When Stereotypes Meet Robots: The Effect of Gender Stereotypes on People's Acceptance of a Security Robot

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Abstract. A recent development of social robotics suggests the integration of human characteristics social robots, which allows a more natural interaction between users and these social robots targeting better task performance and greater user acceptance to such social robots. It is interesting to note that the recent successful integration of human characteristics has brought an overarching research paradigm, known as Computers Are Social Actors (CASA) theory which suggests that people react and respond to computers and robots, often similar to the way they treat another social entities. Based on the research paradigm of CASA theory, this study further examined the impact of gender-related role stereotypes on the assessment of a social robot in a particular occupation. Though previous research in social science found that stereotyping makes a significant influence on personal decisions, involving career promotion, development, and supervision, as well as personal competence evaluations, limited insights has been found in HRI research. A between-subject experiment was conducted with 40 participants (gender balanced) at a public university in Singapore to investigate the effect of gender-related role stereotypes on user acceptance of a social robot as a security guard. Largely within our expectations, the results also showed that users perceived the security robot with matching gender-related role stereotypes more useful and acceptable than the mismatched security robot as a second-degree social response.

Keywords: Social Robots, Human—Robot Interactions, User Acceptance, Gender Stereotypes.

1 Introduction

United Nations (UN) projected one out of every five people in the world to be elderly in year 2050 (Population Division UN, 2000). Due to the problems of aging populations and labor shortages in healthcare industry worldwide (World Health Organization,

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2006), a rising demand for automation is highly expected. Combining the intention to support independent living for elderly, such demand has pin-pointed the usage of social robots as a potential solution for elderly-care at home. These social robots could provide a wide range of home services involving companion, healthcare, house-chores, and security purposes (Carpenter et al., 2009; Dautenhahn et al., 2005; Groom, 2008; Hudlicka et al., 2009; Ray, Mondada, & Siegwart, 2008). Different from the conventional labor-intensive robots in workplaces such as factory, these social robots at home work closely and frequently interact with other humans and its surrounding environment. As a result, their social skills and abilities become pivotal in their performance indicators. Therefore, recent developments of social robotics have suggested the integration of human characteristics social robots, which allows a more natural interaction between users and social robots targeting better task performance and greater user acceptance to such social robots (Fong, Nourbakhsh, & Dautenhahn, 2003).

Though researchers believe that both robots and users can be mutually benefited from the robots integrating 'human social' characteristics (Breazeal, 2003), it stems also potential pitfalls from their benefits in human—robot interaction (HRI). For example, as suggested by Mori's uncanny valley (Mori, 1970), a user response can be revulsive when they are facing robots that look and act almost, but not perfectly, like a human. Therefore, understanding the motivations by which user comes to accept or reject these 'human social' characteristics on social robots is necessary to avoid a potential user repulsion. Such perceptive of user acceptance requires in-depth understanding of human—robot relationship.

Computer as Social Actors (CASA) theory suggests a fundamental social relationship between human and machines (Nass, Steuer, & Tauber, 1994). Within the research paradigm, researchers found that humans mindlessly provide social responses to machines, including computers, virtual agents (Nass, Moon, & Carney, 1999; Nass, et al., 1994; Reeves & Nass, 1996) and social robots (Lee, Peng, Yan, & Jin, 2006; Tapus, Tapus, & Matarić, 2008), similar to the ways that they treat other humans. The point of departure of this paper is the media equation between humans and social robots as suggested by CASA theory. In other words, people will generally apply social model when they are observing or interacting with autonomous robots (Breazeal, 2003). Based on the media equations, this study aims to understand how human responses towards social robots would be affected by the social stereotypes.

2 Literature Review

2.1 Personifying Robots

Apart from building robots and androids with humanoid appearances, researchers suggested also many other interactive 'human social' characteristics including communicating with high-level dialogue, learning/recognizing models of other agents, establishing/maintaining social relationships, possible learning/developing social competencies, and exhibiting distinctive personality and character, to be integrated on social robots (Fong, et al., 2003). Therefore, in order to maximize payoffs in

advocating the most appropriate 'human social' characteristics on robots, researchers tend to apply previous successful examples of human—human interactions in sociology on HRIs.

