

# The Impact of Co-Located Play on Social Presence and Game Experience in a VR Game

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## ABSTRACT

This exploratory case study looks at the scenario of virtual reality (VR) gaming in a social setting. We raise the question whether game experience and social presence (measured through a questionnaire) are impacted by physically separating players versus co-located play. We asked 34 participants to play a two-player VR game using head mounted displays in which they shared a virtual environment. We compared two conditions: 1) playing in the same physical space, allowing direct communication between players and 2) playing in separated rooms, with communication via intercom. Our results indicate no differences between the two testing conditions. Based on this, we conclude that current VR technology can facilitate a multi-user game experience, played from separate locations, that is experienced as if it were played co-located. We see the outcome of the study as an encouragement for designers to involve social elements in online, multi-user VR games.

## Keywords

virtual reality games, social gaming, multiplayer gaming, head mounted displays, player incorporation

## INTRODUCTION

Digital games have spearheaded a wide range of technological advances, frequently focusing on advancing visual aesthetics and novel interfaces as a way to immerse people in experiences that designers have crafted for them. One of the most recent trends in digital game technology is the use of virtual reality (VR) devices. Early efforts in the 1990s 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. The study presented in this paper was motivated by a question that arose during early user testing of the VR game *Little VR Pet Shop* (shown in Figure 1); the question whether physical presence has an impact on game experience and social presence. When two people share a

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**Figure 1:** Screenshot of the game used in this study.

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? To get closer to answering these questions, we asked participants to play the game; measuring their game experience (that is to say, the affect resulting from interacting with a game) and social presence through a questionnaire.

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, as 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 (1981) describes in his thought experiment "Where am I?". 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*) 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 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 (Cairns et al. 2013).

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. Prior research by Cairns et al. (2013) suggests 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. 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. However, given that HMDs effectively confine the visual focus of players to the virtual world, would their game experience and social presence actually be impacted by whether or not they share the same physical space? This is what we explore in this study, using the game that sparked the initial interest in this topic.

## RELATED WORK

Virtual reality (VR) is a human-computer interface paradigm that 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 (Bryson 1996). Although VR frequently involves stereoscopic, head mounted displays (HMD), ‘cave automatic virtual environments’ (Cruz-Neira et al. 1993) and ‘fish tank virtual reality’ (Ware et al. 1993) share the same properties using different display methods. Within the game industry, virtual reality might not always follow the aforementioned definition, as is evident with products such as the discontinued *Virtual Boy*, which offered 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. In this paper we focus on VR as an interface paradigm, displayed through a HMD, and used to interface with a digital game.

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 (Verbeeck and Sterckx 2014; Oculus VR 2015). Especially the development of the *Oculus Rift* has led to what could be considered a renaissance of VR (Heaven 2013). With the release of *Google Cardboard* in 2014, Google launched a low cost VR platform that enabled a wide range of smartphones to be turned into VR HMDs, further lowering the entry barrier for audiences to engage with this kind of interface.

Looking at VR in terms of its effects on the human user, the main aspects that are frequently mentioned are ‘immersion’ or ‘presence’, which describe the feeling of simulated spatial awareness or in other words ‘being there’; a feeling that is generally considered desirable (Morie 2006). 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 (Brown and Cairns 2004). Calleja (2013) 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 acknowledgment of a user’s existence by other actors within the virtual environment (Riva et al. 2003). 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 (Blanchard et al. 1990). Subsequent studies described the use of VR technology for utilitarian purposes - such as collaborative tasks (Galambos et al. 2012) - but also as extensions to social interactions between people (Calvert 2014). Within digital games, social interactions are frequently part of the player experience, whether such interactions were co-located (Szentgyorgyi et al. 2008; Kaye and Bryce 2012) or facilitated by Internet technology (Griffiths et al. 2003; Kolo and Baur 2004). So far there has not been a study that looked at social interactions of players within a VR game that is mediated through a HMD.

