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Blame my Telepresence Robot
Joint Effect of Proxemics and Attribution on Interpersonal Attraction

Josca van Houwelingen-Snippe[1], Jered Vroon[2,✉], Gwenn Englebienne[2], and Pim Haselager[1]

***Abstract*— When remote users share autonomy with a telepresence robot, questions arise as to how the behaviour of the robot is interpreted by local users. We investigated how a robot's violations of social norms under shared autonomy influence the local user's evaluation of the robot's remote users. Specifically, we examined how attribution of such violations to either the robot or the remote user influences social perception of the remote user. Using personal space invasion as a salient social norm violation, we conducted a within-subject experiment (n=20) to investigate these questions. Participants saw several people introducing themselves through a telepresence robot, personal space invasion and attribution were manipulated. We found a significant (p=0.007) joint effect of the manipulations on interpersonal attraction. After these first 20 participants our robot broke down, and we had to continue with another robot (n=20). We found a difference between the two robots, causing us to discard this data from our main analysis. Subsequent video annotation and comparison of the two robots suggests that accuracy of the followed trajectory modifies attribution. Our results offer insights into the mechanisms of attribution in interactions with a telepresence robot as a mediator.**

Fig. 1. The robot approaching the participant to a distance of 70-80cm (left) or trying to invade their personal space by using 30-40cm (right).

I. Introduction

Imagine you want to be somewhere, but cannot physically go there – e.g. visiting school when you are in a hospital, a meeting on another continent, or joining activities in an eldercare facility if you are too tired to leave your room.

Mobile Robotic Telepresence systems (**MRP**s) might be the answer. They consist of video conversing equipment mounted on a mobile robotic base; someone can control the robot from a computer (**remote users**) to be represented by that robot on a remote location and interact with the people there (**local users**), instead of being physically present [1].

One important goal is to let the users forget as much as possible that the interaction is mediated by a robot.

Controlling MRPs can put a high load on the remote user, distracting them from the conversation; this can be remedied by introducing semi-autonomous behaviours for the MRP. Several studies suggest that semi-autonomous navigation is preferable for the remote user [1], [2].

What effects do such autonomous behaviours have on the impression remote users make on local users? To our knowledge there exists no prior work investigating such effects. Yet, the behaviours of an MRP can violate social norms. Consider, for example, personal space invasion. If an MRP (autonomously) stands too close to local users, this may negatively affect how they perceive the remote user.

Moreover, it also seems important whom the local user thinks is accountable for the violation of the social norm: the MRP or the remote user. It seems more appropriate to attribute the violation to the remote user if the remote user is manually controlling the robot, than if the robot is navigating autonomously, and vice versa. It thus appears that this can be a key modifier; we will refer to this as **attribution**.

We conducted a study to investigate how social norm violation (specifically, personal space invasion) by an MRP influences the way in which the remote user is perceived by the local user, as well as the role of attribution in this. We first give an overview of related work, from which we derive our hypotheses (Section II) and then specify our within-subject methodology (Section III). Midway through the experiment, after 20 participants, technical issues necessitated a switch to a highly similar back-up robot. Despite our efforts to the contrary, we found significant differences between robots, so that only the first 20 participants were used for our main results (Section IV). In addition, we conducted a qualitative analysis, yielding further insights regarding the differential effects between the two robots (Section V). Together, these main results and further insights are a first step towards understanding the effects autonomous behaviours of an MRP can have on an interaction (Section VI).

II. Theoretical Background

We will here discuss related work on MRPs (II-A) and the role of proxemics in HRI and impression formation (II-B), based on which we will specify our hypotheses (II-C).

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[1]Department of Artificial Intelligence – Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen. Montessorilaan 3, 6525 HR Nijmegen, the Netherlands.

[2]Department of Human Media Interaction – Faculty of Electrical Engineering, Mathematics and Computer Science, University of Twente. P.O.Box 217, 7500 AE Enschede, the Netherlands.

