

Persuasive Robotics: The Influence of Robot Gender on Human Behavior

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Abstract—Persuasive Robotics is the study of persuasion as it applies to human-robot interaction (HRI). Persuasion can be generally defined as an attempt to change another’s beliefs or behavior. The act of influencing others is fundamental to nearly every type of social interaction. Any agent desiring to seamlessly operate in a social manner will need to incorporate this type of core human behavior. As in human interaction, myriad aspects of a humanoid robot’s appearance and behavior can significantly alter its persuasiveness – this work will focus on one particular factor: gender. In the current study, run at the Museum of Science in Boston, subjects interacted with a humanoid robot whose gender was varied. After a short interaction and persuasive appeal, subjects responded to a donation request made by the robot, and subsequently completed a post-study questionnaire. Findings showed that men were more likely to donate money to the female robot, while women showed little preference. Subjects also tended to rate the robot of the opposite sex as more credible, trustworthy, and engaging. In the case of trust and engagement the effect was much stronger between male subjects and the female robot. These results demonstrate the importance of considering robot and human gender in the design of HRI.

I. INTRODUCTION

Creating truly sociable robots requires an understanding of how our knowledge of human interaction applies to human-robot interaction (HRI)[1]. These robots will be less like tools and more like partners. Their role or function will be increasingly human-centric; where human interaction is not a means to an end, but rather the end itself.

A sociable robot must be able to interact with people across many different social dimensions. Social psychology tells us that persuasion is a fundamental aspect of human social interaction[2]. Seiter et al. write that “the most common human enterprise is, by and large, influencing other people” [3, p.165]. Attempts to change one’s own, as well as others’ beliefs and behavior, play a large part in almost every human interaction, thus a truly social robot would have to incorporate this type of behavior into its core social intelligence.

Appropriate persuasiveness, designed to benefit people and improve interaction, has far-reaching practical implications in HRI. A search-and-rescue robot might need to quickly establish credibility in order to convince disaster victims to follow important instructions. Autom, a robotic weight loss coach, assists people in changing their diet and exercise

habits over a long-term interaction [4]. Even the rather simple scenario in which a robot conveys information to a human counterpart could be enhanced given a deeper understanding of persuasion in the context of HRI. How this information is received is dependent upon how the robot is perceived. For example, a presentation by a museum tour guide would be quite ineffective if all of the information presented was met with skepticism and doubt. If the robot’s appearance or behavior could be altered in some way as to increase its persuasiveness, it would have a much greater positive impact.

Beyond the practical, there are other reasons which motivate the exploration into Persuasive Robotics. Ethical considerations drive us to prevent robots from being unintentionally designed to manipulate or influence humans in unexpected or negative ways. Such outcomes can be avoided with the knowledge of how exactly humans are influenced by machines. And of course, a number of research areas stand to be elucidated, as knowledge of how humans perceive and respond to robots can teach us much about human psychology, amongst other things.

As in human-human interaction, many factors influence the persuasiveness of a robot. It is important to understand these factors in order to successfully design robots that are appropriately persuasive. Some examples of these factors include appearance, style and content of communication, and non-verbal behavior[5]. This work examines the role of human and robot gender in the robot’s ability to change human behavior. We also explore the implications of gender on how credible, trustworthy and engaging a robot is perceived to be. Gender is a deeply fundamental part of how people understand and respond to one-another. Though its role in persuasion is complex and in some ways evolving, it is clear that if we are to introduce robots into our social environment, we must consider gender and its implications in that process.

II. BACKGROUND

Work on the design and behavior of Sociable Robots has helped to establish many of the important components of social HRI[1]. This research suggests using the model of human social behavior as a guide for designing robot behavior. A number of social robots have been built for a variety of social environments including hospitals, homes, museums and educational settings[6]. Work by Nass and Reeves provides weight to the belief that humans will respond to these social machines in much the same way that people respond to each other[7].

