MITIGATING THE NEGATIVE EFFECT OF TELEPRESENCE ROBOTS VIA AN EMPATHY-ELICITING ROBOT MODERATOR

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Mitigating the negative effect of telepresence robots via an empathy-eliciting robot moderator[1]

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***Abstract*— Despite various advantages that telepresence robots offer in mediated interaction, the users of these robots have been found to be perceived as less trustworthy compared to their communication partners who are physically present (i.e., collocated participants) in multiparty interaction contexts [1]. In this study, we investigate whether an empathy-eliciting behavior of a social robot moderator can affect the way the personality of telepresence robot users is judged by their collocated partners. In a within-subject design, middle school students (N=48) were put into groups of three – two onsite and one via a telepresence robot – and were instructed to complete an escape room moderated by a social robot. In addition to facilitating the experiment session, the robot moderator asked a question which was aimed at creating empathy toward the telepresence robot operator. We collected data on the perceived personality of participants via two questionnaires, one before and one after the empathy-eliciting question. The analysis of the data shows that following the empathy-eliciting intervention, collocated participants rated telepresence robot pilots as significantly more trustworthy and less tense, irritable, shy, and faultfinding. Furthermore, remote participants rated collocated students as significantly more trusting and outgoing, and significantly less tense. Moreover, the robot moderator was regarded as more desirable after it made the intervention. The findings suggest that not only does the empathy-eliciting question improve the way the personality of telepresence robot pilots is judged by collocated participants, it also improves how remote participants judge the personality of their teammates.**

Keywords*— *Telepresence robot, robot moderation, empathy, personality perception, mediated multiparty interaction.

I. INTRODUCTION

Telepresence robots, through which remote users are able to communicate with onsite people from a distant location, offer benefits in different mediated interaction contexts, especially compared to other onscreen tools of online communication such as Skype and Zoom [2]. In this sense, mobile telepresence robots give remote participants some degree of control during interactions by enabling them to move about freely, change height, or adjust video angle. These mobility capabilities coupled with the robot's physical embodiment make mediated communication one step closer to face-to-face interaction [1], [3]. In addition, telepresence robots can reduce the negative effects of social isolation and emotional barriers that are created due to lack of contact between an individual and the society [4], [5]. For example, one study on isolated children and adolescents with a chronic disease shows that using a telepresence robot helps patients remain connected to their family members and gain some degrees of autonomy due to the mobility capabilities of the robot [6].

However, despite various advantages that telepresence robots offer in mediated multiparty interaction, the users of these robots can still experience drawbacks compared to the people who are physically present in face-to-face communication settings. For example, remote participants are susceptible to being perceived as less favorably or to experiencing technical difficulties [1], [5], [7]. As a result, various aspects of mediated interaction might still need improvements to make it as close as possible to face-to-face interaction.

Past research has shown that one of the factors that can positively affect social interaction is empathy (see [8], [9]). Empathy can promote cooperative behavior between individuals [10], increase people's productive thinking [11], facilitate bidirectional benefits between colleagues [12], and improve students' positive attitudes toward themselves and toward schooling [13]. According to [11], it is a positive factor that boosts the feeling of safety in relationships and enables people to feel that they are worthy of respect. For example, in one study, [14] investigated relations between empathy, prosocial behavior, and aggression among primary school students (N = 240). They found that empathy can decrease aggression by promoting prosocial behavior. In another study, [15] investigated the effect of an empathy-eliciting intervention on the perceived personality of remote participants. The participants were put into three-person groups, where one of the participants used a telepresence robot to join their teammates. The findings of the study suggest that using an intervention aimed at eliciting empathy can positively affect the way collocated participants judge the personality of their virtually present teammates [15].

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In the present work, we investigate whether a social robot moderator that uses an empathy-eliciting intervention can mitigate the negative effects of mediated communication among children. More specifically, we group children into three-person teams, in which one of the participants joins via a telepresence robot, and examine them as they complete an escape room cooperatively by following the robot moderator's instructions. Our objective is to determine whether the empathy-eliciting intervention that is uttered by the robot in the middle of the game can positively affect the way collocated participants perceive the personality of their remote teammates. Therefore, we aim to address the following question:

RQ: In mediated multiparty interaction, does an empathy-eliciting intervention made by a social robot moderator improve the perceived personality of telepresence robot participants?

