Gender and Robots: A Literature Review

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ABSTRACT
Here, I ask what we can learn about how gender affects how people engage with robots. I review 46 empirical studies of social robots, published 2018 or earlier, which report on the gender of their participants or the perceived or intended gender of the robot, or both, and perform some analysis with respect to either participant or robot gender. From these studies, I find that robots are by default perceived as male, that robots absorb human gender stereotypes, and that men tend to engage with robots more than women. I highlight open questions about how such gender effects may be different in younger participants, and whether one should seek to match the gender of the robot to the gender of the participant to ensure positive interaction outcomes.

I conclude by suggesting that future research should: include gender diverse participant pools, include non-binary participants, rely on self-identification for discerning gender rather than researcher perception, control for known covariates of gender, test for different study outcomes with respect to gender, and test whether the robot used was perceived as gendered by participants. I include an appendix with a narrative summary of gender-relevant findings from each of the 46 papers.

1 MOTIVATION AND METHOD
In service of a separate study, Wang et al. found in 2014 that of 190 papers published in the Conference on Human Robot Interaction only 106 (56%) provided the sex breakdown of their participants, and within those, only 21 (20%, 11% overall) "provided at least minimal or passing sex-based analysis" [45]. However, we know that gender has important effects in human-human interaction, so as robots learn to interact with and emulate humans better, it stands to reason that gender will increasingly affect these interactions. Despite this importance, I have not found a literature review of empirical studies on gender in robotics.

In this paper, I attempt to establish what "big facts" are known, only concluding when there appears to be a significant body of work in agreement. I limit my scope to social robots. Notably given the topic of gender, this excludes studies on sex robots, which has seen significant theoretical and empirical treatment elsewhere. I limit my scope to empirical pieces involving human participants, thus excluding critical or theoretical pieces, though I have read those to find more empirical studies and to inform my thinking, and robot design papers which have not been evaluated by participants in some way. I note that these studies tend to be quantitative experimental studies (with one exception [33]). I found the included studies by using Google Scholar to find studies which included the words "gender" and "robot" in the title or abstract, and retaining both studies which modify the robots gender or analyze with respect to the gender of their human participants. This review was conducted in 2018, and there have undoubtedly been many gender relevant robotics papers published since. This review not conducted using a Systematic Literature Review (ie. [3]), so it may not be exhaustive. Nonetheless, I hope that this review of 46 studies on gender in robotics may nonetheless prove useful as a starting point for further reading.

I try to maintain a critical tone when reporting conclusions drawn from the papers reported here, especially as a result of concerning statistical choices I saw in many papers, such as bivariate correlations with no controls for confounds, reporting non-significant results, or not reporting effect sizes.

Almost all of the work I read assumed a male-female gender binary, which is not reflective of reality. However, because of this, my literature review cannot comment on the experiences of non-binary people, and thus my work is restricted to this binary.

The headings of the next three sections reflect the three broad conclusions I feel comfortable drawing from these papers: 1) by default, robots are perceived as male, 2) robots absorb human gender stereotypes, 3) men tend to engage with robots more than women.

I conclude with a practical set of guidelines for robotics researchers, and in the appendix I leave a narrative summary of each paper I read, which may be of interest, but is very verbose.

2 BY DEFAULT, ROBOTS PERCEIVED AS MALE
By default, I find that people will think robots are male, even in the absence of intentional gender cues, or even just when thinking about robots in the abstract. One study asked older adults to draw a robot, most tended to draw a robot with male or gender neutral features [35]. Another study asked robots to name a robot, and found that a mixed gender participant pool assigned the robot mainly neutral or male names, with only 1% assigning it a female name [44], even though this robot had no anthropomorphic features, and thus no explicitly gendered cues. An in depth ethnographic study of a robot deployed in a hospital found that higher status males tended to be excited about the robot, but see it as a non gendered machine, whereas women and lower status males tended to see it as something out of their control, not likely to help them perform their jobs (one of its designed intentions) and for the entertainment of the higher status men who acquired it [33], and they referred to it using male pronouns despite it being non-anthropomorphic and lacking explicit gender cues.

3 ROBOTS ABSORB HUMAN GENDER STEREOTYPES
Robots can be endowed with their creators with a gender, with consistent effects on the interactions they have with participants. For example, one study found that male participants were more likely to donate to a robot with female gender cues [32]. However and worryingly, human stereotypes often appear to transfer to gendered robots: one study shows that a large sample of 84 men and 79 women preferred a healthcare robot when it was female presenting,
and a security robot when it was male presenting, aligning with the “female-nurturing” and “male-controntational” stereotype [41]. Similarly, another study found that having a robot’s voice to align with the gender stereotype between “male” functional tasks and “female” social tasks made this communication more effective [26].