However, one research examined the relationship between social presence and co-located play (Cairns et al. 2013). They found that social presence was rated higher when players were co-located in the same room than when they were not. While participants in that study did not use HMDs, 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 AND HYPOTHESIS

**The central question of our study is whether players of a multi-user VR game find their game experience or social presence to be significantly impacted by playing from physically separated locations versus playing co-located.**

Based on indicative findings by Cairns et al. (2013), we hypothesize (H1) that factors indicating social presence will be higher for co-located play than for playing from separated locations. Although the research is not fully comparable, as the aforementioned study did not involve HMDs, it provides the same argumentative framework for why social presence could be impacted by co-located play. Our null hypothesis (H0) is therefore that there is no difference between the two conditions. As far as game experience factors are concerned, we assume that they will have less impact, 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.



(a) In-game appearances of the player roles: (A) Human, (B) Fish, and (C) Dog. (b) Character card that was shown to human players to identify the animal opponent.

**Figure 2:** Character appearances in the game.

## The VR Game

We conducted our study using the game that motivated it in the first place: *Little VR Pet Shop* (see Figure 1), a two-player VR game that was originally designed to provide a ‘board game like’ experience in the form of a VR game. The intention of the designers 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 (Xu et al. 2011). 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. The game has been evaluated prior to this study by 34 test players, who rated the game in terms of enjoyment ( $N=34$ ,  $M=8.44$ ,  $SD=1.52$  - ratings ranged from 0, ‘not at all’ to 10, ‘extremely’) and provided additional feedback regarding their game experience. Based on the results of these early evaluations we were confident that the majority of participants would be engaged in their interactions with the game, thus ensuring that the outcome of our study would not be influenced by unsatisfactory gameplay.

## Premise and Design

In the game, two players play against each other, assuming the roles of either the ‘mysterious stranger’ (referred to as ‘human’) character or the ‘animal’ character, which can be either a dog or a fish (see Figure 2a). Both players share the same virtual environment - the titular pet shop - but perceive it from individual, first person perspectives, corresponding to their virtual characters. Both human and animal characters are controlled through the head movements of the respective players, and an additional single button input (located on the side of the HMD) to trigger character-specific actions. 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. A character card of all animals, featuring indication numbers, is shown to the players to simplify the description of which animal has been

chosen (see Figure 2b). 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. Animal players can perform tricks that motivate the shopkeeper to close early, at the risk of visually standing out among the other animals.

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. Another strategy used by animal players was to comment on aspects in the virtual pet shop that would place them at a location that they actually could not get to in their current animal form (e.g. commenting on the bubbles in the aquarium while playing as a dog).

The following list indicates which interactions, both in-game and out-of-game, were designed to impact social presence:

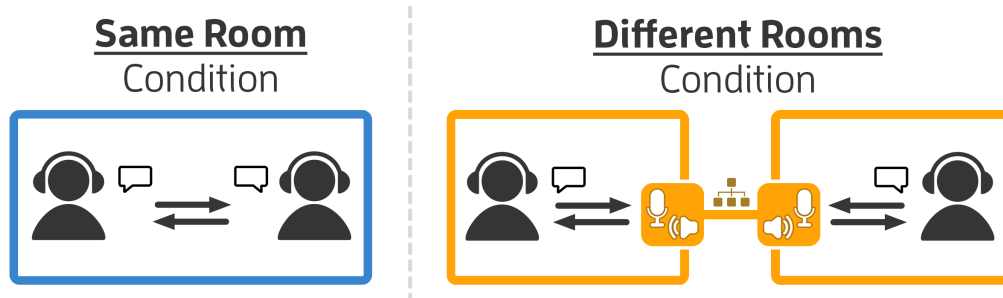
- (in-game) Direct connection between physical head movements and in-game character movements.
- (in-game) Interaction triggers for players in the role of the human character (whistling towards dogs, knocking on the in-game aquarium).
- (in-game) Interaction triggers for players in the role of an animal character (performing tricks to appeal to the shopkeeper non-player character).
- (out-of-game) Talking to the other player (to bait out information or provide misinformation).
- (out-of-game) Listening for physical movements made by the other player to infer actions taken in the game.