There is a small body of research investigating persuasion as it applies to HRI directly [8], [9], [10], [11], [12], and

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of those, very few address robot gender [10], [11]. The field of human-computer interaction (HCI) and embodied virtual agents has devoted more attention to this topic than the field of HRI [13], [14], [15]. Computers and mobile technology are now becoming popular platforms for exploring attitude and behavior change [16]. Also, the persuasive abilities of virtual humans is being explored from a number of different angles [17], [18], [19], [20], [21].

It has proven difficult to achieve consensus on a basic definition of “persuasion.” Gass et al., in their consideration of multiple disciplinary views, propose that “persuasion involves one or more persons who are engaged in the activity of creating, reinforcing, modifying, or extinguishing beliefs, attitudes, intentions, motivations, and/or behaviors within the constraints of a given communication context” [5]. In this light, it should be made clear that persuasion is, in fact, a conscious and intentional act, which requires that the recipient be aware of the attempt, and have the ability to decline. This is in contrast to *coercion*, which is generally thought to involve force, or a lack of conscious choice.

III. THE CURRENT STUDY

The present work explores how the gender of a humanoid robot affects its ability to influence human behavior, and the way it is perceived along three dimensions: trust, credibility, and engagement. It is hypothesized that these three traits, which are believed to be important for a persuasive communicator, should also be correlated to a robot’s ability to achieve compliance to some request. In this instance, compliance is measured based on subjects’ willingness to donate real money in response to a request made by the robot. This request comes after an educational interaction during which the robot explains a number of its own technical capabilities. Following the donation request, subjects are asked to fill out a questionnaire containing the three attitude measures mentioned above. The gender of the robot is solely determined by the use of a pre-recorded masculine or feminine voice.

IV. METHOD

A. Design

This experiment was based on a 2 (robot gender: male vs. female) \times 2 (subject gender: male vs. female) between subjects factorial design. The case of whether or not the subject was alone is also considered, producing a 2 (robot gender: male vs. female) \times 2 (subject gender: male vs. female) \times 2 (subject alone: alone vs. not alone) between subjects factorial design.

B. Participants

Participants included 134 museum visitors to Cahners ComputerPlace in the Museum of Science (57% were male ($n = 76$) and 43% were female ($n = 58$)). All participants had entered the study space freely and willingly, unaware of the study being run. Only adults over the age of 18 were able to act as study subjects, though minors were able to accompany adult subjects. The average age of subjects

was 35.6 ($SD = 11.58$). Also, because the post-study questionnaire required English fluency, some prospective subjects were asked not to participate¹. All subjects were given \$5 for participation, though many donated some or all of that money.

C. Setup

1) *Museum of Science: Cahners ComputerPlace*: The study took place in Cahners ComputerPlace (CCP) in the Museum of Science (MOS) in Boston. CCP is an exhibit at the MOS devoted to hands on technology education with a special focus on computers and robotics.

A space within CCP measuring approximately 6’ by 20’ was devoted to this experiment (see Figure 1). The space was defined by two walls along the long edges, and curtains along the short edges creating a fairly distraction free area.



Fig. 1. Study space in Cahners ComputerPlace in the Museum of Science.

2) *Mobile Dexterous Social Robot*: The Mobile Dexterous Social (MDS) robot was developed as a platform for research into human-robot interaction. Its development was led by Cynthia Breazeal of the Personal Robots Group at the MIT Media Laboratory, and contributors include the Laboratory for Perceptual Robotics at the University of Massachusetts at Amherst, Xitome Design, Meka Robotics, and digitROBOTICS. The purpose of the MDS platform is to support research and education goals in human-robot interaction and mobile manipulation with applications that require the integration of these abilities.

