, J. R. and Henry, J. D. 2004. "The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample." *British Journal of Clinical Psychology.* 43 (3), 245-265.

Dawadi, S., Shrestha, S., and Giri, R. A. 2021. "Mixed-methods research: A discussion on its types, challenges, and criticisms." *Journal of Practical Studies in Education.* 2 (2), 25-36.

Dishman, R. K., Berthoud, H-R., Booth, F. W., Cotman, C. W., Edgerton, V. R., Fleshner, M. R., Gandevia, S. C., Gomez-Pinilla, F., Greenwood, B. N., Hillman, C. H., Kramer, A. F., Levin, B. E., Moran, T. H., Russo-Neustadt, A. A., Salamone, J. D., van Hoomissen, J. D., Wade, C. E., York, D. A., Zigmond, M. J. 2006. "Neurobiology of Exercise." *Obesity.* 14 (3), 345–56. https://doi.org/10.1038/oby.2006.46.

Gao, Y. and Mandryk, R.L.. 2011. 'GrabApple: The Design of a Casual Exergame'. In *Entertainment Computing – ICEC 2011*, edited by

Anacleto, J.C., Fels, S., Graham, N., Kapralos, B., Saif El-Nasr, M., and Stanley, K.. Lecture Notes in Computer Science.

Greiner, B. 2015. "Subject Pool Recruitment Procedures: Organizing Experiments with ORSEE." *Journal of the Economic Science Association.* 1, 114-125.

Heale, R. and Forbes, D. 2013. "Understanding triangulation in research."

Evidence-based Nursing. 16 (4), 98-98.

Jaeger, R. G. and Halliday, T. R. 1998. "On confirmatory versus exploratory research." *Herpetologica.* 54 (Supplement), S64-S66.

Kluge Interactive. *Synth Riders*. VR game. Marina del Rey, CA, USA: Kluge Interactive.

Konami. 1998. *Dance Dance Revolution*. Video game. Tokyo, Japan: Konami. Kultima, A., Alha, K., Syvänen, A., Tyni, H., Mäyrä, F., Koivu, K., Nummenmaa,

T., Serola, S., & Törnkvist, K. 2014. *Rainbows, Unicorns and Hoverboards: Making of OASIS*. Tampere, Finland: University of Tampere.

Li, J., Theng, Y. L., & Foo, S. 2016. "Exergames for older adults with subthreshold depression: does higher playfulness lead to better improvement in depression?" *Games for Health Journal*. 5 (3), 175-182.

Lilliefors, H. W. 1967. "On the Kolmogorov-Smirnov test for normality with mean and variance unknown." *Journal of the American Statistical Association*. 62 (318), 399-402.

Lin, H., Zhu, Y., Liu, Q., and Li, S. 2024. "The Mediating Effect of Resilience

between Physical Activity and Mental Health: A Meta-Analytic

Structural Equation Modeling Approach." *Frontiers in Public Health.* 12 (October). https://doi.org/10.3389/fpubh.2024.1434624.

Lyons, E. J., Tate, D. F., Ward, D. S., Ribisl, K. M., Bowling, J. M., and

Kalyanaraman, S. 2014. "Engagement, Enjoyment, and Energy Expenditure during Active Video Game Play." *Health Psychology.* 33 (2), 174–81. https://doi.org/10.1037/a0031947.

Mahindru, A., Patil, P., and Agrawal, V. 2023. "Role of Physical Activity on Mental Health and Well-Being: A Review." *Cureus.* 15 (1). https://doi.org/10.7759/cureus.33475.

Martín-Rodríguez, A., Gostian-Ropotin, L. A., Beltrán-Velasco, A. I., Belando-Pedreño, N., Simón, J. A., López-Mora, C., Navarro-Jiménez, E., Tornero-Aguilera, J. F., and Clemente-Suárez, V. J. 2024. "Sporting Mind: The Interplay of Physical Activity and Psychological Health." *Sports.* 12 (1), 37. https://doi.org/10.3390/sports12010037.

Masek, L. 2023. "How playfulness can enable greater understanding of game-based adult mental health interventions." Paper present at *Simulation and Gaming for Social Impact: 53rd International Simulation and Gaming Association Conference (ISAGA*

2022), Boston, MA, USA, July 11-14. ISAGA – International Simulation and Gaming Association.

Mikac, E. and Bernik, A. 2022. "The Impact of Video Games on Physical Activity and Motivation for Exercise Using VR Technology." *Advances in modelling & analysis. B, Signals, Information, Data, Patterns.* 65 (4), 1-8.

Moller, A. C., Sousa, C. V., Lee, K. J., Alon, D., and Lu, A. S.. 2023. "Active Video Game (AVG) Interventions Targeting Physical Activity Behaviors: A Systematic Review and Meta-Analysis (Preprint)." *Journal of Medical Internet Research.* 25 (May): e45243–43. https://doi.org/10.2196/45243.

Montoya, A. K. and Hayes, A. F.. 2017. "Two-Condition Within-Participant Statistical Mediation Analysis: A Path-Analytic Framework." *Psychological Methods.* 22 (1), 6–27. https://doi.org/10.1037/met0000086.

