Effect of Avatar Anthropomorphism on Body Ownership, Attractiveness and Collaboration in Immersive Virtual Environments

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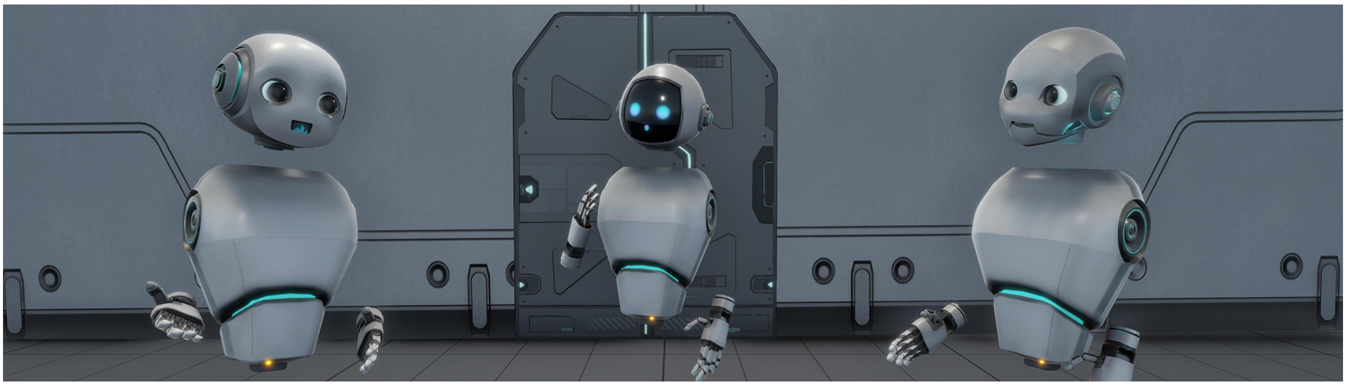


Figure 1: *Screenshot of the three avatars embodied by the participants in the immersive collaborative virtual environment of the experiment.*

Abstract

Effective collaboration in immersive virtual environments requires to be able to communicate flawlessly using both verbal and non-verbal communication. We present an experiment investigating the impact of anthropomorphism on the sense of body ownership, avatar attractiveness and performance in an asymmetric collaborative task. Using three avatars presenting different facial properties, participants have to solve a construction game according to their partner's instructions. Results reveal no significant difference in terms of body ownership, but demonstrate significant differences concerning attractiveness and completion duration of the collaborative task. However the relative verbal interaction duration seems not impacted by the anthropomorphism level of the characters, meaning that participants were able to interact verbally independently of the way their character physically express their words in the virtual environment. Unexpectedly, correlation analyses also reveal a link between attractiveness and performance. The more attractive the avatar, the shorter the completion duration of the game. One could argue that, in the context of this experiment, avatar attractiveness could have led to an improvement in non-verbal communication as users could be more prone to observe their partner which translates into better performance in collaborative tasks. Other experiments must be conducted using gaze tracking to support this new hypothesis.

CCS Concepts

• ***Human-centered computing*** → ***Virtual reality;***

1. Introduction

Understanding the processes allowing people to collaborate in immersive virtual environments is a current challenge at the crossroad of computer science and psychology for virtual reality researchers. It is necessary to understand such mechanisms to develop applications allowing users to interact together through virtual characters (avatars) [RWS*16] while providing a satisfying user experience. Several studies aim at investigating the impact of multisensory integration (e.g. visuomotor and visuotactile synchrony [KS14]) or virtual characters' properties such as realism, eye gaze or lip synchronization relying most of the time on human characters [SWM*08, SOM*09, Gar03, GSV*03]. Such research uses eye tracking technologies and/or full-body tracking. However, there is a technological gap between lab experiments and most available virtual reality applications. In this context, we decided to conduct an experiment based on lightweight setups avoiding relying on full-body tracking to control virtual legs and arms to be in line with a lot of use cases and mass market virtual reality devices. Therefore, we designed an experiment involving three robotic avatars allowing to use non-human body schema (no legs, and floating hands) presenting different anthropomorphic facial properties (Figure 1). First, we are interested to analyze if, whether or not, more realistic anthropomorphic facial properties favor attractiveness [ZAJ*15, FMR*17, GCHR18] as well as users' sense of body ownership [SMESV09]. Second, we aim at investigating if such facial properties allow for better performance in collaborative tasks thanks to a better adequacy between verbal and non-verbal communication. Finally, we explore the relationship between body ownership, attractiveness and users' performance in immersive virtual environments.

