Responses to Robot Social Roles and Social Role Framing

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ABSTRACT

Promoting dependents' perceptions of point-of-injury care robots as social actors may elicit feelings of companionship and diminish stress. However, numerous rescuers may control these robots and communicate with dependents through the robot, creating communication and interaction challenges that may be best addressed by creating a pure medium robot expressing no social identity. In addition, setting dependents' expectations regarding the robot's social role may improve perceptions of the robot and trust in the robot's suggestions. In a 3 (role: pure medium vs. social medium vs. social actor) x 2 (framing: framed vs. unframed) between-participants design, participants interacted with a simulation of a robot in a search and rescue context (N=84). Robot social behavior decreased participants' fear, yet made participants feel more isolated. Framing generated increased trust in the robot. Implications for the theory and design of robots and human-robot interaction are discussed.

KEYWORDS: Human-robot interaction, social roles, framing, disaster response

1. INTRODUCTION

In search and rescue contexts, trapped dependents typically have no access to the outside world, may be injured, and are likely to endure emotional and physiological stress. Even when uninjured, dependents may be isolated for at least several hours. Robots can be used to locate dependents, provide companionship, and facilitate communication with rescue teams. Using robots in place of human rescuers minimizes the threat of harm to rescue workers. In addition, robots may navigate small or hazardous spaces inaccessible to humans, and may demonstrate the endurance and resiliency needed to stay with dependents throughout the period of isolation.

Despite the growing interest in using robots for point-of-injury care, robotics research in this area has been narrow in scope, focusing on the improvement of mechanical design and navigational capabilities. Research typically ignores the psychological needs of dependents and fails to improve robots' interaction and communication strategies.

The lack of research is particularly problematic given the complexity of interactions that feature search and rescue robots. These robots not only engage in direct interaction with dependents, they also serve as proxies for numerous rescue personnel sharing use of a single robot, typically including a medical provider, extrication specialist, search team leader, and robot operator. [1].

The work presented here examines two aspects of human-robot interaction in the point-of-injury context. First, this study examines the influence of robot social role on dependent attitudes and behaviors. Interactions with robots are inherently social, yet little attention has been paid to the human-robot social dynamic. Developing an optimal social

978-1-61284-639-2/11/$26.00 ©2011 IEEE

role is particularly challenging given the fact that dependents are likely to engage in direct social interactions with the robot, while the robot simultaneously facilitates direct communication with rescue personnel. Such complex interactions may prove cognitively challenging, particularly given the stress dependents experience.

In this study, three different robot social roles were created by manipulating the precise language used by the robot. The robot presented itself as either a "pure medium," facilitating direct communication with rescuers without expressing any unique social identity, much like a radio; a "social medium," facilitating direct communication while also expressing a unique social identity, like a dispatcher; or a "social actor," expressing a unique social identity without facilitating direct communication, like an advocate. In addition, this study examines the impact of framing on dependents' attitudes and behaviors. Participants were either explained the robot's role before the interaction, setting expectations, or interacted with the robot without any framework for anticipating and understanding the robot's role. We hoped to determine if framing the interaction provided extra benefit to dependents, or if dependents responded to robot social role regardless of framing.

2. RELATED WORK

2.1 Social Roles

The Computers as Social Actors (CASA) paradigm [2, 3] suggests that people respond to technologies as social actors, applying the same social rules used during human-human interaction. While early studies identified social responses to computers, more recent research has demonstrated that people treat robots as social actors, establishing social rapport with robots [4].

Research has only recently begun to investigate the impact of incorporating social features into robots. Studies have shown that robots benefit from demonstrating some social skills in high-level [5], multi-step [6], or persuasive [7] tasks, or assisting with autism therapy [8]. Some researchers have cautioned against overly social design. Mori [9] warned that creating humanlike robots could set human expectations too high, causing disappointment when the robots' behavior fails to meet them. Similarly, some entertainment and servant robots display cues designed to minimize perceptions of them as social actors, such as the Huggable [10], Roomba [11], and therapeutic aids [12].

