“A-Maze-ing arguments in Virtual Reality”

An Analysis of the Connection between Shared Situational Awareness and Social Modes of Co-Construction in Virtual Reality

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Abstract

Background Virtual Reality is an increasingly hot topic these days. As a user, you can play more and more high-quality games and strides are being made to use this medium for education and new kinds of workspaces. Previous research on Virtual Reality shows that it could improve teamwork by letting users share information easier. Users in Virtual Reality can communicate in ways exclusive to the medium, like highlighting exact locations, so this paper analyzed how effective verbal communication is in this situation.

Methods To analyze how Virtual Reality influences group interaction, an experiment was set up that ascertained in the presence and absence of visualizations of user actions whether a group being more aware influences how they communicate in Virtual Reality. To approach this, this paper used a maze in Virtual Reality where participants need to communicate hints of their color.

Results The data encoding of the experiment showed that when a group's Shared Situational Awareness decreased between sessions, their level of Social Modes of Co-Construction did as well to a similar degree. When the awareness remained around the same level, only decreasing slightly, the level of social modes remained as well, going slightly up or down depending on the reading of the data.

Conclusions From the research experiment, this paper observes there is a positive correlation between group Shared Situational Awareness and their Social Modes of Co-Construction. Because of limited time and data sources, it is suggested that this experiment is reproduced over a longer period on a larger scale to support these findings.

1 Introduction

Virtual Reality (VR) has been an exciting concept since the mid 1900s, when the first VR machine was made by Morton Heilig[1]. There are a plethora of stories, such as "The Matrix", "Ready Player One" and "Tron", that try to analyze how far this technology can be developed, and debate whether their outcomes are desirable[2][3][4]. This technology can let someone fully immerse themselves in a setting that does not have to be realistic. On the contrary, games that adopted this technology have made experiences that let people escape reality more than any other medium of entertainment by letting them do things that would be impossible otherwise.

Analyzing VR in a group setting leads to interesting takeaways. For instance, there exist multiplayer VR games in which you can take the appearance of an entity in the game and interact with others who do the same. In games, we are able to do things that are not possible in real life. If we were to use VR and see how players cooperate with each other using methods that as of now are only possible with games and VR, what would the result be?

This paper seeks to analyze how people learn together in VR, so we need to be able to quantify how this happens. We need to define how VR interacts with the participants, how the participants interact with their environment and how the participants learn with each other. The way this paper implements aspects of VR into a learning situation is through Visualizations of activities. Visualization of activities is the act of making certain actions of a player visible to themselves and others, this is a way to show aspects of VR and is this experiment's independent variable. A term for learning together is Collaborative Learning. In 2006, Weinberger and Fischer created a framework that grades this called Social Modes of Co-Construction, which this paper will use[5]. Social Modes of Co-Construction (SMOCC) indicate how effective a discussion is and whether people are reacting to things others are saying. The way this paper expresses how particpants interact with their environment is with a term called Shared Situational Awareness[6]. Shared Situational Awareness (SSA) is a way to score how aware people are of their surroundings and of their observations as a group of people. This will be the experiment's mediator. This paper uses these three aspects to make a research question.

Having defined the terms that are used to analyze the main question further, this paper will tackle the question "Does shared situational awareness between group members have an effect on their level of social modes of co-construction inside Virtual Reality?" In order to answer this question, a fitting experiment was needed to collect and analyze data. The conclusion the research group settled on was a maze in VR.

2 Related Works

This section will analyze some previous work and state where this paper fills in some blind spots in this branch of research.

Some of the first important research into Situational Awareness (SA) was done by Endsley, who laid out ways how situational awareness could be calculated and stressed that SA needed to be more widely implemented [7]. The experiment of this paper uses one of the methods highlighted there, SART to record a participant's subjective situational awareness. [8] Endley's research was later expanded to define the SA of a group as Shared Situational Awareness in Kulyk's work. [6] Research into Collaborative Learning by Weinberger tells us we can quantify learning through discourse with Social Modes of Co-Construction[5].