The next section presents a state of the art relative to both body ownership and attractiveness as well as an overview of several factors influencing communication and collaboration in immersive virtual environments. Section 3 presents the design of the experiment and its protocol. Results are analyzed in Section 4, discussed in Section 5 and limits are highlighted in Section 6. Section 7 presents the conclusion of the study and Section 8 introduces our future work.

2. Related Work

2.1. Body Ownership

The sense of body ownership is part of the embodiment process in virtual environments. The sense of embodiment refers to the feeling of being located inside, of owning and controlling another body. According to Kilteni *et al.* [KGS12], the sense of embodiment towards a virtual body could be defined as the sense that emerges when the virtual body's properties are processed as if they were the properties of one's own biological body. Three dimensions are identified as part of the sense of embodiment in immersive virtual environments:

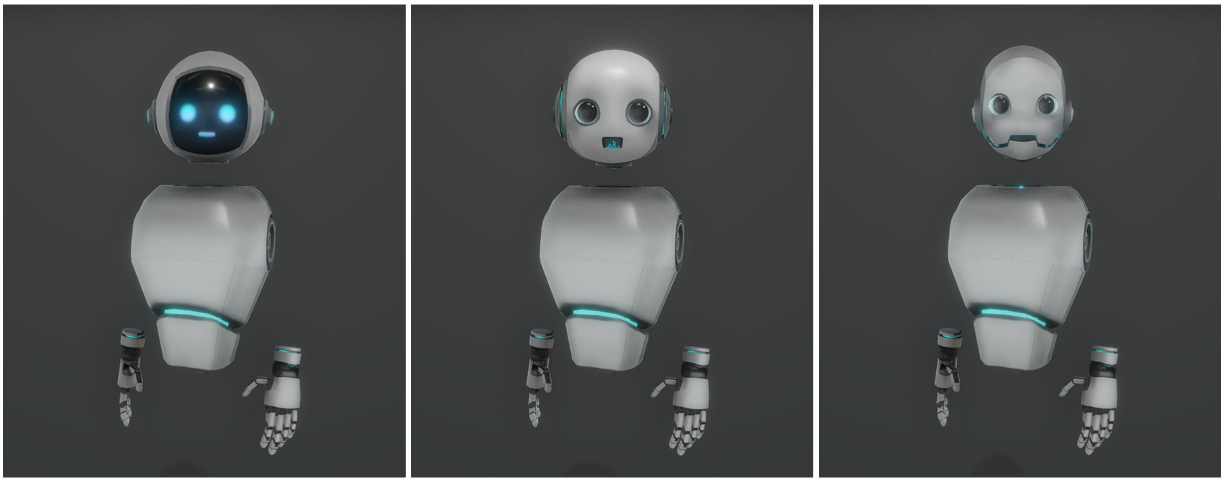
- Self-location, corresponding to a determinate volume in space where users feel located. The sense of self-location is mainly affected by bottom-up factors such as visuotactile synchrony [LTMB07, Ehr07] or perspective [GCAR17, DMHB15, SSSVB10].
- Agency, defined as the *"global motor control, including the subjective experience of action, control, intention, motor selection and the conscious experience of will"* [BM09]. As for self-location, bottom-up factors impact the sense of agency. For instance, visuomotor synchrony appears to be a very effective contributor [DMHB15, GCHR19, JAAL18, CCH15]. The sense of agency is also correlated with an internal locus of control [DFA*19].
- Body ownership, which refers to one's self-attribution of a body [KGS12]. Both bottom-up [BDH*18, KS14, SMESV09] and top-down factors [GCHR19, WGR*18, LRG*17, AHTL16] can impact the sense of body ownership.

