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DOI
10.1016/j.actpsy.2022.103812

Publication date
2023

Document Version
Final published version

Published in
Acta Psychologica

License
CC BY

Link to publication

Citation for published version (APA):
Lemmens, J. S., & Freiherr von Münchhausen, C. (2023). Let the beat flow: How game difficulty in virtual reality affects flow. *Acta Psychologica*, *232*, [103812]. https://doi.org/10.1016/j.actpsy.2022.103812

Acta Psychologica 232 (2023) 103812

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Let the beat flow: How game difficulty in virtual reality affects flow

Jeroen S. Lemmens *, Constantin Freiherr von Münchhausen

Amsterdam School of Communication Research, University of Amsterdam, Netherlands

ARTICLE INFO

Keywords:
Virtual reality
Flow
Exergaming

ABSTRACT

Virtual Reality Games offer highly immersive experiences that allow users to effectively dissociate themselves from reality. VR gaming leads to a strong sense of presence and can facilitate the experience of flow among its players. The current study examines how the balance between a player's skill and the difficulty of a VR rhythm game can influence the sense of flow. An experiment was conducted among 201 university students who played the rhythm game *Beat Saber* in VR. Difficulty settings were adjusted to each individual player's skill, making the game either too easy, matched, or too hard. Results indicated that the match between skill and difficulty led to higher levels of flow. If the game was too hard, this caused a decrease in flow due to frustration, but too easy did not lead to the expected decrease in flow due to boredom. A stronger sense of flow while playing this VR game was also related to better performance, higher physiological arousal, and more enjoyment.

1. Introduction

Virtual reality (VR) has evolved from a nausea-inducing novelty to an immersive and enjoyable extension of traditional video gaming. Due to their immersive sensory and physical affordances, VR games are more effective at generating a state of flow among its players than traditional games (Kim & Ko, 2019; Pallavicini & Pepe, 2019; Rutrecht et al., 2021). Flow describes an optimal psychological state in which users are fully engaged in an activity, experiencing high levels of focus, control, and enjoyment (Bodzin et al., 2021; Csikszentmihalyi & Csikzentmihaly, 1990). Although some have argued that the terms immersion and flow can be used interchangeably because they are not substantially different (Michailidis et al., 2018), immersion is generally defined as the objective and measurable properties of a mediated environment (Bystrom et al., 1999; Lemmens et al., 2022; Nash et al., 2000), whereas flow is described as an optimal user experience of effortless attention and enjoyment (Csikszentmihalyi & Nakamura, 2010). Thus, immersive environments can be understood as technological antecedents to the user experience of flow.

Video games are very effective at evoking a flow state because they have concrete rules and goals, adjustable difficulty settings, provide clear feedback on players' performance, and facilitate concentration through abundant multimodal information (Jin, 2012). Game flow is a compound construct describing various dimensions of an engaging and enjoyable experience, including concentration, control, clear goals, feedback, and balance between challenge and skills. The relation between the latter has proven to be particularly important for enabling a state of game flow (Klasen et al., 2012; Pallavicini & Pepe, 2019; Schmierbach et al., 2014). Flow is induced when the difficulty of challenges continuously adapts to the developing skills of a player, thereby providing a sensation of mastery. Low difficulty can lead to apathy and boredom, whereas high difficulty can lead to anxiety and frustration (Rutrecht et al., 2021; Sweetser & Wyeth, 2005). Players should unconsciously feel that challenges are balanced and manageable to keep flow and enjoyment at optimal levels (Bodzin et al., 2021; Schmierbach et al., 2014).

The 2019 rhythm game *Beat Saber* (Beat Saber (VR version), 2019) is one of the most popular games in VR, having sold over four million copies worldwide since its release (Verdu, 2021). Rhythm games like Beat Saber use music as a central gameplay component by letting the beat or rhythm, in combination with visual elements, dictate the actions a player has to perform (Mueller & Isbister, 2014). The combination of physical activity and music increases interest and diminishes audible distractions, which heightens concentration and positively contributes to flow (Bronner et al., 2013; Sites & Potter, 2018). Flow is linked to increased activity of the sympathetic nervous system, increased respiratory depth, and higher heart rate (Bian et al., 2016; Harmat et al., 2015). During gameplay, players experience heightened arousal and positive affect. Heart rate increases to meet the metabolic demand that comes from sympathetic nervous activity (Tian et al., 2017).