✉Corresponding author, j.h.vroon@utwente.nl

A. Mobile Robotic Telepresence Systems

MRPs mediate interaction between the pilot and the local user, resulting in a complex interplay of different interactions; Human-Robot Interaction between the remote user and the MRP, Human-Computer Interaction between the remote user and the control system interface of the MRP, Human-Robot Interaction between the local user and the MRP, and Human-Human Interaction between the remote user and the local user. This complexity makes it challenging to disentangle the effects of MRP behaviour on its users.

1) Autonomous behaviour of an MRP: Manually controlling an MRP can be an intensive task, distracting remote users from focusing on the social interactions the MRP is supposed to support. Therefore, several projects, like the TERESA project [3], focus on the development of autonomous social behaviour, such as social navigation and social conversation. It has been shown [2], that a system with semi-autonomous navigation control and semi-autonomous people tracker, yielded significantly higher remote user satisfaction compared to a system without assisted control. In contrast, user-controlled movements of MRPs have been found to produce a stronger feeling of social telepresence for remote users than autonomously generated movement [4].

While the effects of autonomous behaviour on the remote user have thus been studied, we are not aware of any previous work investigating the effects on local users.

2) MRPs and social norms: If a technology, such as an MRP, violates social norms, this can be perceived as social incompetence and thus be offensive [5]. For example, when the volume of an MRP was too loud, local users described that the *remote user* was disturbing the workplace [6].

In addition, failure of the teleconferencing system can lead to different perceptions of a remote user as well. It has been shown that a delay of audio and video causes users to evaluate a speaker as less interesting, less pleasant, less influential, more agitated and less successful in their delivery, even if they did not notice the asynchrony itself [5].

B. Proxemics

Proxemics is the study of personal space and interpersonal distance. Hall [7] defined *personal space* as a psychological and physical buffer zone towards other people. Distances people take towards each other are affected by several factors, such as gender, age and personality traits [8].

The equilibrium theory builds on proxemics, further predicting that if someone invades your personal space, you will show compensatory distancing behaviour [9].

1) Proxemics and Impression Formation: Interpersonal distance has in some cases been shown to have an effect on impression formation of personality during an interview setting [10]. With larger interpersonal distances (2, 4, 6, or 8 feet), aggressiveness, friendliness, extroversion and dominance of the confederate were rated lower [10]. In contrast, Tesch [11] tested interview settings at two different interpersonal distances and measured impression formation, but found no significant effects.

In a virtual reality study [12], users judged the personality and interpersonal attitudes of virtual agents in first encounters, i.e. the first 12.5 seconds of an interaction. Among others, proxemic behaviours of the virtual agent were manipulated and perceived extroversion, friendliness and likability were tested. Results show a main effect of these behaviours on perceived extroversion of the virtual agent.

2) Proxemics for artificial agents: There has been a wide range of work investigating proxemics for robotic and virtual agents, of which we will here discuss a few. It has been found [13], that personal space for Human-Robot Interaction has the same circular shape and the same size as personal space for Human-Human Interaction. Non-humanlike characters in virtual reality were approached closer than humanlike characters [14]. In [15], proxemic and gaze behaviours of characters in virtual reality were found to have an effect on intimacy, in line with what the aforementioned equilibrium theory would predict. Together, these works show that proxemics play an important role in the perception of such artificial agents, similar but not always equal to the role proxemics play in human-human interaction.

Similar findings have been reported for proxemics in the context of approach. Approach distances for humans approaching a robot and a robot approaching a human have been found to be comparable [16], although the same study found indications that humans tend to approach robots more closely than they allow robots to approach them. Other work [17] showed that the freely chosen minimal frontal interaction distance with a mechanical robot is greater than 45cm. The average distance that participants took towards a humanoid robot was 78cm, i.e. within personal space [13].

In conclusion, for various artificial agents, people did not choose or feel comfortable with distances of less than 45cm, which suggests that using such distances would violate social norms. In line with the social zones of Hall [7], a distance of 70-80cm seems to be socially normative for artificial agents.