II. Previous work

A. Telepresence robot

Telepresence robots have been shown to offer various advantages to children in school settings. A study by [16] found that after using an AV1 telepresence robot to attend school, homebound children (N=37) felt less lonely and isolated, and had a lower level of uncertainty and anxiety compared to the time prior to the experiment. Moreover, by the end of the study, around 65% of the homebound students reported their willingness to continue attending school using the telepresence robot. [17] helped an 11-year-old student with a long-term illness attend school virtually via a telepresence robot. The findings of the study show that the remote child had an improved sense of autonomy, engagement, and social inclusion in the classroom and was more active compared to the time that she participated in her classes using a videoconferencing tool. [18] observed young students who suffered from cancer as they attended school on a telepresence robot. Their findings suggest that using the telepresence robot allowed the sick students to remain socially and academically connected with other students and continue to be included in school programs.

Despite many benefits of telepresence robots, users of these robots are still susceptible to negative effects of mediated interaction. For example, [1] investigated the extent to which task engagement, task difficulty, and perception of teammates are affected in mediated multiparty interaction. They formed groups of three, in which one participant used a telepresence robot to join the other two collocated participants in order to solve a translation puzzle collaboratively. The researchers found that not only did the remote participants participated less and experienced more task difficulty compared to onsite participants, but they were considered less trustworthy [1]. The negative impacts of the results of the study were stronger in conditions in which telepresence robot users did not have access to the translation key. Findings of a study by [19] suggest that in mediated group meetings, participants who joined via a telepresence robot had a significantly lower sense of belonging and were less willing to contribute to group aims compared to onsite participants. Furthermore, in another study on the effect of physical embodiment and social presence in a hybrid class, remote and collocated participants experienced difficulty in their collaborations because the telepresence robot provided a limited field of vision and comprehension was difficult in noisy contexts [20].

B. Empathy in human-robot interaction

Empathy has been defined as the ability to share feelings and emotions of another person [21]. According to [22], empathy occurs when an individual is affected by or shares the emotions and experiences of another person, understands why those feelings occur, and adopts the perspective of that individual. In human-robot interactions, robots can be either the target of empathy, like when someone is empathic toward the robots, or they can produce empathic behaviors which address humans [23]. Empathic behaviors of a robot can be created through verbal communication, body language, gestures, facial expressions, or sounds, among others [23]. Similar to human-human communication, empathy is an important aspect of interactions between humans and robots or virtual agents (see for example [23], [24]). In a study by [25], an autonomous iCat robot was programmed to produce empathic utterances toward one chess player, while acting neutrally toward the other. Their findings suggest that the robot was considered friendlier by the users that were the target of empathic responses. [26] also reported that in communicating with a chatbot, empathic utterances were perceived more favorably compared to unemotional expressions. In another study, a robotic agent provided empathic feedback to participants in a practice job interview session. It was found that the participants' stress level decreased after the virtual agent gave them empathic feedback [27]. Furthermore, [28] found that compared to a non-empathic embodied agent, an empathic agent is perceived more positively by participants in terms of likeability and trustworthiness.

The JD Humanoid robot that we used in this study does not aim to produce or imitate empathic behavior. Instead, it asks a question, the aim of which is to elicit empathy from collocated participants toward a remote participant on the telepresence robot. Since the overview of the previous work suggests that raising empathy can positively affect interaction, we hypothesize that the empathy-eliciting intervention improves the way the personality of remote participants is perceived by their collocated peers.