## Hardware

In our experiment, we used two laptops (one running the server, another as second input terminal for the questionnaire) and two smartphones (*Nexus 5* running *Android 5*) that were inserted into *Google Cardboard* cases. Each of these has an integrated magnetic trigger button on the side and was modified with a Velcro headband so that a player did not have to hold it during gameplay. 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 Figure 3). Participants played both conditions in succession, separated by about 10-15 minutes of time to answer a questionnaire for the



**Figure 3:** Graph illustrating the condition groups and setup throughout the four game rounds of a testing session.

first game session. The same questionnaire was again given after the second game session, which then concluded the experiment. The questionnaire was used to measure the game experience of the participants, as well as the social presence felt during the game.

The order in which the conditions were played was 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. It should be noted that in this case, players heard each other through headphones. 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  $N=34$  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 (Ravaja et al. 2006). 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) (IJsselstein et al. 2008) choosing the questionnaire modules ‘core’ and ‘social presence’ (Kort et al. 2007). A number of peer reviewed publications (Al Mahmud et al. 2008; Drachen et al. 2010; Nacke et al. 2010; Gómez-Maureira et al. 2014) have used the GEQ to quantify aspects of game experience and/or 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





(a) Photo of a co-located game session in progress.



(b) Photo of the testing equipment used in this study: Two *Google Cardboards*, two smartphones with external batteries, two headphones, and laptop running the game server.

**Figure 4:** Photos from the testing procedure.

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 an 11-point Likert scale (ranging their enjoyment from ‘not at all’ to ‘extremely’). Players were also asked at the end, which of the two conditions they preferred (with ‘no preference’ being a valid option), which character role they enjoyed the most, and whether or not they would want to play the game again.

## 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 (see Figure 4a), 2) another room far enough from the central room so that participants would not be able to hear each other through the walls (when not playing co-located), 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. It should be noted that the experiments took place in spaces that were familiar to the participants. While conducting all experiments at the same location would have ensured a consistent test environment, testing at different locations allowed us to increase the amount of participants and involve participants outside of the immediate academic environment. Given that participants were subjected to both testing conditions at each location, we argue that changes in the testing location should not have an impact on our results. It is, however, a limitation of this study as we cannot rule out interaction effects between experimentation site and results. 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



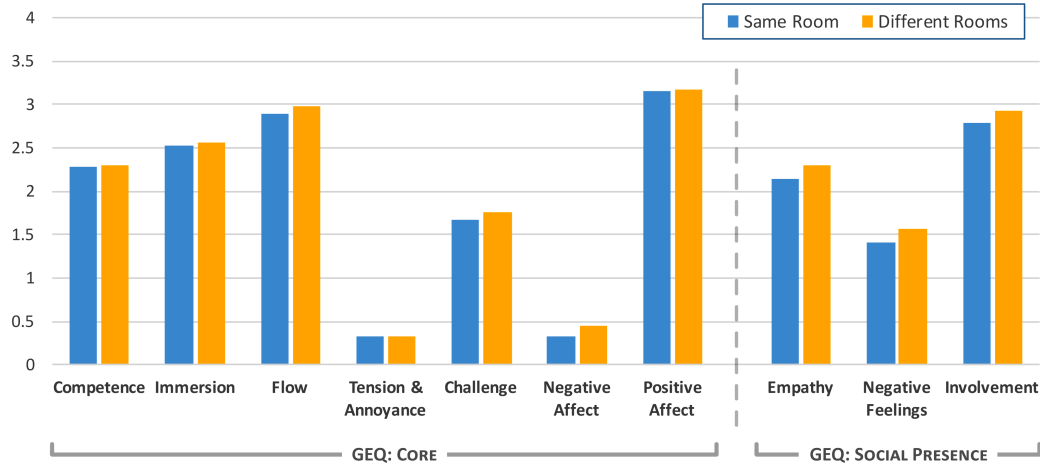
chair was placed in the extra room and in both rooms there was a printed sheet with the possible animals so that human players could indicate their choice at the end of the game round. The headphones and battery packs (see Figure 4b) were connected to the mobile phones. A sound volume check was done for the game and (in case of testing in different rooms) the intercom application that ran in the background. The *Google Cardboards* were also prepared, but the phones were not inserted until the player roles for the first round had been decided.

