Studying the Effect of Symmetry in Team Structures on Collaborative Tasks in Virtual Reality

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Studies involving collaboration in groups are frequently carried out under symmetrical conditions, meaning that all team members have the same role at the same time. In Virtual Reality, symmetrical collaboration often seems attractive as it allows all participants to be included in the VR environment, but it is not clear whether this provides any benefits over asymmetric forms of collaboration, such as when some team members are in VR while others are working on laptops. We conducted a study to compare the conditions of symmetric configurations (both team members use VR) and asymmetric configurations (one member in VR, and the other uses a laptop) when two participants performed a creativity task together. We found that there were differences in participant behavior and the ideas generated. We conclude by proposing guidelines for future work in the area, particularly related to the use of Virtual Reality for creativity workshops.

Keywords: Multi-user Virtual Reality; Symmetric Collaboration; Creativity Workshops

1 Introduction and State of the Art

In recent years, Virtual Environments (VE) have been used in order to better understand creativity, and find ways to improve it (Ward and Sonneborn 2009; Guegan *et al.* 2016;Fleury et al., 2020). More recently, with the democratisation of virtual reality and increased access to the required hardware, scientific research has highlighted the capacity of immersive VEs to improve creativity when compared to conventional tools and systems (Feeman *et al.* 2018; Mille, Christmann, Fleury & Richir, 2020; Yang and Lee 2020), particularly in collaborative settings.

Creativity workshops, regularly used in companies (Nutzmann *et al.* 2019), are often designed so that all participants have the same role, also known as symmetric collaboration (Osborn 1957; Kohn and Smith 2011). Some specific methods involve giving different roles to participants, such as the six hats method (Alkhateeb 2015; Ekahitanond 2018) or world café (Chang and Chen 2015; Fouché and Light 2011). However, when collaboration formats are compared, it is usually symmetrical arrangements that are considered, such as classic brainstorming (Coskun and Göçmen 2019; Dugosh *et al.* 2000) or the use of sketching as an ideation tool (Van Der Lugt 2002). Similarly, many studies dealing with VR in a multi-user context focus on symmetric collaboration, where all participants have the same role (*e.g.* Buisine *et al.* 2016; Eynard *et al.* 2015; Slater *et al.* 2000). There are clear benefits to collaboration provided by symmetric team structures - all participants are equally included, and have similar viewpoints and methods of interacting with the tools involved, thereby facilitating intra-group communication. Symmetrical setups also seem to perform better than asymmetrical ones at tasks such as solving puzzles (Heldal *et al.* 2005).

Despite these benefits, symmetric collaboration may not always be possible. Virtual and Augmented Reality technologies are increasingly being used for creative tasks because of superior spatial visualisation and manipulation abilities (Grandi et al. 2019), but many teams may not be able to provide VR or AR headsets to all members due to lack of access to the required infrastructure. Teams may find themselves in situations where few members are able to use immersive media headsets, while others have screen-based video feedback of the virtual environment, and collaborate using conventional devices like tablets or laptops. Issues of access and team dynamics may be adversely affected by this asymmetry, and hierarchical asymmetry may be reinforced if team leaders or superiors are given access to these ‘better’ forms of technology.

That being said, the real constraints of technology access make the question of studying the effect of asymmetrical collaboration in VR an important one. Technological asymmetry can take different forms. It can regard for instance ability (users have different actions they can take), challenge (they have different obstacles), interface (different ways of interaction with the system), roles and levels of controls or information receives by the users (Ouverson and Gilbert, 2021). Some recent studies show rather positive effects of technological asymmetry, for example in education when several students use technology together (Thomsen, Nilsson, Nordahl and Lohmann, 2019). In a learning situation, the VR+tablet configuration appears to be better than the VR+VR configuration in terms of presence, immersion and reduction of cognitive load (Drey et al., 2022). In collocated asymmetric VR, the use of a tablet with functionalities of visualization and annotations improve the performance of the collaboration (less time wasted, less errors on the task) in comparison with a simple streaming of the VR content on a screen (Thoravi Kumaravel, Nguyen, DiVerdi and Hartmann, 2020). Collaboration with a larger team can also be efficient in asymmetric configuration based on videoconference tools and VR when use a specific software with relevant functionalities to facilitate this collaboration (Burova et al., 2022).