C. Hypotheses

Following the equilibrium theory [9], [14] and its successful application in artificial agents [15], we formulate our first hypothesis; **Hypothesis 1 -** *when an MRP invades the personal space of the local user, the local user will show compensatory distancing behaviour*. Since personal space can only be invaded by entities with sufficient human likeness [18], we will use this hypothesis to test whether the personal space invasion was successful.

If the personal space invasion of the robot is indeed perceived as such, and assuming that the discussed effects of such a personal space invasion carry over to the remote user, we would further expect that; **Hypothesis 2a -** *when an MRP invades the personal space of the local user, the local user will form a more negative impression of the remote user*. We will later operationalise this 'impression' by using the Interpersonal Attraction scale as a measure [19].

More specifically, the effects of the personal space invasion on the impression of the remote user intuitively seems to also be dependent on the attribution of those behaviours to either the robot or the remote user. We capture this intuition in our third hypothesis; **Hypothesis 2b -** *when the local user attributes the personal space invasion by an MRP to the remote user, the local user will form a more negative impression of the remote user*. We will again use the Inpersonal Attraction scale to operationalise 'impression'.

III. Methods

We used a 2x2 within subjects design, manipulating **proxemics** (the robot approached the participant at a *close* or *far* distance) and **attribution** (the participant was told that the robot navigated either *autonomous*ly or *manual*ly controlled by the candidate). The robot approached each participant four times, each of which a different remote user would introduce themselves; participants were tasked with choosing which of the four remote users they would like best as a roommate (Section III-A). Each of the four approaches represented one of the four conditions, in counterbalanced order (Section III-B). Participants filled in questionnaires, four brief ones about the remote user after each interaction, and one after all interactions; we also recorded the interactions (Section III-C). Based on these aspects we specified a detailed procedure (Section III-D), listed the main used materials (Section III-E), and recruited our participants (Section III-F).

To finalize our method, we conducted a pilot of the study (4 participants), resulting in various minor modifications that will be discussed throughout this section.

As mentioned before, technical issues necessitated a switch to our back-up robot halfway through. Of course we did not change the procedure, but while the robots were very similar in hardware and looks (see Section III-E), we still did find a difference in our results, which we will discuss there.

A. Task

The experimental setting was introduced to the participants as an event to choose a new roommate. Participants were told that four male candidates were going to introduce themselves to the participant and that afterwards they were to pick their favourite.

To keep the interactions consistent and comparable between participants, we simulated interaction by using prerecorded videos of remote users, rather than using real-life interaction. To explain that participants could not ask questions to the candidates, we told participants that the candidates were not able to hear the participant because of the WiFi connection. To further suggest that the interaction was real, videos were played through the interface of the robot, and recorded as if the remote candidate was talking to the local user. The order in which the videos occurred during an experiment was counterbalanced over participants using a balanced Latin-square design.

We created the videos to be similar in tone and style. They were comparable in duration (between 1m11s and 1m21s), and all started and ended with a few seconds of silence in which the robot could navigate. To eliminate gender or age of the candidates as a confound, we used four male students of similar age (between 21 and 23).

To minimize the effect of the candidates on our findings, in addition to counterbalancing, they should ideally have comparable baseline attractiveness. This was not the case in our pilot study, as we there found that all four participants chose the same candidate as their favourite. We thus set up a small online questionnaire to determine average IPA scores for the four videos used in the pilot, and three additional videos. The questionnaire was filled out by 8 respondents (6 female, ages between 19 and 60 with a mean of 36). While this group of respondents did not resemble the expected participants, the outcomes were in line with those of the pilot study and the presumed rankings in response to the pilot study. Based on these results, we selected the four videos that had the most similar average IPA scores.

B. Conditions

1) Attribution [Autonomous & Manual]: We manipulated attribution by telling the participant that the robot navigated autonomously (Autonomous condition) or was controlled by the candidate (Manual condition).