While self-location and agency are important to embody avatars in virtual environments, our study focuses especially on the sense of body ownership. Indeed, according to previous work, none of our variables are supposed to impact other dimensions of the sense of embodiment. The famous Rubber Hand Illusion (RHI) paradigm [BC98] demonstrated that it was possible to induce a proprioceptive drift through synchronous visuotactile stimulation between a real and a fake hand resulting in a sense of ownership over the fake limb. Based on such results, the same paradigm has been replicated in virtual environments [SPESV08] demonstrating that multisensory integration (e.g. visuomotor and visuotactile synchrony) [KS14] is a critical contributor to the emergence of a sense of ownership that allows the embodiment of avatars with different morphological and demographic characteristics [BGS13, KBS13, PSAS13, SSSVB10]. It is also demonstrated that morphological similarities can impact positively the sense of ownership [AHTL16, LRG*17, WGR*18, GCHR19]. That's why, thanks to visuomotor synchrony (head, torso and hand positions and rotations), we expect participants to be able to embody every robotic avatar proposed in our application, as it has already been observed in previous experiments [LLL15], but that the different facial properties can impact the sense of ownership. In addition, it should be noted that sharing a virtual environment with other users, as in the proposed experiment, does not impact the sense of embodiment [FAHL18].

2.2. Attractiveness

It is acknowledged that attractiveness of avatars has a significant impact in both single and multi-user applications. On the one hand it can impact the way participants evaluate their avatar and to what extent they feel comfortable using this one [GCHR18]. On the other hand, it can affect the way people behave and interact when they are exposed to social situations in immersive virtual environments [YB07] or even their performance in massively multiplayer online games [YBD09]. Several characteristics can affect attractiveness evaluations of virtual characters. For instance, previous studies demonstrated that realism is not a good predictor of attractiveness [ZAJ*15, FMR*17]. The work of Zell *et al.* [ZAJ*15] illustrates the importance of consistency between the level of stylization of the shapes and materials of the characters, with inconsistencies having a negative impact on their attractiveness. The work of Fleming *et al.* [FMR*17] also reveals the significant influence of shapes and proportions. Their results showed that attractiveness evaluations are more favorable for avatars with an intermediate level of stylization compared to the original and highly realistic scanned 3D models. However, McDonnell *et al.* [MBB12] demonstrated that both highly realistic and highly abstract character could be rated as more appealing, which may be explained by the occurrence of an uncanny valley effect for intermediate conditions [MMK12, SN07]. Therefore, avatar visual fidelity has to be taken into account when designing virtual characters as it affects the way users behave when controlling and interacting with their avatar [GCHR18, GCHR19]. According to Garau [Gar03], visual fidelity of virtual characters can be categorized in three criteria:

- Anthropomorphism (*non-humanoid* <-> *humanoid*): Morphological characteristics of the virtual character.



(a) *Robot 1: Virtual eyes and mouth* **(b)** *Robot 2: Physical eyes and virtual mouth* **(c)** *Robot 3: Physical eyes and mouth*

Figure 2: *Screenshots of the three avatar conditions of the experiment*

- Realism (*few detailed* <-> *photorealistic*): level of detail of the mesh and textures of the 3D model.
- Truthfulness (*does not look like the user* <-> *looks like the user*): degree of similarity between the user and the virtual character [BBF*97].

Based on previously reported studies, it is acknowledged that realism [ZAJ*15, FMR*17, MBB12] and truthfulness [GCHR18, GCHR19] can affect users' perception of virtual characters. To further complete such results, we are interested to investigate if anthropomorphism impacts avatar attractiveness evaluations in immersive collaborative virtual environments.

