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Analysis of Customized Avatars, Environments, and AI support on Group Decision-Making in Virtual World

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Abstract : This paper designs a VR conferencing system to maximize performance in group decision-making work contexts. A combination of aspects were analyzed, the design of avatars and scenarios, and AI as a communication facilitator. Experiments reveal certain design combinations enhance performance.
Keywords: group decision making, performance, organizational behavior, work communication, AI facilitator

1. Introduction

With the advent of accessible AI tools and digital environments, people's lives are increasingly becoming a hybrid between virtual and real world experience, but little, consistent, application of virtual environments can be found in work environments by companies [1].

Although video conferencing software like Zoom has been widely adopted in recent years for remote communication by corporations and educational organizations [2], three dimensional virtual meetings tools are yet to be established in these institutions' workflows for a variety of reasons [3]; the cost of virtual reality (VR) hardware is high, the required set-up time is high, using the hardware may cause physical discomfort, there are issues with the integration of VR into existing non-VR systems [4]. There is record of VR adoption focusing on training purposes [5], showing faster tasks learning time and increased confidence of learners while applying the skills acquired in VR. However, some companies like Meta and HTC are pushing their business oriented VR meeting tools. One of the issues identified with the extensive usage of two dimensional video conferencing tools is fatigue, in literature also defined as "Zoom Fatigue" [6] or "video conferencing fatigue" [7], which negatively affects its users over long periods of time because of the format in which people keep interacting with each other.

The user experience of a VR conferencing system is as important as the implementation feasibility issues. Freedom of movement, realistic simulation of movement, especially on regards of facial expression, environment customization (i.e., avatar, scenario) [8], are some design elements that must be taken into account to build an efficient business VR communication tool. Artificial intelligence (AI) based conversational agents support is another element that could support meetings [9]; in VR their presence could be felt more through avatar representation.

In this paper the effects of different design elements will be analyzed and discussed, with a keen interest on performance, both quantitatively and qualitatively, in order to define necessary VR conferencing system functions that are best suitable for business contexts.

2. Related papers

Moser's tells us that such system should allow users to communicate at least at the same efficiency level of other mediums [10]. However, allowing agency over each user's avatar, could provide increased system usage continuance intention [11]. Building an avatar that resembles qualities of creative persons, makes their users perform better in terms of fluency and originality of ideas [12]. Training scenarios with visual high fidelity to the real life task made individuals feel a higher sense of presence [13]; however, their completion time (i.e., performance) is lower in lower fidelity scenarios. Participating in straightforward, unrelated tasks that give room for the mind to wander could help in fostering inventive solutions to problems [14]; the design of the user experience may influence how the conversations between participants unfold.

3. Proposed System

Accounting for the notions mentioned above, we may build a system with custom avatars, custom scenarios and with AI discussion facilitator.

3.1 Phase 1 - Visual variables

Let's consider two opposite avatar styles, a humanoid avatar with realistic movements and facial expressions, and an arcade avatar with no lower limbs and no facial expressions. The humanoid shown below is made with "Ready Player Me[1]", the arcade was created with the "Hackweek Avatar Maker[2]".

Figure 1 From the left, a humanoid avatar and an arcade avatar

We may now consider two opposite scenario designs, the "usual" work office room, and the "unusual" outer space meeting ambience. Both were built using Unity Store free assets.

Figure 2 From the top, the office and the space scenarios

Considering what has been stated in Chapter 2, the following hypotheses are produced:

H1: The design combination of humanoid avatar and outer space scenario produce the best performance.

H2: The design combination produces different behavior while sharing information.

3.2 Phase 2 - Discussion Variables

Knowing that in group discussions, one of the roles taken by its members is the facilitator [15], we must address their do and don'ts. One point which may be difficult to maintain for a human is neutrality. An AI could achieve this by setting up proper rules, making it a neutral, acceptable by all, and with no decision making power. Therefore, the AI Facilitator would only focus on applying facilitation techniques to reach the ultimate set objective. Two hypothesis are then formulated:

H3: The AI Facilitator, compared to a team established human facilitator, allows a team to exchange more information.

H4: The AI Facilitator makes the decision-making process be perceived qualitatively as more efficient by humans.