This paper will combine aspects of these research papers to fill in the blanks regarding Collaborative Learning in Virtual Reality since none of this research addresses SSA or SMOCC in the context of Virtual Reality.

3 Methodology

This section will outline how the experiment was conducted and how its data was to be analyzed.

3.1 Participants

For this experiment six participants were scouted, four male and two female, making up two groups of three people. The participants were all university students between the ages of twenty and twenty-five, known by individual members of the

research project group. To make sure the experiment was conducted as fair as possible, there were a few requirements that the participants needed to adhere to.

- Participants should not know each other before the experiment to keep interactions neutral between them.
- Participants should be able to understand and communicate in English for the experiment's instructions and for the collected data to be globally understood.
- Participants should not get motion sick or claustrophobic easily in order to be able to partake in the experiment safely.
- Participants should not be color blind in order to be able to understand its instructions.

The participants were asked to fill in a consent form before the experiment to give permission for their data to be collected during the experiment. During the experiment, they were also asked to fill in a form to inquire about previous experience with VR and games. Both of these forms can be found in Appendix A.

3.2 Materials

There were a few ways in which this experiment collected data. First of all, audio and video footage was recorded by one VR headset for each participant. This was done in order to make an accurate transcription of what the participants said during every session. All the footage from a session was synchronized and merged, so an audible conversation could be extracted. This was done by using the Otter.AI platform, which uses AI to recognize speakers, and transcribe and timestamp a conversation[9]. These transcriptions were a nice starting point and were later checked and corrected where needed by the research team using the original footage. Secondly, the participants were given multiple questionnaires throughout the experiment. Halfway through each session, the participants were given a break to answer a questionnaire called SART, which is used to give a score to someone's personally perceived Situational Awareness[8]. After the first session, the participants were also given the additional questionnaire that asks them about any prior background and experiences with games and VR, along with some limited personal information.

This recorded data also needed to be analyzed. Firstly, the transcriptions of the sessions were used for both SSA and SMOCC by using different methods to score them. For SSA, the SALIENT rubric was used, which is a rubric that objectively scores a person based on how they interacted in a number of predetermined scenarios[10]. The average of all the participants' total scores was used to calculate the score for the whole group. For SMOCC, every line of dialogue was analyzed to match them to one of the five levels of SMOCC when they were relevant to working as a team to solve the maze and were scored higher for a higher level, from zero to five[5]. Again, the average of all participants' total scores was used to make a group score. Secondly, the results for the SART questionnaire are divisible into three scores, which are combined into a final score using a formula[8]. And again, the average was used to make a group score.

3.3 Design

The intent of the experiment was to use Visualisations of Actions as the independent variable, which was hypothesized to influence the two dependent variables, Shared Situational Awareness and Social Modes of Co-Construction. SSA was also suspected to influence SMOCC, which also made SSA a mediator variable. The independency of the Visualisations of actions relies on the maze setup.

There were two experiment setups, one with the functionality to visualize two actions, and one without extra functionality. The visualized action was a vision cone that showed participants the current field of view of the other participants at all times. The second visualized action was a laser beam pointer, similar to how a pinger is often effectively used in video games, that could be turned on to highlight something from a distance with accuracy[11]. The total experiment adheres to a Within-Subjects design. Both participant groups tried to solve this maze twice, once with the Visualizations as the experimental run and once without as the controlled run.

3.4 Procedure

The individual groups were scheduled to meet in a room where the equipment could be set up, their proximity enabling them to verbally communicate with each other by speaking out loud. There were three VR headsets, each connected to a separate device that ran the maze program and could connect to each other for a multiplayer function. Each player in the maze program was visible as a colored entity with a torso and a hand. Each participant was wearing one of the VR headsets that showed them the maze and the other participants, while they used a single controller to control a hand. They were able to move by pressing a specific button on the controller that teleported them one step forward. The participants had 30 minutes to progress as far as they could, with a break about halfway in order to give them a survey.