Aligning with psychological theory the author cite that women are perceived as warm whereas men are perceived as having agency, one study found that men had an “uncanny valley” reaction with a female-cued robot which aligned with her gender stereotype, but women have an similarly negative reaction to a male cued robot aligned with his stereotype, suggesting that aligning with the gender stereotype is a way to heighten anthropomorphism [22].

One study found that when being instructed on a typically female versus male task by a robotic collaborator, people made more errors, were less willing to accept help from the robot on a future task, and anthropomorphize the robot to a lesser extent. This held regardless of the gender cues of the robot (even when a female cued robot instructed on female stereotyped tasks), suggesting that they viewed “male” as the natural gender of the robot, and that robots are better suited to work with people to complete male stereotyped tasks [15]. However, another study appears to suggest that a mismatch between the gender of the robot and the gender stereotype associate with a task may increase increased willingness to be taught by an instructor robot during learning tasks [25].

One study found that Roombas are more likely to be given as gifts to women than men, using this to propose the previous effect: vacuum’s association with “women’s work” housework shifts their gender association from the default male (above) towards the feminine, despite lacking anthropomorphic features or explicit gender cues, though roombas were as likely to be given female names as male names [38].

In an example of appearance-based gender norms, one study found that men and women discussed a highly anthropomorphic robot’s female gender, and female stereotyped qualities such as “pretty” and “comforting” when explaining why they would feel more comfortable letting it in their home than a more mechanical robot [4], while one related study did not find a statistical robot gender when asking people if they’d let a robot in their home, but the authors acknowledge this may be due to having few participants and thus low statistical power [8]. Another study found that people speak quieter to a female robot, even when it spoke louder [37].

A study with children found that they also recognize the gender of robots, and apply the same norm of “gender-segregated” play with robots as they do with other kids [27].

In an example of showing that ability based gender norms transfer to robots, two researchers gendered a robot using cues such as longer hair for female or a hat for male, they found that participants found math tasks more suitable for the male cued robot, and verbal tasks more suitable for the female robot, and that they found the male robot to have more agency, whereas the female robot was more communal [9]. Another such example found that participants assumed a female cued robot knew more about dating norms, a topic they believe is stereotypically female, leading participants to use more words when describing these norms to male cued robots. [23].

As shown, robots can be used to perpetuate gender norms and harmful gender stereotypes. Even though gender norms can be used to improve human robot interaction, roboticists should resist exploiting this advantage, in order to improve society, even if aligning with, and thus perpetuating gender norms, helps their robots interact better in the short term.

4 MEN TEND TO ENGAGE ROBOTS MORE THAN WOMEN

People of different genders react to robots differently. Men tend to like, be more comfortable with, and engage with robots more than women. For example, in an evaluation of a social robot for eldercare, one study found that men rated the robot higher in all conditions higher than women with a medium effect size [35]. The affect of men engaging with robots more appears to overpower gender norms in some cases: men were more likely to ask for help from a robot than women, despite the assumption that men are less likely to ask for help [1]. Another study found that men like robots more than women, and women identify with feelings of robophobia more than men [11]. Another study found that men feel more positively about engaging robots in a healthcare setting than women [16]. For example, having a robot’s head facing towards men makes them more comfortable when it approaches them, but makes women less comfortable [40], and another study found even more gendered differences in the preferred method of robot approach [7], and another found that men were more comfortable with the robot approaching closer when it did so from the side than the front, but that women let it approach from the front to a closer distance than men did [39].

Another study placed a robot in a public place, and found that men approached the robot closer than the women did [43]. Men answer surveys in more socially desirable ways and also perform worse on tests when they are administered with a robot rather than on paper suggesting that men see robots as more of a social, human like presence than women [30], though another study found that men perform in less socially desirable ways when interacting with a robot rather than a disembodied voice [6]. The ethnographic study referenced above found that males were excited about what a robot could do, and appeared to see it as entertaining whereas females saw it as distracting, and not helpful for their work [33]. Another study found that when interacting with robots in diads, conversation time was most imbalanced with older males and younger females, with males dominating interaction with the robot [34]. Offering one possible explanation for the mechanism why men tend to engage with robots more, one study found that men in their sample were more likely to have experience using computers, and also a higher perceived ease of use with a healthcare robot [12]. Another study found that men were more willing to be aggressive when instructed to kill a robot than women were [2]. One study found that women rate a robot worse when it looks at them more, whereas men did the reverse [18], and another found that women were more apprehensive about approaching robots which appeared to have broken down [24]. One study found that fathers were more positive about using robots in their kids education than mothers, and more willing to help their kids use them [17], and another found that when working on robotics projects in groups, girls were
more likely to choose to program, blog about, or build websites for the robot, leaving boys to build the robot [46]. Men and women sometimes believe that a robot mirrors their personality, but that the kinds of personalities they believe the robot mirrors is different based on the participant’s gender [47].

