The Impact of Co-Located Play on Social Presence and Game Experience in Virtual Reality Games

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ABSTRACT

As virtual reality (VR) in digital games is making a return, this explorative study looks at the scenario of VR gaming in a social setting. The question is raised whether physical proximity during gameplay - co-located play - has an impact on game experience and social presence when compared to playing from separated locations. To answer this question, we asked 17 pairs of participants (N=34) with prior social connection to each other to play a two-player VR game using head mounted displays (HMDs). Two conditions were tested and compared to each other: playing in the same room, and playing in separated rooms. During the game, players would interact with each other in a shared virtual environment, and by talking to each other either directly (same room) or via an intercom (different rooms). Our results indicate that there is no difference between testing conditions. We conclude that current VR technology can facilitate a multi-user game experience over large distances that is experienced the same way as if it were played co-located.

INTRODUCTION

Digital games have spearheaded a trend of immersion - to make people increasingly engaged with the experiences designers craft for them. This has been attempted through the development of a wide range of technologies, special hardware, and visual aesthetics. One of the most recent trends in digital game technology is the use of virtual reality (VR) devices. Early efforts in the 1990s had already provided users with stereoscopic VR devices such as Nintendo's *Virtual Boy* and the *Virtuality* arcade system developed by W. Industries, but ultimately failed to gain much traction. With recent developments such as the *Oculus Rift* and *Google Cardboard* it seems VR is making a return as a game interface with improved and more affordable technology.

This study was the result of a question that arose while user testing a VR game ('Little VR Pet Shop' [18], shown in Fig. 1); the question of whether physical presence has an impact on game experience and social presence. When two people share a virtual world, does their physical proximity have an impact on the experience? Or is being connected through virtual reality on its own as effective as being close to one another in the real world?

Virtual reality through head mounted displays (HMDs) promises to put the user's mind into a different world, free from many of the restrictions of physical reality. The experience is immediate, for the user is placed inside the virtual environment, rather than looking at an interpretation of said environment on a screen. The simulation interfaces almost directly with the senses, much like philosopher and cognitive scientist Daniel Dennett describes in his famous thought experiment "Where am I?" [12]. While there are many proposed use cases of VR (such as medical training purposes, therapy, and military simulations), one of the most culturally prominent is the area of entertainment and, more specifically, digital games.

Parallel to the progress of virtual reality technology, digital games have become more socially oriented than during the first wave of virtual reality devices, where only a handful of games (such as 'Dactyl Nightmare' [38]) offered this. In the past this focus on the social aspect of gaming was seen mostly in consoles, with co-located play in front of a shared display. Computers went more for an approach of one player per device, possibly due to their control devices being intended for a single person, and connecting multiple players through a network. With the rise of the internet, games were able to offer the possibility of connecting with other players over large distances. Nowadays, even single player games offer features such as sharing achievements, thereby adding a social component to the game.

Seeing this increased emphasis on social components in gaming, it is plausible that future VR games will likely involve social facets as well. Virtual reality technology is very well suited to emphasize the experiential aspects that make digital games captivating for players, and prior research has indicated that the feeling of immersion increases when accompanied by social presence [6].

Does that mean we are looking at a future in which games are played by people in physical solitude, connected only by technology? Not necessarily. Research suggests [6] that social presence is stronger when players play co-located, despite the fact that their focus is not face-to-face as is the case with board games for example. In fact, immersion, another dimension explored by the same study, was shown to not be affected by this. A possible explanation for this is the fact that in multiplayer situations there is the component of out-of-game conversation and reflection, as well as the possibility to taunt each other. These aspects are often found in board

Figure 1: *Screenshot of the game environment.*

games as well, but are not typically part of digital games. However, if such interactions increase the degree of social presence among players, then a case could be made to turn the attention to co-located VR games that offer players a similar experience. This is what we have explored in this study, using the game that sparked the initial interest in this topic.

RELATED WORK

Virtual reality (VR), also often referred to as virtual environments (VE) in academic sources, is a human-computer interface paradigm that originated from vehicle simulation and teleoperation technology from the 1960s [15]. It is defined by the visual representation of computer generated, three-dimensional content, in a way that interactively responds to the head position of a viewer to mimic visual spatial cues of objects in reality [5]. Although VR frequently involves stereoscopic, head mounted displays (HMD), 'cave automatic virtual environments' [9] and 'fish tank virtual reality' [39] share the same properties using different display methods. The use of VR technology has been researched in a wide range of fields: for training purposes [27], data visualization [5], industrial prototyping [10], phobia treatment [17], education [29], art [2], and entertainment [30] among others.

