Virtual Reality vs. Non-Virtual Reality: A Comparison of Two Rhythm Games

Willeke van der Varst

2013588

Tilburg School of Humanities and Digital Sciences, Tilburg University

Bachelorthesis CSAI

Dr. Maryam Alimardani

June 26, 2020

Abstract

Recently, a lot of interest has been shown into investigating player experience of Virtual Reality games and how these kind of games can be made more interesting. However, as of now, there has been no study that directly investigates the difference of player experience and enjoyment between a Virtual Reality game and its' non-VR counterpart, which are alike in both gameplay and objective of the game. Following from this, the main research question for the current study is: "In which type of game, VR or non-VR, do players feel the most immersed and do they also find this game more fun and are they thus more likely to play this game again, opposed to the less immersive game?" with sub-questions focussing on differences in game preference between people of different gender, musical ability and general sports experience. The games that were chosen to be investigated were the Virtual Reality game Beat Saber and the non-VR game ''In The Groove'' (or other similar games played on a dance pad), which are both rhythm games with similar gameplay and objectives. Data collection was done via an online questionnaire and participants responses were subsequently analysed. The main finding was that there is a correlation between immersiveness, enjoyment and replayablity of the game and that the non-VR game played on a dance pad was more immersive, enjoyable and replayable. These results are likely due to the bias in the participant pool, which has a lot more experience with dance pad rhythm games than with Beat Saber. Furthermore, no significant difference in game preference could be found between the previously mentioned sub-groups.

Virtual Reality vs. Non-Virtual Reality: A Comparison of Two Rhythm Games

Videogames and the use of virtual reality (VR) in those videogames has become an increasing source of interest, both from a business and an academic point of view (Sherman, 2019). This increase of interest has mainly been due to relatively quick advancements in the field of VR and the commercial availability of VR hardware, enabling people to have their own home setups which they can freely use, mainly to play VR video games. Moreover, businesses increasingly use it to train their employees, militaries use it to prepare their soldiers for the battlefield, and even educational institutes try to incorporate VR in their curricula to get students more engaged in the subject being taught. The reason for this increasing usage of VR in all sorts of fields in mainly due to it being fully immersive, engaging and interactive, making it an excellent teaching tool for real life experiences. As a consequence of this increased interest, a great deal of research has recently been done in VR applications, from how to best design them to the effect of VR on people. Some of these

studies will be addressed under “Related work”. However, despite the abundant material on the subject, there have been few studies that actually compare VR videogames to their “standard” non-VR counterpart. In other words, videogames, which have very similar gameplay and mainly differ in that one is a VR game and the other is a traditional non-VR game, have hardly been compared in academic studies.

From this follows the main subject of this thesis, namely comparing player experience between two games, one being a VR game and one being a non-VR game. The two games that were chosen to be compared for this study were: In The Groove (ITG) as non-VR game, and Beat Saber as VR game. Both these games are rhythm games, meaning that actions in the game have to be performed according to both visual and musical cues (Rollings, 2003). There were multiple reasons for choosing these games. The first one is that the core gameplay and goal of both games is basically the same: performing actions in a certain pattern, according to audio-visual cues in the game, on a specific song and timing these actions as accurately as possible to maximize the received points. In this way, the main difference between the gameplay of both games is the VR aspect, which is exactly what was needed. The second reason for choosing these games is accessibility to the rhythm game community. As this study had to be performed online, via questionnaires, it was important that enough participants could be gathered that had experience with both games. Since there was access to the necessary community, these games were a logical choice for investigation. The third reason for choosing these games is because both of them can be used as a source of exercise (gameplay involves movement) and can thus both can be used as a motivation to get people to exercise in the form of a game. This makes these games interesting from a developer standpoint as games are increasingly seen as a source of motivation to get people to exercise. As a result of this, it is interesting for developers to know which type of game would possibly sell better: a virtual reality game or a traditional, non-virtual reality game.

In ITG, players need to step on certain arrows on a game pad with their feet, according to visual cues on a screen (In The Groove 2, 2020). The arrows are timed with the music, creating a sense of rhythm. There are multiple games that go by other names (Dance Dance Revolution, Stepmania, etc), that offer exactly the same gameplay, the only difference being appearance (look of the background, arrows, menu). These games are developed by different companies, but for the purposes of this study they can all be used, as gameplay is exactly the same and the interest of this study is gameplay experience. These games will be referred to as “dance pad rhythm games”. An example of gameplay and the necessary dance pad (the controller) can be seen in figure 1.

Figure 1: In The Groove/Stepmania gameplay (left) and gamepad (right)

In Beat Saber, players need to slash cubes in a certain direction in a virtual environment, according to visual and musical cues (Beat Saber, 2018). These slashes are performed by holding the controllers and moving them in a slashing motion in the right direction. In the virtual environment, the controllers are seen as lightsabers. An example of gameplay and the necessary VR headset and controllers can be seen in figure 2.

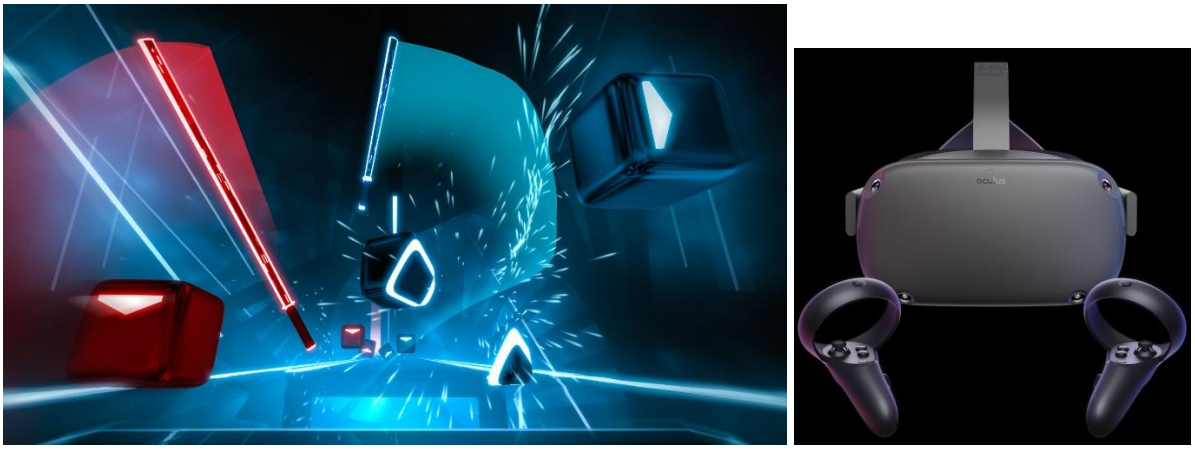

Figure 2: Beat Saber gameplay (left) and VR-headset + controllers (right)

As mentioned above, little to no research has been conducted evaluating and comparing the difference of the user experience between the two types of games. Mostly, research into user gaming experience has focused on just one game at a time, not comparing multiple games. Most of these studies have made use of a general Game Engagement type of questionnaire (Denisova, 2016), more on this in "Related work". Following from this, almost no research has as of yet been conducted that focuses on the cognitive aspects of gaming. These cognitive aspects of user experience have been addressed in previous studies not focussed on games, which reported users' opinions on software usability, enjoyment and immersion. The studies made use of a construct called Cognitive Absorption, which was first described in a paper of Agarwal & Karahanna (2000) and made it possible to evaluate overall

user experience with a focus on the cognitive aspect of the experience, more on this can be found under “Related work”. Cognitive absorption measures the difference in user experience on five dimensions, which makes it very useful to compare two games which not only differ in level of immersion, with VR games being assumed to be overall more immersive, but also in the way they are played: the controls for Beat Saber are different compared to the controls for the dance pad rhythm games. Obtaining more knowledge about differences in player experience could be useful for companies that develop games. Knowing what kind of games people prefer, could help companies decide on what type of game should be developed to be the most profitable and most effective for use in work related settings: business, education, and so on. Next to this, developing this cognitive approach to evaluating user experience could be useful as a new methodology for future studies. Ascertaining exactly what makes a VR or non-VR game enjoyable and replayable could be useful to develop this new methodology which sheds more light into users’ behaviour, the way in which they interact with different technologies, and the differences between the interactions.

In summary, the main goal of this thesis is a comparison between the gameplay experience between the two games ITG (non-VR) and Beat Saber (VR). This leads to the following research question: In which type of game, VR or non-VR, do players feel the most immersed and do they also find this game more fun and are they thus more likely to play this game again, opposed to the less immersive game? Alternatively: Is there a correlation between immersiveness of the game, how fun players feel the game is and how likely players are to play the game again? Intuitively, Beat Saber is likely to give the players more of a sense of immersion than dance pad rhythm games, as Beat Saber provides a full virtual environment, while a dance pad rhythm game does not. However, this does not necessarily have to mean that players also find this game more fun and are more likely to play this game again. It could be that people prefer a less immersive game as opposed to the more immersive game.