4. Experiments

The two scenarios were built in Unity and then uploaded to VRChat[3]. The avatars were built by the participants, to address agency over their virtual representations. Then they were sent to the researcher to allow body and facial movements using Blender[4]. Finally, they were uploaded to VRChat through the Unity SDK[5], which allowed for eye movement simulation and voice-based face motion. Participants completed a financial investment task remotely, completely in VR [16], using Meta Quest 2 head mounted displays. Performance was measured in terms of probability of exchanging information. Following the hidden profile paradigm for a fictitious financial task, eighteen information was distributed unevenly: each person possessed six information regarding one company, the shared information among all members, and three information regarding the second company, as the unshared information. The more information is shared, the more likely is to decide, as group, for the correct answer. Behavior was recorded whenever any one of the avatars was sharing a single unit of information. Avatar's behavior can either be "reading", to represent checking the information being shared on their own information pamphlet, "looking at others", when the avatar moves their head towards another and doesn't focus on the pamphlet, and "moving", for anything excluded from the previous two classifications; playing with the information pamphlet, go around the virtual environment, play with themselves or others being distracted by the environment. Peeking another avatar's information was not allowed and would cause the iteration to be invalidated. Data obtained includes video recordings of the virtual meetings, discussion transcripts and qualitative questionnaire items response.

4.1 Results - Phase 1

In the first experiment, four humans interacted with each other, trying to solve the financial investment task. Six groups experienced the four variables combinations, being "Arcade Office", "Arcade Space", "Human Office" and "Human Space".

We measured performance in terms of mean information shared and behavior in terms of probability of performing a certain action while exchanging information.

Combinations Arcade Office (Mean: 0.63, S.D.: 0.28) and Arcade Space (Mean: 0.67, S.D.: 0.29) are similar, while Human Office performed worse (Mean: 0.52, S.D.: 0.26). Human Space performed the best (Mean: 0.98, S.D.: 0.03), even though three

[1] Ready Player Me: https://readyplayer.me/
[2] Hackweek Avatar Maker: https://mozilla.github.io/hackweek-avatar-maker/
[3] VRChat: https://hello.vrchat.com/
[4] Blender: https://www.blender.org/
[5] VRChat SDK: https://creators.vrchat.com/sdk/

instances, the most among all design combinations, were invalidated. The univariate analysis of variance (ANOVA) performed on SPSS shows a trend of 0.09 in regards of the environment design being significant. Therefore **H1** cannot be verified quantitatively.

In terms of behavior, we notice that the Arcade design predicts higher "reading" actions (p=.001), the Human design predicts higher "looking at others" actions (p<.001), and that the "moving" actions are predicted higher by the Arcade design (p=.009), by the Space design (p=.021) and by the combination of Arcade and Space (p=.041). Therefore **H2** is confirmed.

To address the experience of participants, they were asked: "What did you pay attention to complete the task?", after each iteration. In the Arcade Office instance, they focused on reading carefully the documents, understanding differences in information and ensuring clear communication; however, they lamented difficulty in controlling their avatar's hands. In Arcade Space, they focused on innovation and market potential for the final decision; the outer space scenario was appreciated, but some thought sometimes the combination with a non-humanoid avatar made the whole experience distracting from the task. In Human Office, effective communication was achieved through clear articulation and the use of body language, to synthesize information from different sources, ensuring everyone was heard. In the Human Space combination, they focused on logical consistency of information and tangible company performance results, while speaking concisely, clearly and listening carefully to each other; this environment was described as "fun", as some mentioned playing "Rock, Paper, Scissors" together.

4.2 Results – Phase 2

In the second experiment, three humans and one AI interacted with each other trying to solve the financial investment task. Eight groups experienced the two variables combinations, being "Human Space", the most performant combination found in the previous experiment, and "Human Space + AI".

AI was implemented using OpenAI's GPT4o voice function[6] and by building a Custom GPT, the "Team Communication Facilitator". The instructions given specified the context "*You are a member of the financial investment team. The financial investment team is composed by you and 3 other humans.*", by specifying the role "*Your role in the discussion is to facilitate the humans to share their knowledge.*", and by specifying the objective "*Drive the conversation flow and ensure the team agrees on which one of the two companies is the best to invest in.*". Additional rules to limit the choice of wording (i.e., "*you are a colleague*", try to be appropriately formal), the length of interventions and the forbidden interactions with humans (i.e., "*If someone asks you a question regarding the content of the task, mirror the question to another human participant*" and "*Avoid having an opinion*") were added.