III. Methods

A. Participants

48 middle school students (M = 24; F = 24; age range = 11-13) participated in the experiment which was conducted in a public school in Naples, Italy. One week before initiating the experiment, we collected informed consent forms from the parents or legal guardians of all the participants in the study. After that, a sociometric questionnaire (see section III, C) was given to the children to collect data on their interpersonal relationships on two levels of group organization and affective aspects. Based on the results of the questionnaire, we put the students who had the closest affinity with each other into groups of three. On the day of the experiment, in each group, the students were asked to choose someone among themselves to operate the telepresence robot. In total, 32 students (M = 16, F = 16) did the experiment in person and 16 students used the telepresence robot, among whom eight were male and eight were female. The experiment was approved by the ethics committee of The University of Naples Federico II.

B. Robots

We used two different types of robots: (a) a Double 3, which is a mobile two-wheeled telepresence robot with a 9.7-inch screen and remote adjustable height, and (b) a JD Humanoid, which is a 33-centimeter tall social robot that can be programmed by either drag-and-drop languages such as Blockly or text-based coding languages such as Python, JavaScript, and C++. JD humanoid was used to moderate the session. We used the wizard-of-Oz technique [29] to operate the robot and control its gestures and language interventions such as asking questions, giving instructions, providing suggestions, etc. The robot moderator's dialog lines had been scripted and recorded before the study. During the experiment, the wizard chose from the pool of dialog lines based on the context and made sure nothing was uttered off-script.

Figure 1a. Double 3

Figure 1b. JD humanoid

C. Measures

Since all children participating in the experiment where native speakers of Italian, all questionnaires used in the study were in Italian. The questionnaires were provided to students on paper. The data collected were later inserted manually in Excel sheets and finally analyzed in SPSS.

Sociometric test. The first questionnaire given to participants was a sociometric test, which was used to collect data on their interpersonal relationships. The test explores group dynamics and members' links at two levels, including (a) the affective and psychological affinities of participants and (b) the organization and functional aspects of the group [30]. The affective section of the sociometric test included the following four questions: (1) Write the names of those classmates that you would like as a seatmate on the bus during a school trip. You can write as many names as you like. (2) Write the names of those classmates that you would not want as a seatmate on the bus during a school trip. You can write as many names as you like. (3) Write the names and surnames of those classmates who, according to you, would like you as their seatmate on the bus during a school trip. You can write as many names as you like. (4) Write the names of those classmates who, according to you, would not want you as their seatmate on the bus during a school trip. You can write as many names as you like.

The group organization section of the sociometric test included the following four questions: (1) Write the names of those classmates who you would gladly make a working group with. You can write as many names as you like. (2) Write the names of those classmates who you would not gladly make a working group with. You can write as many names as you like. (3) Write the names of those classmates who, according to you, would gladly make a working group with you. You can write as many names as you like. (4) Write the names of those classmates who, according to you, would not gladly make a working group with you. You can write as many names as you like.).

The data collected via the sociometric questionnaire was used to assign students to groups with the highest level of affinity. In this way, all groups of the study consisted of participants who had a high level of affinity with each other. Therefore, the intervening effects of the familiarity variable on the final results of the study were limited.

Personality test, self-evaluation. The second questionnaire that we used in this study was a self-evaluation test composed of three parts. The first part contained four questions on trustworthiness, adapted from [31]. The 5-point Likert scale items in this part include: (1) Do you think you can keep secrets? (2) Do you think you are a truth teller? (3) Do you think you are trustworthy? and (4) Do you think you can help others? These items were rated on a 5-point Likert scale from never (1) to always (5).

The second part included the Italian version of the 10-item Big Five Inventory taken from [32]. The Big Five Inventory assesses five dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. This personality test has been used in previous research on children and adolescents [33], [34], [35]. The test inquired whether the participants consider themselves someone who: (1) tends to find fault with others; (2) is generally trusting; (3) tends to be lazy; (4) does a thorough job; (5) is relaxed, handles stress very well; (6) gets nervous easily; (7) is reserved; (8) is outgoing, sociable; (9) has few artistic interests; and (10) has an active imagination. These items were rated on a 5-point Likert scale from strongly disagree (1) to strongly agree (5).