Some sub-questions that can be addressed have to do with demographics, such as: 1. Is there a difference in game preference between people who have more musical experience (playing an instrument, singing, and so on) and people who have less musical experience? 2. Is there a difference in game preference between people who have more experience in sports and people who have less experience in sports? 3. Is there a difference in game preference between male and female players? These sub-questions give more insight into which demographic prefers which game best, and thus, if you were developing a game for a certain demographic, which type of game would be best.

The main finding of this study was that there is a correlation between immersiveness, enjoyment and replayablity of the game. And, more surprisingly, that not the Virtual Reality game Beat Saber, but the non-VR game played on a dance pad was more immersive, enjoyable and replayable. These results are likely due to the bias in the participant pool, which has a lot more experience playing dance pad rhythm games compared to the game Beat Saber. Furthermore, no significant difference in game preference could be found between the previously mentioned sub-groups.

Related work

As mentioned in the above, recently there have been multiple studies that have focused on the usage of VR in different settings. A prominent domain of research has been the usage of VR in rehabilitation settings. These studies focus on the usefulness of VR applications when people are rehabilitating from a certain condition/disease (a plethora of conditions and diseases have been studied for this end) and, if they are useful, what kind of application would work best (Layer, 2017). Other health related studies have focused on VR and mental health, researching if VR can help assessment, understanding and treatment of mental health disorders (Freeman, 2017). Furthermore, research has been done into VR for education (Fogarty, 2018), data collection for VR (Anderson, 2016), limitations in VR usage (Bastug, 2017), and many more topics. Moreover, a great deal of research into VR games has been done, such as: Educational VR games (Drey, 2020), players feelings towards VR games (Jang, 2019), Emotion sharing in Cooperative VR games (Hart, 2018), and, here also, many more topics. Next to this, quite some research has already been done into rhythm games. Most of these studies have focused on either the health benefits of rhythm games (Prahm, 2017), as movement and thus exercise are involved, or if rhythm games could be useful in education (Soszunski, 2016). Also, some more general research into what makes games more engaging, both for ‘standard’ rhythm games (Pichlmair, 2007) and virtual reality rhythm games (Yi, 2017) has been done.

As can be seen from the above examples, as of now, there has been no focus on the difference between VR and non-VR games that are very similar, their main difference being the VR aspect. There has been research which addresses the difference between VR and non-VR in similar settings: a study that looked into the difference of how peoples’ physical reaction differed (heart rate and skin conductance) between a virtual reality and non-virtual reality condition (Egan, 2016). However, this was not in a game setting. What could be concluded form this research, is that people are likely more immersed in the virtual reality

environment than the non-virtual environment, as both heart rate and skin conductance were higher for the virtual reality condition. Based on this study, it would be more likely that people are more immersed when playing Beat Saber as opposed to ITG. Moreover, research of Egan, et al. has focussed on a realistic setting (realistic buildings, parks, etc), while the rhythm games that will be studied in this project have a more abstract environment of shapes, which could affect how immersed people feel. Furthermore, the research of Egan, et al. did not focus on a game, so measuring if people would want to play a more immersive game over a less immersive game has not been done.

Another important fact is that studies relating the relative skills and/or enjoyment of people playing rhythm games and their musical ability have not yet been performed. Thus, it is not yet known if people with better overall musical skills perform better in rhythm games or if they enjoy them more. Therefore a measure to objectively assess the musical ability of participants was of interest for the current study, next to their self-assessed musical ability. Multiple tests for assessing musical abilities have previously been developed, such as the standard test of musical ability of Edwards, et al. (2000) and the Musical Ear Test of Wallentin, et al. (2010). These tests, and many others, focus on many different aspects of musical ability, such as: pitch awareness, rhythm duration, structure and meter, chord structure and awareness, melody and dynamics. However, most of these aspects are not tested in rhythm games. Constructs such as pitch, chord structure and melody are not what is being scored in these games. Rhythm games are, as the name suggest, almost purely rhythmic and beat dependent and players need a good sense of the rhythm or the beat to be able to perform well, with the rest of the musical constructs being far less important to performance (Rollings, 2003). Therefore, a test to assess musical ability on the basis of rhythm/beat detection was needed. This test did already exist and is called the Beat Alignment Test, BAT, which was developed by Iversen & Patel (2008). During the BAT test, participants had to listen to sound clips and determine if the beat tick they heard was on- or off-beat for the music they heard. A follow-up study which covered objective tests of musical abilities confirmed that the BAT correlates with self-reported musical abilities and can thus be used as a simplified measure of musical ability (Musil, 2014).

Additionally interesting for this project, is the research that has been done for developing questionnaires, as this project used a questionnaire as a means to collect data from its participants. There were two main types of previously developed questionnaires that were of particular interest for this project, namely the game engagement type questionnaires (Denisova, 2016) and the cognitive absorption questionnaire (Agarwal, 2000). The game

engagement type questionnaire, and in particular the Game Engagement Questionnaire, GEQ for short, (BrockMyer, 2009), focuses on the experience of a person playing a video game. Items such as immersion in the game environment, flow, absorption, enjoyment, and replayability are central in this questionnaire. Several questionnaires developed after the GEQ were based on it (Abbasi, 2017) and a multitude of game experience studies have relied on the GEQ, or derived questionnaire, to obtain their data (Norman, 2013). Thus, the GEQ was considered a good starting point. However, even though the GEQ does have game immersion as a part of its focus, it does not try to illuminate different parts of the cognitive experience. This issue was addressed by combining the GEQ with the Cognitive Absorption questionnaire developed by Agarwal & Karahanna (2000). In the Cognitive Absorption Questionnaire, users of a specific type of software have to evaluate the extent to which they agree with certain statements regarding their experience. These statement are subdivided into the five dimensions of cognitive absorption: focussed immersion, temporal dissociation, curiosity, control, and heightened enjoyment. Multiple studies have reported the Cognitive Absorption Questionnaire as being successfully applied. A selection of them: Saadé & Bahli (2005) about the adoption of online learning platforms, Zhang & Li (2004) about the importance of perceived affective quality of Human-Computer interaction, Negut et al. (2016) about virtual reality-based attention assessment of ADHD, and Sepehr & Head (2011) about the role of competitiveness in games on the level of cognitive absorption. These, and other previous studies, prove the Cognitive Absorption Questionnaire as being an effective tool for evaluating user experiences with specific software and thus a necessary addition to the questionnaire for the current study, which also focusses on the cognitive aspects of user experience. The questionnaire that was developed for the current study was thus a combination of the GEQ and the Cognitive Absorption questionnaire to address all aspects necessary.

Methods

Using Qualtrics (Qualtrics Experience Management Software, 2020), an online survey was developed, consisting of several parts. The first part was created to obtain demographic information about the participants such as age, ethnicity, and educational level as well the participants experience levels in musical ability, general sports ability, dance pad rhythm game ability and Beat Saber ability (see Appendix A). Participants had to rank their ability on a seven-point Likert scale, with the lowest number, one, equalling “No, or almost no

experience" and the highest number, seven, equalling "A lot of experience". Demographics, such as gender, had to be provided by marking the appropriate checkbox.

The second part of the survey was created to administer the Beat Alignment test as mentioned in "Related work", to obtain objective data about the participants' musical abilities. Certain sound clips from the BAT were used, however not the whole BAT test was administered due to concerns over the length of the survey, so a shortened version of the BAT was administered to the participants (see Appendix B).

In the third part of the survey, the game experience questionnaire of this study, questions were drafted from the Game Engagement Questionnaire and the Cognitive Absorption Questionnaire to assess the participants' gameplay experience (see Appendix C). These questions were converted into statements with which participants could agree more or less. A seven-point Likert scale was used to assess the level of agreement to the statements with the lowest number, one, equalling "I don't agree at all" and the highest number, seven, equalling "I completely agree". Each questionnaire had to be filled in once for both games.

Participants were subsequently drafted from an online, global community of rhythm gamers to which the survey was distributed via Qualtrics. Participants were only eligible to fill out the survey if they had previous experience in both a dance pad rhythm game and Beat Saber. Before filling in the survey, participants were made aware that the collected data was anonymized to ensure their privacy. After this, the participants could start filling in the survey, starting from the demographics part, then moving to the beat alignment test, and finally the game experience questionnaire. As this was an online survey, it could be the case that the participants had not played one, or both, of the games recently. To combat this problem, participants were provided a video, showcasing the game there were about to fill in the corresponding game experience questionnaire for, to refresh their memories about the game and possibly evoke the emotional state corresponding to them actually playing the game (see appendix D). After watching the video, the participants could fill in the game experience questionnaire for the related game, first for Beat Saber and then for a dance pad rhythm game.

After completion of the survey, statistical analysis could be performed in R to answer the research questions. For this analysis, scores for categories needed to be compared between participants and games. These categories were derived from specific parts of the questionnaire and were: immersion (see Appendix D, "immersion"), enjoyment (see Appendix D, "enjoyment") and replayability/play again (see Appendix D, "play again"). For each of these categories a minimum and maximum score could be obtained, according to the Likert-scale point distribution. These minimum and maximum scores are listed in table 1.