While current research clearly indicates that people perceive robots as social entities and that social displays impact interactions, very little research has systematically examined human responses to specific social features [13]. Therefore, there is little guidance to aid designers in creating social behaviors that optimize human-robot interaction. In addition, studies have not yet varied the extent of social expression and evaluated humans' responses. It is not presently known if robots should emphasize their social identity and promote human perception of them as social actors, or if they should minimize this perception.

The effects of robot self-presentation of social role may depend on the interaction context. Social role may play a particularly important role in search and rescue situations. Because a robot displays social cues, dependents respond to robots as social actors. Because dependents are likely to feel isolated and scared, robots presenting a strong social presence could provide companionship, calming and entertaining dependents. At the same time, human controllers are likely to communicate with the dependent through the robot. Promoting a strong connection between dependent and human rescuers may be desirable. Minimizing social cues and presenting the robot as a pure medium could promote this human-human connection and support or encourage feelings of connection to the outside world.

The roles of social actor and medium may at first appear mutually exclusive, suggesting that designers must choose between optimizing the human-robot and human-human connection. However, designers could create a robot in the role of social medium, presenting a unique social identity like a social actor, but also expressing a close connection to human controllers and displaying an ability to channel their words and actions.

2.2 Framing

A frame is one of a number of "structures of expectation" that help people process information [14]. Frames are definitions of what is going on in an interaction. Without a frame, people have difficulty interpreting the meaning of actions within an interaction. Bateson [15] offers the example of a monkey's response to being pushed by another monkey. The frame of interaction informs the monkey of the nature of the push, elucidating whether the interaction is playing or fighting. With a "play" frame the monkey interprets the push as a playful gesture, and with a "fight" frame, the push is viewed as an aggressive act.

Frames help people establish coherence when interpreting an interaction. Frames provide an understanding of the context and purpose of an interaction, which enables people to recognize connections between interaction elements, such as intentions and actions. Frames encourage the activation of relevant schema, or knowledge structures, which help people negotiate and interpret interactions appropriately [16]. When people experience an interaction without a frame, they are unaware of the purpose of the interaction and experience difficulty interpreting elements of the interaction. Without a frame to structure interpretation of an interaction, therefore, people may experience a cognitive burden, emotional distress, and a failure to interact appropriately.

Researchers have begun to study human expectations of robots. For example, Copleston and Bugmann [17] examined people's beliefs regarding future uses of robots and found that people expected robots to complete housework, help with food preparation, and perform personal services. Similarly, Takayama, Ju, and Nass [18] identified the jobs people thought robots were well-suited to hold in the future. While these studies provide examples of examinations of existing expectations regarding robots, researchers have largely ignored studying framing as an independent variable. Paepcke and Takayama [19] provide a rare exception. They studied the effects of setting either high or low expectations of a robot's technical capabilities and found that framing the robot as having low technical capabilities generated more positive evaluations of the robot's performance.

No previous work has examined the effects of framing robot social role. Robots increasingly demonstrate social behavior and serve in a number of social roles, but the work presented here is the first to examine how setting expectations of a robot's social role impacts human attitudes and behaviors. Framing has been demonstrated to improve coherence and performance in other contexts, and framing is often relatively easy to implement. Manipulating the framing of social robot role allows us to determine if framing social role can improve human-robot interactions.

3. STUDY DESIGN

We used a 3 (role: pure medium vs. social medium vs. social actor) x 2 (framing: framed vs. unframed) between-participants experiment design. All participants interacted with a simulation of a search and rescue robot. The robot presented itself as either a medium devoid of personal identity that directly channeled human controllers' statements and actions (pure medium), a social entity channeling a human controllers' statements and actions (social medium), or a social entity in touch with human controllers but communicating and acting independently (social actor). Some participants completed the interaction without any explanation of the robot's role (unframed), while other participants viewed and listened to an explanation of the robot's particular role before beginning the simulation (framed).