2.3. Communication in Collaborative Virtual Environments

If visual fidelity is an important factor to consider when dealing with attractiveness, it has also been demonstrated that behavioral fidelity, through gestures and facial expressions, has to be taken into account to allow for a flawless communication in virtual environments [Gar03, MESRPN06]. Social interactions rely on both verbal and non-verbal communication. It is acknowledged that verbal communication favor co-presence, defined as sense of being there with others [DS00], in immersive virtual environments [EPCR15, OBW18]. This study does not focus on this aspect as it is not directly linked to virtual characters' facial properties. However, non-verbal communication could be affected by the anthropomorphism level, as the more realistic facial properties are, the more users' real expressions can be reproduced and therefore affect the way they communicate and collaborate.

Non-verbal communication can be either conscious, when it comes to intentional behaviors such as gestures, body postures, facial expressions, or unconscious such as micro-expressions. Used in combination with verbal communication, gestures add an emotional valence and help to communicate. Regarding virtual characters, it has been demonstrated that more accurate gestures allow for a better non-verbal communication [WWJ*19]. In addition, unconscious and therefore uncontrolled expressions have been the subject of studies aiming to investigate the impact of virtual agents expressiveness and their ability to communicate emotions [MGKR19, LML09]. However, current mass market virtual reality devices do not allow users' facial expressions to be recorded and transferred to their avatar, unless a custom headset is used [RUY18]. On the other hand, conscious non-verbal communication (gestures and facial expressions) appears to improve users' sense of co-presence [CB01]. Moreover, avatars' gaze animations can impact users' perception of communication [GSBS01] and provide visual clues concerning the attention state of their partner [SWM*08, SOM*09, RKB*18]. According to these studies, a more realistic eye gaze implementation leads to higher communication potential and more realistic responses during dyadic interactions.

Therefore we designed this experiment using three avatars presenting different facial properties to investigate if anthropomorphism impact attractiveness evaluations and collaboration in immersive virtual environments.

3. Materials and Methods

In order to investigate the impact of anthropomorphism, each pair of participants embodies one of the three characters (same avatar for each pair of participants (Figure 2)) in a between subject design. They have to collaborate to solve two puzzle games (Figure 3). Each participant has the plan corresponding to his/her partner's puzzle. It creates an asymmetric collaborative situation where they have to explain alternately where to place the 3D parts on the game boards. At the end of the experiment, the participants evaluate the attractiveness of the avatar as well as their sense of body ownership. These data are then compared with their performance to achieve the collaborative task. The three avatar conditions are classified according to their facial properties:

- Robot 1 (R1) (Figure 2a): screen based face that displays a set of textures to animate both the eyes and the mouth using different

sets of textures. The robot's mouth is animated when the user is talking using a sequence of six textures.
- Robot 2 (R2) (Figure 2b): physical eyes and virtual mouth. The virtual mouth is an equalizer displaying bars matching the intensity of the user's vocal frequencies.
- Robot 3 (R3) (Figure 2c): physical eyes and jaw. The physical jaw moves according to the user's voice intensity.

It should be noted that in this experiment, the different anthropomorphism levels require different gaze implementation due to the nature of the eyes (texture versus mesh) to achieve a convincing gaze behavior.

3.1. VR application

The virtual reality application used for the experiment was developed using the real-time 3D engine Unity. The environment consists in a room matching the avatars' appearance and textures to create a coherent and plausible environment. Both avatars appear in the center of the room on each side of the table where the game boards are located. Participants are able to communicate using both verbal and non-verbal communication, but they cannot see their partner's plan required to complete their own puzzle.

3.2. Apparatus

Two HTC Vive pro are used to display the virtual environment at a refresh rate of 90 Hz with a resolution of 2880 x 1600 pixels (1440 x 1600 pixels per eye) and a field of view of 110 degrees (Figure 4).

Figure 3: *Participants performing the collaborative task.*

Computers are composed of an Intel Xeon E5-1607 @ 3.10 GHz processor and a Nvidia GeForce GTX 1080 graphics card.