The maze itself was filled with hints of different colors, each of which could only be seen by the participant of that color. Those showed the participants the way forward but might have been confusing or misleading without the hints seen by other participants. The maze had multiple gates that required a three-digit code, which could be found in the vicinity, but also needed cooperation between participants to decipher. The maze was split into four big parts, each subsequent part having more complicated hints and codes[12]. Since this maze was readily available through the research supervisor, using it was the most effective method to run such an experiment for the research question. The maze forced participants to collaborate to solve it, which were exactly the interactions that needed to be recorded to analyze SSA and SMOCC. In short, because of the availability and applicability of this maze, it was the best choice to use for this particular experiment. While some parts of the maze could be solved with brute force like other mazes, doing so was not advised. The players would not have been able to make enough progress to solve the maze in 30 minutes if that strategy was used, nor would it have helped them through the gates inside the maze. The intended way to progress in the maze was to use the hints at every junction to get to the next hint and to decipher and use codes required at the gates located in the maze. Because

participants could only see hints and parts of the code of their own color, they needed to communicate with each other.

4 Responsible Research

This section will be a discussion on whether the experiment was conducted in a responsible manner.

One important topic to discuss is the participants' privacy regarding data collection. Since the experiment records their actions and information as data to learn something from them, it could be feasible that their likeness and personal information might be spread out to the public if such things were not handled correctly. There were a few ways to combat this. Firstly, it was critical that all participants give their permission to collect personal information and data about themselves even if they are not necessarily used in the final product. This is why the participants were given an informed consent form before the experiment starts. At this point, they were allowed to refuse, which would also mean they could not participate in the experiment and would not be used for data collection. Secondly, the participants are asked to fill in unidentifiable personal information about themselves at the end of the experiment. Under normal circumstances, this info is omitted from the presented data as well and only revisited to explain unexpected outcomes from the experiment. Thirdly, the recordings of the participants were destroyed when all the relevant information was encoded into data. This way the likeness of their voice is not able to be collected in case of a compromised storage device. Lastly, the participants can only be identified by the IDs they received at the start of the experiment, which means they can remain anonymous while the data they produced can still be linked to a number. This way their names remain hidden. By implementing these measures, the participants should remain as anonymous as possible, while still allowing for data collection of their behavior in the test environment.

To reproduce this experiment you would need to follow the steps indicated in the methodology as well as access to the maze that was used, which can be found in the appendix. The human factor will always imply a certain degree of uncertainty in the results, however.

5 Results

This section will show the results of the experiment, having let the two test groups try both mazes.

5.1 Scoring the Data

After the data was acquired, the research group spent time scoring the data by using the formula for SART: $SA = U - (D - S)$ which takes the sum of the points scored by the "Understanding" questions and subtracts the difference between the "Demand" and "Supply" questions. The scores of all participants were summed and divided by three to arrive at a group score.

For SALIENT all the utterances of a session were divided into 4 scenarios, Looking for Markings, Deciding the next Path, Interactions with Passcodes, and Backtracking. After the division, each scenario was scored per participant using every category of the SALIENT Rubric. The score increased whenever a participant showed signs of performing one of the categories, with a maximum score per scenario being equal to 1, and a minimum score being equal to 0. The average scores of the three participants were summed and divided by three to arrive at a group score.

For SMOCC all the utterances of a session were scored individually, being classified as one of the five levels of SMOCC or being irrelevant. An irrelevant statement was scored a 0, while the other statement got a score equal to the SMOCC level it belonged to. As with SALIENT, the average scores of the three participants were summed and divided by three to arrive at a group score.

5.2 Results

Group 1 was first put in the controlled maze, followed by the experimental maze in the next session. For the SSA the recordings were scored by the research group using the SALIENT Guidelines and resulted in the findings of Figure 1.