Dependents in search and rescue contexts may experience emotional stress so severe it can threaten their well-being and chances for safe rescue. Therefore, we were interested in how our manipulations affected participants' affective states. We hoped to identify strategies that could minimize negative affective responses. In addition, we were interested in identifying features that could increase trust in the robot. The success of a rescue operation may depend on the dependent following rescuers' suggestions, as presented by the robot, or physically following the robot out of a dangerous area. Dependents are likely to experience high cognitive load and arousal, making trust in the robot a challenge, so we hoped to identify strategies to increase trust. Lastly, we were interested in determining if our manipulations affected perceptions of intelligence. In particular, we wished to identify any effects of role on evaluations of intelligence.

Because people respond to social cues from technologies, we anticipated that participants would sense a greater social presence with the social medium and social actor robots. We anticipated that the greater social presence of these roles would engender a sense of companionship and support, which would ease the negative affective response to the stressful situation. Because framing helps people understand and process the events of an interaction, we anticipated that participants who experienced framing would demonstrate a more clear understanding of the robot's role, and with this greater coherence, people would place greater trust in the robot. Lastly, we expected both role and framing to impact perceptions of intelligence. We expected participants who interacted with the social medium and social actor robots to extend perceptions of heightened social presence to heightened intelligence. We also anticipated that participants who experienced framing would perceive greater logic and consistency in the interaction, and would extend this to perceptions of heightened logic in the robot. We therefore developed the three following hypotheses:

H1. People will experience less negative affect with the social medium and social actor robots than the pure medium robot.

H2. People with framed interactions will demonstrate greater trust in the robot than people with unframed interactions.

H3. People who interact with the social medium and social actor robots, as well as people with framed interactions, will rate the robot more intelligent.

3.1 Participants

Eighty-four undergraduate students participated in the study. Gender was balanced across conditions (42 male and 42 female). Participants were given course credit.

3.2 Materials

To complete the study task, participants interacted with a web-based simulation of a search and rescue robot, Survivor Buddy. Survivor Buddy is a web-enabled "head" featuring microphones, speakers, and a display capable of displaying media, attached to a mobile base.

A simulation of the robot, rather than the robot itself, was used so that studies could be conducted early in the development process and results incorporated into the final design. The simulation was developed as part of the Search and Rescue Game Environment (SARGE), an open source training game for search and rescue robot operators [20, 21]. SARGE was created using the Unity game engine, which allows game creators to publish both stand-alone and web-based games. For this experiment, a web-based game was used. Unity provides graphics, audio, and physical simulation capabilities that are on par with or superior to other robot simulators such as USARSim and Microsoft's Robotics Studio Simulator. The simulation for this experiment was created such that the condition assigned to a particular participant was determined by parameters in a URL. Participants downloaded and installed the Unity Web Player before completing the study.

3.3 Procedure

Participants were assigned to participate in the study in partial fulfillment of class requirements. They were notified of the study via a welcome email that provided instructions on how to complete the study. Participants were told the experiment would take approximately forty-five minutes and they could complete the study on any computer with an Internet connection by the deadline two weeks away. The email also instructed participants to view a two-minute video before beginning the study. The video was a television news report of a deadly tornado that trapped dependents under collapsed houses. Participants were told the video would help set the scene and were instructed to imagine that they were trapped victims while completing the simulation.

The simulation consisted of four phases: Introduction, Media Use, Examination, and Conclusion. In each phase, some statements made by the robot varied by role, while other statements were identical across role conditions. The simulation began with the Introduction Phase. Once the simulation loaded, participants saw a view of a small, darkened space with walls appearing to be concrete. The robot entered the scene, approached the participant, and stopped. As the robot moved, a sound mimicking the sound of treads moving across the floor could be heard and a monitor rose from the body, displaying a screen with moving colorful dots. The robot began speaking, giving a role-specific introduction and explaining that rescuers were on their way. All robot utterances were pre-recorded and featured an artificial text-to-speech voice.

