People's Perceptions of Gendered Robots Performing Gender Stereotypical Tasks

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Abstract. HRI research shows that people prefer robot appearances that fit their given task but also identify stereotypical social perceptions of robots caused by a gendered appearance. This study investigates stereotyping effects of both robot genderdness (male vs. female) and assigned task (analytical vs. social) on people's evaluations of trust, social perception, and humanness in an online vignette study ($n = 89$) with a between subject's design. People deem robots more competent and receive higher capacity trust when they perform analytical tasks compared to social tasks, independent of the robot's gender. An observed trend in the data implies a tendency to dehumanize robots as an effect of their gendered appearance, sometimes as an interaction effect with performed task when this contradicts gender stereotypical expectations. Our results stress further exploration of robot gender by varying gender cues and considering alternative task descriptions, as well as highlight potential new directions in studying human misconduct towards robots.

Keywords: Social robots · Gender stereotypes · Social perception · Dehumanization · Trust

1 Introduction

The upcoming introduction of robots embracing a myriad of tasks in our everyday lives initiated multiple human-robot interaction (HRI) studies to investigate robots' suitability to perform a given task. Some studies have more generally analyzed people's social acceptance of robots in several potential future jobs [9,12]. Such studies show people's willing to accept robots in roles for entertainment, as personal assistants, and in hazardous environments, yet will probably reject the application of robots requiring sophisticated social emotional interactions. Other studies specifically investigated a fit between task and appearance indicating that a robot's appearance-task fit is affected both by people's expectations about the capacities a robot needs for a particular task [26] as well as a need to match a robot's appearance to its intended application of role [8,15]. A body of research in human psychology may explain these previous findings in HRI. Psychology research indicates that initial impression are formed based on appearance cues

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which, in turn, not only serve as ample triggers for social categorization [1] but also prompt subsequent stereotyping processes [28,37]. Such gender stereotyping has occurred in HRI research as well. People quickly infer a robot's gender based on it's appearance [21] which triggers gender stereotypical beliefs about such gendered robots [13,38]. This study expands existing knowledge in HRI research on robot genderdness and appearance-task fit by investigating stereotyping effects of robot genderedness and assigned task in an online vignette study.

1.1 Social Categorization and Stereotypes

Social categorization is a cognitive process to make sense of the social world by simplifying and systematizing perceptive information [1]. When meeting strangers, such cognitive categorization may aid as a beneficial heuristic when we infer interpersonal characteristics based on the social group that stranger belongs to [28]. However, categorizing others to social groups rather than treating them as unique individuals may also have various negative consequences. Social categorization triggers a tendency to form distort perceptions and stimulate exaggeration of differences between individuals from distinct social groups while perceiving intensified similarities of individual members within those groups [37]. As a consequence, we are more likely to utilize our distort perceptions to individual members of social groups without considering whether the assumed characteristics inhere with that specific individual. The process of such over-generalized assessments of an individual based on the group to which they belong is called stereotyping [20]. Stereotypes are automatically activated immediately following categorization of a target as a member of that group [11].

A large body of research on gender stereotyping reveals a human tendency to ascribe different traits to men and women. Stereotypical male traits comprise competence and agency [35] by highlighting achievement orientation (e.g., competent, ambitious), inclination to take charge (e.g., assertive, dominant), autonomy (e.g., independent, decisive) and rationality (e.g., analytical, objective) [20]. Stereotypical female traits enclose warmth and expressiveness [35] by highlighting concern for others (e.g., kind, caring), affiliative tendencies (e.g., friendly, collaborative), deference (e.g., obedient, respectful) and emotional sensitivity (e.g., intuitive, understanding) [20]. Bem [3] mapped this distinction between stereotypical male and female traits which shows a strong overlap with the Stereotype Content Model's [7] dimensions of warmth and competence. Subsequent research shows that people generally deem competence more desirable for males and warmth for females [4]. Relying on the Computers Are Social Actors paradigm [29], gender stereotypes have also been reported in HRI research.

1.2 Gender Stereotypes in HRI Research

People socially categorize robots and reckon social behaviors in robots based on inferred traits and characteristics, including gender cues from physical appearance [13] as well as facial features and voice [32]. While technical abilities are advancing, robots were originally designed to execute instrumental tasks [41].