3.3. Participants

36 participants (10 females and 26 males), aged from 21 to 47 (M = 23.42, SD = 4.34), were recruited for the experiment. Each subject has a correct or corrected vision thanks to vision glasses allowing them to use the VR headset. All the participants had prior experience with immersive virtual reality and 29 of them play video games at least 2 hours a week. 22 out of 29 are used to playing multiplayer online games. We recruited experienced participants as we believe our results will be more relevant for future use cases considering the fact that in a near future most people will have such an experience with virtual reality. Indeed, participants experiencing VR for the first time may be distracted by the novelty and might be less focused on the task and their partner, which could have an impact on the results in terms of both performance and subjective measures.

3.4. Procedure and Measures

Prior to the experiment, each participant read and signed a consent form. Participants were informed that they were free to withdraw from the experiment at any time without giving reasons. Then, each participant filled the pre-experiment questionnaire to collect their demographic information as well as relevant data regarding the content of the experiment such as any previous experience with virtual reality and video games.

Each pair of participants was provided with the necessary instructions to begin the experiment and was equipped with the virtual reality headset in a separated room. As soon as the participants are geared up, they are immersed in the virtual environment. The experiment begins in two distinct virtual rooms where they embody their avatar for two minutes in front of a virtual mirror. Then, they meet each other in another environment dedicated to the collaborative task consisting in completing two puzzles. Participants com-

(a) *Room 1* **(b)** *Room 2*

Figure 4: *Participants equipped with the virtual reality headset HTC Vive pro and the controllers.*

Table 1: *Body ownership and attractiveness questionnaire. Items range from 1 to 7.*

Body ownership
I felt that the virtual body that I saw when I looked down was my body.
I felt that the virtual body I saw in the mirror was my body.
I felt that the virtual body was not me.*
Attractiveness
To what extent your avatar seemed attractive to you?

* *reverse scored item.*

plete the first puzzle on their side using the plan and the parts on their own virtual table. As soon as both participants have completed their first puzzle, they must collaborate to complete the second one following the instructions of their partner who has the corresponding plan on his/her side. The total completion duration of the two puzzles is recorded by the application.

At the end of the experiment, participants complete the questionnaire to assess the sense of body ownership and the attractiveness of the avatar [ZAJ*15], which is the same for each pair of participants, using seven-point semantic scales. Objective performance data are collected via the application in a CSV (Comma-Separated Values) file. This file contains the completion duration (CD) of the task as well as the speaking duration (SD) of each participant.

3.5. Hypotheses

Based on previous work reported in our literature review and to the proposed experimental design, here is a list of hypotheses relative to the impact of anthropomorphism on attractiveness, body ownership and users performance in collaborative tasks:

- H1: Avatars presenting a high level of facial anthropomorphism improve users' sense of body ownership in immersive collaborative virtual environments.
- H2: Avatars with more anthropomorphic facial properties are more appealing to users in immersive collaborative virtual environments.
- H3: Avatars presenting a high level of facial anthropomorphism enable better communication and performance in collaborative tasks in immersive virtual environments.

4. Results

Data were tested for normality and homogeneity of variance. The Shapiro-Wilk Test revealed that most of the variables were not normally distributed and Levene Test showed that the variances of several variables were not equal ($p < 0.05$). Therefore, as our data violate parametric tests' assumptions, we used alternative non-parametric tests. Results are considered significant when $p < 0.05$ (Table 2). Bonferroni's correction was applied to adjust alpha value for post-hoc pairwise comparisons resulting in a significance level set at $p < 0.017$.