Perhaps offering another explanation for how to engage women with robots, one study found that women rate robots higher when they are polite [36], but also, contradicting other results in this section, expressed a greater interest in interacting with the robot than men. Again contradicting past results, another study appeared to find that women were more likely to stand closer to a robot, and had more positive attitudes towards the idea of robots having emotions [19].

Despite some conflicting evidence, it appears that men are more willing to engage with robots. After reading these studies, the most convincing reasons for this disparity I found were robot self efficacy, and level of past experience, two constructs which often explain gender norms in other contexts. I suggest that future work investigate this by controlling for these two factors, to see if a gender effect remains.

5 OPEN QUESTION: BUT WHAT ABOUT THE CHILDREN?

Gender norms are socialized as one grows up. Future work can use robots as a tool to interrogate the formation of these gender norms. Girls seem to feel more social and attraction to anthropomorphic robots, but boys tend to be more attracted to machine like robots [42]. Further, one study found that boys tend to act more aggressively to a cat like robot, whereas girls are more soothing [29]. When interacting with robots in diads, conversation time was most imbalanced with older males and younger females, with males dominating interaction with the robot [34]. One study found that when interacting with a robot in diads, younger participants allowed the older participant to interact with the robot more [34]. One study suggested that boys were more expressive when interacting with a robot than girls, because it was easier to classify based on their reaction whether they had won or lost a game against a robot [31].

Given that gender norms are sometimes different for kids, and that many adult gender norms are socialized during childhood, I suggest that future HRI work can further investigate age-gender interaction effects.

6 OPEN QUESTION: SHOULD ONE MATCH ROBOT-PARTICIPANT GENDER?

Sometimes it is better to match the gender of the participant to the gender of the robot. Sometimes, the reverse is better. Choosing between the two is hard, and appears to depend on the particularities of the situation, gender norms. Four studies surface this: In one study, males were faster when performing the task than females, while this was only true when they interacted with a same-gender robot [15]. Another found that people generally rated robots of their opposite gender as more credible [32], whereas another found weak evidence that the reverse was true: men like male robots more, and women like female robots more [9]. One study found that younger children prefer a robot of a matching gender, with no effect found for older children or adults [28]. Another study found that when working with a robot to complete a Sodoku task, participants prefer working with robots of the opposite gender [1]. Future work should figure out better guidance or a theoretical model for when to match robot-participant gender, and when to not. Future work should further investigate the circumstances in which matched or unmatched robot-human genders work best.

7 REFLECTING ON THE STUDIES: MY SUGGESTIONS

Based on my own experience conducting research on gender and technology, and after reflecting on statistical concerns I saw when conducting this review, I propose these guidelines:

Suggestions on Gender:

(1) Recruit gender diverse participant pools,
(2) Explicitly try to recruit non-binary participants,
(3) Ask people how they identify, don’t assume or measure gender based on the perception of the researcher,
(4) Measure & control for known correlates of gender (computer self efficacy, past experience with tech & robots),
(5) Analyze outcomes with respect to participant gender,
(6) Try to make sure your research team is gender diverse (especially if studying gender!),
(7) Test and report whether your participants perceived your robot as gendered, even if you did not attempt to explicitly gender it, to aid future work on gender in robotics.

Suggestions on Statistics:

(1) Don’t report effects that are not significant at the 0.05 level (or if you want to, justify your choice of p value, or justify results as significant in some other way)
(2) Avoid testing for bivariate correlations, instead consider statistical methods which can control for confounding covariates, such as regression
(3) Measure, report, and discuss effect sizes, so that people can evaluate the real world impact of your results.

8 APPENDIX: ALL THE STUDIES

Here I report all of the studies I read, and their main results with respect to gender. This may help serve as a literature index. They are organized by 1) studies which only consider the gender of the robot, 2) studies which only consider the gender of human participants, and 3) studies which do both.