Category	Number of questions pertaining the category	Minimum score for the category	Maximum score for the category
Immersion	14	14	98
enjoyment	2	2	14
Replayability/ play again	2	2	14

Table 1: Minimum and maximum scores per category of the questionnaire

For a more in depth analysis according to the specific dimensions of the Cognitive Absorption Questionnaire see "Acknowledgements".

Results

A total number of 63 participants fully completed the survey. Of these participants 12 were female, 49 were male and 2 did not identify as either male or female. Most of the participants were between 26 and 30 years old, Caucasian, had a residence in North America and had a Bachelor's degree as educational level. For a more complete overview, see figure 3.

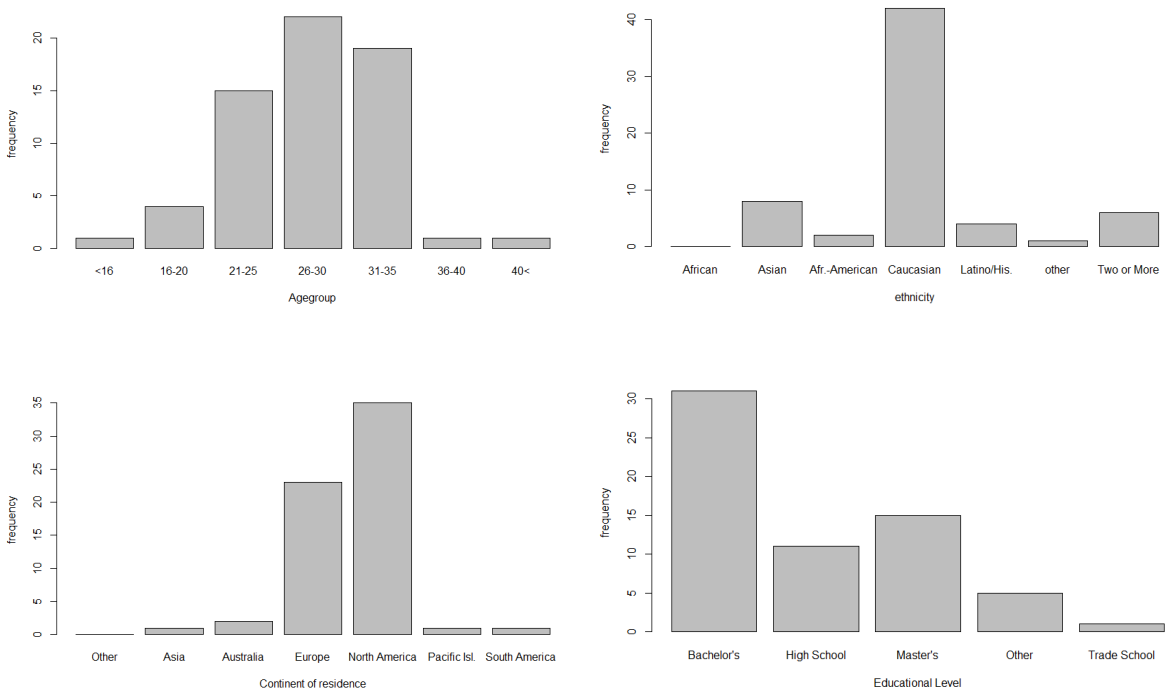

Figure 3: Participant's demographics: Age group (top left), ethnicity (top right), continent of residence (bottom left) and educational level (bottom right)

Moreover, participants had more experience playing a dance pad rhythm game compared to Beat Saber: The mean experience score for Beat Saber was 2.63 (std = 1.45) out of 7 and the mean experience score for a dance pad game was 5.95 (std = 1.30) out of 7.

To answer the main question: “In which type of game, VR or non-VR do players feel the most immersed and do they also find this game more fun and are they thus more likely to play this game again, opposed to the less immersive game?” the first objective was to compare the immersion scores for both games for each participant using a paired samples t-test, to check if differences in immersion between games was significant. The result from the t-test suggest that the difference in immersion participants felt was significant ($t(61) = -2.64$, $p < 0.05$, $CI95 = [-10.85, -1.50]$). The mean of the differences between the immersion scores was 6.18 and participants felt more immersed when playing a dance pad rhythm game (ITG or other similar game) compared to Beat Saber. Figure 4 shows the results in a boxplot.

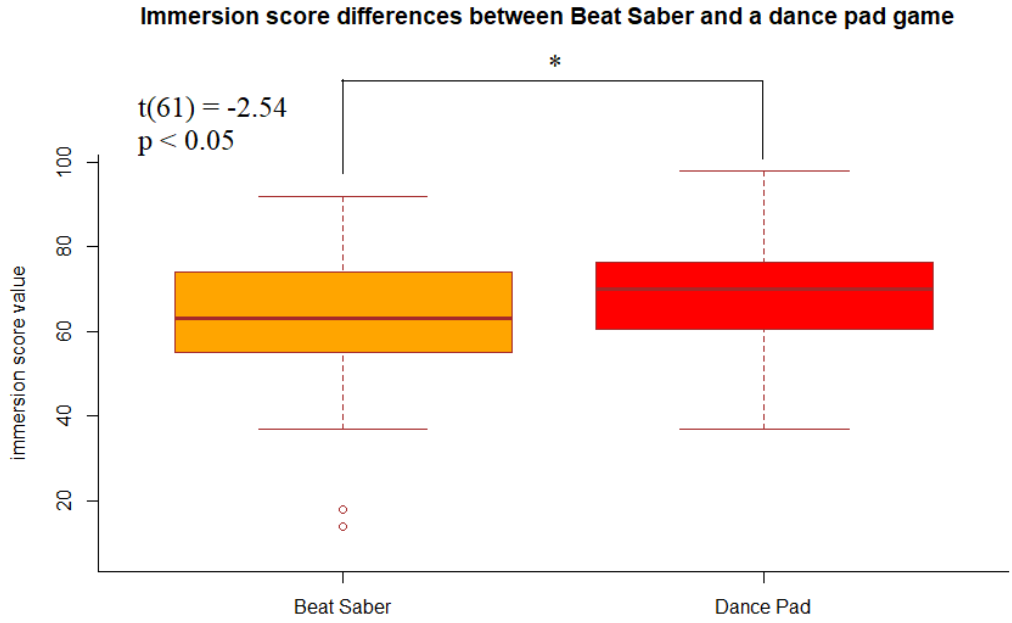

Figure 4: boxplot of immersion score differences: Beat Saber vs. Dance Pad scores. Minimum score = 14, Maximum score = 98. Mean difference = 6.18, $t(61) = -2.54$, $p < 0.05$.

Next, the enjoyment scores for both games for each participant were compared using a Wilcoxon Signed-Rank Test, as the data was non-normally distributed, to check if differences in enjoyment between games was significant. The Wilcoxon Signed-Rank Test indicated that the difference in enjoyment felt by participants was significant ($Z = 82$, $p < 0.005$). The mean difference between the enjoyment scores was 1.90 and participants enjoyed playing a dance pad rhythm game more compared to Beat Saber. Figure 5 shows the results in a boxplot.

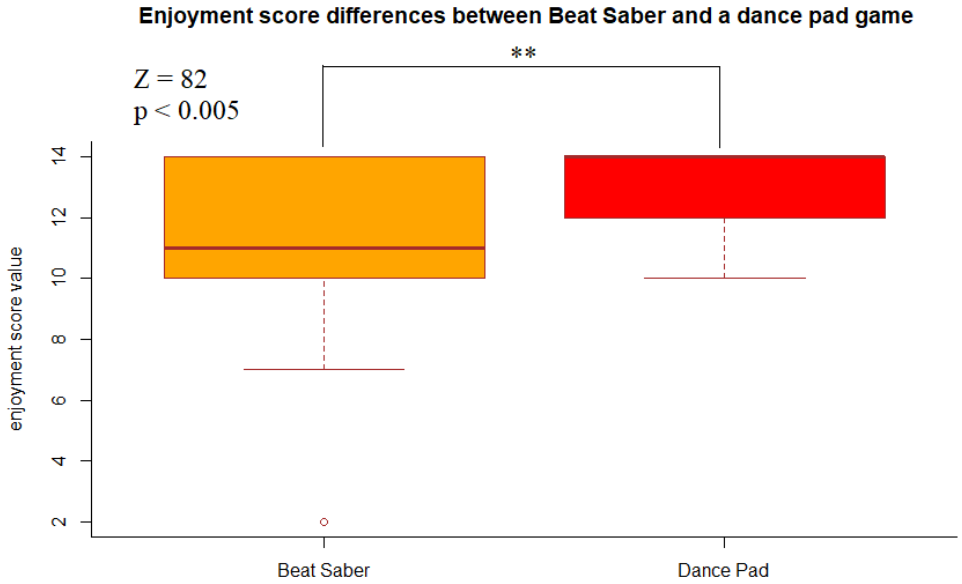

Figure 5: boxplot of enjoyment score difference: Beat Saber vs Dance Pad scores. Minimum score = 2, Maximum score = 14. Mean difference = 1.90, Z = 82, p < 0.005.