The Media Use phase followed the Introduction. This phase began with the robot stating that it had information to share with the participant. It explained that it was typically recommended that the participant view a video that would aid relaxation. The display of moving colorful dots was replaced with a one-minute video of soothing music and visuals. Once the video was finished, the screen once again displayed moving dots.

The initial media presentation was followed by six Media Selections, which comprised the bulk of the Media Use phase. With each Media Selection, the robot presented the participant with the choice of two similar media options, such as viewing a video on daydreaming techniques or a video on breathing techniques. Each Media Selection was comprised of the same three components: Decision Introduction, Decision Statement, and Decision Action.

With the Decision Introduction, the robot indicated there was new information available for the participant. There were two Decision Introduction statements specific to each role, and the robot alternated between the two statements when introducing the Media Selections to avoid sounding too repetitive.

For each Media Selection, the Decision Introduction was followed by a Decision Statement. The Decision Statement explained that participants were typically encouraged to watch one particular media clip, but in this case it was recommended they watch a different but similar clip. The Decision Statements were role-specific. Participants then used the arrow keys on their keyboards to mimic turning their heads and selected a media clip. By presenting the robot's recommendation as contrary to common recommendation, we were able to measure the extent to which participants complied with the robot's suggestions. To avoid confusing simple preference for a particular media clip with compliance, we alternated the order of clips across participants.

The final component of each Media Selection was the Decision Action. After the participant selected a media clip, the robot stated, "Decision noted. Taking action." The selected media clip was displayed on the screen and ran for approximately one minute and fifteen seconds (see Figure 1 for an image of the robot playing a media clip). At the end of that time, the next Media Selection was presented, beginning with the Decision Introduction.

Figure 1. Robot Simulation Displaying Media.

3.4 Experimental Manipulations

3.4.1 Role

The independent variable role had three levels: pure medium, social medium, and social actor. Role was manipulated by varying the precise word selection of the robot, while maintaining the same basic content. The utterances of the pure medium robot indicated that the controller was speaking directly to participants through the robot and controlling the robot directly. When the pure medium robot first introduced itself to participants, it stated, “I am the controller of the robot that is here to help you. I have information for you.” All statements issued by the pure medium clearly indicated that “I” referred to the controller and not the robot.

Like the pure medium, the social medium robot signaled that human controllers were the original source of the communication content. However, the social medium also revealed a unique identity by referring to itself as “I” and referencing “my controller” as the information source. When introducing itself, the social medium robot said, “I am a robot that is here to help you. I will be presenting information to you from my controller.”

The social actor robot, like the social medium, spoke in the first person. Unlike the pure and social medium robots, it presented itself as the source of information. While it made clear it was communicating with the controllers, it gave no indication that it was directly channeling information from the controllers. When introducing itself, the social medium robot stated, “I am a robot that is here to help you. I have information for you.”

Condition-specific statements like the introduction were used throughout the interaction. For the complete list of condition-specific statements, see Table 1.

3.4.2 Framing

The independent variable framing had two levels: framed and unframed. For framed participants, after entering in their participant identification number to begin the study task, a screen appeared with a written explanation of the robot’s role. A text-to-speech voice read the written explanation, and participants could not proceed to the next screen until the audio was completed. Once the audio was finished, participants could click “next” and proceed to the survival simulation.

The topics discussed in each of the three frames were identical, with descriptions of the robot’s features varying by condition. For example, the pure medium framing included the statement, “the robot’s movements will be directly controlled by the human controller.” Framing of the social medium included, “the robot’s movements will be adapted by the robot based on the human controller’s proposed movements,” and the social actor framing included, “the robot’s movements will be selected by the robot, informed by the controller’s suggestions.”

For unframed participants, robot role was never mentioned and they received no explanation of the robot’s role. After entering their participant identification number, the simulation automatically loaded, bypassing the framing explanation.