The third part of the questionnaire included six additional items on the neuroticism scale of the Big Five personality test by [36]. These items include: tense, irritable, not contented, shy, moody, and not self-confident. These items were rated on a 5-point Likert scale from strongly disagree (1) to strongly agree (5). We added the neuroticism-emotional stability scale because we hypothesize that telepresence users are more likely to be perceived as less emotionally stable, especially since our previous study [37] suggests a correlation between the quirkiness/smoothness of a telepresence robot's movement and how the personality of its users is perceived.

Personality test, peer-evaluation. The other questionnaire used in the study was a peer-evaluation test that assessed the perceived trustworthiness and personality of participants from the perspective of their teammates. This questionnaire was similar to the self-evaluation test mentioned above, except that instead of inquiring how participants felt about themselves, it asked them how they felt about the other group members. In addition to the 20 items on trustworthiness, Big Five Inventory, and neuroticism, it also had an extra question about the robot moderator, asking whether the participants would like to have a JD Humanoid robot at home. This item was rated on a 5-point Likert scale from not at all (1) to very much (5).

D. Procedure

After the parents and legal guardians of the participants signed the informed consent forms, a sociometric test and a self-evaluation personality questionnaire was given to students. The aim of the personality questionnaire was measuring any prospective correlations with the following

personality scores that students received from their peers later during the experiment. As for the sociometric test, we used the results to create groups of three students by grouping the children with the highest level of affinity together. On the day of the experiment, as each group entered the school's lab, they were asked to choose a volunteer to operate the Double 3 telepresence robot. The telepresence pilot was then taken to another room and received a short training on how to control the robot, while the robot stayed in the lab along with the two other participants. After that, the experimenters – i.e, the first two authors – sat in one corner of the lab and the robot moderator started the session by greeting the participants and introducing the activity that the students were expected to complete, i.e., an escape room game.

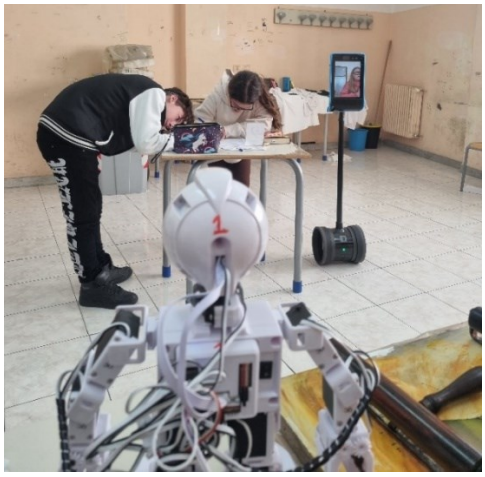

Figure 2. Experiment setup

The robot presented the game by saying that it had caught a computer virus as it was updating itself, and that it needed three items – i.e., a flashlight, a bolt, and a USB stick – to fix itself. The participants' task was to work together to solve puzzles to find the items. Then, the robot guided the participants to the first puzzle, which was a maze game printed on a piece of paper. Printed copies of the puzzle were also given to the students on the telepresence robot to make sure that they were not left behind. By solving the puzzle and answering a follow-up question, students would find the combination to a lock that opened box number one which contained the first main item of the game, i.e. a flashlight. If after five minutes students did not find the answers, robot moderator would start giving them hints until the puzzles were solved. In cases where students were unable to solve the puzzles, the robot provided the answer so that the game could go on. Figure 2 shows a group of students working together to solve a puzzle that was presented to them by the robot moderator.

Then, the robot moderator presented the second puzzle, which included a table with a number of letters and numbers that initially appeared to be written there randomly. To solve this puzzle, students needed to use a morse code guide to find the right letters/numbers required to open the combination to the lock on the second box. The second box contained the second game item, a bolt. The telepresence robot user also had a copy of the puzzle. Similar to the first round of puzzles, the robot moderator provided hints about puzzles when students asked for help or seemed to have been stuck. After this step, the robot moderator asked the students to fill out the first set of questionnaires of the study, which included two peer-evaluation measures of personality test that each participant filled out about their two group members. When all participants finished completing the questionnaires, the robot moderator asked the telepresence robot operator the empathy-eliciting questions, i.e., "how does it feel to be on a telepresence robot? What difficulties do you face while operating the telepresence robot?".