Asymmetry in collaboration is not always technological. Past work has shown that hierarchical asymmetry (involving superiors or leaders in the collaborative task) can be useful at the stage of idea selection (Keum and See 2017), if not during idea generation. Recent studies have looked at such asymmetrical structures (Chan and Minamizawa 2017; Clergeaud *et al.* 2017; Yang *et al.* 2018), and have shown improvements in social engagement, interest, and interaction among team members (Gugenheimer *et al.* 2017; Serubugo *et al.* 2018; Abadia *et al.* 2018; Lee *et al.* 2020). Through our work, we hope to more clearly compare the effects of symmetry on collaboration in VR. Therefore, the aim of this study was to evaluate the effects of technological asymmetry on the performance on a creative task in VR while collaborating in pairs.

The research question of the present study was "**how do technological asymmetry influence creativity and behavior during collaboration in pairs?"**. Two hypotheses related to this question have been formulated.

In a collaborative situation aimed at generating ideas of solutions to a specific problem, the performance of this collaborative task can be measured by the quality of the ideas generated or by their quantity. In this study, we consider asymmetry as an adaptation to a material constraint that can hinder of slow down collaboration because of the reduction of possible interactions (less immersion and different pattern of human-machine interactions). Similar viewpoints and methods of interaction may improve the collaboration (Heldal et al., 2005). The abovementioned researches revealing positive effects of asymmetry regard activities of communication and learning, but not co-creation of creative solution. In the case of co-creation, the ideas co-created are analysable output to assess the effectiveness of the collaboration.

H1: Quality of ideas is better in symmetrical collaboration than in asymmetrical collaboration.

H2: The participants generate more content in symmetrical condition.

2 Method

2.1 Participants

We recruited 28 participants for our study (20 men and 8 women). The age of the youngest participant was 21, and of the oldest was 27. The mean age was 23.1 (SD = 1.65). All participants were students in the field of virtual reality, which avoids possible biases related to the first use of virtual reality which can make it difficult for participants to concentrate (Ochs & Sonderegger, 2022).

2.2 Procedure

We conducted a within-subjects experiment, where each pair of participants performed a similar creativity task but in two different configurations: a symmetrical one with two VR headsets, and an asymmetrical one with one VR headset and a desktop. In both cases, participants were given 25 minutes to complete the task. The HTC Vive headset was used for the VR component

The virtual environment in which participants were placed was that of an underground train station. The task involved the generation of creative ideas to help solve the problem of air pollution of this type of station by sketching there ideas of solution in the virtual environment. This environment and task was chosen because it is a creative problem, in the sense that several new solutions are possible. Participants in VR are represented by their headset and controllers floating in the VE. The participant on the computer controlled a virtual drone that can be controlled using a keyboard to move around in the VE. Asymmetry here is characterized by immersive or non-immersive visualization (what Ouverson and Gilbert, 2021 name "Information"), but especially by the fact that the participant in VR can draw while the participant on desktop cannot (what Ouverson and Gilbert, 2021, name “Ability”).During the experiment, one or both participants using a VR headset could draw and move around using a teleportation system. In the asymmetrical configuration, the participant on the computer could interact with their partner with a laser pointer that they could orient appropriately with a mouse. In the asymmetric configuration, participants had the liberty to exchange their devices. While we realise that the drone allows for a limited range of interaction, our goal was to develop a system that could realistically be suggested as part of a product or service offer.

During the experiment, in the two conditions, the participants were collocated in the same room and the desktop participants could see the VR participants. They could communicate directly by voice. After the completion of each configuration (symmetric or asymmetric), participants filled a questionnaire that evaluated their collaboration.

2.3 Measures

The creativity of the proposed solutions was measured using the Cropley and Cropley (2008) test to reflect creativity according to four criteria: Relevance and effectiveness (the output is fit for purpose; CC1), generation of novelty (the product is original, surprising and germinal; CC2), elegance (the output is well-executed; CC3) and genesis (which means “generalizability”, the output changes how the problem is understood; CC4). All the ideas were rated by a panel of 3 judges.