8.1 Gender Of Robots

In a CHI extended abstract, Jung et al. test the effect of gender cues (pink earmuffs for female, a man’s hat for male, or no cues) on the gender of a robot as perceived by 144 undergraduates [13]. They found that people find the robot with female cues is perceived as female, and the robot with no cues is perceived as male, and that one with male cues is perceived as even more male. The authors use these results to conclude that robots are by default perceived as male, whereas I believe this better supports the idea that the single specific robot they use is perceived as male. The authors neglect to report participant’s gender, which is puzzling given the subject
of the study and that they collect other demographics such as age and race.

Orefice et al. studied the effect of robot handshake firmness and movement on ascribed robot gender as perceived by 11 female and 25 male participants [21]. They recorded the handshakes of extroverted and introverted male and female participants, had a robot emulate these, and found that these secondary participants could successfully perceive the original gender and level of extroversion of the handshake originator. While they include participants of different genders, they do not analyze with respect to participant’s different genders. They discuss effect size.

8.2 Gender Of Participants

Takayama and Pantofaru studied the impact of different approach situations, notably a participant approaching a robot, an autonomous robot approaching a participant, and a teleoperated robot approaching a participant. They found that when a robot’s head is oriented towards the participant, it makes women less comfortable having it near them, but makes men more comfortable having it near them. The authors do not report effect sizes [40].

In a series of experiments conducted by Tung to investigate children’s reactions towards robots with varying degrees of anthropomorphism, she found that girls felt more social and physical attraction to human-like robots, especially female robots, whereas boys felt more attraction to mechanical looking robots [42]. They do not discuss effect size.

When studying robot smiling behaviors Chung-En had 92 male and 141 female hotel guests in Macau look at a digitally manipulated photo of a robot or human head with different levels of head tilt [5]. She found that male and female participant’s ratings of robots differed in many respects, finding that younger females rated robots higher than their male counterparts, but the author recognizes that the fact that human staff photos were all female, introducing a possible confound. They do not discuss effect sizes.

Scheeff et al. qualitatively report the experiences of 15 girls and 15 boys interacting with a wheeled cat like robot which could display emotions both in the lab, and even more participants in a public science museum. [29]. They report that older boys tended to act more aggressive or harmful towards the robot, whereas older girls were gentle, said kind things to it, and were soothing.

Lin et al. surveyed Taiwanese 39 parents about their attitudes towards the use of educational robots in their kids’ learning environments [17]. They found that men (fathers) were more positive toward using educational robots than females (mothers), with respect to their usefulness, willingness to help their kids with robots, and confidence doing so.

Weinberg et al. studied the impact of school robotics programs on girl’s self efficacy and future career interests in STEM fields, and found that they have a positive impact on both [46]. However, they also found that girls were more likely to choose to program, blog about, or create presentations about instead of build the robot, because they perceived these tasks as easier. In mixed gender teams with good mentors, they found that girls were more likely to have increased confidence and expectations of success in science and math, but this effect was not observed for all girl teams.

Schmerhorn et al. studied the social presence of robots on 24 men and 23 women while completing short tasks: a survey on their perceptions of robots, a standard measure on social desirability, and easy and hard arithmetic tasks [30]. They found that when the robot administered a survey vocally, men answered in a more socially desirable way than when they answered the same survey on paper. They further found that men’s scores on the arithmetic tasks were negatively affected by the robot’s presence, whereas this was not the case for females. They use this to conclude that men see the robot as more of a human peer than do females, thought they acknowledge that the robot’s distinctly male voice may have affected this result.

Siino and Hinds conducted an ethnographic study set in a community hospital in Northern California, which had just acquired and was attempting, at first unsuccessfully, to deploy a robot [33]. They conducted approximately 100 hours of observation and interviews primarily of a male lead “robot users group” responsible for the robot’s acquisition, use and configuration. The robot was able to make deliveries, and had a touch screen and keypad, and could use either a male or female voice to communicate. The robot did not appear to be anthropomorphic. They found that men who held engineering and high ranking administration jobs primarily saw the robot as a machine, using words like “vehicle”, “computer”, suggesting that they saw it as under human control. They found that female directors of majority female departments such as Admin, Medical Records and Media Relations joined female food service workers and low-status female pharmacy technicians anthropomorphize the robot as a human male, even before seeing or interacting with the robot. The authors speculate that these women saw the robot as out of their control, autonomous, and competent, despite being able to give it tasks to perform. Finally, they found that (predominately female) nurses viewed the robot as a novelty, toy or entertainment device, not something that would ease their own workloads but instead entertain the higher status men who acquired it.