At the beginning of the experiment, we used this to get the candidate in either of the two attribution conditions. Between the second and the third trial, the participant was told that due to a bad WiFi connection, there was an error so the robot from that point on would be navigating autonomously or by the candidate, switching the attribution. To avoid confusion and keep this switch believable, we only switched attribution once in each experiment.

2) Proxemics [Far & Close]: In all four conditions, the robot drove towards the participant. It either stopped at 70-80 cm from were the participant stood (Far condition), or at 30-40 cm from were the participant stood (Close condition) (see Fig. 1). A grid of markings was placed on the entire floor of the experimental room at every 30 cm and used to control the proxemics.

In all conditions, the approach behaviour was controlled by a confederate through the interface of the robot (Wizard of Oz design). At the start of each interaction, the confederate would turn the robot to face the participant, use the markings on the floor to determine the position to approach depending on the condition, and then drive to that position at a constant speed. The position to approach was chosen before the actual approach was initiated, to reduce uncertainty about handling compensatory behaviours of the participant, e.g. stepping away. The confederate would not move the robot during the interaction. At the end of each interaction, the confederate would turn the robot and return it to its starting position (facing away from the participant).

Two minor improvements were made based on the pilot. Firstly, we decided to not have the experimenter control the robot, but to use a confederate. The two pilot participants who experienced the former immediately noticed the deception, while the other two did not. Secondly, the image in the interface used by the confederate would occasionally freeze (not visible for participants), which we remedied by providing the confederate with a live video feed of the interaction that served as a back-up.

C. Measures

1) Questionnaires: Questionnaires were presented on a laptop (using SurveyMonkey), and were translated into Dutch.

a) Between-questionnaire: After each introduction round, the participants filled in the between-questionnaire, which consisted of three parts. First, as a proxy for how much the local user is attracted to the remote user, we used parts of the Interpersonal Attraction scale [19]. As those were most relevant to the task of picking a roommate, we only used the constructs Social Attraction and Task Attraction, both consisting of 10 questions, which were reduced to the 5 questions with the highest loading (more than .49) as described in [19]. Secondly, participants were asked to what extent they thought a set of personality traits (extraversion, agression, friendliness, dominance) applied to the candidate (7-point Likert scale), following [10]. Thirdly, the participants had to indicate to what extent they judged the candidate suitable as a roommate on a 7-point Likert scale.

b) Post-questionnaire: After the last between-questionnaire, participants were immediately asked to answer the post-questionnaire. First, the participants were shown pictures of the four candidates, and asked to select their favourite. This question was used to provide insight in the distribution of favourite candidates. Participants were then asked open questions on how they felt during the interaction with the robot and whether they would want another interaction with the robot. After answering these questions, the question appeared whether the robot came too close and when. At last, the participant was asked for all the candidates individually, whether the candidate was responsible for the navigation of the robot. These last two questions were used as manipulation checks.

In closing we collected information about the participant, including various demographics (age, gender, nationality, education, experience with robots). A reduced version of the Big Five-questionnaire was used, following [12], to get a score on Agreeableness, Neuroticism and Extroversion. Lastly, we used a version of the NARS reduced to the items with the highest loading per subscale, to get an impression of participants' general attitude towards robots.

2) Video data: Two video cameras were placed in the experimental room, one facing the floor to capture proxemic behaviours, and one camera facing the participant to capture body posture and facial expressions. Both cameras were aimed at the participant, meaning that the first part of the robot approach was not visible on the recordings.

D. Procedure

The participant was welcomed into the room by the experimenter. The experimenter then introduced the robot and the way it was navigated (depending on the attribution condition), and explained the experimental set-up and task. It was mentioned that the interaction would be filmed but that there was no right or wrong behaviour. After questions of the participant were answered, they were asked to fill in the informed consent form. The experimenter turned on the cameras. When the participant was ready, they were guided to the interaction area.