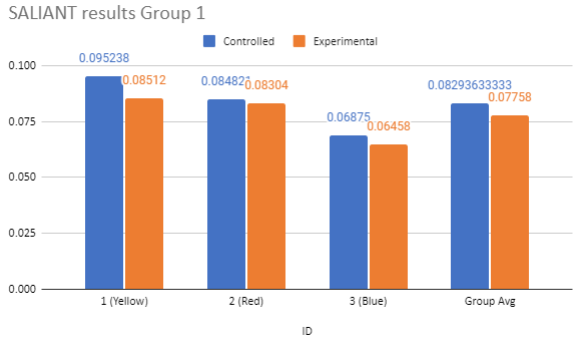

Figure 1: Results of scoring Group 1 using the SALIENT Framework

As a group, Group 1 scored a slightly higher objective SSA in the first session than in the second session. The surveys containing questions about their subjective situational awareness were scored using the SART Guidelines and resulted in the findings of Figure 2.

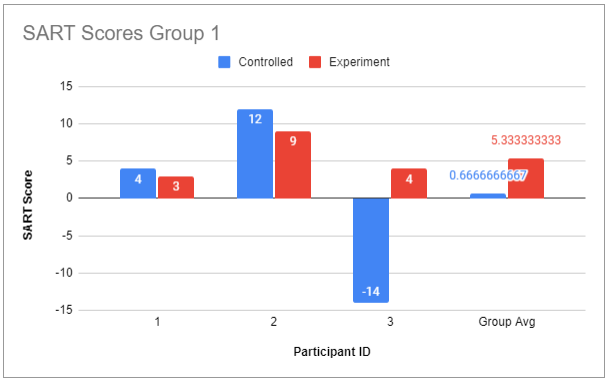

Figure 2: Results of scoring Group 1 using the SART Framework

As a group, Group 1 scored a lower subjective SSA in the first session than in the second session. For the SMOCC the recordings were scored by the research group using the SMOCC Guidelines and resulted in the findings of Figure 3.

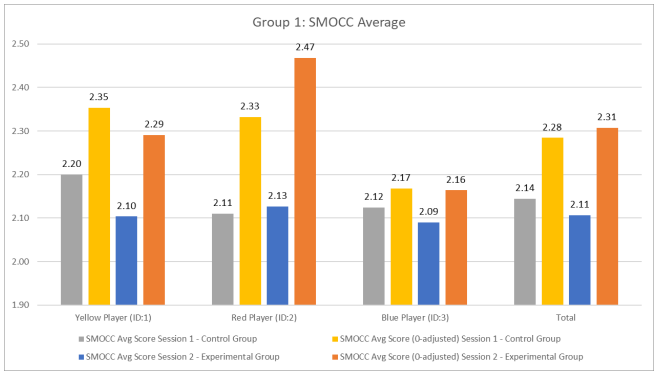

Figure 3: Results of scoring Group 1 using the SMOCC Framework

As a group, Group 1 scored a slightly higher SMOCC in the first session than in the second session when 0-adjusted and slightly lower when not 0-adjusted.

Group 2 was first put in the experimental maze, followed by the experimental maze in the next session. For the SSA the recordings were scored by the research group using the SALIENT Guidelines and resulted in the findings of Figure 4.

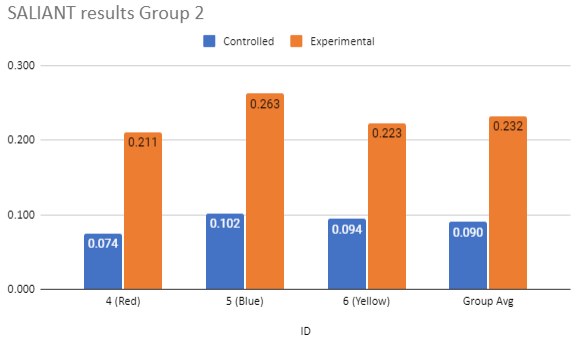

Figure 4: Results of scoring Group 2 using the SALIENT Framework

As a group, Group 2 scored a higher objective SSA in the first session than in the second session. The surveys containing questions about their subjective situational awareness were scored using the SART Guidelines and resulted in the findings of Figure 5.