Since the difficulty of rhythm games is mostly affected by the intensity and speed at which players have to perform movements, higher

* Corresponding author.
E-mail address: j.s.lemmens@uva.nl (J.S. Lemmens).

https://doi.org/10.1016/j.actpsy.2022.103812
Received 30 October 2022; Received in revised form 14 December 2022; Accepted 14 December 2022
Available online 23 December 2022

difficulty should lead to higher levels of physiological arousal (Caronongan & Marcos, 2021; Costello, 2020).

These findings suggest that VR rhythm games may be among the most effective ways to induce a sense of flow, enjoyment, and physiological excitement. Physical challenges that are too easy or too hard should result in less flow and less enjoyment due to dissonance between capabilities and required actions (Csikszentmihalyi & Csikzentmihaly, 1990; Jin, 2012). Whether these specific relationships between enjoyment, flow and difficulty also hold for highly immersive VR games has not yet been examined. The overall aim of the current study is to examine how the match between skills and difficulty in a rhythm VR game affects the experience of flow. We also aim to determine how arousal, boredom and frustration influence performance, flow, and ultimately enjoyment.

2. Method

2.1. Sample

An experiment among 201 English-speaking participants recruited from the University of Amsterdam was conducted. Data collection took place in March and April 2022, during which no Covid restrictions were implemented. Participants were between 18 and 39 years old, *Mage* 21.12 (SD = 2.76). Participants received either research credits or a financial compensation for taking part in this 40-min experiment. The majority of participants was female (n = 150, 74.26 %), 48 participants were male (23.76 %), three participants were non–binary (1.49 %), and one participant did not indicate gender. None of the participants had any experience with Beat Saber.

2.2. Procedure

The procedure involved playing through eight songs (levels) of the Virtual Reality game *Beat Saber*. This included one song as a tutorial, one song that was used to assess their baseline skill, and six more songs whose difficulty was manipulated based on the condition participants were assigned to. Previous studies on the relation between flow and difficulty have applied predetermined difficulty settings regardless of a player's skill (e.g., easy, medium, hard), with medium difficulty settings often showing the highest flow state among participants (Tian et al., 2017; Tordet et al., 2021). However, manipulating (im)balance of skill and difficulty should take the individual skill of each player into account (e.g., medium may be too easy for some and too hard for others). Therefore, difficulty of the experimental conditions was adjusted to players' baseline skills. Difficulty in Beat Saber comes from the speed and direction in which movements need to be performed. All six songs were available in four difficulty levels (easy, normal, hard, expert). Participants would either play the six songs in a condition not matching their baseline skill level (all too easy or all too difficult) or start in a condition matching their skills, with the last two songs increasing slightly in difficulty in order to meet their presumed increasing skills after having played six songs. Participants were randomly and evenly assigned across these three conditions (too easy n = 67, matched n = 66, too hard n = 69).

Each condition included the same six popular songs from various genres: *Gwen Stefani (Hollaback Girl, 110 bpm), Doja Cat (Say So, 111 bpm), Ke$ha (Blow, 120 bpm), Rammstein (Du Hast, 125 bpm), Britney Spears (Toxic, 143 bpm), Wiz Khalifa (Black and Yellow, 164 bpm)*. The order of songs was randomized across participants. The experiment had a duration of 40 min, with 25 min spent in VR, and approximately ten minutes spent on a questionnaire about game flow, enjoyment, frustration, boredom, and demographics. A manipulation check tested whether the difficulty of two conditions was indeed perceived as too easy or too hard. In the too easy condition, 88.2 % of participants indicated that the gameplay was too easy. In the too hard condition, 94.4 % indicated that the difficulty was indeed too high. Randomization to the six experimental groups was also successful, as no overall differences emerged between the groups in terms of age, $F(5, 195) = 2.18$, p = .058, or gender, $F(5, 192) = 0.16$, p = .975.