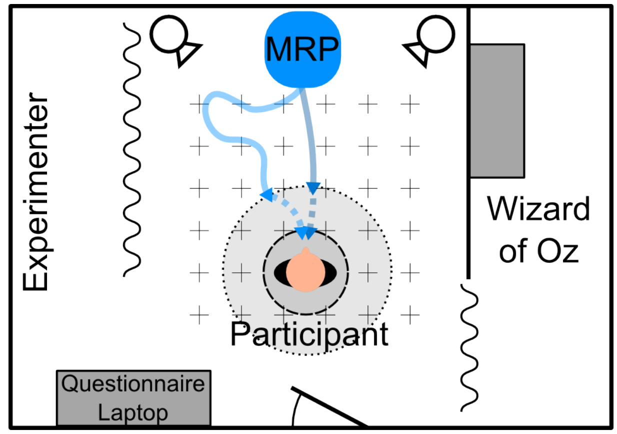

Fig. 2. Schematic overview of experimental set-up (not to scale). The circles from the participant represent the Far en Close stop distances. The figure illustrates a straight trajectory (representative for the Giraff 4.0T) and a curved trajectory (representative for the Giraff 3.3).

The experimenter then initiated the interaction (Giraff 4.0T: pushing red button, Giraff 3.3: using touch screen) and walked away. The robot would then turn around and approach the participant while playing the first interaction video. After the introduction, the robot made a u-turn and drove back to the starting location. During the retreat of the robot, the experimenter appeared to ask the participant to fill in the first questionnaire.

This interaction was repeated four times with each participant, with four different candidate videos. Proxemics and attribution were manipulated as described in Section III-B.

After the fourth trial, the participant was asked to fill in the last questionnaire. The experimenter turned off the cameras. When the participant was finished with the post-questionnaire, the experimenter explained the goal of the experiment in a debriefing.

E. Materials

An overview of the experiment room and the materials in there can be found in Fig. 2.

At first, a Giraff 4.0T telepresence robot (manufactured 2014) was used to run the experiment. This robot was situated in the docking station between the trials for charging. When unexpectedly the battery of that robot died (after 20 participants), we used our back-up, a Giraff 3.3 (manufactured 2012), which had only minor differences in appearance and hardware. We did find that its front wheel tended to slip, affecting the speed, precision and fluency of the navigation. To accommodate this reduced precision, instead of using the docking station, the robot was manually plugged into the charger by the experimenter, also between trials.

F. Participants

A total of 40 participants completed the experiment (17 female). Mean age was 22.46, with ages ranging between 19 and 31 (standard deviation 2.87). After the first 20 of these participants, the robot broke down and we switched to the other robot for the last 20 participants. Two of the first 20 did not fully complete all conditions, one because the robot broke down after the third trial, the other because the participant came so close to the docked robot during the last two trials that proxemics could not be manipulated. Post-questionnaire data of these two participants was excluded, we did use their between-questionnaires where appropriate.

IV. Results

As mentioned before, the use of two robots has been an unplanned factor in our experiment. We will first analyse the IPA data of the two robots, showing a significant effect of the robots (Section IV-A). Given this effect, we excluded the data collected with the Giraff 3.3 when testing our 2nd and 3rd hypotheses (Section IV-B). Our 1st hypothesis could only be tested after the video data had been annotated and will be discussed in the next section.

Cronbach's alpha was unacceptably low for many measures, including self-rated Agreeableness (0.313), self-rated Neuroticism (0.358) and the NARS (0.453). This made further analysis, e.g. regression analysis, less applicable.

We used 10 items from the IPA, which had a high internal consistency (Cronbach's alpha of 0.869). IPA scores were calculated for each trial per participant. IPA scores strongly correlated with the score on the question whether the candidate was suitable as a roommate (Pearson correlation $\rho = .753$, $p < 0.001$).

An overview of the different IPA scores per condition, separated for both robots, can be found in Fig. 3.