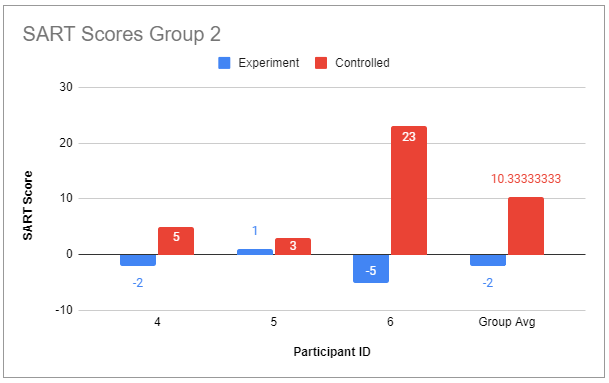

Figure 5: Results of scoring Group 2 using the SART Framework

As a group, Group 2 scored a higher subjective SSA in the first session than in the second session. For the SMOCC the recordings were scored by the research group using the SMOCC Guidelines and resulted in the findings of Figure 6.

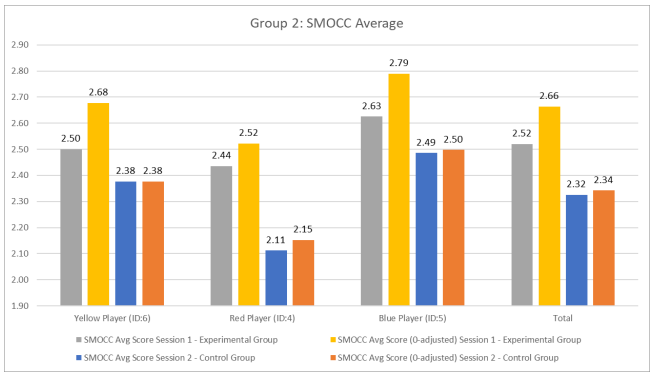

Figure 6: Results of scoring Group 2 using the SMOCC Framework

As a group, Group 2 scored a higher SMOCC in the first session than in the second session.

6 Discussion

This section will discuss what the results from the experiment mean for the research question and where the experiment could have gone better.

When we compare each group's objective SSA score with their SMOCC score, we can see the following:

- Group 1's SSA went down (slightly) and their SMOCC went down about the same degree when not 0-adjusted, but up when 0-adjusted.
- Group 2's SSA went down significantly and their SMOCC did as well though not to the same degree (the change in degree might be due to a coding inconsistency)

From this, we can surmise that regardless of whether Visualizations of Actions are present, a group's SSA goes down on the second session. When SSA goes down SMOCC goes down, indicating a positive correlation between group

Shared Situational Awareness and their Social Modes of Co-Construction.

This observation considers the Group's SART scores but takes into account that a drop in subjective SSA might be the result of adjusting their point of view after spending more time in the maze. Any outliers evened out in the second session, resulting in a more well-rounded data point.

When we compare the results from Group 1 and Group 2 we can see some similarities and some differences. They are similar in the way that both groups scored a higher objective SSA in their first session than in their second session, they had a higher subjective SSA in their second session than in their first session. These similarities can be explained by the fact that the participants had gotten more familiar with the experiment environment, scoring themselves higher, and felt less need to communicate every detail to their group members, making the research group score their interactions lower. It's also possible that in the second session, the outliers scored themselves more accurately due to being more familiar with the experiment, in this case, the SSA might have gone down in comparison to the first session.

They are different in the way that Group 1's objective SSA score is way lower than Group 2's score, which could feasibly be explained because of a mistake in inter-rater reliability between researchers, making the score too high. Another difference is that Group 1's SMOCC score remained around the same level while Group 2's SMOCC score dropped between sessions. This could be explained by the second session and the use of visualizations of actions. If a group returns for a second session, their conversations might become less explicit because they figured out how to effectively communicate their actions and leave out the rest, which lowers their scores. The use of visualizations might boost the score because indicating where you are referring to with statements like "over there, where I'm pointing" give a participant higher points in the framework. When these two suggestions are combined, the scores from Group 1 might stay the same, but the score from Group 2 drops even further.