To measure the level of detail, objective criteria were chosen: the number of lines drawn by the group, the number of mode changes (colour, size of the line) and the time spent drawing (for this variable, data is considered for each participant in VR and not by dyad, to make it comparable between the two experimental conditions).

Finally, the level of collaboration of the group was measured with a short version of the Team Climate Inventory (TCI) questionnaire (Anderson and West 1998). This version contains 14 items (Kivimaki and Elovaino 1999), each on a 5-point Likert scale. The dimensions measured by the TCI are *vision* (focusing on clear and realistic objectives in which the team members are committed), *participatory safety* (interaction between team members in a participative and interpersonally non-threatening climate), *task* *orientation* (commitment to high standards of performance and preparedness for basic questions and appraisal of weakness) and *support for innovation* (enacted support for innovation attempts including cooperation to develop and apply new ideas). Quantifying and measuring collaboration is all the more interesting, as it has been shown that during collaborative tasks, participants behave differently despite not 'performing' the task differently depending on the medium used (Lisiecka *et al.* 2016).

3 Results

3.1 Comparison

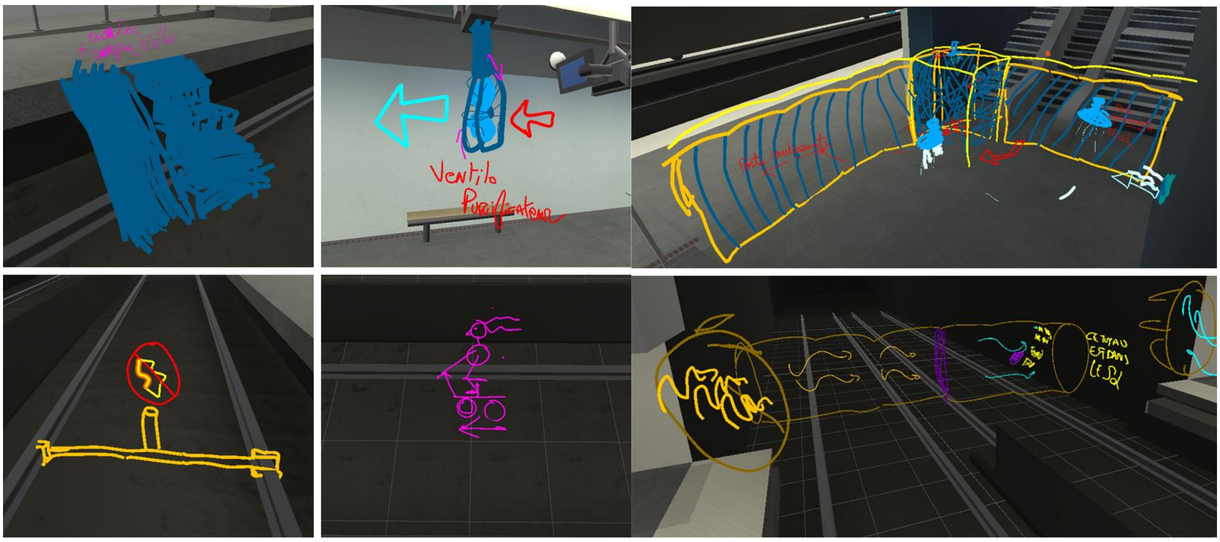

Figure 1. Examples of ideas proposed by participants inside the VR environment (remove electricity and add ramp to allow cycles and pedestrian replace trains, air purifying fan, shower-like device for cleaning travellers).

Screenshots of the virtual drawings were recorded to allow the panel of judges to view and rate them (see Figure 1 for examples of the ideas generated). The internal consistency of the judges' scores was found to be quite high (Cronbach's alpha of the three judges was 0.940). Some of the scores do not follow a normal distribution as measured by Shapiro-Wilk tests. In the symmetric configuration, the overall CC score (.903, $p = .024$), CC1 (.726, <.001), CC2 (.879, $p = .008$), and CC3 (.837, $p = .001$) are not normally distributed, and in the asymmetric configuration the measures of CC1 (.804, $p = <.001$), and CC4 (.871, $p = .004$) do not follow a normal distribution. Table 1 contains all the means and standard deviations for the creativity scores. The results reveal that relevance of ideas are significantly higher in symmetrical condition than in asymmetrical condition, which is consistent with the hypothesis 1. However, none of the other dimensions of Cropley and Cropley (2008) is significantly influenced by the experimental conditions (novelty, elegance and genesis).