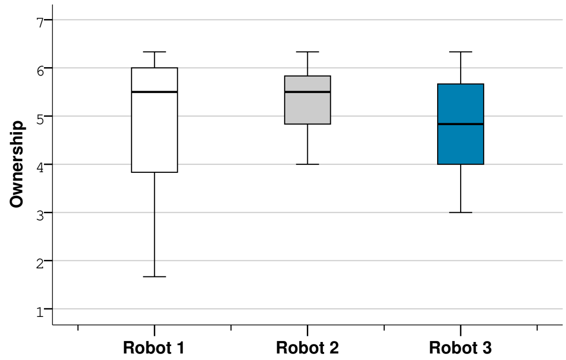


Figure 5: *Boxplot of the ownership scores for the three avatars.*

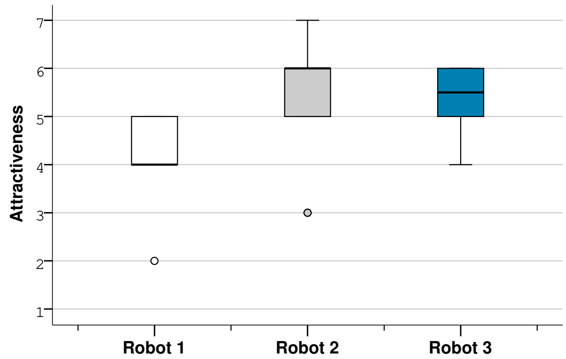


Figure 6: *Boxplot of the attractiveness scores of the three avatars.*

4.1. Body Ownership

A Kruskal-Wallis Test revealed no significant difference in ownership scores between the three avatar conditions (Figure 5) ($p > 0.05$). Thus we cannot state that the anthropomorphism level of the three avatars proposed in this experiment impact users' sense of body ownership leading to reject our first hypothesis (H1).

4.2. Attractiveness

A Kruskal-Wallis Test revealed a statistically significant difference in avatars' attractiveness scores between the three avatar conditions (1 N = 12: R1, 2 N = 12: R2, 3 N = 12: R3), χ^2 (2, N = 36) = 11.61, p = 0.003 (Figure 6). The R2 group recorded the higher median score (Md = 6.00), while the R3 group recorded a value of 5.50 and the R1 group a value of 4.00. A Mann-Whitney U Test revealed a significant difference in the attractiveness scores of R1 (Md = 4.00, N = 12) and R2 (Md = 6.00, N = 12), U = 27, Z = -2.69, p = 0.008. Another significant difference was observed in the attractiveness scores of R1 (Md = 4.00, N = 12) and R3 (Md = 5.50, N = 12), U = 27, Z = -3.15, p = 0.002. Although we observed no significant difference between the Robot 2 and the Robot 3 conditions, our second hypothesis (H2) seems valid and will be discussed further in the next section.

Table 2: *Statistical summary of the answers to the post experiment questionnaire (Ownership (O) and Attractiveness (Att)) and of the objective data (Completion Duration (CD) and Relative Speaking Duration (RSD)).*

	Robot 1 (R1)		**Robot 2 (R2)**		**Robot 3 (R3)**		
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	*p*
O	4.81	1.59	5.31	0.72	4.78	1.07	0.558
Att	4.25	0.87	5.42	1.24	5.42	0.45	0.003*
CD	774.50	213.47	473.00	105.98	538.33	156.61	0.001*
RSD	52.29	10.90	46.25	9.09	47.69	11.00	0.392

*Mean and standard deviation are provided for each condition (R1, R2 and R3). * indicates significant differences.*

Table 3: *Spearman correlation between Ownership (O), Attractiveness (Att), Completion Duration (CD) and Relative Speaking Duration (RSD).*

	O	Att	CD	RSD
Ownership (O)	-	0.129	-0.012	0.123
Attractiveness (Att)		-	-0.564**	-0.07
Completion Duration (CD)			-	0.094
Relative Speaking Duration (RSD)				-

* $p < 0.05$ (2-tailed), ** $p < 0.01$ (2-tailed)