After this, play again scores for both games for each participant were compared using a Wilcoxon Signed-Rank Test, to check if differences in wanting to play the game again between games was significant. The Wilcoxon Signed-Rank Test indicated that the difference in wanting to play the game again was significant (Z = 124, p < 0.005). The mean difference between the play again scores was 1.83 and participants wanted to play a dance pad rhythm game again more compared to Beat Saber. Figure 6 shows the results in a boxplot.

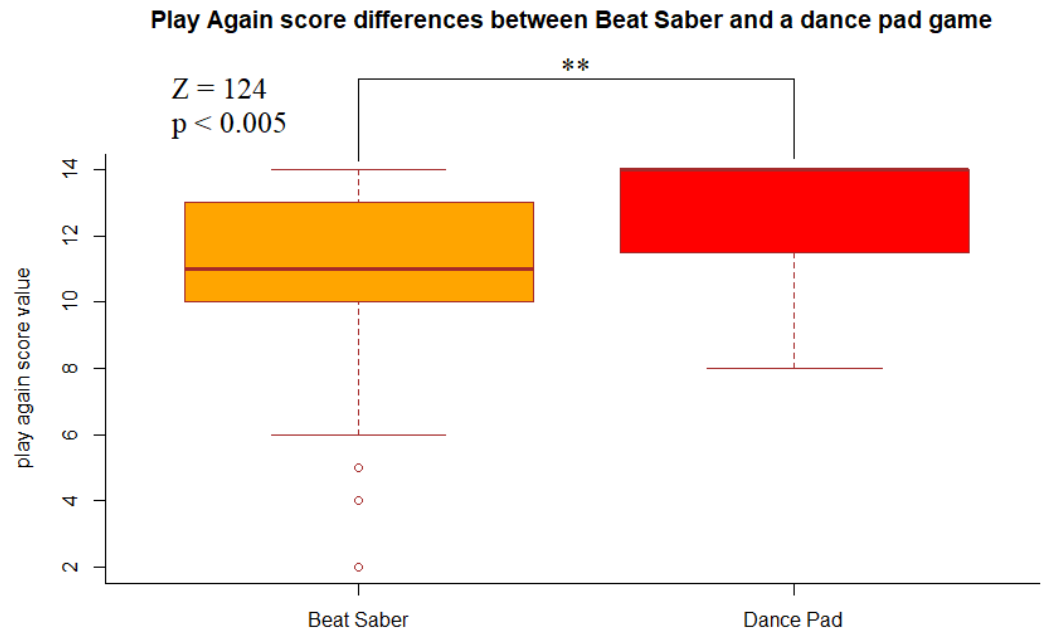

Figure 6: boxplot of play again score differences: Beat Saber vs. Dance pad scores. Minimum score = 2, Maximum score = 14. Mean difference = 1.83, Z = 124, p < 0.005.

Based on Spearman correlation tests, the correlation between immersion and enjoyment was significant for Beat Saber ($r_s = 0.68$, $p < 0.005$) and also for dance pad rhythm games ($r_s = 0.45$, $p < 0.005$). A visualisation of the correlations can be seen in figure 7.

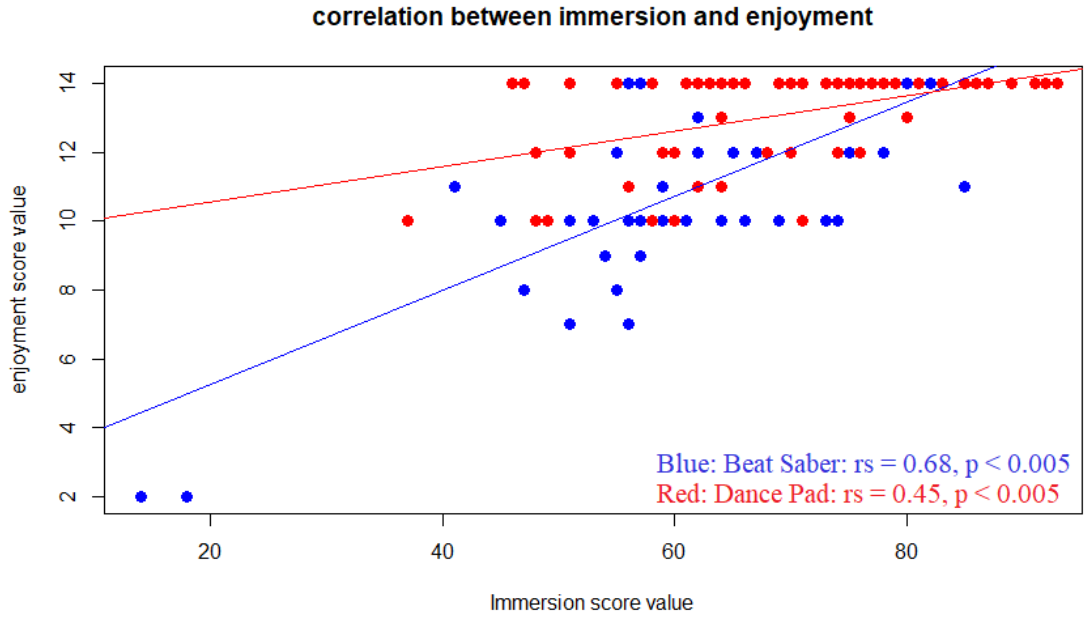

Figure 7: correlation plot: immersion vs enjoyment. Blue points and line: Beat Saber, $r_s = 0.68$, $p < 0.005$. Red points and line: Dance pad rhythm game, $r_s = 0.45$, $p < 0.005$.

Based on Spearman correlation tests, the correlation between immersion and wanting to play the game again was significant for Beat Saber ($r_s = 0.52$, $p < 0.005$) and also for dance pad rhythm games ($r_s = 0.27$, $p < 0.05$). A visualisation of the correlations can be seen in figure 8.

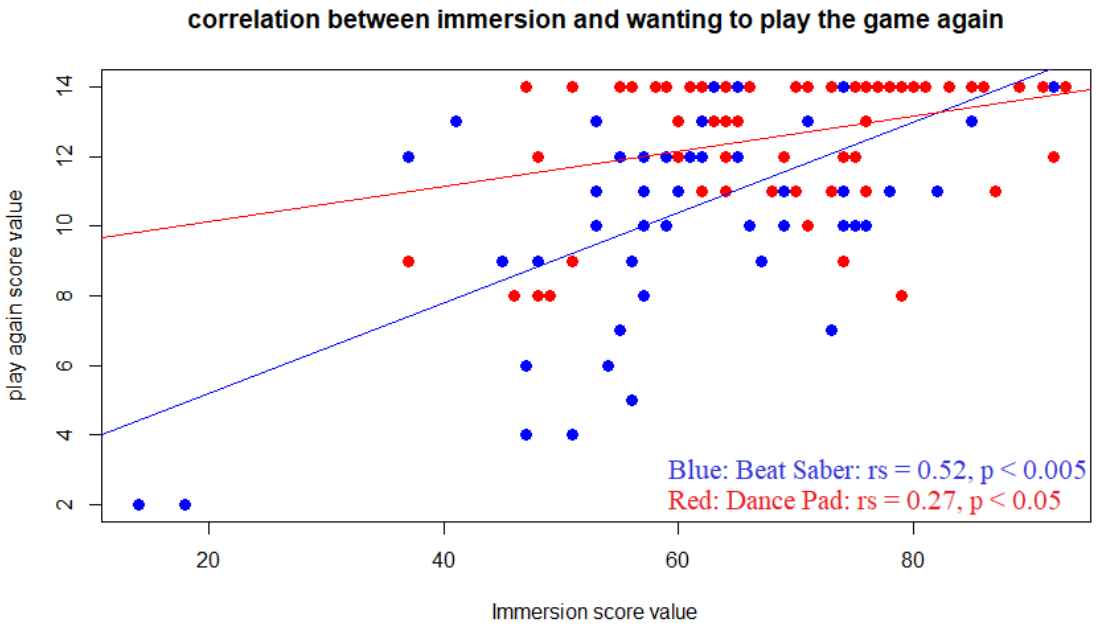

Figure 8: correlation plot: immersion vs wanting to play the game again. Blue points and line: Beat Saber, $r_s = 0.52$, $p < 0.005$. Red points and line: Dance pad rhythm game: $r_s = 0.27$, $p < 0.05$.

Based on Spearman correlation tests, the correlation between enjoyment and wanting to play the game again was significant for Beat Saber ($r_s = 0.75$, $p < 0.005$) and also for dance pad rhythm games ($r_s = 0.52$, $p < 0.05$). A visualisation of the correlations can be seen in figure 9.