When we interpret the results like this, a few observations can be made that are relevant to the research question. Firstly, there is a positive correlation between group Shared Situational Awareness and their Social Modes of Co-Construction when influenced by Visualizations of Actions. Secondly, it seems that a second session lowers the scores of the groups. Thirdly, further, more expansive research would show if these results are within the norm and would strengthen or weaken the first observation.

7 Conclusions and Future Work

Virtual Reality enables us to interact with each other in a different way. While you can use your hands and mouth in public, using VR can allow you to express yourself more explicitly. With visualizations of actions in Virtual Reality, this paper tested if being more aware as a group leads to more effective learning through discourse. A maze was used as the experiment to collect data, which was turned into results using SALIENT, SART, and SMOCC. From these results, we can make the observation that there is a positive correlation between group Shared Situational Awareness and their Social Modes of Co-Construction.

There are ways in which this research could be done again in order to make stronger conclusions. Because of the small number of data sources the data, though seemingly sufficient in number, could be biased or have outliers. Normalizing this data can be hard since the group sizes are so small, and will probably still produce results too positive or negative. Still, the group sizes are unlikely to change to much higher numbers. The focus of this experiment is communication when input from all participants is needed. If group sizes were to grow, the chance for participants to not be heard increases since people can be prone to talk over each other. Even if the test groups were to organize their discussions to prevent this, some participants will be predisposed to only join in discussions relating to their info and some will join in every discussion. This is less likely to happen in a small group, so their contributions will be relatively equal. This data problem has a chance to be solved, however, if the number of groups were to increase. The experiment of this paper was to be conducted in a span of only seven weeks, which limited the number of groups that could be tested and analyzed. If this experiment could be done over a longer period of time, the experiment could be run a vast number of times more as long as there is a suitable setting and willing participants. This would result in more data to work with, and would likely create a widespread of results from which we could draw conclusions with greater certainty. In short, because the amount of data sources was relatively low for this experiment as well as conducting it in a limited timeframe, doing this experiment again might have different results. Though an increase in groups of participants will likely result in more well-rounded data and might bridge this gap in the future.

References

[1] Morton L Heilig. Sensorama simulator. *US PAT. 3,050,870*, 1962.

[2] The matrix, 1999.

[3] Ernest Cline. *Ready Player One*. Crown Publishing Group, 2011.

[4] Tron, 1982.

[5] Armin Weinberger and Frank Fischer. A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & education*, 46(1):71–95, 2006.

[6] Olga Kulyk, Gerrit van der Veer, and Betsy van Dijk. Situational awareness support to enhance teamwork in collaborative environments. In *Proceedings of the 15th European conference on Cognitive ergonomics: the ergonomics of cool interaction*, pages 1–5, 2008.

[7] Mica R Endsley. Toward a theory of situation awareness in dynamic systems. *Human factors*, 37(1):32–64, 1995.

[8] Stephen J Selcon and RM Taylor. Evaluation of the situational awareness rating technique(sart) as a tool for aircrew systems design. *AGARD, Situational Awareness*

in Aerospace Operations 8 p(SEE N 90-28972 23-53), 1990.

[9] S. Liang and Y. Fu. Otter.ai, 2016.

[10] E Muniz, R Stout, C Bowers, and Eduardo Salas. A methodology for measuring team situational awareness: situational awareness linked indicators adapted to novel tasks (saliant). *NATO human factors and medicine panel on collaborative crew performance in complex systems, Edinburgh, North Atlantic Treaties Organisation, Neuilly-sur-Seine*, pages 20–24, 1998.

[11] Jason Wuertz, Scott Bateman, and Anthony Tang. Why players use pings and annotations in dota 2. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 1978–2018, 2017.

[12] Brinkman W.-P. Specht M. Meer, N. van der. How visualisations of actions affect social modes of co-construction inside virtual environments. Manuscript in preparation, June 2023.