Within the game industry, virtual reality might not always follow the academic definition, as is evident with products such as Nintendo's *Virtual Boy*, which offers stereoscopic view, but no head tracking. Also, general consumers may use the term to refer to the virtual worlds offered by digital games rather than the interface technology that is used to mediate between the user and the virtual environment. For the purpose of this paper 'VR' in games refers to the academic definition described above, used in context with digital games.

As the technology required to compute and display VR environments is becoming more ubiquitous and accessible, VR-enabled applications can be created by small teams or even individuals [37, 32]. Especially the development of the *Oculus Rift*, a VR HMD released to developers in 2012 but ultimately aimed for the consumer market, has led to what could be considered a renaissance of VR [21]. Since then, similar devices such as Sony's *Morpheus* or HTC/Valve's *Vive* have been developed and will soon compete for the attention of bringing VR to a wide audience. With the release of Google's *Cardboard* in 2014, Google launched a low cost VR case that would transform a wide range of smartphones into VR HMDs. While the cardboard case was only available to attendees of Google events, many third-party developers have released replicas, making *Cardboard* one of the most affordable VR platforms to date.

Looking at VR in terms of its effects on the human user, the main aspects that are widely mentioned tend to be immersion or presence, which describe the feeling of simulated spatial awareness or in other words 'being there'. A feeling that is generally considered desirable [30]. These terms are also frequently used in the context of digital games, in which case they may alternatively refer to the experiential aspects of game mechanics or narrative. Studies have looked at how these terms are used by the gaming population, and found that it described a general degree of involvement [4]. Calleja [7] proposed the term 'incorporation', which he described as "the absorption of a virtual environment into consciousness, yielding a sense of habitation, which is supported by the systemically upheld embodiment of the player in a single location represented by the avatar".

Another term that is used in context with both digital games and VR is 'social presence', which refers to the acknowledgement of a user's existence by other actors within the virtual environment [34]. While early VR work focused on a single user, research efforts as early as 1990 went into the possibility of sharing virtual spaces with another person [3]. Subsequent studies described the use of VR technology for utilitarian purposes - such as collaborative [16] tasks - but also as extensions to social interactions between people [8]. Within digital games, social interactions are frequently part of the player experience, whether such interactions were co-located [36, 24] or facilitated by Internet technology [20, 25]. So far there has not been a study that looked at social interactions of players within a VR game.

However, one research examined the relationship between social presence and co-located play [6]. They found that social presence was rated higher when players were co-located in the same room than when they were not. It could be reasoned that a similar difference would be found if a game would be played using a VR interface. Whether or not that is the case, is at the center of this study.

RESEARCH QUESTION & HYPOTHESIS

The central question of our study is whether playing a multi-user VR game is experienced differently when played from separated locations as compared to co-located play. We specifically look for differences in how the game is experienced by its players, and how they perceive their social presence.

Based on what is known from prior research, we hypothesize (H1) that factors indicating social presence will be higher for co-located play than for playing from separated locations. Our null hypothesis (H0) is therefore that there is no difference between the two conditions. As far game experience

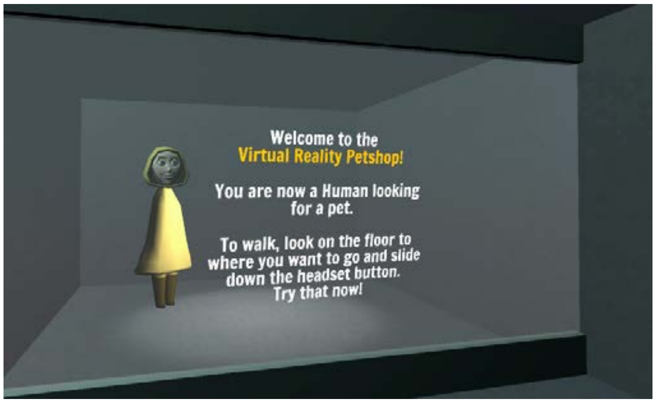


Figure 2: *Screenshot of the tutorial area for the 'mysterious stranger' or simply 'human' character, shown from the characters' perspective.*

Figure 3: *Illustration showing the dog and fish appearances that animal players can take on. The illustration was shown to players taking the role of the human after each game round to identify the animal opponent.*

factors are concerned, we assume that they will be less impacted, but follow the same trend, showing higher ratings in co-located play for positive factors.