A. *Effects of robots combined*

IPA scores for both robots combined were not normally distributed for all conditions (Shapiro-Wilk, $p = 0.013$), so we conducted a Friedman's test to determine the effect of the conditions on those IPA scores. There was no statistically significant difference in IPAS on Proxemics or Attribution ($X^2(2) = 0.804$, $p = 0.849$).

A Mann Whitney U test (MWU test) was run to determine the effect of robot on the IPA scores. In order to compare the two groups, IPA scores for each participant were combined into a single score by adding up the four scores from each of the conditions. There was a significant effect of robot on these combined IPA scores ($p = 0.042$).

B. *Effects of first robot*

Since we found an effect of the robots, we also analysed the data for the first robot, the Giraff 4.0T, only, excluding data from the Giraff 3.3.

A two-way repeated measures ANOVA was run to determine the effects of Proxemics and Attribution on IPA scores for that robot. Data was normally distributed (assessed by Shapiro-Wilk), there were no outliers (no standardised residuals ≤ 3 standard deviations), and there was sphericity for the interaction term (Mauchly's test of sphericity, $p > .05$). There was a statistically significant interaction between Proxemics and Attribution on IPA ($F(1, 17) = 9.448$, $p = .007$, $\eta_p^2 = .357$). Therefore, simple main effects were run.

IPA scores were significantly different when comparing manual attribution with autonomous attribution in the close trials ($F(1, 18) = 5.141$, $p = 0.036$, $\eta_p^2 = .222$, a difference of 7.053 (95% CI, .518 to 13.588)), but not when making the same comparison in the far trials ($F(1, 17) = 2.328$, $p = .145$, $\eta_p^2 = .120$). IPA scores were not significantly different when comparing the close trial with the far trial, neither in the autonomous ($F(1, 19) = 2.925$, $p = .104$, $\eta_p^2 = .133$) nor in the manual attribution ($F(1, 17) = 2.557$, $p = .128$, $\eta_p^2 = .131$).

V. Qualitative analysis of robot differences

In the quantitative analysis, a significant within subjects effect was found for the IPA scores in the group of participants with the Giraff 4.0T, while no such effect was found for the Giraff 3.3. As discussed before, there are several differences between the two robots (Section III-E), all of which could have caused the found effect of the robots. The wheel of the Giraff 3.3 slipped, often causing it to make an unexpected turn to the right after starting its approach (see Fig. 2). Not only did this make its trajectories more indirect and less straight than those of the Giraff 4.0T, it also made the approach take longer. This had the side effect of the remote user (video) often starting to introduce himself while the robot was still approaching and was not always fully facing the participant. In addition, the Giraff 3.3 was unplugged by the experimenter between trials, and had a shell design that had some minor differences with that of the Giraff 4.0T.

These differences between the robots can have influenced the interpretation of the participants. For example, the lack of fluency in the Giraff 3.3's motions may have lead the participant to attribute all (failures in) robot behaviour to technical issues. Or, since impression formation takes place in the first seconds of a conversation [12], it may have been that when the Giraff 3.3 had not invaded the personal space of the participant during these first seconds, the manipulation of proxemics had a weaker effect on the impression formation as measured by the IPA.

We will here discuss the video annotation we used to gain further insight into these differences, as well as to test our first hypothesis.

A. *Methods*

Three human annotators annotated the 149 recordings of the experiment. Annotator 1 evaluated all 149 videos while the other two evaluated approximately 20% with an overlap of 10%. The data of Annotator 2 and 3 was used to validate the data required from Annotator 1. A total of 9 questions were asked per video, three of which had a substantial inter-rater agreement (see Table I). For these questions we will here further analyse the data of Annotator 1.