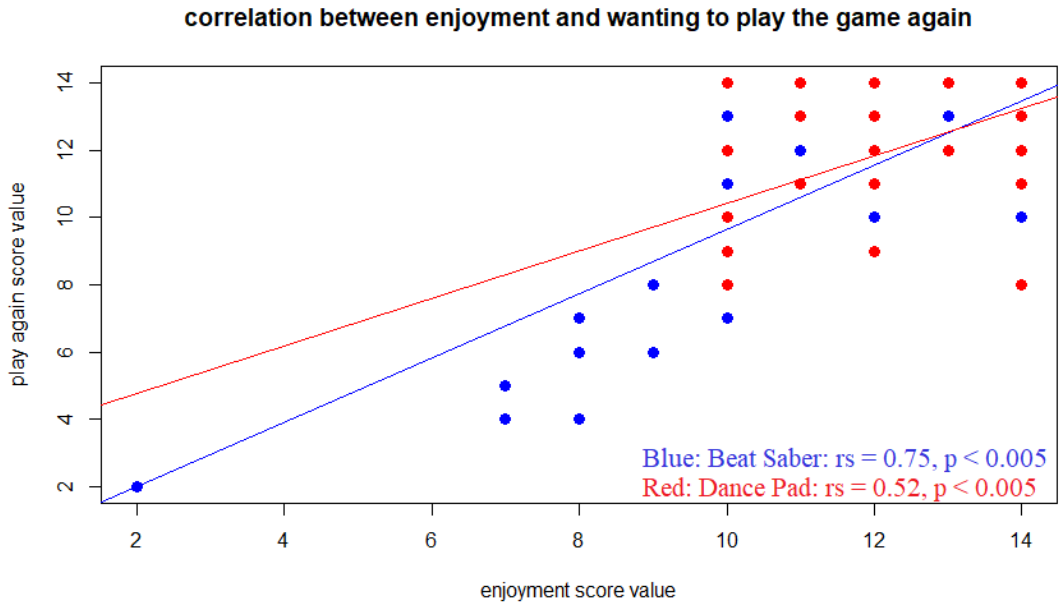

Figure 9: correlation plot: enjoyment vs wanting to play the game again. Blue points and line: Beat Saber, $r_s = 0.75$, $p < 0.005$. Red points and line: Dance pad rhythm game: $r_s = 0.52$, $p < 00.05$.

From the above, it can be gathered that there is indeed a significant correlation between immersion, enjoyment and wanting to play the game again for both games. Meaning that participants enjoyed the most immersive game most and also wanted to play the immersive game again the most. The game participants viewed as the most immersive and fun was a rhythm game played on a dance pad.

Musical abilities

To answer the sub-question "Is there a difference in game preference between people who have more musical experience (playing an instrument, singing, and so on) and people who have less musical experience?", it was first tested if there was a significant correlation between the self-assigned musical abilities of the participants and their number of correctly answered beat test questions. A spearman correlation test proved there was no significant correlation between the two ($r_s = -0.04$, $p = 0.74$), indicating that either participants did not rate their musical experience well or that the test was not a good indicator of musical ability, in contrast to what the literature suggested. The participant group was then split in two, according to their self-assigned musical ability score: The high musical ability group (participants with a self-assigned musical ability score of 5 and above out 7, 30 participants) and the lower musical ability group (participants with a self-assigned musical ability score of

4 and below out of 7, 33 participants). A two-way ANOVA was conducted that examined the effect of sports experience and game type on the enjoyment score. There was not a statistically significant interaction between the effects of musical ability on enjoyment ($F = 0.91$, $p = 0.34$). Moreover, the relationship between enjoyment score and the type of game does not depend on the musical ability of the player ($F = 0.12$, $p = 0.73$). These results are visualised in figure 12.

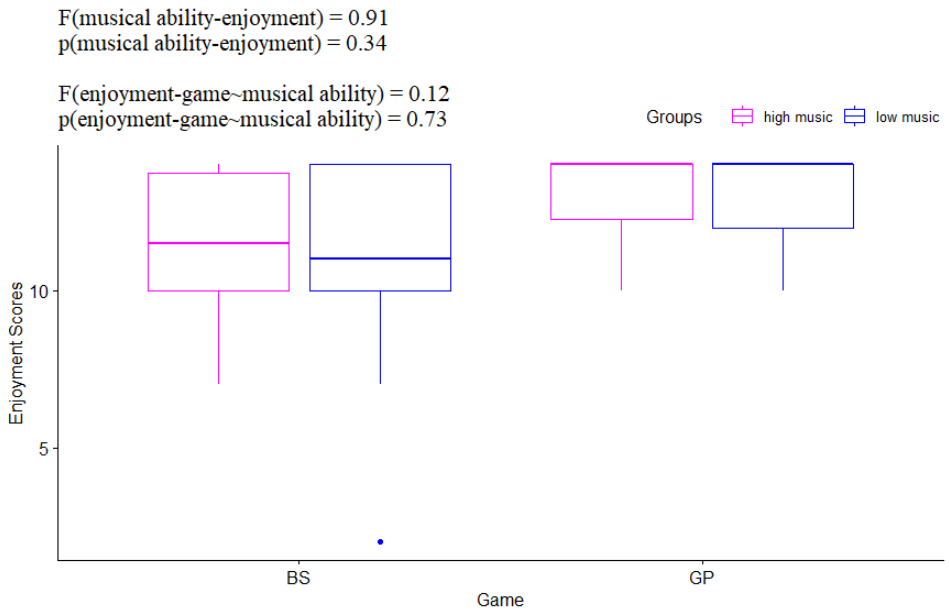

Figure 12: boxplots of enjoyment score differences between Beat Saber (BS, left) and Dance/Game pad Rhythm games (GP, right) according to musical ability. Minimum score = 2, Maximum score = 14. F(musical ability-enjoyment) = 1.12, p = 0.29. F(enjoyment-game~musical ability) = 0.03, p = 0.86.

Sports experience

To answer the sub-question "Is there a difference in game preference between people who have more experience in sports and people who have less experience in sports?" it was first tested if there was a significant correlation between the self-assigned sports experience and the amount of time people practice a (non-rhythm game) sport. A spearman correlation test proved that there was a significant correlation between the two ($r_s = -0.64$, $p < 0.005$). This means that people who on general practice sports more, also have given themselves a higher sports experience rating, as is to be expected. The participant group was then split in two, according to their self-assigned sports experience score: The high general sports experience group (participants with a self-assigned general sports experience of 5 and above out of 7, 23 participants) and the lower general sports experience group (participants with self-assigned general sports experience of 4 and below out of 7, 40 participants). A two-way ANOVA was conducted that examined the effect of sports experience and game type on the enjoyment score. There was not a statistically significant interaction between the effects of

sports experience on enjoyment (F = 1.12, p = 0.29). Moreover, the relationship between enjoyment score and the type of game does not depend on the sports experience of the player (F = 0.03, p = 0.86). These results are visualised in figure 13.

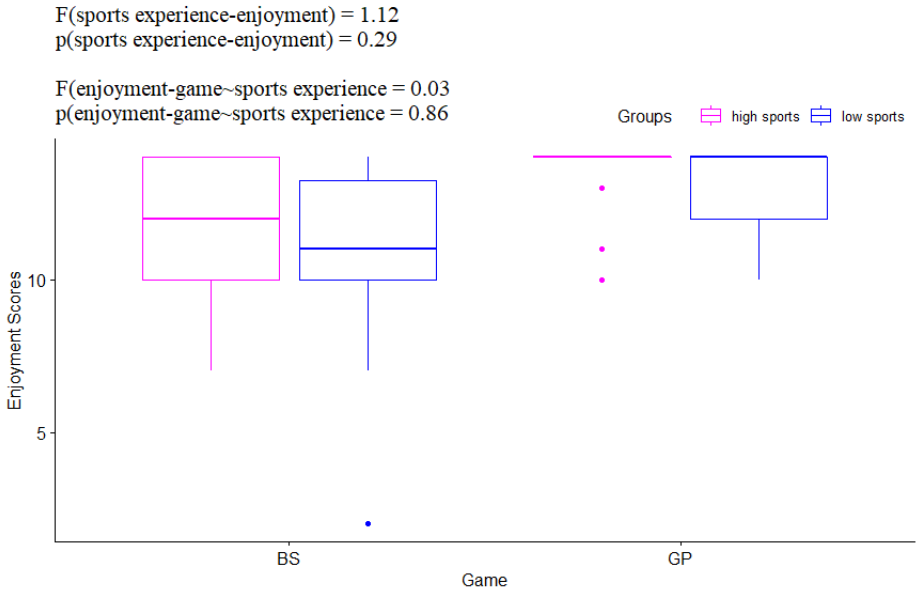

Figure 13: boxplots of enjoyment score differences between Beat Saber (BS, left) and Dance/Game pad Rhythm games (GP, right) according to sports experience. Minimum score = 2, Maximum score = 14. F(sports experience-enjoyment) = 1.12, p = 0.29. F(enjoyment-game~sports experience) = 0.03, p = 0.86.