METHOD

Our research should be considered an explorative study, based on investigating potential differences in game experience and social presence in a case study involving a single game. We opted for within subject testing in our experiment in order to allow changes in the experiment environment between experiment sessions. This also meant that variances in player behavior, personality, and interpersonal connection between players, would be less likely to affect our measures unevenly. We also considered it important that the experiment environment would reflect the way in which people would play if they were not part of an experiment.

The VR Game

We conducted our study using the game that motivated it in the first place: 'Little VR Pet Shop' (see Fig. 1), a two-player VR game that was originally designed to provide a 'board game like' experience in the form of VR gaming. The intention of the designers (one of which is the author of this study) was to create a social VR game experience in which players would frequently communicate with each other, involving elements of banter and playful psychological manipulation or 'mind games'. These aspects are often found in board games where players compete against each other and where even the requirement of timely actions leaves players with enough time to comment on each other's progress [40]. While the design of the game was aimed specifically at co-located play, the question came up whether players would perceive their interactions as socially less engaging if they were not in physical proximity, which in turn would cause them to have a different game experience. This question yielded polarizing answers from the designers and ultimately led to this study.

Premise and Design

In the game, two players play against each other, assuming the roles of either the 'mysterious stranger' (also referred to as 'human') character or the 'animal' character, which can be either a dog or a fish. Both players share the same virtual environment - the titular pet shop - but perceive it from individual, first person perspectives, corresponding to their virtual characters.

The goal of the player in the role of the human character is to find out which of the animals in the shop is controlled by their opponent. For this, the human player has a maximum of five minutes, at which point the shop closes and a choice must be made. Human players can interact with animals in the game to elicit actions that could lead animal players to give themselves away. The goal of the animal player is to blend in among seven computer controlled animals and remain unidentified for the duration of a game round, which can be reduced by performing risky tricks that motivate the shopkeeper to close early.

Apart of in-game interactions, the game is designed with out-of-game interactions in mind. Players could use such interactions for their advantage, such as misleading the human player when playing as an animal, to have them make a wrong choice. An interesting strategy was observed in early test session where a human player made the animal player laugh and then looked for which animal character's head shook rhythmically in the virtual environment.

Both human and animal characters are controlled through head movements and a single button input.

Technical Considerations

The game was created using the *Unity* game engine, with VR support provided by the *Google Cardboard SDK*. The target platform was *Android* (using *Google Cardboard* as HMD) for the client side of the game and *OSX* for the server side, which handles networking between the devices as well as game logics and AI computation for computer controlled animals. The server view is shown on a regular display and is operated by an impartial game master, or in the case of our study, an experimenter.

One of the most important technical requirements for the game was to maintain a high frame rate on the mobile target platform. Apart from reducing the fluidity of on-screen motion, and thereby negatively impacting the visual aesthetics, a low frame rate can also cause motion sickness in players [26]. This meant that the visual and computational complexity had to be restricted wherever possible. During our experiments the game ran at an average frame rate of 40-50 fps.

Another aspect that had to be considered was the possibility of network delay. Especially when testing gameplay between physically separated players, the chance of packet loss increases. To reduce the amount of visual glitches caused by such interferences, we interpolated between position updates that were synchronized over the network. Discrete game interactions, such as button presses, were buffered to ensure a successful synchronization in case of packet loss.

Iterative Changes

Before using the game for our study, a few aspects were modified in response to early user testing, as well as to make the experiment process easier. In the original version of the game, players were not able to see themselves, which meant that animal players did not know their specific visual appearance. Animal players did not know whether they had been correctly identified or not without confirmation through the server view. To remedy this, we added a mirror to the tutorial area of the game (see Fig. 2). Another modification was to give players the ability to choose their character within the VR interface instead of using on-screen buttons. Before this change, players had to remove their head mounted display in order to select their characters for the next game round. Other changes included a clearer visual distinction between animal textures, a change in the virtual layout of the pet shop, improvements in lighting and texture quality, and addition of the ability for animal players to reduce the amount of time humans would have to find them.