Table 1. Values of the creativity scores

Measure	Symmetrical Means (SD)	Asymmetrical Means (SD)	Wilcoxon test (p value)
CC	11.75 (4.511)	10.103 (4.874)	185.000 (.060)
CC1	2.333 (0.933)	1.744 (.906)	95.000 (**.008**)
CC2	5.306 (1.988)	4.872 (2.331)	84.000 (.422)
CC3	2.444 (1.486)	1.949 (1.466)	157.000 (.053)
CC4	1.667 (.667)	1.538 (.589)	95.000 (.694)

Table 2 presents Cronbach's alpha values of the TCI dimensions. The items that were removed to adjust the dimensions are indicated in parentheses, and the items in bold indicate acceptable results (Taber 2018).

Table 2. Cronbach’s alphas of the TCI dimensions

Dimension	Cronbach’s alpha S	Cronbach’s alpha A
Vision	**.704** (TCI 2)	.270
Participatory Safety	**.751**	**.822**
Task orientation	**.639** (TCI 11)	.348
Support for innovation	**.639** (TCI 13)	**.776**

Some dimensions of the TCI do not follow a normal distribution: in the symmetric configuration, Vision (0.918, p = 0.031), Participatory Safety (0.880, p = 0.004) and Support for Innovation (0.919, p = 0.033); in the asymmetric configuration Participatory Safety (0.867, p = 0.002) and Support for Innovation (0.923, p = 0.042). The dimensions were calculated by averaging their items (see Table 3), and each item is on a 5-point scale. As shown in table 3, no significant difference appeared between the two experimental conditions for the dimensions of TCI. Therefore, regarding the variables measuring the perception by the users of the way in which the collaboration takes places, symmetry or asymmetry does not make a significant difference.

Table 3.Values of the TCI items and dimensions

Measure	Symmetrical Means (SD)	Asymmetrical Means (SD)	Wilcoxon test (p value)
Vision	4.161 (.541)	4.170 (.457)	-
TCI1	4.250 (.967)	4.393 (.737)	30.500 (.510)
TCI2	4.714 (.535)	4.750 (.701)	10.000 (1.000)
TCI3	3.893 (.786)	3.786 (.957)	122.000 (.512)
TCI4	3.786 (.917)	3.750 (.844)	63.000 (.882)
Participatory Safety	4.321 (.645)	4.438 (.530)	151.000 (.430)
TCI5	4.464 (.693)	4.214 (.787)	82.500 (.190)
TCI6	4.143 (1.008)	4.536 (.576)	29.500 (.081)
TCI7	4.429 (.742)	4.357 (.678)	58.000 (.743)
TCI8	4.250 (.928)	4.643 (.559)	18.500 (.057)
Task orientation	3.833 (.657)	4.202 (.604)	-
TCI9	3.929 (.940)	4.286 (.897)	44.000 (.206)
TCI10	3.5000 (.923)	3.857 (1.044)	76.000 (.161)
TCI11	4.071 (.858)	4.464 (.793)	42.500 (.098)
Support for innovation	4.060 (.529)	4.024 (.660)	230.500 (.166)
TCI12	4.143 (.705)	3.893 (.786)	101.000 (.230)
TCI13	3.821 (.819)	3.893 (.875)	68.500 (.704)
TCI14	4.214 (.686)	4.286 (.713)	49.000 (.835)

Some dimensions of level of detail measures do not follow a normal distribution: in the symmetric configuration, time spent drawing (.914, p = .032); in the asymmetric configuration, number of mode changes (.900; p = .011), time spent drawing (.914, p = .024) and number of lines (.838, p < .001). The results presented in Table 4 reveal that mode changes and time spent drawing are significantly higher in symmetrical condition than in asymmetrical condition, which is consistent with the hypothesis 2.