Dautenhahn et al. tested the effect of different of the direction by which a robot approaches a human to present a fetched item on the participant’s level of comfort [7]. Their studies revealed gender differences: a first study held outside of laboratory conditions had 21 males and 18 females, and a second one held in controlled, laboratory conditions had 9 males and 6 females. More females preferred a frontal approach compared to males, and more males preferred a right approach compared to females. More males least preferred the front robot approach compared to females, who least preferred the left approach. However, the authors often report quantitative results without discussing whether they are statistically significant, and also report that some results are significant with associated p values as large as 0.08, (with no discussion of using an alpha level other than the conventional 0.05) leaving me unconvinced as to the statistical trustworthiness of this study. At no point is there a discussion of effect size, further bringing into question the real world value of their results.

Skantze et al. conduct a study on participation equality in human–robot conversations, in which 254 perceived females and 330 perceived males interacted with a male–appearing anthropomorphized robot in a museum, in pairs [34]. They find that interaction equality with respect to speaking time is lower when the two users
are different with respect to age and gender, with the most im-
balanced pairing being perceived female children with perceived
male adults. They find that they can also predict imbalance, and
that interaction equality can be improved when the robot directs
questions to the user who is interacting less.

Halpern and Katz conducted a survey of 873 undergraduate stu-
dents about their attitudes towards robots: one third toward a hu-
manoid, one third toward a doggy robot, and a final third toward an
android [11]. They find that the humanoid robots were perceived
as more humanlike. They analyzed these responses with respect
to gender, religion, and self efficacy with technology, and find that
those identifying with Judeo-Christian religions liked robots less,
that those with high technology self efficacy expressed more agree-
ment with themes of cyber-dystopianism. Finally, they found that
self identified women like robots less, and agree with robotopho-
bria more than men. They do not discuss effect sizes, do not discuss
how they identify participant’s gender, nor discuss why they as-
sumed a religion binary (Judeo-Christian vs not Judeo-Christian).

Marcel Heerink showed a video of an robot interacting with
an old person of unreported gender and age to 43 female and 23
male participants, where the robot is shown monitoring the user,
reminding to take medication at the prescribed time, and as a fit-
ness advisor, and measured participants attitudes using multiple likert scale questions along different axes like trust or anxiety [12].
They found that men were more likely to have experience using
computers, and that they also have a higher perceived ease of use
with the robot, but didn’t find gendered affects along other con-
structs.

Shahid et al. investiate how boys and girls of 8 and 12 years of
age experience playing a collaborative game with a cat robot. In the
first study, they evaluate their change in emotional state after play-
ing this game, and do not investigate effects with respect to gender
despite having a balanced girl/ boy participants [31]. In their sec-
ond study, they evaluate whether adult men and women can efect-
ively evaluate expressiveness and whether game was won from
recordings of kids in the previous study. They investigate but do
not find a significant main gender effect, but do find an interaction
between age and gender: participants find 8 year old boys easier
to classify whether they had won or lost the game than 8 year old
girls. Effect sizes were not discussed.

Woods et al. studied the extent to which 14 male and 14 female
university students preferred and felt similar, personality wise, to a
non humanoid robot which was designed to be socially interactive,
and one which was designed to be socially ignorant [47]. They find
that participants overall did not view the robot’s personality as sim-
ilar to either style, and viewed their own personality characteris-
tics as stronger. With respect to gender, they found that males who
believed themselves to be anxious and psychotic, the more they
rated the socially ignorant robot as also anxious and psychotic.
They further found that females who believed themselves to be
assertive and dominant, the more they rated the socially ignorant
robot as also assertive and dominant. No such gender effects were
noticed for the socially interactive robot. The authors do not dis-
cuss effect size, bringing the real world significance of these results
into question. As is common in HRI studies, the authors calculate
pairwise correlations, meaning that gender effects may instead be
a correlate with a different underlying variable.

Straight et al. conduct a study by recruiting 193 female and 317
male participants off of Amazon Mechanical Turk, and showing
them one of two kinds of videos: one with a robot interacting with
a participant using polite speech, and one with a robot exhibiting
direct speech [36]. They measure the extent to which participants
perceived the robot as comforting, considerate, and controlling us-
ing a multi item questionnaire. With respect to gender, they find
that while using polite speech improved participant ratings of com-
fort, considerateness, and being less controlling, this effect was
stronger for female participants. Female participants also rated the
task the drawing task the robot and human in the video were per-
forming as less difficult, and expressed a greater interest in inter-
acting with the robot. The authors note that their small effect sizes
pose a threat to the real world relevance of their study.