2.3. Measures

2.3.1. Game flow

Within his flow theory, Csikszentmihalyi & Nakamura (2010) identifies eight determinants: (1) a challenging activity that requires skill, (2) the merging of action and awareness, (3) clear goals and feedback, (4) complete concentration on the task, (5) effortless control, (6) the loss of self–consciousness, (7) an intrinsically rewarding experience, and (8) the transformation of time. Because a valid measurement of flow should cover these eight dimensions, the following eight items from an existing flow scale (Fang et al., 2013), were adapted. All responses were measured using 7-point Likert-type scales: 1) *This game provided a good test of my skills*; 2) *I found myself doing things spontaneously and automatically without having to think*; 3) *It was clear what I needed to do*; 4) *I was totally concentrated on what I was doing*; 5) *I felt in control over what I was doing in the game*; 6) *I had the feeling that I "melted" into the game*; 7) *Playing this game was rewarding in itself*; 8) *I lost track of time*. Although EFA indicated that these items loaded on two dimensions, explaining 33.1 % and 14.1 % of the variance, flow theory suggest one underlying construct. This 8-item flow scale showed acceptable reliability (α = 0.70, M = 5.54, SD = 0.72).

2.3.2. Enjoyment, boredom and frustration

A range of cognitive and emotional responses were measured (Kendzierski & DeCarlo, 1991), using 7-point Likert-type response scales. Four items were used to create a scale for *enjoyment*, forming a reliable scale (α = 0.89, M = 6.14, SD = 0.98). Participants were asked to reflect on the game when answering the following four items: 1) *I enjoyed it*; 2) *I disliked it* (reverse coded); 3) *I found it pleasurable*; 4) *It was no fun at all* (reverse coded). The scale was unidimensional, explaining 76.1 % of the variance. The high mean score and low standard deviation indicate that participants generally found the game very enjoyable. Similar to enjoyment, boredom and frustration were each measured with four items. These items formed a reliable scale for *boredom*, α = 0.79, M = 2.37, SD = 1.00. Participants were asked to reflect on the game when answering the following items: 1) *I found it boring*; 2) *I would rather have done something else*; 3) *I found it exciting* (reverse coded); 4) *I was absorbed* (reverse coded). The scale was unidimensional, explaining 61.3 % of the variance. Frustration was measured using four items, creating a reliable scale, α = 0.71, M = 2.91, SD = 1.03. Participants were asked to reflect on the game when answering the following four items: 1) *I found it frustrating*; 2) *I felt a sense of accomplishment* (reverse coded); 3) *I found it satisfying* (reverse coded); 4) *I found it pleasant* (reverse coded). The scale was unidimensional, explaining 57.3 % of the variance.

2.3.3. Physiological arousal

To measure physical excitement, a Polar H10 heart rate monitor captured heart rate (HR) during gameplay. Baseline HR (N = 200) was measured during the tutorial and baseline skill assessment song (M = 98.53, SD = 16.07). During the experiment, HR was measured during the first set of two songs (M = 116.82, SD = 19.56), the second set (M = 115.48, SD = 18.43), and the third set (M = 117.83, SD = 19.12). During the total experimental manipulation, participants had an average HR of 112.13 (SD = 16.83).

2.3.4. Performance

During each song, players were presented with a stream of approaching blocks from various positions, with different markings that indicated how each block should be cut. Points were awarded based on the length and angle of the swing, and the accuracy of the cut. Total scores ranged from 42,116 points through 931,573 points (M = 419,365, *SD* = 242,115). Since difficulty affected the speed and manner in which blocks were presented, scores differed significantly between difficulty levels, *F* (2,199) 220.91, $p < .001$, with players in easier settings earning more points (see Table 2 for details). In order to compare performance between difficulty levels, players were ranked based on their scores within each condition (range 1–39), with higher rankings indicating higher scores.

3. Results

3.1. General results

An overview of the correlations between relevant variables can be found in Table 1. Flow showed a very strong positive correlation with enjoyment ($r = 0.65, p < .001$) and negative correlations with boredom ($r = -0.66, p < .001$) and frustration ($r = -0.69, p < .001$). Players with better performances experienced higher levels of flow ($r = 0.29$, $p < .001$), and more enjoyment ($r = 0.34$, $p < .001$), less boredom ($r = -0.32$, $p = .001$) and less frustration ($r = -0.27$, $p = .010$). Flow was correlated with a higher heart rate ($r = 0.17, p = .015$), whereas a lower heart rate was correlated with boredom ($r = -0.25$, $p < .001$). This negative correlation between heart rate and perceived boredom provides further validity for both measures. Age was not correlated with any variable, possibly due to the limited age range in our sample. Gender was correlated with performance, indicating that players who identified as male ($n = 48$) generally performed better within and across difficulty settings ($M = 43.38$, $SD = 19.25$) than players who identified as female ($n = 150$), ($M = 31.05$, $SD = 18.67$), *t* (196, 77.32) 3.95, $p < .001$.