After answering the empathy-forming intervention, the robot moderator presented the last puzzle that was a word game, the answer to which would lead students to the final key item needed to complete the escape room, i.e. a USB stick. Having finished the final puzzle, the robot moderator asked the participants to fill out the second set of peer-evaluation questionnaires, which were identical to the first set of questionnaires before the intervention. After that, it thanked the participants and ended the session.

IV. Results

In this section, we report the results of the analysis of the sociometric test as well as the questionnaire data collected throughout the study.

A. Sociometric test

The sociometric test was comprised of eight questions that measured the levels of affective and group organization affinity of students prior to running the experiment. We used the results of this test to put participants into three-person groups in a way that students with the highest levels of affinity are grouped together. Table 1 summarizes the sociometric index measured for the participants involved in the experiment.

TABLE 1. SOCIOMETRIC INDEX

Affinity index	Nodes	Edges	Average	Density	Average Clustering Coefficient
(a) Affective, Q.1&2	48	183	3.26	0.05	0.15
(b) Affective Q.3&4	48	184	3.34	0.06	0.16
(c) group, Q.1&2	48	197	3.51	0.06	0.13
(d) group, Q.3&4	48	195	3.48	0.06	0.13

As shown in table 1, there is no significant difference between the average degrees of distribution, graph densities, and clustering coefficients of the four indexes, and both the affective and group organization data show consistent patterns. Since the degree of familiarity and affinity of all participants in all groups were consistent, we used the sociometric data to put students into three-person groups. Moreover, since we grouped participants with the highest affinity ratings, all the groups of the study are considered to be at a similar affective and group organization affinity level. That is, the students' familiarity with each other is not regarded as an interfering variable with a significant impact on the results of the data analysis.

B. Questionnaires

Our research question inquired whether an empathy-eliciting intervention that was uttered by a robot moderator could have a positive effect on the way remote participants were judged. To investigate this research question, we collected data using two personality questionnaires, one before and one after the robot made the intervention. A Paired-

Samples T Test (confidence interval = 95%) was run to compare the mean differences of the two questionnaires.

Compared to the first questionnaire that was completed before the empathy-creating intervention, in the second questionnaire, collocated participants judged the telepresence robot users as significantly more *trustworthy* (t(32)=-3.58, *d*=0.80; p=0.001; Q1 (questionnaire1): M=3.64, SD=1.36 & Q2 (questionnaire2): M=4.52, SD=0.75), and significantly less *tense* (t(32)=2.81, *d*=0.66, p=0.008; Q1: M=3.39, SD=1.24 & Q2: M=2.55, SD=1.30), *irritable* (t(32)=3.95, *d*=0.85, p<0.001; Q1: M=3.18, SD=1.21 & Q2: M=2.12, SD=1.26), *shy* (t(32)=2.85, *d*=0.63, p=0.008; Q1: M=3.09, SD=1.44 & Q2: M=2.22, SD=1.28), and *faultfinding* (t(32)=2.03, *d*=0.31, p=0.050; Q1: M=2.85, SD=1.10 & Q2: M=2.50, SD=1.10). The effect size values of each of the items above were calculated via Cohen's *d* formula, that is by calculating the difference between the mean scores of the two groups, and then dividing it by the pooled standard deviation.

By calculating the mean differences between the two questionnaires, after the intervention, telepresence robot users rated collocated participants to be significantly more *trusting* (t(32)=0.64, *d*=0.65, p=0.013; Q1: M=3.21, SD=0.92 & Q2: M=3.82, SD=0.88), *outgoing and sociable* (t(32)= -3.97, *d*=1.32, p<0.001; Q1: M=3.03, SD=0.69 & Q2: M=4.06, SD=0.86), and less *tense* (t(32)= 2.73, *d*=0.60, p =0.010; Q1: M=3.48, SD=0.90; Q2: M=2.88, SD=1.08). After the intervention, collocated participants were also rated significantly lower in the item *someone who does a thorough job* (t(32)=2.07, *d*=0.005, p=0.046; Q1: M=3.79, SD=0.69; Q2: M=3.45, SD=0.86).