4. MEASURES

4.1 Negative Affect

4.1.1 Isolation

Isolation was an index of two items from the questionnaire. Participants were instructed to reflect on their experience

Table 1. Summary of Robot Statements by Role Condition

	Pure Medium	Social Medium	Social Actor
Interaction Introduction	I am the controller of the robot that is here to help you. I have information for you.	I am a robot that is here to help you. I will be presenting information to you from my controller.	I am a robot that is here to help you. I have information for you.
Decision Introduction 1	I have information for you.	I have information from the controller for you.	I have a message for you.
Decision Statement	Typically it is recommended that you watch (A). However, in this case, I recommend (B).	Typically it is recommended that you watch (A). However, in this case, the controller recommends (B).	Typically it is recommended that you watch (A). However, in this case, I recommend (B).
Exam Statement 1	I am going to use the robot to examine you for injuries.	The controller is going to guide me to examine you for injuries.	I am going to examine you for injuries.
Conclusion	This is the controller. I’m interrupting what you are watching because I have important information for you.	This is the robot. I’m interrupting what you are watching because my controller has important information for you.	This is the robot. I’m interrupting what you are watching because I have important information for you.

during the simulation and indicate their agreement with the following statements: "I felt lonely" and "I felt like I was all alone." Participants responded on ten-point scales ranging from "Strongly Disagree" to "Strongly Agree." The index was reliable (r=.54).

4.1.2 Fear

Fear was as index of three items from the questionnaire. Participants were instructed to reflect on their experience during the simulation and indicate their agreement with the following statements: "I was scared," "I felt stressed," and "I felt claustrophobic." Participants responded on ten-point scales ranging from "Strongly Disagree" to "Strongly Agree." The index was reliable (α=.88).

4.2 Trust

4.2.1 Compliance

The Compliance score was the number of times participants followed the robot's advice in selecting media clips. Media was selected by hitting an arrow key after each Decision Statement. Participants selected the typically recommended media using the left arrow key and selected the currently recommended media using the right key. Left arrow keystrokes received a score of zero and right arrow keystrokes received a score of one. Because there were six Media Selections, the score indicating greatest compliance was six.

4.2.2 Rescue Confidence

Rescue confidence was an index of three items from the questionnaire. Participants were instructed to reflect on their experience during the simulation and indicate their agreement with the following statements: "I was confident the rescuers would find me," "I believed that rescuers were on their way," and "I felt optimistic." Participants responded on ten-point scales ranging from "Strongly Disagree" to "Strongly Agree." The index was reliable (α=.88).

4.3 Intelligence

Intelligence was an index of seven items. Participants indicated how well the following words described the robot: "competent," "cooperative," "experienced," "informed," "intelligent," "qualified," and "skilled." Participants rated each item on a ten-point scale ranging from "Describes Very Poorly" to "Describes Very Well." The index was reliable (α=.91).

4.4 Manipulation Checks

4.4.1 Social Actor

The social actor manipulation check was included to determine if participants perceived a difference in the extent to which robots in each of the roles had an independent social identity. Because the pure medium was designed to have no independent identity, we anticipated low scores for the pure medium on this measure. The social actor manipulation check was an index of two items: "The robot was the source of recommendations," and "The robot was communicating directly with me without the help of a human operator." Participants indicated their agreement with the statements on ten-point scales ranging from "Strongly Disagree" to "Strongly Agree." The index was reliable (r=.51).

4.4.2 Medium

The medium manipulation check was included in the questionnaire to determine if participants perceived differences across role conditions in the extent to which the robot was directly channeling the controllers. Because both the pure medium and social medium channeled the controllers directly, we anticipated these conditions would elicit higher scores. The medium manipulation check was an index of two items: "A human operator was source of recommendations," and "An operator was communicating directly with me through the robot." Participants indicated their agreement with the statements on ten-point scales ranging from "Strongly Disagree" to "Strongly Agree." The index was reliable (r=.55).