Gender

To answer the sub-question "Is there a difference in game preference between male and female players?", the participant group was split in two according to gender to obtain two groups: The female group (12 participants) and the male group (49 participants). Participants that did not identify as either female or male were omitted, as there were only 2, which is too few to perform analysis on. A two-way ANOVA was conducted that examined the effect of gender and game type on the enjoyment score. There was not a statistically significant interaction between the effects of gender on enjoyment (F = 1.23, p = 0.27). Moreover, the relationship between enjoyment score and the type of game does not depend on the gender of the player (F = 1.77, p = 0.19). These results are visualised in figure 14.

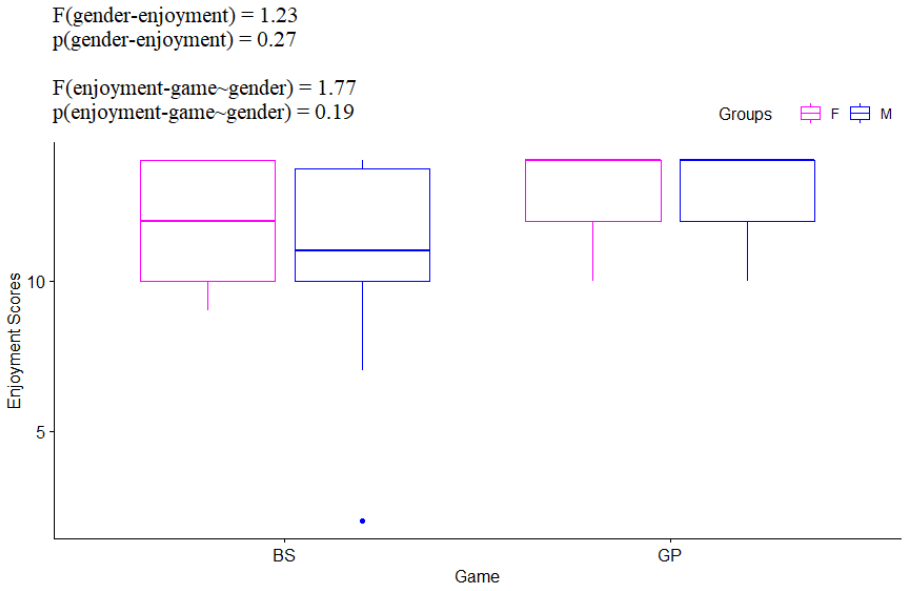

Figure 14: boxplots of enjoyment score differences between Beat Saber (BS, left) and Dance/Game pad Rhythm games (GP, right) according to gender (F = female, M = male). Minimum score = 2, Maximum score = 14. F(gender-enjoyment) = 1.23, p = 0.27. F(enjoyment-game~gender) = 1.77, p = 0.19.

Discussion

To find out which type of game, a VR rhythm game (Beat Saber) or a non-VR rhythm game (ITG, DDR, Pump it Up, etc.), players feel the most immersed in and if this more immersive game is felt as more enjoyable and replayable, analysis was performed to check if the differences between games were significant and if there was a significant correlation between immersion, enjoyment and feelings of wanting to play the game again. It turned out that there were indeed significant differences between the games for immersion, enjoyment and feelings of wanting to play the game again and there was also a significant correlation between all of these items. From this it could be concluded that a rhythm game played on a dance pad (such as ITG, DDR, Pump It Up, etc.) was felt to be more immersive, enjoyable and replayable, compared to the VR game Beat Saber, according to the responses of the participants. The finding that the more immersive game would also be the most enjoyable is not surprising, as this phenomenon of more immersive games being more enjoyable to play has been proven previously (Fu, 2009). It is also not surprising that people would want to play the more enjoyable game again more compared to the game they enjoyed less. What is surprising, is that the participants find the dance pad rhythm game more immersive compared to Beat Saber, as one would expect that a VR setting would be felt as a more immersive environment than a non-VR setting. That a VR environment is more immersive than a 2D environment was already proven by Egan, et al. (2016), so the finding that for this study this

doesn't seem to be the case, causes some questions. There are however, some explanations for this being the case in this particular study.

A first reason for this finding could be that the immersion that was tried capture, was actually not captured as intended. As can be seen from previous studies, trying to determine what immersion is exactly, is very tricky and challenging (Cairns, 2004). Therefore it could be that not the immersion in the game environment was captured, but just the immersion into the task, without concern for the game environment. Clearly separating these two measures is not an easy job to do, especially using questionnaires. Making use of more physical measurements as was done by Egan et al. might be useful to separate the two. However, there likely needs to be more research into how different aspects of immersion could be measured.

A second reason for the finding that not the VR game, but the non-VR game was more immersive in this case, is that the participant group was very biased. As can be seen from the responses, most of the participants were a lot more experienced with playing the dance pad rhythm game compared to Beat Saber (a mean experience score of 5.95 out of 7 for a dance pad rhythm game versus a mean experience score of 2.63 out of 7 for Beat Saber). A reason for the results could thus be that people feel more immersed in a game they are more experienced in. If you have a lot of experience in a game, you have likely invested quite a lot of time into it, making you more invested into the game and therefore also likely more immersed. You might feel that the stakes are higher or that you are more invested into improving, making it necessary to immerse yourself into the game more. However, as of now, there has been no study that examines this phenomenon.

From the results it could also be seen that there seems to be no significant difference in game preference between the analysed different subgroups: gender, general sports experience, and musical ability. Detailed analysis between the subgroups, showed that there was no interaction between the effect of gender on the perceived enjoyment and the relationship between perceived enjoyment and the type of game does not depend on the gender of the player. The same is true for both the amount of general sports experience and the musical ability of the player.

Another interesting finding was that the scores for the Beat Alignment Test (BAT), which were intended as a test measure for musical ability, did not seem to correlate with the self-assigned musical ability score. This means that either the test was too simple to measure musical ability, or that people are not that adept in rating their own musical abilities. Seeing as only a small part of the BAT was used, it seems most likely that the administered test was too simple a measure to objectively test participants' musical ability. In previous literature,

the BAT test was found to be an affective measure of musical ability (Musil, 2014), however, there the whole BAT was administered, likely accounting for the different finding in the current study. As the test was most probably too short and simple, participants' self-assessed musical ability was used instead of the simplified-BAT test score as the measure for musical ability.

Shortcomings and Future studies

Some important notes to address are the participant pool and the way the data was collected for the study. As mentioned before, the participant group was very homogeneous; largely male, Caucasian, living in America, and a lot more experienced playing a dance pad rhythm game compared to Beat Saber experience. This was due to way in which there was sampled: via convenience sampling with the social media platforms Discord and Whatsapp. Collecting data this homogeneous is not desirable for most studies, including this one. The original design of the study was different, to prevent this homogeneity from happening. This original design was: Gather as many participants as possible, from different age ranges, genders, ethnicities, and so on, such so that the group would be balanced. None of these participants should have played either type of game before. Then, during data collection, the participants would play both games for the first time and then fill in the same survey as was developed for this study. In this way, all biases that were now present within the participant group, would be eliminated as much as possible. Another problem that would be addressed within the original design, is the time between gameplay and filling in of the questionnaire. During this study, participants could fill in the questionnaire long after they had actually played the game, which could affect the responses they give, as memory is not always perfect. Moreover, there was no way to assess if participants had actual experience in both games and that they didn't just make up their experience. In the original design, time between gameplay and filling in of the questionnaire would be minimized and researchers would have been present during gameplay, circumventing these problems. However, due to the Covid-19 situation, this originally planned design could not be used. It would thus be interesting for a future study to actually perform the original design.

Additionally, some other future study that could be of importance is a study into the different kind of aspects of immersion, as from this research it might be concluded that it was not exactly clear what aspect of immersion was measured and how it could be assured that the aspect you are interested in is measured. Previous studies have also indicated that this is a problem, so further research into this topic might be necessary to improve measurements of immersion. Another possible interesting future study linked to immersion, is a study that links

feelings of immersion to the amount of experience people have with a certain task. As can be seen from this study, the reason that people might find a task more immersive opposed to another could be because they have more experience with the former and less with the latter. To make sure that this is indeed the case, specialized studies would need to be developed that test this hypothesis.

Lastly, as the developed questionnaire based on the Game Experience Questionnaire (BrockMyer, 2009) and Cognitive Absorption Questionnaire (Agarwal, 2000) was completely new, some further studies that check the effectiveness of the questionnaire need to be performed. Checking if all the dimensions of Cognitive Absorption have been successfully incorporated, while also checking that the main essence of the Game Experience Questionnaire is still present, is important if the developed questionnaire would be incorporated in future studies. These studies could, with the help of the developed questionnaire, offer new insights into a more cognitive based assessment of gameplay experience.