Table 4. Values of the level of details

Measure	Symmetrical Means (SD)	Asymmetrical Means (SD)	Wilcoxon test (p value)
Number of mode change	224.692 (97.463)	151.143 (53.262)	38.000 (**<.001**)
Time spent drawing	457.474 (168.811)	266.420 (71.639)	<.001 (**<.001**)
Number of lines	397.000 (188.959)	401.500 (244.358)	143.000 (.416)

3.2 Correlations

We conducted a correlational analysis to interpret the results. There is a correlation between the general creativity scores between both conditions: rho=.509, p=.016. Because there were the same participants in the two experimental conditions, this correlation mean that the participants who are the more creative in one condition tend to be also the more creative in the other condition.

3.2.1 Symmetry

As for the relationship between the results of the TCI and the creativity scores, there are several results. As a reminder, TCI1 corresponds to “Agreement with the objectives”, TCI2 corresponds to “team’s objectives clearly understood”, TCI3 corresponds to “Team’s objectives achievable” and TCI13 corresponds “Time taken to develop ideas”. First, Spearman’s correlation showed a significant correlation between TCI1 and CCS (rho=.681, p<.001). More specifically, it showed a significant correlation between TCI1 and CCS1, CCS2 and CCS3 (respectively rho=0.633, p<.001; rho=.621, p=.001; rho=.660, p<.001). This means that in symmetry condition, agreement with the objectives is positively correlated with relevance of the ideas, their novelty and their elegance. Secondly, Spearman's correlation showed a significant correlation between TCI3 and CCS4 (rho=.651, p<.001). Finally, Spearman's correlation showed a significant *negative* correlation between TCI13 and CCS (rho=-.490, p=.015). More specifically, it showed a significant *negative* correlation between TCI13 and CCS3 and CCS4 (respectively rho=-.524, p=.009; rho=-.488, p=.016). As for the dimensions of the TCI, Spearman's correlation showed a significant relation between general creativity scores and Vision (or clarity) (rho=.501, p=.013). More specifically, it showed a significant correlation between Vision and CCS1 (rho=.434, p=.034), CCS2 (rho=.446, p=.029) and CCS3 (rho=.497, p=.014). Spearman's correlation also showed a *negative* link between time spent drawing and TCI2: rho=-.462, p=.018. To sum up, in symmetry condition, the main correlations with creativity scores are with the items of Vision.

3.2.2 Asymmetry

In the asymmetric condition, only the correlations between some TCI and CCA4 (genesis) were significant. As a reminder, TCI5 corresponds to "*'We are together'* attitude", TCI10 to "Critical appraisal of weaknesses", TCI12 to "Search for new ways of looking at problems" and TCI14 to "Cooperation in developing and applying ideas". Firstly, Spearman's correlation showed a significant *negative* correlation between TCI5 and CCA4 (rho=-.524, p=.006). Secondly, Spearman's correlation showed a significant correlation between TCI10 and CCA4 (rho=.443, p=.023). A *negative* correlation also appeared between the number of mode changes and the TCI dimension "Support for Innovation" (rho=-.538, p=.003), as well as the items in it (12: rho=-.446, p=.017; 13: -.447, p=.017; 14: rho=-.448, p=.017). Finally, a Spearman's correlation showed a *negative* link between the time spent drawing and TCI14: rho=-.378, p=.047. To sum up, in asymmetry condition, the main correlations with creativity scores are with the items of participatory safety, task orientation and support for innovation.

4 Discussion

The objective of this study was to determine how a difference in collaboration patterns (symmetric and asymmetric configurations) influences participant creativity and behaviour in a paired task. Our results tend to show that there are certain relationships between specific aspects of behaviour and creativity, although there is no significant difference in the overall creativity score between the two configurations.