A Appendix A

Study information for Experiment #01: Effects of Visualization of Actions on Social Modes of Co-Construction inside Virtual Reality

Purpose of this research

In this study, the effect of Virtual Reality on collaboration between group members will be studied as part of the PhD trajectory of Nesse van der Meer, PhD candidate at the Delft Technical University. As a participant, you will be asked to collaborate with two other participants to solve a selection of tasks while inside Virtual Reality; only by collaborating and communicating together will you be able to make progress. In total, the experiment will take approximately 60 minutes, of which 30-35 minutes will be spend in Virtual Reality. We will explain the rest of the experiment in detail after you have finished this consent form.

Benefits and risks of participating

By participating in this study, you will contribute to research on collaborative learning. As the team already will have explained, this study requires you to return in approximately one week to repeat the experiment; upon completion of the second session, you will receive a reimbursement for your participation and time.

Please be aware of the following risks:

- **Physical safety**: To prevent any physical injuries or accidents, the team behind this study will make sure that you and your group members have sufficient space to safely interact inside Virtual Reality without hitting anything or each other. We do however ask you to try and be aware of this while participating by not actively walking / running around and / or actively swinging your arms and legs.
- **Claustrophobia**: While the Virtual Reality experience is not meant to induce claustrophobic responses, those who are sensitive to claustrophobia might still experience it as such. If you have a history with claustrophobia, please inform us right away. If you experience claustrophobia during the experience, please make sure to inform our team so we can help you accordingly.
- **Motion sickness**: Some experience motion sickness (i.e. dizziness) while using Virtual Reality. If you have a history with motion sickness (either because of Virtual Reality or other reasons), please inform us right away. If you experience motion sickness during the experience, please make sure to inform our team so we can help you accordingly.

Procedures for withdrawal from the study

Please be aware that you have the option to quit your participation in this study at any time and will face no negative consequences for doing so. If you wish to withdraw from the study during the experiment, you can state this to the team responsible for the study. In case you wish to withdraw outside of the experiment, please contact us, using the contact information below, within one month of signing this informed consent. Please know that, as a participant, you also have the right to request access to and rectification or erasure of any personal data collected during this experiment within that month.

Collection and usage of personal information and data

During the experiment, audio will be recorded to register your communication with your fellow participants. This audio recording will be stored privately and securely and will not be shared publicly at any point. The recordings will be transcribed at a later stage and analysed for the purpose of this study (i.e. how Virtual Reality influences your communication with your group members); your identity will be anonymized in these transcripts. Additionally, recordings will be made of your screen while inside Virtual Reality. To clarify: you will not be recorded physically, but your avatar and activities inside Virtual Reality will be recorded through your point of view. As such, you will not be identifiable in these recordings. These recordings will be stored privately and securely and will not be shared publicly at any point. As with the audio, these screen recordings will be analysed to study collaboration between you and your group members. During the experiment, certain information regarding how you and your fellow group members solve collaborative tasks will be logged. This information will not be usable to identify you. After the experiment, you will be asked to fill in a questionnaire. This questionnaire will ask you about certain points related to the experiment, as well as your past experience with video games and Virtual Reality and personal information such as your gender and age. Again, this data will not be usable to identify you.

The collected data will be used only for research purposes, including publications intended for scientific and academic audiences (e.g. academic papers) and only the research team will have access to the data. All data collected during this study will be archived for a period of 10 years, in accordance with the VSNU guidelines.

Contact details

Nesse van der Meer
Phone: 06 44 02 04 78
E-mail: nessvdmeer@gmail.com

Figure 7: Consent Form Page 1 of 3

Consent Form for Experiment #01: Effects of Visualization of Actions on Social Modes of Co-Construction inside Virtual Reality