Nilsen, E. B., Bowler, D. E., & Linnell, J. D. 2020. Exploratory and confirmatory research in the open science era. *Journal of Applied Ecology*, *57*(4), 842-847.

Nintendo. 2007. *Wii Fit*. Wii game. Kyoto, Japan: Nintendo.

Oades, L. G. and Mossman, L. 2017. "The Science of Wellbeing and Positive Psychology." In *Wellbeing, Recovery and Mental Health* edited by M. Slade, L. Oades, and A. Jarden, 7-23. Cambridge, MA, USA: Cambridge University Press.

Odders Lab. *OhShape*. VR game. Seville, Spain: Odders Lab.

Pallavicini, F., Pepe, A., & Mantovani, F. 2021. "Commercial off-the-shelf video games for reducing stress and anxiety: systematic review." *JMIR Mental Health*. 8 (8), e28150.

Proyer, R. T. 2017." A new structural model for the study of adult playfulness: Assessment and exploration of an understudied individual differences variable." *Personality and Individual Differences.* 108, 113-122.

Proyer, R. T., Gander, F., Brauer, K., and Chick, G. 2021. "Can playfulness be stimulated? A randomised placebo-controlled online playfulness intervention study on effects on trait playfulness, well-being, and depression." *Applied Psychology: Health and Well-Being.* 13 (1), 129-151.

Robertson, R. J., Goss, F. L., Rutkowski, J., Lenz, B., Dixon, C., Timmer, J.,

Frazee, K., Dube, J. and Andreacci, J. 2003. "Concurrent validation of the OMNI perceived exertion scale for resistance exercise." *Medicine & Science in Sports & Exercise*. 35 (2), 333-341.

Rodriguez-Ayllon, M., Cadenas-Sánchez, C., Estévez-López, F., Muñoz, N. E., Mora-Gonzalez, J., Migueles, J. H., Molina-García, P., Henriksson, H., Martínez-Vizcaíno, V., Catena, A. Löf, M., Erickson, K. I., Lubans, D. R., Ortega, F. B., and Esteban-Cornejo, I. 2019. "Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and Adolescents: A Systematic Review and Meta-Analysis." *Sports Medicine.* 49 (9), 1383–1410. https://doi.org/10.1007/s40279-019-01099-5.

Rubio-Arias, J. Á., Verdejo-Herrero, A., Andreu-Caravaca, L., and Ramos-Campo, D. J. 2024. "Impact of immersive virtual reality games or traditional physical exercise on cardiovascular and autonomic responses, enjoyment and sleep quality: a randomized crossover study." *Virtual Reality.* 28 (1), 64.

Shen, X. and Masek, L. 2024. "The playful mediator, moderator, or outcome? An integrative review of the roles of play and playfulness in adult-centered psychological interventions for mental health." *The Journal of Positive Psychology.* 19 (6), 1037-1050.

Shosha, M. 2020. "A Brief Introduction to Therapeutic Boxing." *International Journal of Physiology, Nutrition and Physical Education*. 5 (2), 29–31.

Steptoe, A. and Bolton, J. 1988. "The Short-Term Influence of High and Low Intensity Physical Exercise on Mood". *Psychology & Health.* 2 (2), 91–106.

Szpak, A., Michalski, S. C., and Loetscher, T. 2020. "Exergaming with beat saber: an investigation of virtual reality aftereffects." *Journal of Medical Internet Research.* 22 (10), e19840.

Tammy Lin, J. H., Wu, D. Y., & Bowman, N. 2023. "Beat Saber as virtual reality exercising in 360 degrees: A moderated mediation model of VR playable angles on physiological and psychological outcomes." *Media Psychology.* 26 (4), 414-435.

Ubisoft. 2009. *Just Dance*. Video game. Saint-Mandé, France: Ubisoft. Xu, W., Liang, H. N., Baghaei, N., Ma, X., Yu, K., Meng, X., & Wen, S. 2021.

"Effects of an immersive virtual reality exergame on university students' anxiety, depression, and perceived stress: pilot feasibility and usability study". *JMIR Serious Games.* 9 (4), e29330.

Xu, Z., Gao, F., Fa, A., Qu, W., & Zhang, Z. 2024. "Statistical power analysis and sample size planning for moderated mediation models." *Behavior Research Methods*. 56 (6), 6130-6149.

Yin, R. K. (2015). *Qualitative Research from Start to Finish, 2nd Edition*. New York, NY, USA: Guilford Publications

ENDNOTES

[1] Lighthearted playfulness showed significant main effect on NA ($F(1,38.12) = 4.60$, $p = .038$; $\beta = -0.25$, $SE = 0.49$, $t(56.24) = -0.50$, $p = .620$), but the specific estimated effect was small which only provides weak evidence. This suggests that there was some model-level evidence that Lighthearted playfulness was associated to Negative affect but the interpretation that participants with lower level of Lighthearted playfulness experienced higher Negative affect should be treated as tentatively.