We also calculated correlations between age/gender and questionnaire scores to assess any potential impact of external factors on our findings. We used Eta Correlation formula to measure correlations between gender of the students and their questionnaire scores. The results show that the correlations ranged from $r = 0.018$ to $r = 0.376$, with either no association or weak associations between the scores. Thus, we conclude that participants' gender did not have a significant impact on the findings of the study. Furthermore, the Pearson bivariate correlations were calculated to determine any significant correlations between the participants' age and questionnaire ratings. The results show that the correlation between age and the personality trait *reserved* of collocated participants' scores for telepresence robot users ($r = 0.421$, $p = 0.026$) as well as the trait *outgoing, sociable* of telepresence robot users' scores for collocated participants ($r = -0.586$, $p = 0.001$) were significant at the 0.05 level. This means that older collocated participants found telepresence robot pilots to be significantly more reserved, while older telepresence robot users found collocated students to be significantly less outgoing and sociable. The rest of the correlations lie between $r = -0.328$ and $r = 0.248$, and none are significant. Regarding the correlation between self-evaluation questionnaires that were administered prior to the experiment and peer-evaluation questionnaires before the empathy-eliciting intervention, the correlation between the scores that telepresence robot users gave themselves and the ones they received from their collocated partners is significant for the item *shy* ($r = -0.412$, $p = 0.026$). In the second questionnaire, the correlation between the scores collocated participants gave themselves and the ones they received from their telepresence robot partners is significant for the item *tense* ($r = 0.424$, $p = 0.028$). The rest of the data ranged from $r = -0.385$ to $+0.286$ and none were significant.

Finally, in the peer-evaluation versions of the personality questionnaire, we asked participants whether they liked to have a JD Humanoid robot at home. For this question, compared to the first questionnaire, both collocated participants (t(32)= -2.18, p =0.037; Q1: M=4.09, SD=1.11; Q2: M=4.38, SD=0.97) and telepresence robot users (t(32)= -2.10, p =0.044; Q1: M=4.00, SD=1.04; Q2: M=4.13, SD=1.04) had significantly higher ratings in the second questionnaire that was administered after the intervention. The results suggest that after the robot moderator made the empathy-eliciting intervention, the participants found it more likeable.

V. Discussion

The aim of this study was to examine the effect of an empathy-eliciting question that was asked by a social robot on the perceived personality of telepresence robot users. The findings of the study suggest that after the robot moderator makes the intervention, collocated participants consider telepresence robot participants significantly more trustworthy and less tense, irritable, shy, and faultfinding. Out of the significant items, tense, irritable, and shy belong to the neuroticism-emotional stability spectrum and 'finding fault with others' belongs to the agreeableness category of the Big Five personality traits. Thus, it can be concluded that following the empathy-eliciting intervention, the telepresence robot participants were perceived as more emotionally stable (less neurotic), agreeable, and trustworthy. In addition, after the intervention, telepresence robot users judged collocated participants as significantly more trusting, and outgoing, and significantly less tense. They were also rated significantly lower as being a person who does a thorough job. Thus, we can conclude that the robot moderator's empathy-eliciting question positively affected the way collocated and remote participants perceived the personality of each other. These results are supported by an earlier experiment that found that a text-based empathy-creating intervention improved the way collocated participants judged the personality of telepresence robot users [15]. In this study, remote participants were perceived by their teammates as significantly more trustworthy, reliable, and fascinated by art, music, or literature in this study.

Limitations. The number of participants of the study included 48 middle school students from Naples, Italy. More generalizable data could have been collected from a larger or more diverse sample that involved students from different age groups or ethnic backgrounds. Besides, based on the results of the sociometric tests, we grouped the students who knew each other well before the experiment and felt more comfortable to be in a group together. However, recruiting participants with different degrees of familiarity with each other could have resulted in more comparable data.

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