In sociology, human gender and personality were extensively used to explain a variety of personal difference in abilities, attitudes, and social behaviors (Dunn & Guadagno, 2012; Li & Chignell, 2010; Muscanell & Guadagno, 2012; Streiff et al., 2011; Woods & Hampson, 2010). Likewise, these two traits have also been commonly used to personify robots in social settings (e.g., Edsinger, Reilly, & Breazeal, 2000; Eyssel & Hegel, 2012; Kim, Kwak, & Kim, 2008; Lee, et al., 2006; Powers et al., 2005; Siegel, Breazeal, & Norton, 2009; Tapus, et al., 2008; Woods, Dautenhahn, Kaouri, Boekhorst, & Kheng Lee, 2005). After robots become more and more common to public, they took out certain tasks that were previously carried out by humans. Since then, how robot designers gender their humanoids represents a tangible manifestation of their tacit understanding of femininity in relation to masculinity, and vice versa (Robertson, 2010). The creation of gender is largely based on the vague and unreflexive assumptions about humans' differences in gender.

Since the proposal of CASA theory, researchers are given confidence to rationally apply social concepts in modeling and explaining the nature of human-robot relationship. Some successful applications of social concepts include social role identity and personality attraction rules in explaining user's preference of robot's gender and personality type. Upon successful applications, the genders of robots were found to affect user's preference as well as the task suitability and persuasive power of social robots (Carpenter, et al., 2009; Eyssel & Hegel, 2012; Powers, et al., 2005; Siegel, et al., 2009). Besides, personality of social robots was also found to influence user's preference (Tapus, et al., 2008), perceived enjoyment, intelligence, and social attraction (Lee, et al., 2006) of social robots. Generally, the previous successful examples of gendering robots suggested that people see and understand the traits of robots similar to those on humans (Eyssel & Hegel, 2012; Powers, et al., 2005). Largely, this understanding is drawn from their knowledge in head and can be interpreted in the light of role stereotypes founded in real world.

2.2 Social Role Stereotypes

Asch's (1946) defined stereotype as a gestalt view of personal perception, which emphasized the notion that certain traits, characteristics or prototypes are more 'central' and important in organizing our perceptions of other people than other traits. As early as the age of five, children have already developed an impressive constellation of gender stereotypes. They often use these stereotypes to form impressions of others, help guide their own behavior, direct their attention, and organize their memories (Martin & Ruble, 2004). The process of stereotyping is claimed to be automatic and almost unavoidable (see Bargh, 1999; Devine, 1989). Via the simple and automatic act, a perceiver gains a large amount of 'functionally accurate' information to help them guide their perceptions and responses (Swann, 1984). This information includes the important background characteristics of group members, such as personality traits (Grant & Holmes, 1981; Linville & Jones, 1980), individual beliefs, and values

(Rokeach & Mezei, 1966). Besides, certain identity traits such as age, gender, and race were also consistently found as primary categories in the contents of stereotype labeling (Brewer, 1988; Fiske & Taylor, 1991; Schneider, 2004, *p*. 96). This information, though not entirely accurate, could guide our responses toward the others (Stangor & Schaller, 2000). It provides an anchor for us to organize our behaviors, including self-protections or communicative patterns, towards others and surrounding. Thus, the information obtained through is essential to our well-being (Fiske & Taylor, 1991).

Particularly, the role stereotypes and its impact in social environment can be specifically highlighted by a substantial amount of occupational stereotypes studies concerning individual differences, such as gender, ethnicity, and personality. General public has particular gender and/or personality stereotypes towards many occupation roles including engineer, police officer, politician, homemaker, and model (Crowther & More, 1972; Garrett, Ein, & Tremaine, 1977; Levy, Kaler, & Schall, 1988; McCauley & Thangavelu, 1991; McLean & Kalin, 1994; Shinar, 1975; Triandis, 1959; Walker, 1958). Since the information of stereotypes help us organize the behaviors and characters of others, it may also impact the nature of social interactions (Bargh, Chen, & Burrows, 1996). Largely found in occupational studies, gender-typing was found influential in personal decisions such as job hiring decisions (Glick, Zion, & Nelson, 1988), personal competence evaluations (Gerdes & Garber, 1983; Goldberg, 1968; Rosen & Jerdee, 1973, 1974a), career promotion, development, and supervision (Rosen & Jerdee, 1974b).