Participants were asked beforehand to watch a short video showing the game environment, to read about the rules, and to read the consent form they would need to sign for the experiment to take place. The consent form specifically pointed out that VR HMDs are known to cause nausea and that participants should stop if they felt uncomfortable. At the time of the test, participants were welcomed into the testing room and asked to sign the 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 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 among 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 under each of the two testing conditions. For the first round, the choice of whether to play as a human or animal had to be put in manually by the experimenter. In subsequent rounds, players could select their role from within the game itself. 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 each round the human player was asked to look at a graphic showing 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. After three rounds the HMDs were removed and the participants filled in the questionnaire, which took about ten minutes. The condition was then switched and the participants played another three rounds, followed by the same 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.



**Figure 5:** Graph showing the aggregated results of the separate Game Experience Questionnaire (GEQ) components for the two experiment conditions.

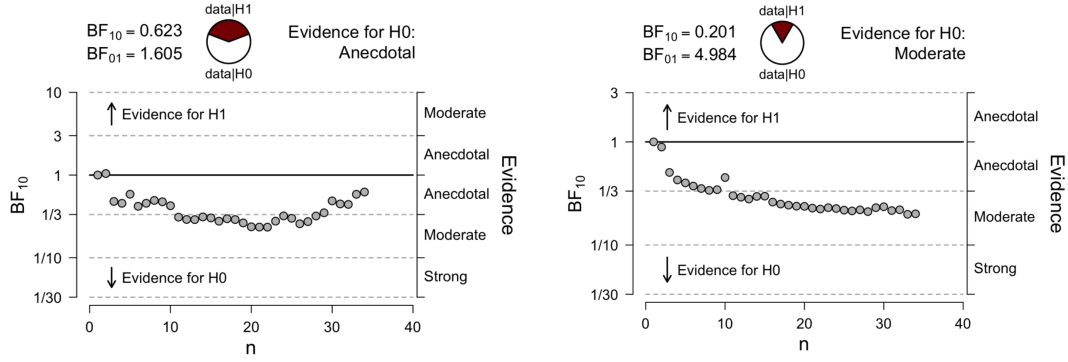
## RESULTS

For our statistical analysis we used the Bayesian paired samples t-test (Rouder et al. 2009) as it allows researchers to accept the null hypothesis instead of merely rejecting it, and offers a 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 Figure 5. 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’ (Jeffreys 1961) evidence in support of  $H_0$  where  $BF_{10}$  is smaller than 0.33, as is shown in Table 1. Generally, a  $BF_{10}$  of 1.0 would mean that  $H_1$  is as likely as  $H_0$ , while 0.33 means that  $H_0$  is three times more likely than our hypothesis  $H_1$ . To recall, our research hypothesis ( $H_1$ ) was that there would be a significant difference, pointing to increased social presence when playing co-located. Conversely, the null hypothesis ( $H_0$ ) is that there is no difference between the two conditions.

A sequential analysis, provided by the statistics software JASP (Love et al. 2015), is shown in Figure 6 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 Figure 6a), most plots provide stronger evidence for  $H_0$  as more data points are added (see Figure 6b).

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 ‘yes’. In



(a) Sequential analysis of the *Empathy* component. (b) Sequential analysis of the *Immersion* component.