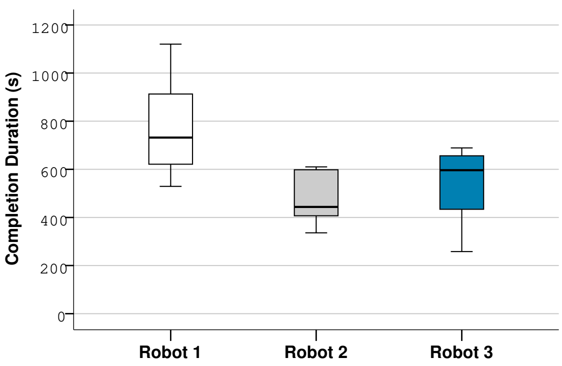


Figure 7: *Boxplot of the completion durations.*

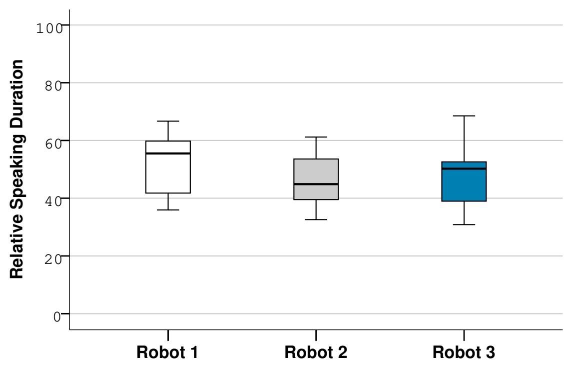


Figure 8: *Boxplot of the relative speaking durations.*

4.3. Completion and Speaking Durations

A Kruskal-Wallis Test revealed a statistically significant difference in the completion duration depending on the controlled avatar (1 *N* = 12: R1, 2 *N* = 12: R2, 3 *N* = 12: R3), χ^2 (2, *N* = 36) = 13.33, *p* = 0.001 (Figure 7). The R2 group recorded the lower median duration (*Md* = 443.50 s), while the R1 group recorded a duration of 732.00 s and the R3 group a duration of 596.50 s. A Mann-Whitney U Test revealed a significant difference in the completion duration between R1 (*Md* = 732.00 s, *N* = 12) and R2 (*Md* = 443.50 s, *N* = 12), *U* = 8, *Z* = -3.71, $p < 0.001$. A trend can be observed in the completion duration between the R1 (*Md* = 732.00 s, *N* = 12) and R3 (*Md* = 596.50 s, *N* = 12), *U* = 40, *Z* = -1.86, *p* = 0.064.

The speaking duration being obviously linked to the completion duration, we first calculated a relative speaking duration (score between 0 and 100, where 0 means that the participants did not speak and 100 that they spoke for the entire duration of the experiment). A Kruskal-Wallis Test revealed no significant difference in the relative speaking duration between the three avatar conditions ($p > 0.05$).

According the completion duration of the experiment, it seems that the anthropomorphism level of the three avatar conditions can impact users' performance, especially when comparing the avatar presenting the lower anthropomorphism level (R1) to the others (R2 and R3) which is consistent with our third hypothesis (H3). However, it does not impact the duration of their verbal communication.

4.4. Correlations

Using Spearman correlations (Table 3), we unexpectedly observed a strong negative correlation between avatar attractiveness and completion duration, *rho* = -0.564, *n* = 36, $p < 0.001$, the more attractive the avatar the shorter the completion duration. However, the collected data are not sufficient to explain such results and no mediation analysis can be carried out to test if attractiveness could act as a mediator between anthropomorphism and performance as normality and homogeneity of variance assumptions are not met. This result is discussed further in the next section.

5. Discussion

Based on our data analysis, we observed several significant differences between the three anthropomorphism conditions (virtual eyes and mouth, physical eyes and virtual mouth, physical eyes and mouth), especially concerning attractiveness and users' performance regarding the task completion. However, we observed no statistically significant difference concerning the sense of ownership. Therefore, we cannot state about our first hypothesis (H1). Nevertheless, the sense of ownership is high for each avatar, which means that participants were able to embody every robot independently of their facial properties. We expected high ownership scores for every condition thanks to visuomotor synchrony, which is a critical bottom-up contributor [KS14]. Nevertheless, according to previous experiments, we also expected potential significant differences with higher sense of ownership for avatars presenting higher anthropomorphism levels as human-like similarities could increase the sense of embodiment [WGR*18, GCHR19]. However, it seems that the differences between our anthropomorphism conditions, only limited to facial properties (same virtual body and hands), are too slight to affect the sense of ownership. Indeed, participants cannot see their own avatar's face as soon as they join the collaborative room (no virtual mirror anymore).