At the time of speaking, it was not possible to utilize the voice feature on computers, so the above design was built.

We measured performance and behavior similarly to the first experiment.

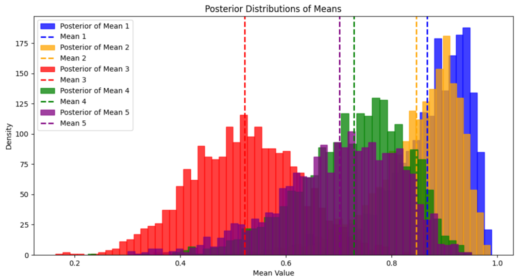

Figure 3 Posterior distribution of Means

We run Markov chain Monte Carlo simulation (samples=2000) to obtain posterior samples based on our results on the first experiment, in green "Arcade Space", purple for "Arcade Office", red for "Human Office" and blue for "Human Space"; yellow represents "Human Space + AI" (Mean: 0.9, S.D.: 0.12). Difference between the two latter ones is not significant (T-test p=.258). As a result, **H3** cannot be confirmed.

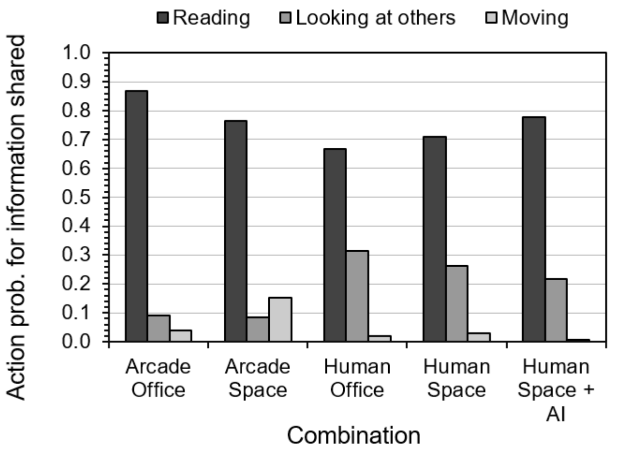

Figure 4 Action by design combination

In terms of behavior, there is no significant difference with Human Space, indicating similarity. However, the post-experiment questionnaire provides interesting qualitative data. Participants emphasized the importance of listening to others' opinions and reading texts accurately. They focused on fully understanding the task and sharing their own information while also extracting information from others. The AI facilitator's guidance influenced participants to pay close attention to both content and nuances of their teammates' contributions. AI was particularly effective in breaking silences and maintaining the flow of conversation. Some participants appreciated the AI's

[6] GPT4o: https://openai.com/index/hello-gpt-4o/

ability to offer objective, unbiased facilitation based on the participants words, which helped to streamline discussions and focus on relevant points to reach a conclusion. Nevertheless, participants noted that despite the AI's ability to kick-start conversations, it could not always adapt to the dynamic nature of human interactions as effectively as a human facilitator. This time, AI's avatar was a robot with head, hands and feet. It was appreciated as some felt added a sense of professionalism and objectivity. Some think that a more casual or cute avatar might make the ambience feel more relaxed and approachable. Few think it didn't affect significantly their communication. On the other hand, a humanoid avatar might create a sense of competition, whereas non-humanoids could help distinguish roles and responsibilities within the discussion. Thus, **H4** is verified.

5. Discussion

Unusual scenarios, unrelated to the task to be done, increase the performance, while avatars need to be able to replicate realistic movements, especially in more detail for face and hands, allowing users to fully communicate non-verbally; a VR conferencing system should allow for high customizability within these terms. Further research on the effects of such high detail level of control, in conferencing system should be addressed.

AI Facilitation is a powerful tool that should be integrated, as long as it maintains its virtual presence with a distinctive look. Its visual representation effects should be furtherly researched.

More comprehensive behavioral measurements should be conducted, allowing to check if any relationship between behavior and performance exists in such VR work contexts.

6. Conclusion

In this paper we explored the boundaries of some VR conferencing tool requirements, analyzing their effects on decision-making in business related contexts. We found that design elements influence performance and interaction also in work contexts. Finally, we suggest new research approaches.

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