5. RESULTS

5.1 Negative Affect

5.1.1 Isolation

A significant main effect of role on isolation was found, $F(2, 78)=3.15$, $p<.05$, partial $\eta^2=.08$. Contrary to the predictions of H1, pure medium participants, M=6.54, SD=2.44, felt less isolated than both social medium participants, M=7.36, SD=1.81, and social actor participants, M=7.48, SD=1.98.

5.1.2 Fear

Consistent with H1, a significant main effect of role on fear was found, $F(2, 78)=4.04$, $p<.05$, partial $\eta^2=.09$. Social actor participants experienced less fear, M=3.86 SD=2.64, than pure medium participants, M=5.45, SD=2.25, and social medium participants, M=4.77, SD=2.61.

5.2 Trust

5.2.1 Compliance

As predicted by H2, a significant main effect of framing on compliance was found, $F(1, 78)=4.76$, $p<.05$, partial $\eta^2=.06$, with framed participants demonstrating greater compliance, M=3.57, SD=1.31, than did unframed participants, M=3.12, SD=0.99.

5.2.2 Rescue Confidence

Consistent with H2, a significant main effect of framing on rescue confidence was found, $F(1, 78)=4.22$, $p<.05$, partial

η^2=.05, with framed participants demonstrating a greater confidence in rescue, *M*=8.30, *SD*=1.61, than did unframed participants, *M*=7.42, *SD*=2.28.

5.3 Intelligence

A significant interaction effect of role and framing on intelligence was found, $F(2, 78)=3.64$, $p<.05$. Pure medium participants gave similar ratings when framed, *M*=6.22, *SD*=1.56, and unframed, *M*=6.73, *SD*=1.36. Social medium participants gave higher ratings of intelligence when unframed, *M*=7.44, *SD*=1.45, than framed, *M*=6.68, *SD*=1.73. Social actor participants gave lower scores when unframed, *M*=5.91, *SD*=2.28, than framed, *M*=7.07, *SD*=1.64.

5.4 Manipulation Checks

5.4.1 Social Actor

A significant main effect of role on the social actor manipulation check was found, $F(2, 78)=5.93$, $p<.01$, partial η^2=.13, with social actor participants giving the highest scores, *M*=5.21, *SD*=2.23, followed by pure medium, *M*=4.45, *SD*=2.22, and social medium participants, *M*=3.62, *SD*=1.56. A significant interaction effect of role and framing on the manipulation check was also found, $F(2, 78)=3.69$, $p<.05$, partial η^2=.09. Ratings varied less across role when unframed than when framed, with unframed pure medium, *M*=4.61, *SD*=1.97, social medium, *M*=4.25, *SD*=1.71, and social actor participants, *M*=4.39, *SD*=2.34, reporting middling scores. Post-hoc analysis (Tukey's LSD) revealed that framed social actor participants, *M*=6.04, *SD*=1.86, rated the robot significantly higher than unframed pure medium participants, $p<.05$, unframed social medium participants, $p<.01$, unframed social actor participants, p<.05, and framed pure medium participants, *M*=4.29, *SD*=2.51, $p<.05$. Framed social medium participants, *M*=3.00, *SD*=1.13, gave the lowest scores, and post-hoc analysis revealed scores were significantly lower than those of unframed pure medium participants, $p<.05$, unframed social actor participants, $p<.05$, and framed pure medium participants, $p<.05$.