Based on the reappraisal of previous literatures, the purpose of this study is to extend the insights of social role stereotypes from human—human interactions into HRI based on the research paradigm of CASA theory. Though some previous studies have discussed the importance of gender (e.g., Carpenter, et al., 2009; Siegel, et al., 2009) and stereotypical images (e.g., Eyssel & Hegel, 2012; Powers, et al., 2005) in affecting user's perceptions towards social robots, these studies did not fully cover the effect of occupational-gender stereotypes on robot usage in home settings. The objective is to examine the validity and impact of gender stereotypes for social robots in home settings. Based on the insights from studies in occupational field, this study expects social robots that violate their occupational stereotypes will be evaluated less advantageous than those that comply with the stereotypes. Two pre-requisites are required to examine the backlash effect of role stereotypes in HRI. First, it is essential to understand user's role stereotypes of the social robots. The second pre-requisite is the successful recognition of gender manipulation in this study.

3 Methods

3.1 Participants

Forty participants from a public university of Singapore participated in this study (M=22.57, SD=2.25). The participants were randomly recruited from various faculties in the university. Each participant received 10 dollars as a compensation for their time spent for the experiment.

3.2 Experimental Design and Manipulations

The usage of male robots in home-settings is rarely discussed in previous research. Therefore, this study selected a security robot which is a stereotypical male occupation in real world to understand how users change their perceptions in accordance to different genders. This study employs a between-subject experimental design. Twenty participants were randomly assigned to interact with a male security robot and the rest was assigned to the condition of female security robot. The male gendered security was given a typical name of a male, John (Swim, Borgida, Maruyama, & Myers, 1989). Similarly, the female gendered security robot was given a typical name of a female, Joan (Swim, et al., 1989). Besides, the gender was also manipulated with male and female voices provided by the gender ready Windows text-to-speech (TTS) software. On the other hand, the appearance, speech rate, and gesture of the robots remained identical for the male and female gendered robot.

3.3 Experimental Procedures

Participants firstly entered a briefing room and given a brief introduction of the security robot that they are going to meet. After signing on a consent form, they were directed to the experimental room and started their interactions with the security robot. To enhance the flexibility of the experiment, an operator acted as a "wizard" behind the one-way mirror in the wizard-of-oz experimental setting. In the first phase of the interaction, the security robot introduced himself/herself to the participants. On the other hand, in the second phase of experiment, the participants were requested to view a closed-circuit television of four surveillance cameras positioned outside of the experimental room. An alert was triggered when the security robot detected a suspicious intrusion through the CCTV. Followed by the alarm, the security robot asked the participants whether they wanted to zoom in into a specific camera view that detected the intrusion. Later on, the security robot determined the intrusion to be safely resolved after the stranger left the surveillance zone. After the intrusion, the security robot found that the participants left their belongings in the briefing room and left the briefing room unlocked. Therefore, the security robot asked if the participants would like the door to be locked with its tele-remote system. In the last task scenario, the security robot alerted the participants that an electric kettle inside the experimental room was unintentionally left switched on. The participants were given freedom to answer and behave on their own during the experiment. With the different responses from participants, the security answered and behaved differently. After the session, the participants were guided back to the briefing room to answer a set of questionnaire for their post-usage responses.

3.4 Measures

To ensure a successful gender manipulation, participant's perceived gender of the security robot was measured after the experiment. Participants rated their perceived masculinity and femininity of the robots on a 7-point Likert scale.

Similar to any IT implementations, a social robot cannot be well utilized unless it is wholly accepted by its user. Therefore, similar with the study of Ezer, Fisk, and Rogers (2009), this study employed the Technology Acceptance Model (TAM) to study user's acceptance of security robot at home. The measures included perceived usefulness, perceived ease of use, and intention to use (i.e., acceptance). The perceived usefulness was measured with four items, 1) *I think the security robot will be useful in my daily life*, 2) *I think using the security robot will improve the effectiveness of my daily life*, 3) *It would be convenient for me to have the security robot* and 4) *I think the security robot can help me with many things*. The perceived ease of use was measured with three items, 1) *My interaction with the security robot is clear and understandable*, 2) *I find it easy to get the security robot to do what I want it to do*, 3) *I find the security robot to be easy to communicate*. Lastly, participant's intention to use was measured by three items 1) *If given a chance, I plan to use the security robot in near future*, 2) *If given a chance, I think I'll use the security robot in near future*, 3) *If given a chance, I'm certain to use the security robot in near future.* Participants rated their agreement of each statement on a 7-point Likert scale (1=strongly disagree, 7=strongly agree).