This classical image of robots performing dirty, dangerous, and dull tasks still prevails in people's minds [27]. Nonetheless, human encounters and collaborations with robots increasingly become everyday practice [22]. A successful introduction of robots in society heavily relies on people trusting these systems [16] as a mediator for people's willingness to collaborate with robots [42]. Although trust has been frequently debated in human-robot interaction research –as a theoretical concept as well as an empirical measure– consensus arises on a dichotomous dimension of trust. On the one hand, people may trust a robot based on its capacity or reliability, and on the other hand based on its integrity or morality [14,39]). These trust dimensions resemble the gender stereotypical traits associated to men and women. Female stereotypical traits, such as "loyal" and "compassionate" [3], better fit the items of moral trust, such as sincerity, genuineness and ethicality [31]. Male stereotypical traits, such as "ambitious" and "self-reliant" [3], better fit the items of capacity trust, such as "competent" and "skilled" [18]. Based on this resemblance, we hypothesize that *people have higher trust in robots that perform tasks"fitting to their gender"* (H1).

Other HRI studies specifically focus on the interaction effects between a robot's gender and their occupational domain. When a robot performs tasks in line with existing gender-stereotypes regarding gender-task fit, people will more easily accept that robot [38]. Moreover, when our social schema for gender-task fit is violated during a collaborative task with a gendered robot, people will even perform less well (i.e., higher error rate) [25]. These findings from HRI research map similar results from psychology research illustrating that occupational roles are reliably stereotyped along the social perception dimensions of warmth and competence [19], which in turn have been linked to gender-stereotypical traits [3]. Given the strong underlying social schema regarding the appearance-task fit in HRI research [26], we expect a dominating effect of the gendered embodiment over the potential effect of task-fit. Therefore, we hypothesize that *robot gender affects people's social perception of a robot, independent of performed task* (H2).

A growing body of research investigates human misconduct with robots in terms of discrimination (e.g., [2]) and abuse (e.g., [23]). Gendered robotic agents with female characteristics encounter a specific form of human misconduct, namely objectification. Observations of conversations between pupils and a female-gendered virtual tutor reveals a frequent objectification of that virtual agent whilst placing it in an inferior role [40]. Systematic analysis of online commentaries on videos displaying humanoid robots exposes a pervasively blatant objectification of female-gendered robots [36]. Psychological research has a long historical focus on sexual objectification of the female body [27] indicating that men and women hold similar tendencies to perceive sexualized women as lacking mental capacity and moral status [24]. Combining the literature on female objectification with the gender-stereotypical expectations regarding occupational suitability of gendered robots [38], we hypothesize that *people's perceptions of a robot's humanness is a combined (interaction) effect of both robot gender and performed task* (H3).

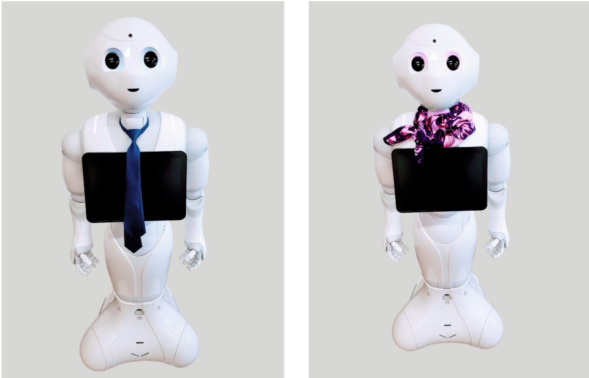
2 Method

We have conducted an online vignette study ($n = 89$) manipulating robot gender (male vs. female) and task type (analytical vs. social) in a between subject's design to investigate stereotyping effects of robot genderedness and assigned tasks on social perception, trust, and humanness.

2.1 Stimuli

We manipulated both the gender of the robot as well as the type of task it performed. The mixture of these stimuli (robot gender X task type) resulted in four different vignettes. To manipulate the robot gender, we modified a picture of the Pepper robot by either giving it a blue tie for the male or a pink scarf for the female robot (see Fig. 1). Such apparel serve as subtle but powerful gender cues [21]. Additionally, we referred to the robot as either *Alexander* in the male or *Alexandra* in the female task description respectively. Task type was manipulated by altering some words in a text description to indicate either an analytical or social task, which were kept at similar length (i.e., 69 and 67 words respectively). The analytical task [***A***] described the robot studying large datasets with medical data to provide an overview of treatment plans for hospital patients to support healthcare professionals in making solid decisions of patient treatment. The social task [***S***] described the robot utilizing large datasets with verbal and non-verbal behaviors to provide emotional support to hospital patients facilitating healthcare professionals in monitoring patient well-being. A full description of the task descriptions is given below:

> *Alexander/Alexandra* supports healthcare staff in...
> *...[**A**] developing individual treatment plans for hospital patients.*
> *...[**S**] providing emotional support to patients with chronic diseases*].
> *Alexander/Alexandra* has access to large data sets with...
> *...[**A**] medical data including medical conditions and symptoms, diagnoses, treatments, medication, test results, hospitalization, and demographic patient data such as gender and age.*
> *...[**S**] verbal and non-verbal behaviors including speech utterances, body language, facial expressions, and social customs and etiquette.*
> *Alexander/Alexandra...*
> *...[**A**] analyzes this data, draws connections between cause and effect, and quickly provides an overview of potential treatments.*
> *...[**S**] listens actively, recognizes a patient's emotions and feelings, and offers emotional support to patients.*
> This way, healthcare professionals can...
> *...[**A**] make a solid decision for an appropriate treatment for individual patients.*
> *...[**S**] monitor and respond optimally to the emotional well-being of individual patients.*



(a) Male robot (b) Female robot

Fig. 1. Robot gender manipulation

We pretested these stimuli (n = 12). The female robot (M = 7.67) was perceived as more female than the male robot (M = 5.56) measured on a 9-point Likert scale from mostly male to mostly female (p = .012). The analytical task (M = 8.22) was perceived as more analytical (p = .032) than the social task (M = 6.78), and the social task (M = 6.67) was perceived as more social (p < .001) than the analytical task (M = 2.22) measured on two separate 9-point Likert scales from not at all [*analytical/social*] to very [*analytical/social*].

2.2 Procedure

After giving consent, the survey topic was introduced by addressing the ageing society and that robots could aid the growing demand for optimization in healthcare. Participants were randomly assigned to one of the four vignettes with a picture of the robot (male or female) above the task description (analytical or social). After reading, participants were asked to respond to several statements regarding their perception of the robot (see Sect. 2.3). The questionnaire ended with some demographic items and thanking the participant for their contribution.

2.3 Dependent Variables

Participants' social perception of the robot was measured with the 10-item scale by Cuddy et al. [7] containing the dimensions of warmth (α = .69) and competence (α = .67). To measure participants' trust in the robot, we administered the 16-item Multi-Dimensional-Measure of Trust scale by Ullman & Malle [39] containing the dimensions of capacity trust (α = .77) and moral trust (α = .78). Perceptions of the robot's humanness were collected using the 20-item scale by Haslam et al. [17] containing the dimensions of human uniqueness (α = .68 after removing item 'logical') and human nature (α = .67 after removing item 'individual'). All measures were presented on 7-point Likert scales, and average construct scores were calculated. Table 1 presents means and standard deviations of all dependent variables in each of the conditions.

Table 1. Means and standard deviations of dependent variables in each condition

	Condition			
	Male robot		Female robot	
	Analytical task	Social task	Analytical task	Social task
Dependent variables	*Means (SD)*	*Means (SD)*	*Means (SD)*	*Means (SD)*
Trust				
Capacity trust	5.09 (1.00)	4.70 (0.94)	4.90 (0.79)	4.46 (0.83)
Moral trust	4.31 (0.92)	4.13 (1.02)	4.06 (0.96)	3.93 (1.15)
Social perception				
Warmth	4.18 (1.03)	4.29 (1.24)	3.88 (1.13)	4.00 (1.42)
Competence	4.41 (0.88)	4.04 (1.11)	4.46 (0.81)	3.63 (1.34)
Humanness				
Human uniqueness	4.21 (1.21)	4.17 (1.16)	3.87 (0.89)	3.71 (1.19)
Human nature	3.32 (0.93)	3.17 (1.08)	2.99 (1.06)	3.68 (0.83)

2.4 Participants

We recruited 95 participants via various social media, of which we deleted 6 responses (i.e., completion rate below 75%) from further analyses. We analyzed the data of the remaining 89 participants (52% male, 48% female), with age ranging from 18 to 79 (M = 29.1, SD = 14.4). Participants had an average knowledge in the robotics domain (M = 3.6, SD = 1.7) but a lower experience with robots (M = 2.6, SD = 1.6), as indicated on a 7-point Likert scale from 1 = 'no knowledge/experience' to 7 = 'very knowledgeable/experienced'. Neither knowledge about nor experience with robots influenced any of the measures in our study (i.e., no significant correlations with any of the dependent variables).