On the dubious premise that “The ultimate test for the life-likeness
of a robot is to kill it”, Bartneck et al. conduct a study in which they
observed the destructive behavior on a robot of 15 male and
10 participants in which they were instructed to “kill” a small bug-
like crawling robot by hitting it with a hammer [2]. The study con-
irms that women were significantly less likely to break the robot
into as many pieces, and to perceive the robots as more intell

gent, than 8 year old boys easier to classify whether they had won or lost the game than 8 year old
girls. Effect sizes were not discussed.

Nomura et al. performed a study with 22 male and 31 female
university participants about their negative attitudes towards robots,
then had them talk to an anthropomorphic robot which then in-
structed participants to touch it [19]. Additionally, they measure
the participants distance from the robot, how long it took them to
talk to the robot initially and also how long it took them to respond
to its question, and how long it took them to touch the robot after
being commanded to do so. They found that people with negative
experiences is correlated with not talking or taking longer before
talking to the robot. They found that female participants had lower
negative attitudes towards robots having emotions (no gender ef-
ects for interacting with or the social influence of robots), and that
they initially stood closer to the robot in the study. The grammar
of this paper made its results hard to interpret. The subscale on
which significant results was found was negative coded, and it is
unclear if the authors properly reversed participant answers.

Mutlu et al. test the effect of robot gaze frequency on 12 male
and 8 female participants’ assessment of the robot and their recall
of a story it told them, and found that robot gaze had a significant
effect on female participants with respect to their recall, but males
did not, and that women rated the robot worse when it looked at
them more whereas males did the reverse [18].

A 1990 experimental study by Rahimi and Karwowski found
no significant statistical difference between male and female uni-
versity participants’ perceived robot safe speed, but that women
tended to wait longer for a robot’s motion to cease before deciding it was safe to approach it [24].

Syrdal et al. studied the effect of different approach scenarios on comfort for a robot approaching 20 males and 13 females for a one-off study, and 8 males and 4 females for a 5 week longitudinal study, measuring their comfort 3 times over 5 weeks of interaction with the robot [39]. They found that men had a closer preferred approach distance when it is approaching from the side than the front, whereas no difference was observed for women. When the robot approached from the front, females also allowed the robot to approach closer than males did. However, these effects were only witnessed on the first encounter with the robot, and appeared to wear off as participants became more acclimated. The authors do not discuss effect size.

Oosterhout and Visser discuss a study in which they place a large and a small robot in a public space, and photograph 135 non-consenting people as they interact with it as it moves, and record the distance they interact with it at [43]. I didn’t find any discussion of the number of female and male participants, nor discussion of how their gender was assigned, but I assume it was assigned from the photographs because that is how they assigned their ages. They found that teens of different genders approached the robots at significantly different distances: males approached about 20 centimeters closer. They report that among adults, males approached “significantly” closer, despite reporting a p value greater than 0.05 for this test, so I do not trust this study.

8.3 Gender Of Both Robots and Participants

Tay et al. had a robot perform healthcare and security functions, while manifesting different genders [41]. They found that their 84 male and 79 female participants tended to react better to the healthcare robot when it was female presenting, and reacted better to the security robot when it was male presenting. This shows that robots are received better when they match the stereotype of the task they are performing. They report effect sizes consistently, but only discuss it to compare which effects are stronger.

Otterbacher and Talias study the effect of human and robot gender with respect to the uncanny valley (the proposition that less anthropomorphic robots are well received, and very anthropomorphic robots are well received, but there exists some gul in between which is uncanny) [22]. They find that the 25 men’s uncanny reactions to 25 female cueued robots (from YouTube) are best explained by their perceptions of experience, whereas women’s uncanny reactions to robots is driven by perceived agency. They report but do not discuss effect sizes, except to compare which effects are stronger.

Siegel et al. study the effect of robot and subject gender on the ability of robots to persuade the subjects to donate money they had been given for the experiment. They find that the 76 men were more likely to donate money to the female robot, while the 58 women didn’t show a robot gender preference [32]. Subjects also generally rated robots of the opposite gender as more credible, trustworthy, and engaging. While they do not discuss effect size, they report means for each group which allows readers to evaluate this themselves. I evaluate effect sizes to be small.