5.4.2 Medium

A significant main effect of role on the medium manipulation check was found, $F(2, 78)=5.07$, $p<.01$, partial η^2=.12, with social medium participants rating the robot highest, *M*=6.20, *SD*=2.04, followed by pure medium, *M*=5.89, *SD*=2.51, and social actor participants, *M*=4.46, *SD*=2.23. A significant interaction effect of role and framing was found, $F(2, 78)=4.50$, $p<.14$, partial η^2=.10. Ratings varied less across role when unframed than when framed, with unframed pure medium, *M*=5.57, *SD*=2.42, social medium, *M*=5.50, *SD*=2.12, and social actor participants, *M*=5.43, *SD*=2.7, reporting middling scores. Post-hoc analysis (Tukey's LSD) revealed framed social actor participants, *M*=3.48, *SD*=0.76, rated the robot significantly lower than unframed pure medium participants, $p<.05$, unframed social medium participants, $p<.05$, unframed social actor participants, $p<.05$, framed pure medium participants, *M*=6.21, *SD*=2.64, $p<.01$, and framed social medium participants, $p<.01$, *M*=6.89, *SD*=1.77. Framed social medium participants gave the highest scores, and post-hoc analysis revealed scores were significantly higher than those of framed social actor participants, $p<.01$.

6. DISCUSSION

The results showed mixed support for H1. As predicted by H1, participants experienced greater fear with the pure medium robot than with the robot demonstrating the strongest social presence, the social actor. There was not a significant difference in fear between the pure medium and social medium participants, and social medium participants experienced significantly greater fear than social actor participants. These results indicate that the social actor role fares best at minimizing fear and suggests that maximizing levels of social behavior while limiting channeling capabilities generates lowered fear levels. The moderate fear experienced by social medium participants indicates that social behavior is not sufficient to reduce fear without limiting the channeling function.

The results for isolation conflicted with the predictions of H1. While we anticipated that the more social roles would reduce feelings of isolation, pure medium participants reported the lowest levels of isolation. This result suggests that the direct connection to rescuers afforded by the pure medium made participants feel less lonely. While the social medium and social actor robots may have provided some companionship, these results indicate that feeling connected to people outside the point-of-injury location is more important to reducing feelings of isolation than feeling connected to a social entity at the point-of-injury location.

The results revealed strong support for H2. Framed participants demonstrated greater compliance and rescue confidence. These results indicate that providing some expectation of robot role before an interaction increases trust.

The results for intelligence were more complex than predicted by H3, with results revealing an interaction of role and framing. Pure medium participants gave similar ratings of intelligence when framed and unframed. Social medium participants rated the robot more intelligent when unframed, while social actor participants rated the robot more intelligent when framed. Unframed social actor participants gave the robot the lowest ratings of intelligence. These results indicate that setting expectations regarding robot role has a greater impact when the role features a strong social component. Evaluations of the social medium were damaged when role expectations had been set, suggesting that the robot's performance was more impressive without knowing the robot would be acting socially yet transmitting information.

The social actor manipulation check revealed, as expected, that social actor participants gave the highest scores. Interestingly, social medium, not pure medium participants, rated the robot lowest. The low scores for the social medium may be attributable to the fact that the social medium was a social entity bound to another social entity. The social medium robot acted much like a dispatcher, faithfully relaying information. Unlike the social medium, the pure medium gave no indication of social identity, so its channeling of the rescuers' information may not have been interpreted as a limitation of autonomy. As expected, the results also revealed an interaction of role and framing, whereby the differences in ratings of roles were greater when framed. Framing set expectations of robot roles, and generated a deeper understanding of robot roles.

A similar pattern of results emerged for the medium manipulation check. As expected the social actor elicited the lowest medium manipulation check scores. However, once again, the results for the pure medium and social medium conflicted with expectations. The social medium received the highest scores, providing further indication that participants perceived the social medium to be most closely connected to human controllers. As with the social actor manipulation check, these results suggest that the behavior of the pure medium set moderate expectations for autonomy, while the juxtapositions of the social medium's independent social behavior with its explicit dedication to channeling the controllers highlighted the social medium's function as a medium.