3 Results

To test our hypotheses, we ran a series of two-way ANOVAs with robot gender (male vs. female) and task type (analytical vs. social) as independent variables. Normality checks and Levene's test indicated that test assumptions were met.

3.1 Trust

We observed a significant main effect for task type (F(3,1) = 4.79, p = .031, d = .47) on capacity trust, but not for robot gender (F(3,1) = 1.27, p = .264, d = .25) nor their interaction effect (F(3,1) 0.02, p = .885, d = .05). However, no significant main effect was found for robot gender (F(3,1) = 2.05, p = .156, d = .31) or task type (F(3,1) = 1.26, p = .264, d = .25) on moral trust nor for their interaction effect (F(3,1) 0.10, p = .748, d = .06). These results suggest that only people's capacity trust in a robot is affected and exclusively by the given task. Specifically, participants have higher trust in a robot's capacity when it performed an analytical task compared to a social task (see Fig. 2).

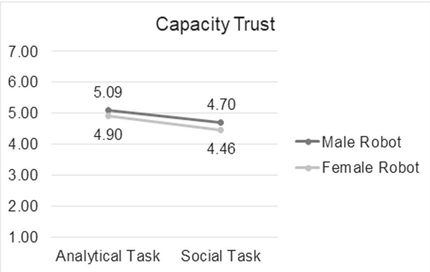


Fig. 2. Effect of robot gender vs. task type on capacity trust

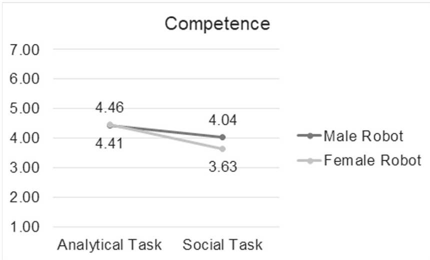


Fig. 3. Effect of robot gender vs. task type on competence

3.2 Social Perception

We found no significant main effect for robot gender (F(3,1) = 1.26, p = .265, d = .25) or task type (F(3,1) = 0.19, p = .666, d = .09) on warmth nor for their interaction effect (F(3,1) ¡ 0.01, p = .990, d = .05). However, we did observe a significant main effect for task type (F(3,1) = 7.11, p = .009, d = .58) on competence, but not for robot gender (F(3,1) = 0.62, p = .434, d = .17) nor their interaction effect (F(3,1) = 1.04, p = .311, d = .22). These results suggest that people's social perception of a robot is mainly affected by the given task. Specifically, independent of robot gender, people ascribe higher competence when a robot performs an analytical task compared to a social task (see Fig. 3).

3.3 Humanness

We observed a nearing significant main effect for robot gender (F(3,1) = 2.77, p = .100, d = .35) on human uniqueness, but not for task type (F(3,1) = 0.17, p = .683, d = .09) nor their interaction effect (F(3,1) = 0.06, p = .812, d = .06). Moreover, no significant main effect was observed for robot gender (F(3,1) = 0.18, p = .671, d = .09) nor for task type (F(3,1) = 1.51, p = .223, d = .28) on human nature while their interaction effect approached significance (F(3,1) = 3.80, p = .055, d = .44). These results suggest a robot's gender or given task does not effect people's humanness perception of a robot, while a data trend appears where: (1) perceptions of a robot's human uniqueness might be affected by robot gender; and (2) perceptions of a robot's human nature might be a combined effect between robot gender and task type. Specifically, participants seem more inclined to dehumanize female robots to animals lacking higher-level mental processes (i.e., lacking human uniqueness) compared to male robots independent of the given task (see Fig. 4). Moreover, participants seem to dehumanize robots to emotionless objects (i.e., lacking human nature) exclusively when female robots perform analytical tasks or male robots perform social tasks (see Fig. 5).