Stafford et al. studied how people’s prior robot attitudes affect their evaluations of a conversational robot, with 7 older men and 13 older women participants [35]. Among other results, they did not find that the gender of the robot affected the interaction, but they did find that men rated robots higher in all conditions higher than women, with a medium effect size. They find that when asked to draw pictures of robots, most tended to draw male or gender neutral robots.

Kuchenbrandt et al. studied whether the gender typicality of a task would affect the extent to which 38 female and 35 male participants correctly performed and accepted help when performing a task when instructed by a male or female robot [15]. They found that participants made more errors when participants worked with the robot to complete typically female tasks, and that after performing a typically female task, they were less likely to accept help from the robot in future and anthropomorphize the robot less, showing that the gender stereotype assigned to tasks participants perform with robots affect their perceptions and acceptance of the robot. The authors present a rigorous discussion of effect sizes which stands as a shining example which should be emulated by other other HRI studies, noting that because they detect medium to large effects this underscores the practical relevance of their findings.

Reich-Stiebert et al. examine the influence of a robots gender teaching either a stereotypically male or female subject to either 60 male or 60 female participants [25]. They found that participants that robot gender does not affect participants’ learning, intrinsic motivation, and the evaluation of the robot. However, they found that when the gender of the robot is mismatched with the gender typicality of the subject matter being taught, participants were more interested in future learning with a robot when the robots’ gender did not match the task gender typicality of a task. The authors did not find (or did not discuss) any interaction between participants gender and robot gender.

In a study by Alexander et al. 24 male and 24 female participants completed four Sudoku-like puzzles with a robot with a female name and voice and another with a male name and voice. Contrary to assumptions they form from the psychological literature, hey found that male participants asked the robot for help more frequently regardless of its assigned gender. Participants of both genders reported feeling more comfortable with a robot assigned the other gender and preferred the male robot’s help. Findings indicate that gender effects can be generated in human-robot collaboration through relatively unobtrusive gendering methods and that they may not align with predictions from psychology [1].

Koulouri et al. conducted an experiment in which one participant instructed another remote participant, who they thought was a robot, on how to navigate to a goal using chat [14]. The second drove an on screen turtle (which the authors call a robot) through a map, which both participants can see. They tested the efficiency and word use of all combinations of male and female participants, but in no case did the participant know the gender of the other. The authors found that matched gender participants outperform mixed gender participants, and that males tend to employ landmark references when interacting with females compared to female/female pairings or when instructing males.

Sung et al. surveyed 379 iRobot Roomba (vacuuming robot) owners, and found that they were equally likely to be female as male,
and use this to problematize the notion that vacuum use and ownership is stereotypically female whereas robot ownership and use is for men [38]. Despite this, they found that participants were more likely to give Roombas and thus be more useful to women, and further that participants who ascribed gender to their robot were more satisfied with the robot than those who did not, and those who did were equally likely to refer to it as male as female, and a large fraction likely to ascribe both genders to it. They also found that men and women were approximately equally likely to name their Roombas.

Carpender et al. exposed 10 women and 9 male university students to videos of two robots interacting with humans, both introduced as designed to be a friend or member of the family [4]. One was highly anthropomorphic and appeared female with skin and hair, and the other had eye like things and arms but looked distinctly mechanical. They administered a three question likert scale questionnaire about machine/humanness, friendly/unfriendly, and comfort level of having the robot in their home, to which they found no significant results except for machine/humanness, followed by a semi structured interview. The female appearing robot’s perceived gender came up frequently in this interview, with participants saying they felt more comfortable with it because it was female, pretty, and comforting. Participants mainly suggested that both robots could do menial tasks, but felt less comfortable letting it do social tasks such as answering the phone or taking care of kids, and especially uncomfortable with the robot touching humans in a social or affectionate way. Unfortunately, they did not discuss how participants of different genders may have reacted differently, nor identify the gender of participants when presenting participant quotes.

Alternately, Dautenhahn et al. conducted questionnaires and human subject trials with 14 male and 14 female participants to study their perceptions of having a robot companion in the home [8]. They found that few participants wanted a robot friend, nor did they want it to perform child or animal care tasks instead wanting it to perform household chores. They wanted it to be able to communicate in a humanlike way, but cared less about having humanlike behavior or appearance. They did not find a statistical relationship between the participant’s gender and these attitudes, but this may be due to the small sample size, and unfortunately while they did ask open ended questions yielding qualitative responses, they did not report many results nor analyze these results with respect to participant gender.