Hardware

To conduct our experiment, we used two laptops (one running the server, another one as second input terminal for the questionnaire) and two smartphones (*Nexus 5* running *Android 5*) that were inserted into *Google Cardboard* (see Fig. 4) cases. Each of the smartphones was connected to a mobile battery pack to extend the amount of time the game could be run before having to recharge. Open headphones (i.e. not providing an acoustic seal around the wearer's ears) were used to provide each player with their own sound environment, while ensuring that communication between the players would be possible. Finally, a wireless router was used to establish a network between the server and the two client devices.

Experiment Conditions

In our study we tested two experiment conditions: playing the VR game within the same room, and playing from different rooms (see Fig. 5). Participants played both conditions in succession, separated by about 10-15 minutes of time to answer the questionnaire for the first game session (see Fig. 6). The order in which the conditions were played was

Figure 4: *'Google Cardboard' VR headset with opened phone compartment. The mobile phone on the left is inserted into the compartment with the display facing the lenses.*

Figure 5: *Graph illustrating the condition groups and setup throughout the four game rounds of a testing session.*

switched after each experiment session to control for potential influences due to experimentation order. When playing in the same room, players were able to communicate by directly talking to each other. When playing from different rooms, an intercom application was used in the background to facilitate voice chat between the players. In both conditions, players had to communicate with each other in order to agree on who would take the role of the human character, as well as communicate with the game master to indicate when they were ready to start or ready to identify which animal character was played by the opponent.

Sampling

Our study involved a total of N=34 valid participants that fully completed the experiment. Ages ranged from 20 to 68 (Mdn=26.0, SD=11.02) with a gender distribution of 50% female and 50% male. A combination of snowball and purposive sampling was used as player pairs had to have a prior social connection with each other to participate in the study. This decision was made as prior studies have shown that social play between strangers differs from that of players who know each other [33]. We also argue that it most closely reflects the real world condition if the game was played outside of a research context.

Measurements

To measure whether or not players experienced the game differently under the two experiment conditions, we used the Game Experience Questionnaire (GEQ) [22] choosing the questionnaire modules 'core' and 'social presence' [11]. While the publication outlining the GEQ [22] has not been published yet, the questionnaire can be requested from the involved researchers. A considerable number of peer reviewed publications [1, 13, 31], including one by the author of this study [19], have used the GEQ to quantify aspects of game experience and social presence.

The core module of the GEQ consists of 33 questions - the social presence module consists of 17 questions. Each of the modules combines certain questions to form the component scores 'Competence', 'Immersion', 'Flow', 'Tension & Annoyance', 'Challenge', 'Negative Affect', and 'Positive Affect' for the core module, and 'Empathy', 'Negative Feelings', and 'Involvement' for the social presence module. All questions are phrased as personal statements, such as "I thought about other things", and are scored on a 5-point Likert scale with the descriptive values 'not at all', 'slightly', 'moderately', 'fairly', and 'extremely'.

In addition to the GEQ, players were asked to rate their enjoyment of the game on a 11-point Likert scale (ranging from 'not at all' to 'extremely'). These measures were used in early user testing and would provide a reference for the improvement (or lack thereof) in response to the performed modifications. Players were also asked at the end, which of the two conditions they preferred in case they had a preference ('no preference' was a valid option), which character role they enjoyed the most, and whether or not they would want to play the game again (allowing the answers 'yes' or 'no').

PROCEDURE

Tests were carried out over the duration of four weeks and took place in a variety of locations. Requirements for testing locations were 1) a central room with enough space for the experimenter and server setup, as well as chairs for the participants with enough space around them to move freely, 2) another room far enough from the central room so that participants would not be able to hear each other through the walls, and 3) the possibility to create a network that reached both testing rooms. To this end we tested people in Leiden University, NHTV University of Applied Sciences, and in various participants' homes.

The laptops, one that ran the server application and one that was used as a secondary input station for the questionnaire, were set up in the central room. In this room two chairs were also placed for the participants. An additional chair was placed in the extra room and in both rooms there was a printed sheet with the possible animals so that human players could indicate their choice at the end of the game round. The headphones and battery packs were connected to the mobile phones. A sound volume check was done for the game and (in case of testing in different rooms) the intercom application that ran in the background. The *Google Cardboard*s were also prepared, but the phones were not inserted until the player roles for the first round had been decided upon.