3.2. Difficulty and flow

To test whether matching game difficulty resulted in higher levels of flow compared to too high or too low difficulties, a one–way analysis of variance was performed. All three groups were of similar size and each included >65 cases. ANOVA with Bonferroni correction indicated that the effect of game difficulty on flow was statistically significant, *F*(2, 198) = 3.42, $p = .035$. However, the effect size was small, explaining 3 % of the variance, $\eta^2 = 0.03$. A *t*-test confirmed that those playing with matching difficulty experienced a stronger sensation of flow ($M = 5.68$, $SD = 0.65$) than those playing on too hard difficulty ($M = 5.37$, $SD = 0.80$), *t* (134, 129.89) 2.42, $p = .17$, $d = 0.11$. However, matching difficulty did not provide a stronger sensation of flow than gameplay that was too easy compared to their skill ($M = 5.60$, $SD = 0.65$), *t* (130, 129.89) 0.65, $p = .519$. Flow did not differ significantly between conditions too easy and too hard. Thus, there is a significantly higher sense of flow in matching game difficulty in comparison to gameplay that is too challenging, but not when compared to easy gameplay.

3.3. Difficulty, boredom and arousal

The correlations from Table 1 confirmed the expected negative relations between flow and boredom ($r = -0.66$, $p < .001$), and flow and frustration ($r = -0.69$, $p < .001$). Table 2 shows the differences in frustration and boredom across the three difficulty conditions. Analysis of variance showed no significant effect of game difficulty on boredom, *F* (2, 198) = 1.04, $p = .354$. There was however a moderate effect of game difficulty on frustration, *F*(2, 198) = 23.84, $p < .001$, $\eta^2 = 0.19$. Setting the difficulty too hard was more frustrating ($M = 3.53$, $SD = 1.17$) than the matched difficulty ($M = 268$, $SD = 0.85$), *t* (134, 124.02) 4.84, *p* < 001, $d = 0.83$. Too hard was also more frustrating than too easy difficulty ($M = 2.49$, $SD = 0.70$), *t* (132, 111.85) 6.28, *p* < 001, $d = 1.08$. Thus, playing levels that are too easy for the skillset did not lead to significantly more boredom than matching or too hard conditions, but playing levels that were too hard for a player caused more frustration than matching or too easy difficulty settings.

To examine whether the effect of difficulty on flow is mediated by frustration and boredom, a parallel mediation analysis was performed using the PROCESS macro for SPSS (Hayes, 2012). The categorical independent variable (*Easy*, *Matching*, *Hard*) was regressed on frustration and boredom, the mediating variables, which subsequently predicted flow. This mediation model, including the corresponding path coefficients, is displayed in Fig. 1. The model was significant ($R = 0.75$, $R^2 = 0.56$, *F* (4,196) = 62.46, $p < .001$). Too hard difficulty (compared to matching and easy) significantly influenced frustration ($\beta = 0.84$, t = (2198) 5.30, $p < .001$), whereas too easy (compared to matching and too hard) did not affect frustration ($\beta = -0.19$, t = (2198) -1.18, $p = .240$). In turn, frustration negatively affected flow ($\beta = -0.36$, t = (4196) -7.07, $p < .001$). Therefore, too hard difficulty indirectly negatively affected flow through an increase in frustration, $\beta = -0.31$, $SE = 0.8$, LLCI -0.48; ULCI -0.16. Contrary to expectations, too easy gameplay did not significantly affect boredom ($\beta = 0.15$, t = (3197) 1.21, $p = .230$), but too hard gameplay did negatively influence boredom ($\beta = -0.42$, t = (3197) -3.14, $p = .002$). Boredom subsequently negatively influenced flow ($\beta = -0.23$, t = (4196) -4.85, $p < .001$). Paradoxically, too hard difficulty indirectly positively affected flow slightly through a decrease in boredom, $\beta = 0.09$, $SE = 0.4$, LLCI 0.03; ULCI 0.18. Nevertheless, too hard difficulty when compared to easy and matching difficulties, resulted in much more frustration, diminishing the sense of flow.