B. *Analysis*

1) Compensatory Distancing Behaviour: Of all possible answers, only 'the participant steps away from robot' is

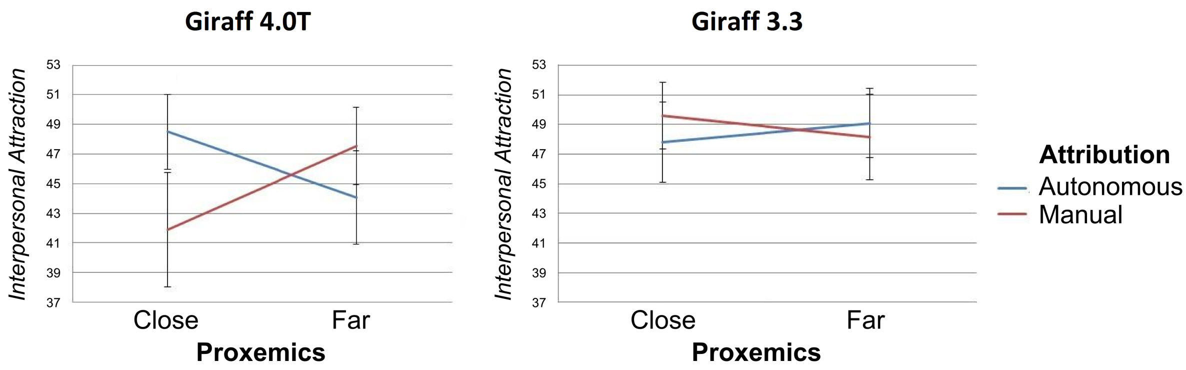

Fig. 3. Mean IPAS per condition for Giraff 4.0T and Giraff 3.3 with 95% confidence intervals. The joint effect of Proxemics and Attribution is significant (p=0.007) for the Giraff 4.0T.

TABLE I
QUESTIONS WITH SUBSTANTIAL INTER-RATER AGREEMENTS.

Question	Kappa A1-A2	Kappa A1-A3
When the robot reaches the final position, the participant: Steps Away from Robot(both feet)/Shows Other Behaviour (Steps Towards robot(both feet)/Steps Aside(both feet)/Hesitates to step(one foot)/Leans Away From Robot/Leans Towards Robot/Does not move).	0.752	1
Trajectory: Robot drives in (more or less) straight line.	0.713	0.618
Orientation: Robot is facing participant when video introduction starts.	0.627	0.739

considered to be compensatory distancing behaviour. The annotation data shows that in 40 of the 75 Close trials, a participant stepped away, compared to 5 of the 74 times in Far trials. The 95% Wald confidence intervals do not overlap, so this difference is considered to be statistically significant.

2) Robot Navigation Properties: The annotation data shows that the Giraff 4.0T drove 67 of the 73 trials in a straight line, while this was only 25 of the 76 for the Giraff 3.3. Additionally, the Giraff 4.0T was facing the participant in 67 of the 73 trials when the verbal video introduction started, while this was only 32 of the 76 trials for the Giraff 3.3. For both questions the 95% Wald confidence intervals of the two robots do not overlap, so the differences are considered to be statistically significant.

To investigate if these differences in trajectory and orientation of the robot could be responsible for the found difference in IPAS, we ran point-biserial correlations to determine their relationship. We considered two ways in which such a relationship could exist. Firstly, we looked if there was a direct correlation, i.e. we tested if the robot's behaviour in one trial related to the IPAS score for that trial. Secondly, we considered the possibility that seeing the robot make a 'mistake' in one trial could have an effect on participants in both that and subsequent trials. For that, we looked at correlation with a memory effect, i.e. we tested if seeing the robot not drive in a straight line, or orient towards the participant, related to the IPAS score for that and all subsequent trials with that participant. With this memory effect, there was a statistically significant negative correlation between IPAS and Trajectory (r_{pb} = -.182, n = 149, p = .026). There was a non significant negative correlation between IPAS and Orientation (r_{pb} = -.154, n = 149, p = .068). Without the memory effect, we found no statistically significant correlations.