The robot is distinct in that it possesses a unique combination of mobility, dexterity and facial expressiveness. This combination grants it a greater potential for sophisticated roles in HRI. Its total height is approximately 48 inches, and its weight is 65 lbs with no external batteries. The

¹Any visitor that so desired, would be allow to interact with the robot, though in some cases the data was not used for the study

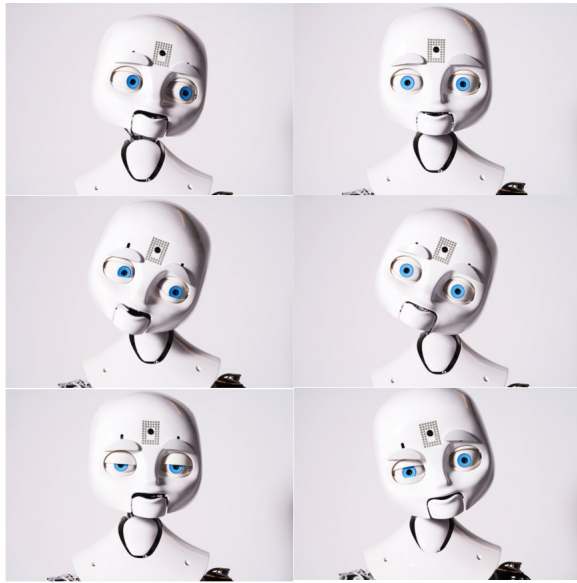


Fig. 2. Mobile Dexterous Social robot showing a wide range of facial expressions.

face has 17 degrees of freedom (DOF), including gaze, eyelids, eyebrows, and a jaw, enabling a wide range of facial expressions (see Figure 2). The neck includes an additional 4 DOFs. The upper arm and shoulders each have 4 DOFs, combined with 1 DOF for the hip rotate. The forearms and hands each have 4 DOFs enabling grasping and manipulation of objects.

3) *Robot Gender*: Voice was the only quality of the robot that was varied in the assignment of gender. Pre-recorded human voices were used for both the masculine and feminine cases. The robot's already non-gendered appearance was not modified, nor was any aspect of the robot's behavior.

4) *Study Control Interface*: The study control interface was built upon a substantial architecture, providing a wide range of tools for developing complex behavior and interactions. The robot was controlled during the study at a very high level, limiting any possible influence by the robot operator on the outcome of the study. The operator's actions were limited to indicating the start point of the study, the timing of the scripted interactions, and recording certain details relevant to the study such as the number of people accompanying the subject. All of this was done using a button-based GUI which would explicitly prompt the robot operator when intervention was necessary.

D. Procedure

1) *Subject Recruitment*: In order to ensure that the recruitment of subjects be as consistent and controlled as possible a recruitment script and procedure was established and strictly adhered to throughout the study. The recruitment process included an initial solicitation, a very general explanation of the study, and eventually the signing of consent forms. Eventually the subject would be handed 5 1\$ bills and asked to stand at a particular place within the study space.

Once the subject and any additional museum visitors were situated inside of the space, the curtain was securely closed and they were left alone with the robot. Finally the robot operator, monitoring the space through a concealed color video camera behind a curtain above the robot's head, would use the study control interface to initiate the interaction.

2) *Donation Protocol*: During the recruitment process the subjects were told that they would be receiving five dollars as compensation for participating in the study. They were also told that the robot may ask for a donation and it was their choice to give any of the money away. The donation money was presented as five one dollar bills attached to an MDS robot sticker with a paperclip.

The donation box, labeled "Donation Box", was approximately the size of a shoe box, and was positioned at waist height between the subject and the robot, against the wall, on the subject's left side (see Figure 1).

The use of a behavioral measure such as donation is important for the validity of this study because of the potential unreliability of subject measures such as questionnaires. Also, it was believed that cash, in-hand, would hold a greater value than some symbolic representation such as a gift card or tokens and thus be a better measure of persuasiveness.

3) *Robot Educational Performance & Persuasive Appeal*: The robot educational performance consisted of two major parts. In the first part, the robot provided a brief explanation of its hardware and software systems and gave a general overview of its technical capabilities. This included a short discussion of its sensors and how they relate to human senses.

In second phase the robot presented a persuasive appeal arguing that the "uneven distribution of technology is one of the most important issues facing our world today." The appeal ends with the following donation request: "The MIT Media Lab, where I was designed, is working very hard to address these issues, and more, but we need your help. Before you leave, I invite you to make a donation towards MIT Media Lab research. Any money you have left is yours to keep." After donations were placed in the donation box, the robot asked subjects to fill out a short questionnaire.