Our results demonstrate that attractiveness levels are significantly higher for both the second condition (physical eyes and virtual mouth) and the third condition (physical eyes and mouth) compared to the first one (virtual eyes and mouth). Participants tend to prefer avatars with more anthropomorphic facial properties, which demonstrate the validity of our second hypothesis (H2). Back to the three criteria of visual fidelity [Gar03], previous experiments demonstrated that realism is not a good predictor of attractiveness [ZAJ*15, MBB12] but that truthfulness can improve attractiveness evaluations of virtual characters [GCHR18]. Based on our results, it seems that anthropomorphism can also positively impact attractiveness of virtual characters, at least concerning their facial properties (eye gaze and mouth type). However, in this context it is important to consider that such evaluations are subjective and, despite the fact that the anthropomorphism levels of the avatars are actually different, artistic design can also impact subjective evaluations of attractiveness.

Objective data revealed that participants performed significantly better using the second condition compared to the first one with shorter completion duration. We also observed a trend between the first and the third conditions, the third one allowing for better performance. Overall participants tend to perform better in collaborative tasks using more anthropomorphic avatars. However, the statistical analysis revealed no significant difference when comparing the relative speaking duration. We argue that more anthropomorphic appearance could favor communication in virtual environments leading to an increase in user performance in collaborative tasks. Unexpectedly, we observed a correlation between attractiveness and performance. This result cannot be explained based on the data we collected and only rises new hypotheses. It is possible that attractiveness led participants to look at each other and to focus on their partner's avatar favoring non-verbal communication and improving their performance. Further studies must be conducted using gaze tracking technologies to analyse if attractiveness increases the time participants spend looking at each other in order to investigate if avatar attractiveness could be a way to improve collaboration in immersive virtual environments.

6. Limitations

Our results provide guidelines to design avatars for immersive collaborative virtual environments. Nevertheless, it should be noted that the analysis is based on a relatively small sample of 36 participants. Other experiments must be conducted to further investigate the impact of anthropomorphism. Moreover, even if it is a design choice to match most VR applications available to the general public not relying on realistic virtual humans, this experiment focuses on facial properties of robotic characters that do not enable an expressiveness similar to organic models using blend shapes. In addition, several other morphological factors potentially affecting non-verbal communication and interactions such as gestures and animations are not considered in this study. Indeed, the three avatars provide the participants with the same chest as well as the same virtual hands. We encourage developers to design avatars with regards to the proposed tasks as affordance and interaction metaphors can also impact the way users collaborate.

7. Conclusion

We investigated the impact of avatars' facial anthropomorphism in immersive collaborative virtual environments. Following a between subject design, we analyzed if the sense of body ownership, avatar attractiveness and performance are affected in collaborative tasks.

We observed a very high sense of ownership for each condition with no significant difference leading to the conclusion that the different anthropomorphism levels of the three robotic avatars are too slight to affect ownership compared to bottom-up factors such as visuomotor synchrony. However, the results revealed several significant differences concerning attractiveness and performance as well as a correlation between these two notions. On the one hand, more anthropomorphic facial properties appear to improve attractiveness. On the other hand, participants performed better to complete the collaborative puzzle game with avatars having more anthropomorphic facial properties. We unexpectedly observed a correlation between attractiveness and performance with high level of attractiveness associated with better performance. We hypothesize that higher attractiveness could lead users to focus more on their partner's avatar, which in turn leads to an improved non-verbal communication and therefore to better collaborative performance, but further experiments must be conducted using gaze tracking data to validate this new hypothesis.

8. Future work

In addition to analysing the link between anthropomorphism, attractiveness and performance, we plan to investigate further the way avatars impact collaboration in immersive virtual environments. We are especially interested to analyse the effect of anthropomorphism on social presence in different tasks. In this experiment we reported a study with an asymmetric collaborative situation. Therefore, we also plan to extend these results to different scenarios and to compare whether the type of task can affect users' sense of co-presence. We will also pursue these investigations using characters with advanced facial expressions such as emotions and advanced labial synchronization.

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