**Figure 6:** Sequential analysis graph plots for two components of the GEQ

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. Finally, players generally rated the game high in terms of enjoyment ( $M=8.66$ ,  $SD=1.33$ ).

| 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’

## 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 ( $H_0$ ), while the rest of the components provide only anecdotal ( $BF_{10} = 0.333 \dots 1.0$ ) evidence for the same statement. Given that prior research (Cairns et al. 2013) found that social presence would be increased for co-located play, we see three possible explanations for why such an effect was not found in this study:

1. **HMDs prevent an increase of social presence that is otherwise gained by playing co-located.** It is possible that, in order to have social presence be impacted by co-location, players require visual affirmation of each other's physical presence even if their attention is focused on the game that is played.
2. **VR through HMDs increases player incorporation to an extent that makes social presence independent from physical proximity.** This interpretation essentially takes the opposite perspective of the previous one, and assumes that co-located play without VR prevents players to become 'fully' incorporated into the virtual environment. In other words, co-location of players in a multi-player game could act as a constant reminder of the fact that a game is being played.
3. **Vocal communication between players has a higher impact on social presence than the ability to see each other.** The games that were used in the study by Cairns et al. (2013) 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 their 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. It is possible then, that voice chat in itself is a major factor in social presence.

Whether one or a combination of these explanations is indeed responsible for our findings will need to be explored in subsequent studies. At this point we should note that it is difficult to generalize results that are based on a single game. Clearly, the game used in our study cannot simulate the wide range of possible gameplay scenarios that can be realized with VR, and different games 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 as an important datapoint in the pursuit to investigate multiplayer VR games in general.

Based on GEQ scores and additional questions, we can conclude that participants generally enjoyed the game and that they would have chosen to play again. While we have not at-

tempted 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.

### **Limitations**

One of the biggest limitation of this study is that the condition of playing from separated locations is merely simulating the scenario of separation. Participating player pairs typically had social contact both before and after the experiment with each other. The knowledge that the other person, while not present in the immediate proximity, is not too far away might have an impact on our results. Going forward, this should be addressed in the future to see if separating players for longer time and by increased distances has an impact on the results that was missing from our study.

As a next point, while the GEQ has been used in several studies (see subsection ‘Measurements’), its validation study has not been published to date. Only the ‘social presence’ module has been published, originally in 2007 as ‘SPGQ’, and later used as part of the GEQ. Even if our study did not find any evidence for doubting the results of the GEQ, in the future we will attempt to find more robust ways to measure the game experience of players.

Another limitation of our methodology is the fact that experiment sessions were conducted at different locations. This allowed us to increase our sample size, but could introduce unintended interaction effects that might persist despite our counterbalancing efforts of testing both conditions at each location.

### **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 their game experience and social presence significantly impacted by physical separation. The GEQ questionnaire results of this study, however, demonstrate that this is not the case. This is also reflected in the preferences of the players, where the majority did not favor one condition over the other, while those who did were split evenly among the two options.

We have discussed three possible explanations for our result: the possibility that 1) HMDs prevent an increase of social presence, 2) player incorporation through VR makes social presence independent from physical proximity, and 3) vocal communication, even if relayed through headphones, is a major factor for social presence. Our current study provides an early datapoint in the still small landscape of explorations into multiplayer VR games. Going forward, we plan to further examine the results of this study with different games, as well as investigate the proposed explanations for our results.

Future 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 multiplayer VR games with more than two players, as well as mixed-reality multiplayer 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. Another point that should be considered in future studies is that VR devices are starting to become more readily available. While many people have not yet been exposed to VR through HMDs, the novelty factor - or its lack - could influence how players experience a VR game. As such, participants of future studies in this area should be asked to report on their familiarity with this medium so that this can be taken into consideration.

Finally, ongoing developments, especially in the area of digital games, show that there is wide support and interest in VR among researchers, developers, and perhaps most importantly, users. While HMDs can, by their design, only accommodate a single user, this does not mean that the virtual worlds they connect us to need to be devoid of social interactions.

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