4) *Post-Study Questionnaire*: ²

Directly after depositing their donation (or moving to leave the space), subjects were met at the entrance/exit of the study space, led to the questionnaire table and invited to sit down. The questionnaire table was positioned in a corner of the CCP space and equipped with three small touch screen computers. The beginning of the questionnaire included personal questions regarding age, gender, race, education, and technical knowledge, which were followed by the dependent attitude measures: trust, credibility and engagement.

Trust was measured using a standard fifteen question scale, answered on a seven-point Likert scale[22]. Credibility was measured using D. K. Berlo's Source Credibility Scale

²Unfortunately space limitations prohibit the publication of the post-study questionnaire though all questions can be obtained by following the associated references.

[22] which is separated into three groups of five seven-point Likert scales. The three groups, safety, dynamism, and qualification each measure one aspect of credibility, which is considered to be a multi-dimensional quality[23]. Engagement is from Lombard and Ditton's scales measuring the six aspects of presence[24].

V. RESULTS

The results for the donation measure did not follow a normal distribution, but rather peaked at \$0 and \$5. In other words, people seemed to give all or nothing. To simplify the analysis, the donation measure was treated as binary (gave nothing vs. gave something), rather than as continuous which suggests the use of a nonparametric statistical method. Using Chi-Square analysis, a main effect for robot gender was found $\chi^2(1, N = 134)=11.9, p < .001$, indicating that subjects donated more often to the female robot ($M = .83, SD = .37$)³ than the male robot ($M = .56, SD = .50$).

Separating the subjects into two groups based on subject gender, it was revealed that this effect was primarily attributed to men, who donated significantly more often to the female robot $\chi^2(1, N = 76)=14.10, p < .001$, while women did not show a statistically significant preference. Incorporating the third independent variable, the binary condition of whether or not the subject was alone or accompanied by other museum visitors, revealed an interesting interaction. While men continued to donate significantly more often to the female robot whether alone $\chi^2(1, N = 37)=12.6, p < .001$, or accompanied by other visitors $\chi^2(1, N = 39)=4.32, p < .05$, women seemed to change their donation behavior. Female subjects donated significantly more often to the female robot when accompanied $\chi^2(1, N = 35)=4.32, p < .05$, but when alone, they actually reversed their preference donating more often to the male robot, though not significantly $\chi^2(1, N = 22)=1.12, p = .290$.

Because of their reliably normal distribution Analysis of Variance (ANOVA) was used to analyze credibility, trust, and engagement. Because none of these measures showed significant main or interaction effects relating to whether or not the subject was alone, we collapsed over that condition, leaving robot gender and subject gender.

Credibility did not exhibit a main effect for robot gender or subject gender. There was a significant interaction between the two though $F(1,116)=4.93, p < .05$, suggesting that men rated the female robot ($M = 78.8, SD = 12.12$) as more credible than the male robot ($M = 73.44, SD = 12.94$), while women rated the male robot ($M = 80.8, SD = 11.79$) as more credible than the female robot ($M = 75.2, SD = 14.97$). This cross-gender effect was at least marginally significant across the three dimensions of credibility: safety $F(1,121)=3.74, p = .055$, qualification $F(1,121)=4.93, p < .05$ and dynamism $F(1,116)=2.67, p = .105$.

Trust, as with credibility, showed no significant main effect for robot or subject gender, but did exhibit the same cross-gender interaction effect seen in credibility