3.5 Results

The Cronbach's alpha value for the items measuring perceived usefulness, perceived ease of use, and intention to use, are 0.73, 0.91, and 0.96 respectively. Hence, the scales measuring the three TAM constructs appeared to be reliable (alpha > 0.7). The participants perceived the male gendered robot (M=5.55, SD=0.83) more masculine than the female gendered robot, M=3.85, SD=1.35, p=0.00, η_p^2=0.38. On contrary, the female gendered had a higher rating of femininity (M=4.45, SD=1.39) than the male gendered robot, M=3.10, SD=1.12, $F(1,38)$=11.40, p=0.002, η_p^2=0.23. Upon the successful recognition of gender, the participants perceived the male gendered security robot (M=5.79, SD=0.82) more useful than the female gendered security robot, M=5.09, SD=0.90, $F(1, 38)$=6.63, p<0.05, η_p^2=0.15. Also, participants found the male gendered security robot (M=5.75, SD=0.88) more acceptable than the female gendered security robot, M=5.05, SD=1.26, $F(1,38)$=4.17, p<0.05, η_p^2=0.10. However, the difference of perceived ease of use between the male gendered (M=5.48, SD=0.72) and the female gendered robot was only marginally significant, M=4.97, SD=1.03, $F(1, 38)$=3.40, p=0.07.

4 Discussions

Humans were gifted the ability to recognize and differentiate gender since early childhood. Hence, it is not surprising that the participants are able to recognize the gender of social robots with simple vocal cues in this study.

Upon successful recognition, user's evaluations towards the security robots changes with their perceived gender. Though user's evaluations could happen almost instantaneously, we can see it as a two-step process. First, the stereotype heuristics

offer a judgment of task suitability based on the different genders of robots. Secondly, based on the perceptions of task suitability, participants evaluated the security robots. The evaluation of one's task suitability is neither novel in society nor HRI. Similar to the documentation of occupational stereotypes, previous studies in HRI found difference in perceived task suitability for social robots with different genders (Carpenter, et al., 2009; Eyssel & Hegel, 2012; Powers, et al., 2005; Siegel, et al., 2009). The results of this study offer a new insight to further relate these gender stereotypes with user's acceptance of social robots.

Carpenter (2009) found that participants generally preferred female gendered robots working in home settings. The reason may be twofold. First, without specifically illustrated, participants assumed the primary task of home-service robots as doing house chores. As a result, they felt that female gendered robot could be more suitable. The second possibility is that they may simply think that female gendered robot would be more suitable in home-setting environment. The former suggests user's evaluations are task-related; whereas, the latter suggests user's evaluations are environment-related. Largely within our expectations, this study shows that participant's perceived the male gendered security robots working at home to be more useful and acceptable than the female security robots. Hence, the results primarily ruled out the second possibility that user's evaluations of social robots are environment-related. In other words, it suggests gender stereotypes as a key determinant of user's evaluations for social robots working at home.

The contribution of this study has two-fold. Practically, it provides an anchor for robot designers to reduce the large design dimensions by possibly laying their focuses on gender stereotypes. Theoretically, it suggests a transfer of high level social concepts in real world to HRI. *Id est*, it serves as an exploratory study that suggests researchers and robot designers to further explore and apply high level social concepts in HRI. The results are supposed to enhance user's attitudes and acceptance towards this newly developed technology at home.

5 Limitations and Future Work

By and large, gender stereotypes are powerful and influential to user's perceptions and attitudes in HRI. Though the study is ambitious in exploring stereotypes in social robotics, it unavoidably suffers from a couple of limitations. First, though the experiment was conducted with male and female gendered robots, it included only a single role of social robots. Hence, the comparison of gender stereotypes is not exhaustive. One may argue, though unlikely, that the participants preferred a male gendered robot working at home and their preference of robot gender is not task-related. This limitation can be solved by duplicating the experiment with another female-stereotyped role of social robots at home. Secondly, some argue that certain occupations are gender-stereotyped because they call for the traits of male or female (Cejka & Eagly, 1999). Hence, subsequent studies exploring role stereotypes in social robotics may include other stereotyped traits such as personality in their studies.

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