Participants were asked beforehand to watch a short video showing the game and read the rules online. At the time of the test, they were welcomed into the central room and asked to read and sign consent forms. This was followed by another, more extended, explanation of the test setup, the game rules and the controls, using the *Google Cardboard* as a visual aid. Participants were also encouraged to act like they would while playing a game together in a non-testing environment. Once both participants understood the game rules and the testing procedure, they were asked to decide amongst themselves who would be playing as a human in the first round and to take place in the chairs (either in the same room or separate rooms, depending on the starting condition), where the experimenter helped them in putting on the HMDs and headphones. While testing in different rooms a second experimenter was always present in the second room.

Participants played three rounds, during the first of which they were guided a bit more by the experimenter. The choice of whether to play as a human or animal had to be put in manually by the experimenter before play could commence for this round. At the start of each round, players were brought into the tutorial space, where they were encouraged to try out their controls. When ready, they relayed this to the experimenter, who would then start the game. At this point participants entered the virtual pet shop and the five-minute timer began. The round would end with a) the human player telling the experimenter they wished to take a guess at the other player's identity, or b) with the timer running out (either at five minutes or earlier, depending on whether the animal player used any tricks). During the game the experimenter could observe both players on the server screen, as well as see which of the eight animals was being controlled by one of the players.

At the end of the round the human was asked to look at a graphic with the eight possible animals and pick which one they thought was controlled by the other player. Players were told if the guess was correct or not, and then asked to put the HMDs back on. From the second round onward players could choose from an integrated VR menu which role they wanted to play in the next round, rather than having it input by the experimenter. They still had to discuss amongst themselves who would play which role.

After three rounds the HMDs were removed and the participants filled in the questionnaire, which took about ten minutes. Sometimes, depending on how participants were feeling, this break ran a bit longer. The condition was switched and players were helped again in putting on the HMDs, after which they played another three rounds, followed by another questionnaire.

When testing in different rooms, the participants could hear each other over the headphones through an intercom app that used the phone's microphone. The second experimenter was present to help the participant in the other room when needed. This participant was able to hear the experimenter controlling the server over the intercom as well, but had to indicate their guess or when they were ready by telling the participant still in the central room, who could then relay the message to the first experimenter.

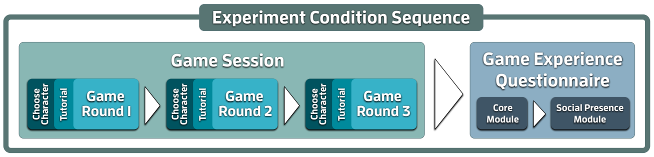


Figure 6: *Flowchart showing the procedure for an experiment condition.*

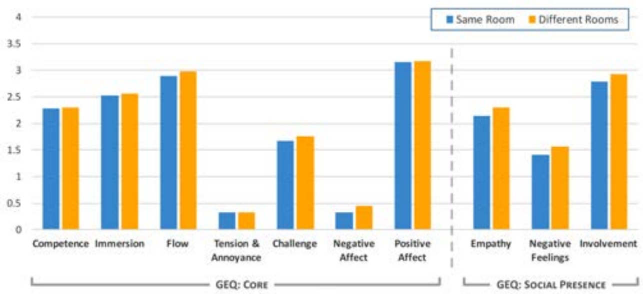


Figure 7: *Graph showing the aggregated results of the separate Game Experience Questionnaire (GEQ) components for the two experiment conditions.*

RESULTS

For our statistical analysis we used the Bayesian paired samples t-test [35] as it allows researchers to accept the null hypothesis instead of merely rejecting it, and offers a straightforward, transparent description of the likelihood of a hypothesis over the null hypothesis.

Answers from the GEQ were combined to create component scores ranging from 0 to 4. The aggregated results of each experiment condition ('same room' and 'different rooms') can be seen in Fig. 7. While some components show differences in the scores between conditions, evaluation of the data shows that the difference is not significant in any of the scores. The same result can also be seen in the measure of self reported enjoyment, which is not part of the GEQ. The analysis provides 'moderate' [23] evidence in support of H0 where BF_{10} is smaller than 0.33, as is shown in Table 1. Generally, a BF_{10} of 1.0 would mean that H1 is as likely as H0, while 0.33 means that H0 is three times more likely than our hypothesis H1. To recall, our research hypothesis (H1) was that there would be a significant difference, pointing to increased social presence when playing co-located. Conversely, the null hypothesis (H0) is that there is no difference between the two conditions.