7. LIMITATIONS

There are several limitations to this study. First, the study featured a simulation of a robot, rather than the physical robot. Using the simulation was preferable in this case as this was the first in a series of studies exploring the influence of social role on dependent responses. Findings from this study will inform the design of the robot and future directions for research. Additional studies using the physical robot will be conducted to replicate the results. Second, participants completed the study online from a location of their choice. Participants' physical environment did not mimic and actual survival environment, minimizing the ecological validity of the study. Similarly, while we induced low levels of anxiety by requiring participants to view video of a disaster situation and instructing them to imagine they were in a disaster situation, our induction was not nearly powerful enough to generate levels of anxiety comparable to those experienced by real victims in search and rescue situations. Future studies will be completed at a site with a physical layout designed explicitly to realistically resemble a disaster area. Participants will be positioned within the rubble, and greater anxiety will be induced. In this context, we will test the replicability of our findings. Lastly, our participant pool was limited to college students living in the United States. Future studies will feature people of different ages and backgrounds.

8. CONCLUSION

This study was the first to examine the effects of framing robot social role. The study results clearly demonstrate that framing the role of a robot before interaction increases trust in the robot, as shown by increased compliance and rescue confidence. The benefits of promoting trust in a robot are clear. In search and rescue contexts, eliciting trust is a challenge, yet may be essential to the survival of dependents. Promoting trust in a variety of contexts outside the search and rescue context is also desirable. Therapeutic robots and educational robots, for example, may demonstrate improved performance when human-robot trust is increased. In some cases, framing human-robot interactions is as simple as telling people a few facts about the robot before an interaction. Because increasing trust is so often desirable in human-robot interaction, designers in most contexts should consider taking any easy steps to frame human-robot interactions.

In many contexts, it is impossible to frame an interaction before a robot approaches. In search and rescue contexts, dependents may have very little understanding of robots when the robot approaches and initiates contact or may be cognitively impaired. In these situations, the interaction may be improved if the robot attempts to provide some framing before launching into the primary interaction. If the robot features a voice technology, simply speaking a few lines explaining its role, or framing other factors, such as the broader rescue effort, may succeed in eliciting trust and compliance. Future studies should investigate cases of robots setting expectations regarding their own performance.

The study results regarding social role were more complex, and while the results did not entirely match our expectations, the consistent findings provide clear design guidelines. Participants experienced the least isolation when interacting with the pure medium, though they felt the least fear when interacting with the social actor. These results suggest that a strong social presence mitigates fear, but a pure medium channeling controllers' communications helps people feel connected to the outside world. Designers, therefore, must weigh the desire to minimize fear with the desire to promote connection to controllers.

Designing robots with multiple optional role capabilities could prove particularly helpful when balancing these needs. When promoting connection is paramount, such as cases when the rescue team fears secondary collapse and must engage in complex communication with dependents, a pure medium role is desirable. If rescuers are concerned the dependent may be experiencing shock, or if little coordination with controllers is needed, the social actor role would be preferred. Creating a single social medium role does not eliminate the need for the social actor and pure medium roles. The social medium was in some cases evaluated positively. When unframed, social medium robots received the highest scores for intelligence. However, as the manipulation checks reveal, participants' responses to the social medium's combination of social behavior and channeling ability revealed a perception of the robot as bound to controllers.

The results of this study clearly indicate that framing human-robot interactions increases human-robot trust, which improves the overall interaction. Setting expectations of the robot's role helps people understand the robot's actions, and provides greater perceptions of coherence for the overall interaction. Therefore, whenever possible, framing should be implemented. When selecting robot role, designers should take a more goal-specific approach. If the interaction is unframed and high perceptions of robot intelligence are desirable, or if designers wish people to perceive the robot as low in personal autonomy, a social medium robot is desirable. If minimizing fear is the primary goal, the social actor role should be implemented. If minimizing isolation is instead desired, the pure medium social role should be implemented. Incorporating framing into the interaction, and implementing goal-appropriate robot social roles will improve the interaction, promote overall task success, and improve the well-being of dependents.

ACKNOWLEDGMENTS

This work was supported in part by the National Science Foundation under Grant Numbers 0904321 and 0937060 (to the Computing Research Association for the CIFellows Project) and through a grant from Microsoft External Research. The authors would like to thank Aaron Rice for his assistance in the preparation of the video.

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