Conclusion

To answer the main research question: “In which type of game, VR or non-VR, do players feel the most immersed and do they also find this game more fun and are they thus more likely to play this game again, opposed to the less immersive game?” survey responses were collected and analysed. The games that were compared were the VR rhythm game Beat Saber and the non-VR rhythm games played on a dance pad, such as ITG, DDR, Pump It Up, and so on. From this analysis it could be concluded that there is indeed a correlation between immersiveness, enjoyment and feelings of wanting to play the game again. Surprisingly, the game that was felt as the most immersive, and thus also the most enjoyable and replayable, was not the VR rhythm game Beat Saber, but the non-VR rhythm game played on a dance pad. This finding could be because immersion was not correctly captured in the questionnaire or that a game that people have more experience with is also felt as more immersive, as the participant group consisted of people with more experience playing dance pad rhythm games opposed to Beat Saber. The other important findings were: there was no significant difference in game preference between people with high musical ability and people with lower musical ability, there was no significant difference in game preference between people with high general sports experience and people with lower general sports experience, and there was no significant difference in game preference between people with a different gender.

Further studies need to be conducted to correct for some previously described shortcomings of the current study and more knowledge into the domain of human-computer interaction needs to be obtained in order to develop more insights into the cognitive aspects of human behaviour and immersion. Moreover, to check if the developed questionnaire is indeed a sufficient, new way to measure gameplay experience with a more cognitive focus, future studies need to be developed that test it.

Self-Reflection

During this project, the main thing I learned was to come up with a proper research question, based on existing literature, and to be flexible while developing your research methods, due to the Covid-19 situation. In the beginning I was too focused on a small part of what would eventually become my research question and broadening my horizons to look further and deeper into the literature was something that my supervisor has thought me during the project. During my previous study, Chemistry, delving very deeply into the literature to come up with a research question was not focussed upon much, as you usually just participated in the research that your supervisor did, answering some sub-question or helping them out with a part of their research. This means that actually coming up with a wholly original question yourself was somewhat of a new experience for me, which I think was very useful for the future. Furthermore, learning to adapt your original ideas to an unforeseen situation was also very important for this particular thesis, as Covid-19 made it impossible to perform the originally planned experiments with participants. Dealing with the stress that this caused, while also staying focussed on how either the research question or the experimental methods could be changed was, in the end, a useful experience, as I now feel confident I could handle such a situation better. I feel sure that I would be able to stay calm and focus on the things that are still possible in a limiting situation.

Something I also learned was to develop a questionnaire based upon existing ones; picking out the questions that were useful for my project and filtering out those which were not relevant and then adapting them to better suit my own goals. Moreover, my knowledge of analysis techniques, which I had previously learned in the course Statistics, was refreshed and further expanded. I now know much more about which type of test can be used for a particular kind of data, especially after incorporating the feedback into the second version of my thesis report. At first I did not understand why some statistical test would be applicable for some data, but after processing feedback and further examination of the techniques, my understanding of these techniques began to grow. This knowledge, I am sure, will be very

useful for further projects I will be a part of, as statistics is usually a very important part for the results of any academic research.

Acknowledgements

Firstly, I would like to thank my partner for this thesis project, Amy van Bijsterveldt. We developed our research method together, making sure that both our research questions could be answered using the same questionnaire. For that end, both of us did not need all the questions to answer our individual research question, but we managed to find a good balance and combination for the survey. Amy focused more on the Cognitive Absorption part of the questionnaire, so for a more detailed analysis of the five dimensions of Cognitive Aborption, please consult her paper. Secondly, I would, of course, like to thank my supervisor, Dr. Maryam Alimardani, who was always there to answer my questions and made sure we stuck to the schedule by organising regular meetings. Even during the Covid-19 lockdown, she always made sure to check in on the progress and quality of my research. And lastly, I would like to thank all the people that participated in the online survey and provided both Amy and me with enough data to complete this project!

References

Sherman W.R. & Craig A.B. (2019). *Understanding Virtual Reality: Interface, Application, and Design* (2nd ed.). Cambridge, Morgan Kaufman Publishers.

Agarwal R. & Karahanna E. (2000). *Time flies when you're having fun: Cognitive absorption and beliefs about information technology usage 1*. MIS Quarterly, 24(4) (p. 665-694).

Rollings A. & Adams E. (2003). *Andrew Rollings and Ernest Adams on Game Design* (1st ed.). Indianapolis, New Riders Publishing.

Beat Saber. (2018). Retrieved March 05, 2020, from https://www.cultuurconnect.be/sites/default/files/inline-files/Dig%20it%20Up%20_%20Teksten%20Gameroom.pdf

In The Groove 2 (2020). Retrieve March 05, 2020, from: https://en.wikipedia.org/wiki/In_the_Groove_2

Prahm C. et al. (2017). Increasing motivation, effort and performance through game-based rehabilitation for upper limb myoelectric prosthesis control. *2017 International Conference on Virtual Rehabilitation (ICVR).* DOI: 10.1109/ICVR.2017.8007517

Soszynski F. et al. (2016). *Music games as a tool supporting music education.* Lodz, Offset printing “Quick-Druk”. Computer Game Innovations (p. 116-132).

Pichlmair M., Kayali F. (2007). Levels of Sound: On the Principles of Interactivity in Music Video Games. *Situated Play, Proceedings of DiGRA 2007 Conference.* DOI: 10.1.1.190.2004

Yi J., Lai J. (2017). Virtual Reality Rhythm Game. *Santa Clara University Scholar Commons.* Retrieved from: https://pdfs.semanticscholar.org/41a5/68400cdbbdfbc6bbf9dd67e7013289aaf511.pdf

Egan D. et al. (2016). An evaluation of Heart Rate and ElectroDermal Activity as an objective QoE evaluation method for immersive virtual reality environments. *2016 Eighth International Conference on Quality of Multimedia Experience (QoMEX).* DOI: 10.1109/QoMEX.2016.7498964

Edwards A.D.N. et al. (2000). Development of a standard test of musical ability for participants in auditory interface testing. *Proceedings of the International Conference on Auditory Display (116-120).*

Wallentin M. et al. (2010). The Musical Ear Test, a new reliable test for measuring musical competence. *Learning and Individual Differences, Volume 20, Issue 3 (188-196).* DOI: 10.1016/j.lindif.2010.02.004

Denisova, Alena & Nordin, A. Imran. (2016). The Convergence of Player Experience Questionnaires. *CHI PLAY '16 The annual symposium on Computer-Human Interaction in Play 33-37.* DOI: 10.1145/2967934.2968095.

Harmon-Jones C. et al. (2016). The Discrete Emotions Questionnaire: A New Tool for Measuring State Self-Reported Emotions. *PLoS One (11(8)).* DOI: 10.1371/journal.pone.0159915

Brockmyer J.H. et al. (2009). The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. *Elsevier, Volume 45, Issue 4 (624-634).* DOI: 10.1016/j.jesp.2009.02.016

Abbasi A.Z. et al. (2017). Engagement in Games: Developing an Instrument to Measure Consumer Videogame Engagement and Its Validation. *International Journal of Computer Games Technology, Volume 2017.* DOI: 10.1155/2017/7363925

Norman K.L. (2013). GEQ (Game Engagement/Experience Questionnaire): A Review of Two Papers. *Interacting with Computers, Volume 25, Issue 4 (278-283).* DOI: 10.1093/iwc/iwt009

Saadé, R., & Bahli, B. (2005). The impact of cognitive absorption on perceived usefulness and perceived ease of use in on-line learning: an extension of the technology acceptance model. *Information & management, 42(2), 317-327.*

Zhang, P. & Li, N. (2004). The Importance of Affective Quality. *Communications of the Association for Computing Machinery (CACM), 48(9), 105-108.*

Neguț, A., Jurma, A. M., & David, D. (2017). Virtual-reality-based attention 16 assessment of ADHD: *ClinicaVR: Classroom-CPT versus a traditional continuous performance test. Child Neuropsychology, 23(6), 692-712*.

Sepehr, S., & Head, M. (2011). The role of competitiveness in the cognitive absorption of video games. *The 10th Pre-ICIS Annual Workshop on HCI Research in MIS*.

Laver K.E., et al. (2017). Virtual reality for stroke rehabilitation. *Cochrane Database of Systematic Reviews 2017, Issue 11*. Art. No.: CD008349. DOI: 10.1002/14651858.CD008349.pub4.