A sequential analysis, provided by the statistics software JASP [28], is shown in Fig. 8 for the components 'Empathy' and 'Immersion' to illustrate how the Bayes factor is updated as more data points are added. While some plots show an unclear trend (see Fig. 8a), most plots provide stronger evidence for H0 as more data points are added (see Fig. 8b). This clear trend in the data points also suggests that the sample size used in our study is sufficient to reject H1 and accept H0.

Questionnaire Component	BF_{10}
CR: Competence	0.185
CR: Immersion	0.201
CR: Flow	0.403
CR: Annoyance	0.184
CR: Challenge	0.247
CR: Negative Affect	0.367
CR: Positive Affect	0.186
SP: Empathy	0.623
SP: Negative Feelings	0.611
SP: Involvement	0.381
Non-GEQ: Enjoyment	0.186

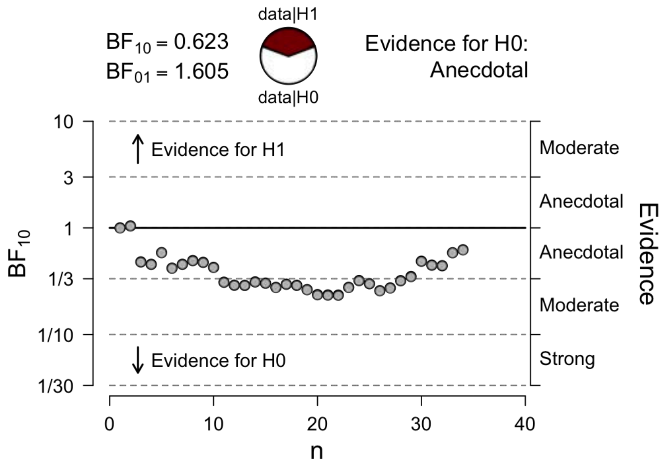
Table 1: *Bayesian Paired Samples T-Test of GEQ core (CR) and social presence (SP) components. The component 'Enjoyment' was not part of the GEQ and was added to allow a comparison with early testing sessions that included the measure. Each component is paired for the conditions 'same room' and 'different rooms'*

In addition to game experience and social presence, we gathered data on player preferences and game metrics. When asked after the experiment which playing condition participants enjoyed the most, a small majority (38.2%) stated to have had no preference, while 32.4% preferred playing in the same room, and 29.4% preferred playing in different rooms. When participants were asked whether they would play the game again, 94.1% answered with 'yes'. In terms of game metrics, a total of 102 game rounds were played (3 rounds per condition, 6 rounds per player pair) in which players in the role of the animal character won 63.7% of the time (human character 36.3%). When taking control of the animal character, the fish character was chosen in 52.9% of the game rounds (dog character 47.1%). While players were not required to alternate between who would take the role of the animal and human character, the overall count of all game rounds had player A (an arbitrary designation given to the player with the lower participant number in an experiment) in the role of the human player 46.1% of the time. This means that, on average, players decided to take turns rather than sticking to a role.

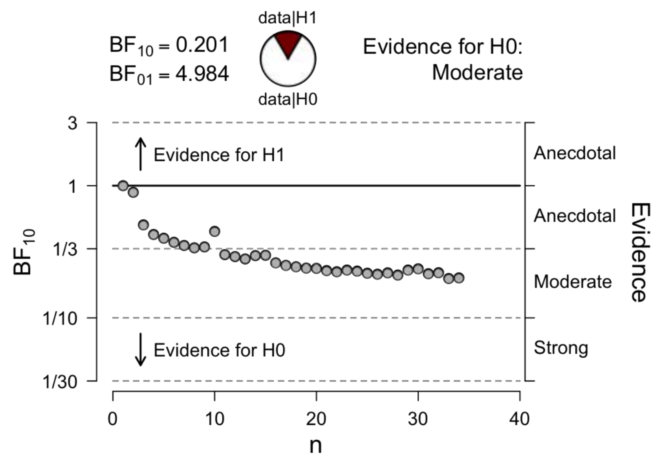
DISCUSSION

The result of our statistical analysis suggests that there is no difference between playing our VR game in the same room versus in different rooms, i.e. in physical separation. A comparison of the individual questionnaire components 'Competence', 'Immersion', 'Annoyance', 'Challenge', 'Positive Affect', as well as self-reported 'Enjoyment' results in moderately strong ($BF_{10} < 0.333$) evidence that there is no difference (H0), while the rest of the components provide only anecdotal ($BF_{10} = 0.333 ... 1.0$) evidence for the same statement.