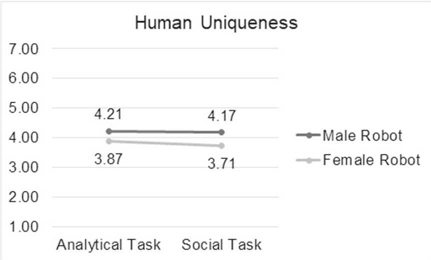


Fig. 4. Effect of robot gender vs. task type on human uniqueness

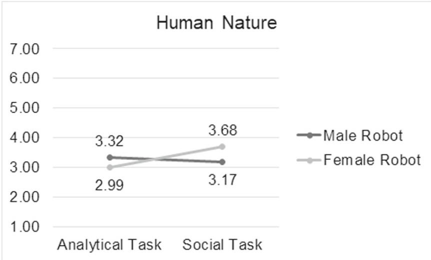


Fig. 5. Effect of robot gender vs. task type on human nature

4 General Discussion

Our study expands existing knowledge in HRI on robot gender and appearance-task fit by conducting an online vignette study manipulating robot gender (male vs. female) and task type (analytical vs. social) in a between subject's design to investigate their effects on social perception, trust, and humanness.

Our results indicate that people's trust in a robot is mainly determined by its capacity, but not its morality, and independent of the robot's gender. These results show that trust evaluations of a robot are not linked to a robot's gender as we hypothesized (H1). Instead, our results indicate that trusting robots is more strongly associated with the performed task. Additionally, robots are perceived as more competent when it performs an analytical task compared to performing a social task, independent of its gender. This finding contradicts our hypothesis expecting an effect for robot gender on people's social perception of a robot, independent of performed task (H2). When associating gendered robots with specific tasks, the observed effects of gender stereotyping in both the psychology [3] and HRI [13] research seem to steer away from the genderedness of the robot's embodiment towards the (perhaps also perceived gender-stereotypical) performed tasks –at least in terms of social perception and trust in such robots. An earlier study examining the relationship among occupational gender-roles, user trust and gendered robots also found no significant difference in the capacity trust of a robot when considering its gender [5]. Similarly, another HRI study on gender-task fit [25] has reported that people are less willing to accept help from a robot when executing a typically female task (i.e., a social task).

These combined results on predominant effects for task type, eliminating the potential effect of the gendered embodiment, are not necessarily surprising. Prior research shows that people in general hold more utilitarian perceptions of robots [9,12,15,41] indicating a preference for executing instrumental tasks. However, we must highlight potential limitation of the stimuli used in our study. Although the male robot was rated as significantly more male than the female robot, it was still on the female side of the gender scale. Similarly, the social task was rated as significantly less analytical than the analytical task itself, yet it was on the analytical side of the scale. Future research should therefore not only explore other task descriptions, occupations, or social roles, but should also further investigate different gendered appearances cues for robots or include a gender-neutral robot as well as explore consequential (interaction) effects of such gender and task manipulations on social perception and trust in HRI. Furthermore, research in psychology [6] as well as HRI [34] shows interaction effects for trust between the gender of the participant and that of the social other. Such interaction effects between participant and robot gender have been reported [30] indicating increased uncanny reactions to other-gender robots when that robot conforms to gender expectations of warm females and competent males. Therefore, exploring interaction effects between the participant gender and robot gender in the context of gender-task fit sounds promising as well.

Psychology literature informed our hypothesized effect of people's humanness perceptions of a robot to be a function of both robot gender and performed task (H3). Although our data did not support this, we feel disposed to discuss the observed trend in our data indicating a potential interaction effect between robot gender and performed task on a robot's perceived humanness. This trend implies that people tend to dehumanize female robots (regardless of given task) to animals lacking higher-level mental processes. Sexist responses to female robots have been reported in HRI research more generally [36,40]. Additionally, the trend implies that people tend to dehumanize robots to emotionless objects only when gendered robots perform tasks contradicting gender stereotypes (i.e., a gender-task interaction effect). Research in social psychology has shown that women are dehumanized to both animals and objects [33], which is a trigger for aggressing women [17]. Intermingling gender effects into current debates on robot abuse (e.g., that mindless robots get bullied [23]) might offer alternative perspectives on these issues which future research should further explore.

The field of social robotics aims to build robots that can engage in social interaction scenarios with humans in a natural, familiar, efficient, and above all intuitive manner [10]. The easiest way to deal with social expectations of gendered robots including consequential stereotypical inferences is to enhance people's social acceptance of gendered robots by tailoring their gendered appearance to their intended task. Alternatively, perhaps an idealistic vision might be that robots could offer a unique potential to illuminate implicit bias in social cognition by challenging persisting gender-task stereotypes in society.

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