4.1 Links between behaviour and creativity

To begin with, the correlations highlight different links between participants' behaviour and their creative performance. In the symmetrical configuration, concerning the TCI dimensions, a good Vision (or clarity) has a positive impact on creativity, especially on the criteria of relevance and effectiveness, generation of novelty, and elegance. Creativity and these same three criteria are correlated with the item ‘Agreement with Objectives’ as well. Similarly, believing the team’s objectives are achievable positively impacts genesis. However, the time taken to develop ideas negatively impacts global creativity, and more particularly elegance and genesis.

The more the objectives were understood, the less the participants spent time drawing. Note that the understanding of the objectives impacted neither creativity nor the other measures of the level of details. Moreover, the time spent drawing in the symmetric configuration is significantly higher than in the asymmetric configuration, by nearly a factor of 2 (1.70). An additional observation that can be made by looking at the drawings is that some are kind of ‘colored’: some sides are filled with a line, as to show it is solid. It thus seems that there is a line efficiency concept: participants drew more schematic ideas when they understood the objectives well.

In the asymmetrical configuration, a ‘we are together’ attitude (TCI5) negatively impacts genesis, while the critical appraisal of weaknesses impacts it positively. This means that being more focused on the task than on improving group dynamics allows for an improved performance, while also having a critical debate. Negative correlations appeared between the number of mode changes and the dimension of ‘Support for Innovation’, as well as the 3 items composing it. Yet, participants changed modes more in the symmetrical configuration when compared to the asymmetrical configuration, with no difference in their behaviour towards innovation. Thus, participants were more efficient on their use of proposed options during asymmetrical task performance, and this has had a positive effect in terms of innovation.

There is a *negative* link between the time spent drawing and the cooperation in developing and applying ideas. However, participants spent less time in the asymmetrical configuration, and the item cited above was not different between the two conditions. Thus, asymmetric collaboration could indeed allow teams to be more efficient in the production of ideas.

More generally, this means that in order to produce the best ideas in symmetry, users have to have a good ‘Vision’, and be in agreement with the objectives. This will also impact the time spent drawing: they will be more efficient. Believing the objectives are achievable positively impacts genesis, while taking more time to develop ideas negatively impacts creativity, and notably elegance and genesis. In other words, isolation and intrinsic motivation can help improve creativity. This relationship between intrinsic motivation and creativity seems to be coherent with recent literature (Tan *et al.*

2019).

In asymmetrical configurations, users should focus on the task itself, while encouraging constructive criticism within the group. This state of collaboration can allow for improved creativity, especially genesis. Moreover, we saw that relevance and effectiveness, generation of novelty, and elegance are correlated with the item of 'agreement with objectives' in symmetrical configurations but not in asymmetrical configuration. In asymmetrical configurations, participants are forced to cooperate because the laptop-bound participant cannot draw, they can only participate in the task through interactions with their partner. Maybe this is a way to reduce social loafing that tend to appears in collaborative work (Stieglitz, Mirabaie, Möllmann & Rzyski, 2021). Make the participants communicate with each other could be beneficial to favour mutual trust that can promote teamwork engagement (Zhan, Meng, de Pablos & Sun, 2019), and to favour knowledge sharing that improve group creativity (Zhang, Zhang, Sun, Lytras, Patricia & He, 2017). On the other hand, participants in the symmetrical condition could draw things without directly cooperating with their partner. The fact that they are not compelled to cooperate under the symmetrical condition makes their group performance dependent on their agreement with the objective.

Finally, concerning the results of creativity, it has been seen that there is a strong correlation between the results of the two configurations. In other words, the configurations themselves did not fundamentally impact the creativity of the group, and thus of the individuals, because there is a strong correlation between the creativity of the group and those of its individuals (Pirola-Merlo and Mann 2004). However, there is a significant difference in one of the dimensions: relevance and effectiveness, with a superior score in symmetrical collaboration than in asymmetry. Thus, the symmetric configuration leads to more routine ideas as defined by Cropley and Cropley than the asymmetric one. This can be interpreted as the result of an easier collaboration due to the similar methods of interaction and viewpoint (Heldal et al., 2005). Regarding the hypothesis 2, participants in symmetric condition spent more time in drawing activity and done more lines. Looking at the whole picture, we may interpret that participants in symmetric condition were less focused on cooperation, but more focused on their own drawing. Therefore, they were more “productive” in their drawing activity in comparison with asymmetric condition.