Please tick the appropriate boxes

	Yes	No
Taking part in the study		
I have read and understood the study information dated and I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I have read, understood, and agreed to the following study details: • The goal of this study is to examine how Virtual Reality affects collaboration between group members. • The study will take part in two sessions. The first will take approximately 60 minutes and will take place approximately 35 minutes in Virtual Reality. The second will take place approximately one week later and will take approximately 60 minutes as well. Both will require you to be physically present at the location of the experiment. • At any time during or after this study, the researcher will answer any questions you have regarding the study or your data which is collected.	○	○
Risks associated with participating in the study		
I understand that taking part in the study involves the following risks: • **Physical safety**: To prevent any physical injuries or accidents, the team behind this study will make sure that you and your group members have sufficient space to safely interact. You are aware that we ask you to be cautious of this during the experiment. • **Claustrophobia**: While the Virtual Reality experience is not meant to induce claustrophobic responses, you are aware that if you experience claustrophobia during the experience, you should inform our team so we can help you accordingly. • **Motion sickness**: While the Virtual Reality experience is not meant to induce motion sickness, you are aware that if you experience motion sickness during the experience, you should inform our team so we can help you accordingly.	○	○
Use of the information in the study		
I understand that information I provide will be used for writing publications intended for scientific and academic audiences.	○	○
I understand that personal information collected about me that can identify me will not be shared beyond the study team. My responses will be treated confidentially and my anonymity will be ensured during the data analysis. Hence, the study results cannot be linked back to me as an individual.	○	○
Future use and reuse of the information by others		
I give permission for the (1) audio recordings during the experiment, (2) screen recordings of my interaction inside Virtual Reality, (3) performance data related to collaboration inside Virtual Reality and (4) questionnaire data that I provide to be archived in a SURFdrive cloud storage provided by TU Delft so it can be used for future research and learning.	○	○

Figure 8: Consent Form Page 2 of 3

I understand that the collected data will be used only for research purposes, that only the research team will have access to the data and that all data collected during this study will be stored for a period of 10 years, in accordance with the VSNU guidelines. ○ ○

Signatures

Name of participant [printed]	**Signature**	**Date**

Please provide an e-mail address below on which you, the participant, can be reached during the analysis phase of this experiment. Your e-mail address will only be used in case of an error (e.g., an error regarding the data provided) that requires further contact. Your e-mail address will be deleted as soon as this phase of the experiment is completed and the e-mail address will no longer be required.

E-mail address of participant

I, the researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Researcher name [printed]	**Signature**	**Date**

For further information, please contact:
Nesse van der Meer
Phone: 06 44 02 04 78
E-mail: n.vandermeer@tudelft.nl

Figure 9: Consent Form Page 3 of 3

Virtual Reality Experiment

Participant ID: ☐

Please answer each of the below questions by checking the correct box(es). If prompted, also write down any answers.

Q.1: What is your gender?

- ❑ Male
- ❑ Female
- ❑ Other: _____

Q.2: What is your age?

_____

Q.3: How often per week do you play video games?

- ❑ Never
- ❑ Rarely
- ❑ Sometimes
- ❑ Regularly
- ❑ Often

Q.4: On which of the following platforms do you play video games? (Multiple answers allowed)

- ❑ Computer (Windows, Mac, Linux)
- ❑ Laptop (Windows, Mac, Linux)
- ❑ Mobile phones
- ❑ Tablets
- ❑ Mobile game consoles (e.g. Nintendo 3DS)
- ❑ Game consoles (e.g. Nintendo Switch, PlayStation 4 / 5, Xbox One / Series X, etc.)
- ❑ Other: _____

Q.5: Have you ever experienced Virtual Reality before this experiment?

- ❑ Never
- ❑ Rarely (once or twice)
- ❑ Sometimes
- ❑ Regularly
- ❑ Often

Q.6: Do you own one or more Virtual Reality devices and if so, which one(s)?

- ❑ No
- ❑ Yes, namely: _____

Q.7: Did you face any significant issues while experiencing Virtual Reality (and if so, what kind of issues)?

- ❑ No
- ❑ Yes, namely: _____

Q.8: What are your thoughts on usability of the Virtual Reality application? Was it easy or difficult to use and control? Please elaborate your answer.

Q.9: What are your thoughts on collaboration with your group members when using the Virtual Reality application? Was it easy or difficult to work together? Please elaborate your answer.

Q.10: Are there any other thoughts you would like to share regarding the experiment and/or the Virtual Reality application?

Thank you for your participation!

Figure 10: Questionnaire Personal Details