VI. DISCUSSION

We investigated whether a local user holds a remote user accountable for the autonomous proxemic behaviour of an MRP. In a 2x2 within-subject experiment, manipulating proxemics (Close & Far) and attribution (Manual & Autonomous), participants rated Interpersonal Attraction of four videos played on an MRP. Since halfway during the experiment the battery of the Giraff 4.0T died, a theoretically comparable Giraff 3.3 was used for the rest of the experiment. We found an effect of robot, and thus discarded 20 of our 40 participants when testing Hypotheses 2a and 2b.

We annotated videos from the interaction, and found that, independent of the robot, in the Close condition participants stepped away from the robot significantly more often than in the Far condition, confirming **Hypothesis 1**. This means that participants showed compensatory distancing behaviour when the MRP invaded their personal space.

The collected data did not confirm **Hypothesis 2a**, i.e. when an MRP invaded the personal space of a local user, the local user was not automatically less likely to be attracted, according to the Interpersonal Attraction scale, to the remote user. The Interpersonal Attraction was not found to be significantly different in the Close conditions compared to the Far conditions.

We did find a significant interaction effect of attribution and proxemics, confirming **Hypothesis 2b**, with the only significant simple main effect being that in the close condition Interpersonal Attraction was significantly higher for autonomous than for manual attribution. The attribution of the robot behaviour thus plays a crucial role, which may explain why we could not confirm hypothesis 2a (see also Fig. 3). A possible explanation is that local users do not hold the remote user accountable for the close behaviour if they believe it to be autonomous.

While we did not use the data collected with the Giraff 3.3, as we found an effect of robot, we did use video annotations to get further insights into what could have caused this effect. We found visible differences between the two robots in robot approach direction, and in its orientation when the verbal video introduction started. These properties did not directly correlate with Interpersonal Attraction. However, when we assumed a memory effect, we *did* find a correlation between trajectory and Interpersonal Attraction; we hypothesize that if the robot trajectory is not a straight line, this may lead local users to attribute this and all later 'mistakes' –including getting too close– to technical errors, instead of to the remote user. In this case, the behaviour of the robot would itself have an effect on attribution of its behaviour.

a) Limitations: The unexpected breakdown of the Giraff 4.0T, and the similarly unexpected effect of using the Giraff 3.3, does impose limitations, if only by limiting the number of usable participants to 20. In addition, the experimental conditions were originally counterbalanced for 40 participants, and we thus ended up with data from two not purely counterbalanced groups of 20 participants.

One conceptual difference that cannot be disentangled with our current set-up is if participants perceived the behaviour of the robot as (awkward) psychological personal space invasion, and/or as physically threatening to almost hit them. While this would apply to most research in this direction, further research should try and disentangle this difference before generalizing our findings to areas where this conceptual difference plays a role.

The navigation software of the Giraff robots does not allow for fine-grained control of speed, which may also have resulted in the perception that the robot was not going to stop in time. Future research should investigate the role of speed in this and similar situations in more detail.

As motivated before, we used videos of the remote user rather than 'real' interactions to keep our conditions consistent and comparable. Future research should investigate if the found effects also generalize to such 'real' interactions.

b) Contributions and Conclusions: Attribution and Proxemics together can affect the impression of a remote user on a local user during an interaction mediated by an MRP. This study shows that attribution plays a key role in shared autonomy, since personal space invasion itself did not affect the impression of the remote user.

From these findings follows an important consideration for the design of shared autonomy in telepresence; it can be desirable to indicate to whom the behaviour should be attributed, especially when social norms can be violated. For when it is clear to people when a telepresence robot navigates autonomously, (unintentional) social norm violations may have a smaller effect on how the remote user is perceived. Moreover, more general inaccuracies in robot behaviour, such as imprecise trajectories, may have strong effects on attribution. Though this study focused on telepresence robots, similar design considerations can be extended to other cases of shared autonomy, such as (semi-)autonomous vehicles.

In all, a clear indication of human vs robot responsibility in MRP behaviour can be of great importance for social interaction.

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