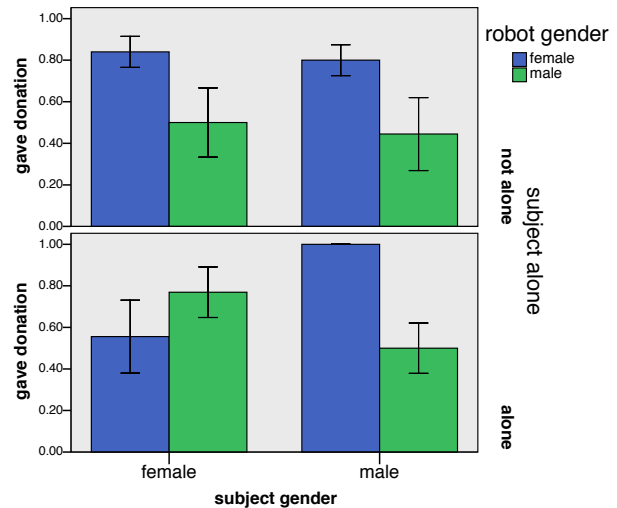


Fig. 3. The proportion of people that gave any donation separated by subject gender, robot gender and whether or not the subject was alone. Men consistently donate more often to the female robot, while women change their gender preference depending on whether or not they were alone with the robot. Error bars represent +/- 1 Standard Error.

$F(1,110)=5.83, p < .05$. Men tended to report that the female robot ($M = 82.8, SD = 11.76$) was more trustworthy than the male robot ($M = 74.68, SD = 10.58$). Women, conversely, reported that the male robot ($M = 81.62, SD = 14.31$) was slightly more trustworthy than the female robot ($M = 77.37, SD = 16.46$).

Splitting the cases into two groups by subject gender shows that it is men who are predominantly affected by the change in robot gender. A t-test run on each group shows that men were significantly more trusting of the female robot $t(41)=-2.66, p < .05$, while women showed very little preference $p = .551$.

Keeping with the pattern found in trust and credibility, engagement shows an interaction effect between robot and subject gender $F(1,110)=7.26, p < .01$. Men reported being more engaged with the female robot ($M = 23.56, SD = 5.49$) than the male robot ($M = 17.28, SD = 6.33$), while women reported more engagement with the male robot ($M = 23, SD = 7.56$) than the female robot ($M = 22.81, SD = 6.01$). Unlike other measures, engagement shows a main effect with both independent variables. Reports indicate the female robot ($M = 23.26, SD = 5.67$) is more engaging than the male robot ($M = 19.89, SD = 7.41$), $F(1,110)=6.45, p < .05$, and women ($M = 22.89, SD = 6.66$) tend to report being more engaged than men ($M = 21.18, SD = 6.54$), $F(1,110)=4.30, p < .05$.

As with the trust measure, separating the cases into two groups according to subject gender shows that men reported significantly more engagement with the female robot $t(41)=-3.12, p < .01$, while women showed no preference $p = .862$.

VI. DISCUSSION

There seems to be a complex relationship between robot gender, subject gender and whether or not the subjects were

³M = Mean, SD = Standard Deviation

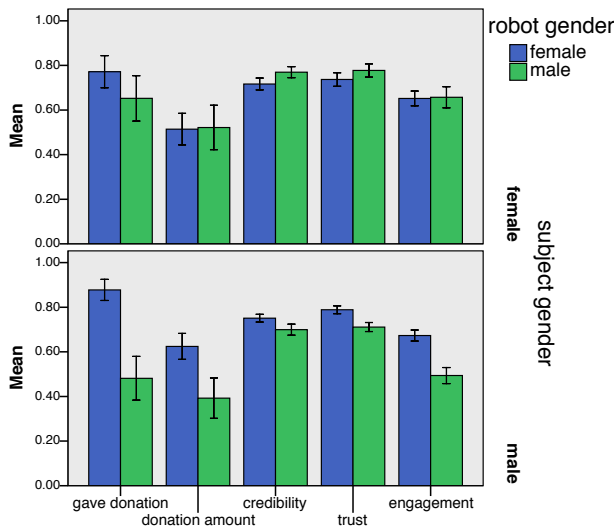


Fig. 4. All DVs including the continuous form of donation, *donation amount*, and the binary form of donation, *gave donation* (normalized). Men tend to rate the female robot higher in credibility, trust, and engagement while female subjects show the opposite tendency. Error bars represent +/-1 Standard Error.

alone. Across the three subjective measures - credibility, trust and engagement - a cross-gender effect is observed wherein men prefer the female robot, and women prefer the male robot.