3.4. Enjoyment, performance and physiological arousal

Flow showed a small correlation with physiological arousal ($r = 0.16$, $p = .010$). Since it has been suggested that too high arousal decreases performance (Peifer et al., 2014), we examined whether

Table 2
Differences between difficulty settings.

	Too Easy	Matched Difficulty	Too Hard
Flow	5.60 (0.65)	5.68 (0.65) [a]	5.37 (0.80) [a]
Enjoyment	6.37 (0.64) [a]	6.32 (0.79) [b]	5.77 (1.26) [a b]
Boredom	2.51 (0.93)	2.29 (0.95)	2.30 (1.11)
Frustration	2.49 (0.70) [a]	2.68 (0.85) [b]	3.53 (1.17) [a b]
Heart Rate	113.08 (14.97) [a]	115.32 (19.83)	120.68 (18.60) [a]
Score	636.94 (117.13) [a b c]	479.12 (188.91) [a b c]	155.51 (75.71) [a b c]

Note. Means within rows with identical superscripts ([a,b,c]) differ significantly at least $p < .05$.

Table 1
Correlations between relevant variables.

	Performance	Flow	Enjoyment	Boredom	Frustration	Heart Rate
Flow	0.29**	–				
Enjoyment	0.34**	0.65**	–			
Boredom	−0.32**	−0.66**	−0.76**	–		
Frustration	−0.27**	−0.69**	−0.76**	0.66**	–	
Heart Rate	0.18*	0.16*	0.10	−0.25**	0.01	–
Age	−0.09	0.09	−0.01	0.03	−0.10	−0.07
Gender	−0.27*	−0.03	−0.11	0.02	0.09	0.04

* $p < .05$.
** $p < .001$.

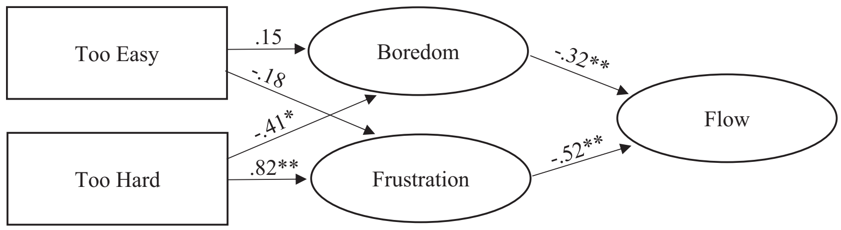

Fig. 1. Difficulty influences flow through boredom and frustration.
Note. Coefficients are standardized beta's, * $p < .05$, ** $p < .001$.

quadratic regression models of heart rate on flow provided a better fit. The addition of the quadratic predictor of arousal on performance explained no additional variance (F change (1197) = 0.33, $p = .568$), indicating that heart rate affects flow linearly. ANOVA indicated that game difficulty affected enjoyment, $F(2, 198) = 7.47$, $p < .001$, with a small effect size, explaining 8 % of the variance, $\eta^2 = 0.08$. If the gameplay was too easy it caused more enjoyment ($M = 6.37$, $SD = 0.64$) than when the gameplay was too hard ($M = 5.77$, $SD = 1.26$), t (132, 102.30) 3.47, $p = 001$, $d = 0.60$. Similarly, when the difficulty matched a player's skill it caused more enjoyment ($M = 6.32$, $SD = 0.79$) than when the difficulty was greater than their skill, t (134, 114.87) 3.04, $p = .003$, $d = 0.52$. Enjoyment was positively related to performance, as shown by the correlation between enjoyment and ranking ($r = 0.34$, $p < .001$), indicating that players enjoyed themselves more when they performed better than other players within the same difficulty setting. Similarly, ranking was positively correlated with flow ($r = 0.29$, $p < .001$) which strengthens the assumption that flow is a state of optimal awareness and peak performance.