This outcome is surprising, given that prior research [6] found that social presence would be increased for co-located play when compared to playing from different locations. It is pos-



(a) Sequential analysis of the 'Empathy' component.



(b) Sequential analysis of the 'Immersion' component.

Figure 8: *Sequential analysis graph plots for two components of the GEQ*

sible that the use of HMDs in our study is responsible for closing the experiential difference caused by physical proximity of the players. This would mean that the addition of head tracking and a stereoscopic view raises the feeling of incorporation [7] enough to let players ignore each other's physical presence as far as their game experience is concerned.

However, another explanation could be that our study offered players the ability to talk to each other in both conditions, which was not the case in the aforementioned research [6]. The games that were used in that study did not offer native voice chat functionality, and were played from separated locations from which the players could not communicate with each other. It is plausible that the researchers felt that the addition of voice chat would change the intended gameplay. While this does not diminish the results of that study, we argue that voice chat is a common feature in a wide range of computer and console games, and as such should be included when researching the impact of co-located play.

At this point we should also note that it is difficult to generalize results that are based on a single game. Different types of games and their gameplay afford varying levels of player-to-player communication. However, the design of the game used in our experiments asked its players to specifically pay attention to each others behaviorisms; this is an aspect that is not generally the case for other games. It stands to reason that games with a focus on other elements, such as enemy behavior or maintaining a tactical overview, would provide even less potential for finding differences in social presence when playing co-located. As such we consider the results of our study in regards to social presence applicable for multiplayer VR games in general.

The results of our study show, based on GEQ scores and additional questions, that participants generally enjoyed the game and that they would have chosen to play again. While we have not attempted to quantify the amount and quality of communication that occurred between players, we observed that players interacted frequently with each other with no apparent inclination for one of the conditions. This suggests that our results are not hampered by unsatisfactory gameplay (which might have made our results unrepresentative) or lack of player-to-player communication (in which case the lack of difference could stem from the gameplay discouraging players from making their presence felt to each other).

Lastly, what stood out in our experiment sessions was the fact that many players did not identify themselves as 'gamers' and expressed their surprise about how much they enjoyed the game. While this has not been explored further in this study, it appears that players in this study considered virtual reality gaming as something that would be primarily intended for those who often engage with digital games.

CONCLUSION

This research has started with a simple assumption based on design intuition and indicative prior research: the idea that players in a VR game, using HMDs, will have a significantly different game experience and feel higher social presence than if the players would be in separate locations. The results of this study however provide evidence that this is not the case. This also seems to reflect the preferences of the players involved, considering that the majority of players stated that they had no preference between the two conditions, and those who did were split evenly among the other two options.

Given the results of this study, it seems that multi-player VR games are not impoverished by restricting communication between players to virtual visual representations. Considering the wide range of social online games, this could mean that embracing virtual reality through HMDs creates an experience that not only incorporates players into a shared virtual world, but also brings them closer to each other. Especially if developers create casual game experiences, VR multi-player could be a remediation of the board game experience that has traditionally served as social activity and continues to do so to this day - maybe even stronger than ever [14].

We have included vocal communication in both conditions, arguing that the ability to talk to each other is a common feature in multi-player games. Further studies could further explore the role of vocal communication in VR games, which might provide insight into its impact on game experience and social presence. Especially the involvement of 3D sound, meaning the virtual positioning of sound sources, could enhance the feeling of incorporation into the virtual environment. Other interesting aspects that warrant further research are the exploration of multi-player VR games with more than two players, as well as mixed-reality multi-player gaming (either through augmented reality applications or by connecting VR players with non-VR players), to name just two of the many further questions that emerged over the course of this study.

Finally, ongoing developments - especifically in the area of games - show that there is wide support and interest in VR among researchers, developers, and most importantly, consumers. Not only is it a way to create fantastic worlds free from physical constraints - it is a world in which we can bring those along who are closest to us, even if they are far away.

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