4.2 General recommendations

In light of these results, in the symmetric configuration, having good clarity of the objectives and not taking too much time per idea improves creative output. This seems to fulfill the basic requirements of a divergent creativity workshop, where the aim is to have as many ideas as possible in as little time as possible. Furthermore, the more time is spent drawing, the less elegant and generic the idea becomes, which may sometimes be inefficient for the divergent phase. Finally, this would allow the generation of a better set of ideas to select from during the next phase of convergence. In the asymmetric configuration, focusing on the task at hand more than group dynamics, and being critical towards the proposed ideas leads to better ideas in our study. These seem like good qualities for a convergence phase during ideation. Moreover, drawing from the results of Keum and See (2017), giving the control of the drone to a superior (team leader) could also be beneficial to the selection process. R&D teams can also benefit from the results pertaining to the asymmetric condition. According to Bain *et al.* (2001), the focus on ideation tasks is of crucial importance to such teams. Therefore, an asymmetrical tool could be particularly useful for this type of team.

In conclusion and in more general terms, the asymmetric configuration forces people to communicate and work together, whereas symmetry allows users to work individually on a creative level towards a broader group goal. Therefore, at the scale of a pairwise collaboration, we now have general recommendations for circumstances where it may or may not be possible to provide VR tools to both participants, and discuss the consequences on creativity and behaviour in both situations. At this stage, we cannot be sure that these results are also applicable to larger groups, neither in asynchronous collaboration. We have also detailed the behaviours in both configurations in order to improve the quality of ideas generated by participants. Through this study and the analysis that has followed, we hope to have given some insights for teams or organisations that want to make the most appropriate decision while setting up collaborative tasks in Virtual Reality, with focus on creativity and ideation.

We also have another recommendation regarding the evaluation of creativity. We found that there was no correlation between the level of details measured in each idea and creativity. As such, it seems that at least the specific levels of details we considered are not relevant to measure creativity without using questionnaires. However, there may be other measures that could be relevant in order to have another source to measure creativity, and we hope that future studies will help investigate the same.

There are a few concerns regarding the experimental setup as well. During the whole experiment, participants were under the attention of at least two experimenters. The question may arise as to whether the participants would have been as active in problem solving had it not been for the experimenters. Moreover, participants also complained about the lack of interactivity of the drone. An increase of the same could also have led to different results, e.g. move closer to the results of the symmetric condition if we had added a drawing tool to the drone. From this point of view, we can even go further and wonder what role(s) can be given to people who would not wear a headset. Should they explicitly have the role of a supervisor? If there are not enough headsets for everyone, what is the sufficient number of asymmetric roles?

The final question we have is whether encouraging the behaviours we observed in the best cases actually improves creativity. Indeed, in the design of the experiment, participants were not incentivised to behave in a certain way. Will encouragement (as so often happens during group work) lead to a perceptible difference in performance or clarity of objectives compared to a control group, and would that improvement lead to a better creativity? This is but one line of questioning that arises from our study. We hope that our work helps spark conversations on the subject of collaboration, creativity and VR, and serves as a good starting point for future work in the area.

5 Conclusion

Technological asymmetry corresponds to work situations that could be frequent in the future. Indeed, the disability of certain employees or the unavailability of equipment in the organization make it critical for these asymmetric situations to function satisfactorily.

Drey et al (2022) revealed some positive results with technological asymmetry, but their control group was also asymmetric, with only less elaborated functions. In the present study, we revealed some positive impacts of symmetry in comparison with asymmetric condition. In the present study, we find that this asymmetry is not necessarily negative in terms of its impact on collaborative work. A key point is that technological asymmetry can lead to participants having different possibilities of action in the digital environment. In this case, it can create situations of dependencies in which they can be forced to communicate because some participants cannot perform certain actions.

In terms of how to foster collaboration, trust between individuals was known to be an important element (Zhang et al., 2019), as was knowledge sharing (Zhang et al., 2017).

This research shows that technological choices can also be a determining factor, providing constraints and opportunities.

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