Performance was related to physiological arousal, indicating that players who exerted themselves more, showed better performances ($r = 0.29$, $p < .001$). Adding a quadratic predictor of arousal on performance explained no additional variance (F change (1197) = 0.33, $p = .568$), indicating that heart rate affects performance linearly. Physiological arousal is not inherently more enjoyable in general, as the correlation between heart rate and enjoyment was not significant ($r = 0.10$, $p = .183$). However, the relation was significant within the too easy condition ($r = 0.25$, $p = .046$). ANOVA indicated that game difficulty also affected players' heart rate, F (2, 197) = 3.17, $p = .044$, with a small effect size, $\eta^2 = 0.03$. Physiological arousal was significantly lower when the game was too easy ($M = 113.08$, $SD = 14.97$) than when the game was too hard ($M = 120.68$, $SD = 18.60$), t (131, 127.35) 2.60, $p = .010$, $d = 0.52$. No significant differences with matching difficulty were found. In sum, flow leads to more enjoyment, higher physiological arousal and better performance.

4. Discussion

The main aim of this study was to examine how difficulty influences players' experience of flow in a VR game. The results indicated that flow was indeed higher among players in the matching difficulty setting when compared to the too hard setting. However, flow among players with matching difficulty was not significantly higher when compared with players in the too easy setting. These findings do not fully support theoretical assumptions of game flow, nor are they in line with previous findings that did show higher flow in matching difficulty settings compared to too easy settings (Rutrecht et al., 2021 Apr 30; Schmierbach et al., 2014). This discrepancy in findings is possibly related to the fact that too easy did not significantly increase players' sense of boredom. Although both boredom and frustration while playing decreased flow, too easy gameplay did not lead to boredom as expected. The mediation model showed that too hard difficulty resulted in much more frustration, which subsequently diminished the sense of flow. Although too hard was also perceived as significantly less boring, the resulting small indirect positive effect on flow still resulted in a strong negative total effect of too hard difficulty on flow experienced by players.

Flow is considered a state of optimal awareness that inspires peak performance (Csikszentmihalyi & Jackson, 1999). Indeed, the higher players' reported sense of flow, the better their performance in Beat Saber. Performance was also positively related to physiological arousal. The higher their heart rate during play, the better their performance, and the stronger their state of flow. Our findings thereby validate a previous experiment on flow in VR games that had indicated that heart rate is one of the strongest physiological indicators of flow (Bian et al., 2016). Although heart rate as an indicator of physiological arousal provides an objective outcome sympathetic nervous activity, it cannot provide specific physiological characteristics of the flow experience in which parasympathetic systems are also activated (Peifer et al., 2014; Tozman et al., 2015). Previous studies have also shown that music and full-body movements in a game environment, positively influence flow and enjoyment in VR games (Farič et al., 2019; Sites & Potter, 2018). Similarly, in the current VR rhythm game, physiological arousal was also related to enjoyment, but only when the game was easy. Too hard difficulty caused lower scores, more frustration, less enjoyment, and less flow. Too hard also caused more physiological arousal, as indicated by a higher heart rate, but this arousal seemed to stem from frustration and not from pleasurable excitement.

In general, our findings underline the appeal of easy gameplay for the current sample of first-time players of Beat Saber in VR, who generally reported high levels of both enjoyment and flow. The positive effect of too easy gameplay on enjoyment and flow may be attributed to the novelty effect of VR (Elor et al., 2022) causing high degrees of arousal and enjoyment among participants. It also seems that players are less likely to become bored with highly enjoyable experiences, such as VR gaming, even if the tasks are too easy. The importance of gender within the experience of flow and enjoyment of difficulty in video games should not be disregarded. The current sample consisted mostly (74 %) of young adult women. Despite their underrepresentation, male players showed better performances across difficulty settings. Other studies have shown similar gender differences in game performance, even when controlling for game experience and competitiveness (Brown et al., 1997). Considering the interrelations between gender, performance, flow and enjoyment, it seems possible that the predominantly female sample may have caused some discrepancies in our findings. Nevertheless, these findings generate further insights into what generates pleasurable, flow–enhancing experiences, especially among first-time users. Emerging fields in VR such as exergaming, socializing, or activities in the metaverse might benefit from easygoing experiences that lead to an enjoyable and performance enhancing state of flow.

Data availability

Data will be made available on request.

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