Freeman D., et al. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine, 47*(14), 2393-2400. doi:10.1017/S003329171700040X

Fogarty J. et al. (2018). Improving Student Understanding of Complex Spatial Arrangements with Virtual Reality. *Journal of Professional Issues in Engineering Education and Practive, 144(2).* doi: 10.1061/(ASCE)EI.1943-5541.0000349

Anderson R., et al. (2016). Jump: virtual reality video. *ACM Transactions on Graphics.* Art. No.: 198. Doi: 10.1145/2980179.2980257

Bastug E., etal. (2017). Toward Interconnected Virtual Reality: Opportunities, Challenges, and Enablers. *IEEE Communications Magazine, vol. 55, no. 6, pp. 110-117*. Doi: 10.1109/MCOM.2017.1601089

Drey T., et al. (2020). Towards Progress Assessment for Adaptive Hints in Educational Virtual Reality Games. *CHI EA '20: Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems.* Doi: 10.1145/3334480.3382789

Jang Y. & Park E. (2019). An adoption model for virtual reality games: The roles of presence and enjoyment. *Telematics and Informatics, vol. 42.* Doi: 10.1016/j.tele.2019.101239

Hart J.D., et al. (2018). Emotion Sharing and Augmentation in Cooperative Virtual Reality Games. *CHI PLAY '18 Extended Abstracts: Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts.* Doi: 10.1145/3270316.3271543

Iversen J.R. & Aniruddh P. (2008). The Beat Alignment Test (BAT): Surveying beat processing abilities in the general population. *Proceedings of the 10th International Conference on Music Perception and Cognition (ICMPC10).*

Musil J.J. et al. (2014). Measuring individual differences in musical beat alignment perception. *Personality and Individual Differences, Volume 60, Supplement.* DOI: doi.org/10.1016/j.paid.2013.07.079

Qualtrics Experience Management Software (2020). Retrieved May 12, 2020, from: https://www.qualtrics.com/nl/lp/brand-demo-request/?utm_source=google&utm_medium=ppc&utm_campaign=brand+exact+nl&campaignid=789362366&utm_content=&adgroupid=68041558015&utm_keyword=qualtrics&utm_term=qualtrics&matchtype=e&device=c&placement=&network=g&creative=338378122773&gclid=EAIaIQobChMIp-SWi5Su6QIVjLt3Ch1R8AVXEAAYASAAEgJGxfD_BwE

Fu F.L., et al. (2009). EGameFlow: A scale to measure learners' enjoyment of e-learning games. *Computers & Education, Volume 52, Issue 1, pp 101-112.* Doi: 10.1016/j.compedu.2008.07.004

Cairns P. & Brown E. (2004). A grounded investigation of game immersion. *Extended abstracts on Human Factors in Computing Systems, pp. 1297-1300.* Doi: 10.1145/985921.986048

Appendices

Appendix A

Demographics Questionnaire

1. What gender do you identify as?

a. Male

b. Female

c. Other: _____

2. How old are you?

a. 0-15 years old

b. 16-20 years old

c. 21-25 years old

d. 26-30 years old

e. 31-35 years old

f. 36-40 years old

g. 41+ years old

3. Please specify your ethnicity.

a. Caucasian

b. African-American

c. Latino or Hispanic

d. Asian

e. Native American

f. Native Hawaiian or Pacific Islander

g. Two or More

h. Other/Unknown

4. Where is your home located?

a. North America/Central America

b. South America

c. Europe

d. Africa

e. Asia

f. Australia

g. Caribbean Islands

h. Pacific Islands

i. Other: _____

5. What is the highest degree or level of education you have completed?

a. High School

b. Bachelor's Degree

c. Master's Degree

d. Ph.D. or higher

e. Trade School

f. Other: _____

6. On a scale of 1 to 7 (1 being the least amount of experience and 7 being the most), how much experience do you feel you have with sports in general, excluding rhythm games

(do you practice a sport on a general basis or did you use to do this?). Please mark the answer you find the most appropriate.

1 2 3 4 5 6 7

7. In general, how often do you practice a sport now (excluding rhythm games).

a. A few times a week

b. About once a week

c. About once every month

d. A few times throughout the year

e. About once a year

f. Less than once a year

8. Did you receive any form of music education **for at least three years**, at some point in your life?

a. Yes b. No c. Unsure

9. {if yes to Q8} What musical instrument did you learn to play? Please provide the name of the musical instrument(s). If you have taken another form of music education (e.g.: singing lessons, participating in a choir, etc.) please describe this to the best of your ability. [textbox]

10. {if yes to Q8} On a scale of 1 to 7 (1 being the worst and 7 being the best), how would you rate your **general** musical abilities? This includes perceived sense of rhythm, the level of skill in playing the above mentioned musical instrument(s), etc. This does **not** include how often you listen to music and/or how often you play your musical instrument.

1 2 3 4 5 6 7

11. On a scale of 1 to 7 (1 being the least amount of experience and 7 being the most), how much experience do you feel you have with the game ‘’In The Groove’’, “Dance Dance Revolution”, “Stepmania”, “Pump It Up” or another rhythm game played on a gamepad? Please mark the answer you find most appropriate.

1 2 3 4 5 6 7

12. In General, how often do you play this game?

a. A few times a week

b. About once a week

c. About once every month

d. A few times throughout the year

e. About once a year

f. Less than once a year

13. On a scale of 1 to 7 (1 being the least amount of experience and 7 being the most), how much experience do you feel you have with the game “Beat Saber”? Please mark the answer you find most appropriate.

1 2 3 4 5 6 7

4. In General, how often do you play this game?

a. A few times a week

b. About once a week

c. About once every month

d. A few times throughout the year

e. About once a year

f. Less than once a year

Appendix B

Sound clips for the Beat Alignment Test (from the BAT test of Iversen & Patel) Can be downloaded from: https://www.researchgate.net/publication/228483453_The_Beat_Alignment_Test_BAT_Surveying_beat_processing_abilities_in_the_general_population, under Supplementary resources: BAT Test v.2.0 stimuli.

Beat Alignment Test – Part 1 : OWA_B20_v2.wav (off-beat)

Beat Alignment Test – Part 2 ACL_B0_v2.wav (on-beat)

Beat Alignment Test – Part 3 : KPS_B20_v2.wav (on-beat)

Beat Alignment Test – Part 4 : KPS_B20_v2.wav (off-beat)

Beat Alignment Test – Part 5 : SMA_B20_v2.wav (off-beat)

Beat Alignment Test – Part 6 : PAN_B0_v2.wav (on-beat)

Beat Alignment Test – Part 7 : RRW_B_20_v2.wav (off-beat)

Beat Alignment Test – Part 8 : NYN_B0_v2.wav (on-beat)

Appendix C

Combination of the Game Engagement Questionnaire and Cognitive Absorption Questionnaire

All these questions need to be answered on a scale of 1 to 7 (1 = don't agree at all and 7 = agree very much) and are about how you experienced the game (Beat Saber or a rhythm game on a dance pad). Please think about a session playing the game and then fill in this questionnaire.

Immersion:

1. Time appears to go by very quickly when I am playing the game
2. Sometimes I lose track of time when I am playing the game
3. Time flies when I am playing the game
4. Most times when I start playing the game, I end up spending more time than I had planned originally
5. Most times when I play the game, I do not want to stop
6. While playing the game, I am able to block out most other distractions
7. While playing the game, I am absorbed in what I am doing
8. While playing the game, I feel immersed in the environment
9. When playing the game, I do not get distracted by other attentions very easily
10. While playing the game, my attention does not get diverted very easily
11. While playing the game, I couldn't tell if I was getting tired
12. While playing the game, I lost track of where I was
13. While playing the game, things seemed to happen automatically
14. While playing the game, I really got invested into the game

Control:

15. When playing the game I feel in control
16. The controls of the game felt easy to grasp
17. The controls of the game felt natural
18. Playing seemed automatic

19. I felt competent playing the game

Curiosity:

20. Playing the game excites my curiosity
21. Playing the game arouses my imagination

Enjoyment:

22. I have fun playing the game
23. I enjoy playing the game

Play again:

24. I would like to play this game again
25. I would like to play this game more often than I do now

Appendix D

Video used for showcasing Beat Saber and ITG

Beat Saber: Emperor's New Clothes by Panic! At the disco | Gameplay | Beat Saber, uploaded by Beat Saber Official (2019).
https://www.youtube.com/watch?time_continue=2&v=niL2Q6Ot_eg&feature=emb_logo

In The Groove: DCS2 High Qualifier: 9000 Miles, uploaded by Kamecro (2018).
https://www.youtube.com/watch?v=dute1BY1MGc&feature=emb_logo

Copyright and collaboration

This project was done in collaboration with Amy van Bijsterveldt. The questionnaire was developed together with her and she was mostly concerned with incorporating the Cognitive Absorption Questionnaire into our survey. For a more elaborate analysis of the cognitive side of our questionnaire, please check out her thesis.

Obtaining more knowledge about differences in player experience could, next to an academic interest, be useful for companies that develop games. Knowing what kind of games people prefer, could help companies decide on what type of game should be developed to be the most profitable and most effective for use in work related settings; business, education, etc.

Another important subject that will be addressed in this thesis is the development of a more cognitive approach to videogame player experience measurements. This is an interesting approach to develop, as most player experience questionnaires that are currently used, don't focus much on the cognitive aspects of gaming (Denisova, 2016), namely temporal dissociation, focussed immersion, heightened enjoyment, curiosity, and the feeling of being in control (Agarwal, 2000). These aspects provide an ability to evaluate overall user experience

and pinpoint which aspects to enhance to improve it. For this end, a novel type of assessment combining traditional game experience questionnaires and cognitive absorption questionnaires was developed.