The donation measure deviates slightly from the cross-gender pattern seen in the subjective measures; men donate significantly more often to the female robot, but women show no preference. Men's donation behavior remains consistent regardless of whether or not they were accompanied by other museum visitors. Women on the other hand donate more often to the female robot when accompanied, but reverse their preference to slightly favor the male robot when alone.

Though the relationship between donation behavior and the presence of additional visitors is not entirely clear, it *does* seem safe to connect the donating behavior of the subject alone, to the views reported in the questionnaire. If this is accepted, then it seems reasonable to conclude that the robot being viewed as trustworthy, credible, and engaging is likely associated with its ability to change the subject's behavior.

This result did come as a surprise as some literature in social psychology would tend to suggest a same-gender preference rather than a cross-gender preference. This stems from a general tendency for people to be more easily persuaded by similar others, or members of their *in-group* [2], [5]. This tendency was found to be true in similar work with virtual humans in immersive virtual environments (IVEs)⁴ [18]. A study by Guadagno et al. varied the gender,

⁴An IVE is a virtual environment where the participant experiences reality through computer controlled stereoscopic head-mounted display. This allows the viewer to freely look and move around the environment, and perceived their perspective change accordingly. For a review of the use of IVEs as a tool for psychological research see [25]

agency⁵, and behavioral realism⁶ of a virtual human, and tested the persuasive effect of those variables. The results show a strong same-gender influence for men, but only a minor same-gender influence for women.

One fundamental difference between the above mentioned study and this work, is the presence of the communicator. In the IVE example recipient's attitude is measured before and after the interaction using a private computer based questionnaire, free of possible scrutiny. In this study, the robot is present and observing the subject during the donation process. There is some justification for a relationship between the presence of human communicators and a cross-gender effect in [26].

A potential problem with this argument is that, if the presence of the robot somehow results in the cross-gender effect, then the questionnaire results, with no robot observing, should present a same-gender effect. An explanation for this might be related to people's desire for consistency in their attitudes, communications, and actions [5, p.56]. This drive for consistency might compel someone who had just donated money to the robot to rate it higher on the questionnaire in order to internally match their behavior to their reported views.

Though credibility, and to a lesser degree the other measures, did exhibit a cross-gender pattern, a tendency for men to be more affected by the change in robot gender also emerged. A recent study by Schermerhorn et al. gives some reason to believe that men, as compared to women, will more readily treat a robot as a social entity. Specifically, it was shown that women viewed a robot as more machinelike and did not show evidence of *social facilitation* (the propensity for people's performance on certain tasks to change when being observed) on an assigned task [27].

A possible confounding factor may be the particular effects of the male and female voices used which could be accounted for by using a number of randomly assigned voices for each gender. Future work should also consider the deeper behavioral components of gender, beyond changes in voice. Men and women can have different motivations during communication, and this should be incorporated into the design of the robot's behavioral systems [28].

We have focused on the role of gender here, as a fundamental human social category that we thought particularly likely to impact the effectiveness of persuasive appeals, but of course the opportunities and uses for Persuasive Robotics are endless. Robots' unique ability to fundamentally change aspects of their appearance and behavior would allow them to adopt a new language, regional accent/dialect, or even affective state to suit a particular interaction.

The ability to maximize the persuasiveness of a robot on a per-interaction basis would actually increase its functionality in certain applications. For example, a hospital robot that was

⁵Agency is the degree to which a virtual human is believed to be controlled by a real human. A virtual human is called an *agent* if it is computer controlled, and an *avatar* if it is human controlled.

⁶Behavioral realism is the degree to which a virtual human exhibits realistic and natural human-like movements and behaviors.

unable to successfully deliver medicine to patients because it was disliked or not trusted would essentially be non-functional. In these cases, dynamically modifying certain properties of the robot, such as gender, to suit a particular patient might be the difference between acceptance and rejection. Thus the continued study of Persuasive Robotics may lead to a more successful integration of robots into our social environment.

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