Walters et al. conducted a human subjects study in which a robot instructed 31 female and 37 participants in a symposium on robotics to approach it using either a high quality recorded male, female, or neutral synthesized voice, or by the experimenter [44]. They found that most participants approached to a zone described as “personal” space, followed by a distance described as “intimate” space. People approached the robot the closest in the human voice condition (mean 42cm), and least close in the neutral synthesized voice (80cm), with the male and female voices separated by less than 10 centimeters, but these effects were only statistically significant when comparing the synthetic and gender neutral voice to all other conditions. They also asked participants to name the robot, and found that the majority provided male names (41%) followed by neutral names (58%), with only one percent giving it a female name, and many refusing to give any name at all, but they did not break out this result with respect to the gender of the robot’s voice or the gender of the participant, nor ask why some refused.

Strupka et al. study the effect of a male and female voiced robot on eight male and eight female participants on their tonal range, volume, and other vocal measurements while answering the robots’ questions [37]. They found that both female and male participants spoke more quietly to the female robot, even though the female robot spoke louder.

The authors warn against making strong conclusions from their findings, but state that their results offer strong evidence that embodiment is important, and can have different effects on men and women, offering their past socialized experience with robots as an explanation for why.

Crowell et al. conduct an experiment with 23 male and 21 female undergraduates assigned to one of four conditions: fully crossed design of male robot, female robot, male voice, and female voice (the last two with no embodiment) [6]. They find that male participants respond in less socially desirable ways in the presence of a robot than a disembodied voice, whereas female participants behave in the reverse. Men and women rated the disembodied voices as more reliable but less friendly than the embodied robot.

The authors warn against making strong conclusions from their findings, but state that their results offer strong evidence that embodiment is important, and can have different effects on men and women, offering their past socialized experience with robots as an explanation for why.

Eysel and Hegel study the effect of gendered facial queues (hair lengths, lip styles of photographs of robots on 30 male and 30 female participants, and found that participants were more likely to rate the male robot as having more agency, and the female robot as more communal [9]. Further, they found that participants...
perceived stereotypically male math tasks as more suitable for the male robot, and verbal tasks for the female robot. They present this as evidence that people project traditional gendered norms onto gendered robots.

Eyssel et al. test the effect of modifying the gender of a robot’s voice on a 31 women and 27 male participants’ ratings of the robot’s likeability, closeness, contact intentions, and anthropomorphism [10]. They did not find a significant effect of participant–robot gender pairing on likeability, but did report weak, non-statistically significant evidence that men rated the male robot as more likeable and that women rated the female robot as more likeable. They found similar evidence of varying levels of statistical significance that participants have more psychological closeness and contact intentions with robots of the same gender. Sadly, the authors do not discuss effect size, but by manual inspection different in means they report means for different genders suggest that there is some meaningful real world effect.

Kuo et al. evaluated how 33 female and 24 male adult participants reacted to a healthcare robot, named Charles and with male on-screen facial features, taking their blood pressure. After having the robot greet the participants and having it check their blood pressure, the participants filled out standard measures of the quality and engagement of the social experience, and novel measures of comfortableness [16]. They found that male participants had a more positive attitude than females on the usefulness of the healthcare robot, and towards the possibility of using them in the future, but with no significant gendered effects observed for social engagement or quality, or ratings of the robot. The authors do not discuss effect size.

Sandygulova et al. had 56 male and 51 female children interact with an anthropomorphic robot with either a female or male synthesized voice. They found that younger children do not successfully attribute gender to the robot corresponding to the voice, but that older children are [28]. Younger children indicated a preference to a robot with a matching gender, while there was no difference in preference for a robot gender by older children. The authors do not discuss sample sizes.

Alexander et al. investigated the effect of having 24 male and 24 female participants complete a Sodoku puzzle while having a male or female robot that they can ask for help [1]. They found that male participants were more likely to ask the robot for help regardless of its assigned gender. They also found that participants prefer to interact with the robot of the opposite binary gender, and in general, preferred the male robot’s help. The authors do not discuss effect size.

Powers et al. study the effect of the gender of a robot on number of words used by 17 male and 16 female participants when describing dating norms to the robot [23]. On the dubious assumption that females are supposed to know more about dating norms than males, they find that users, especially women describing norms for women, use more words explaining norms to a male robot than a female robot, concluding that the assumed common ground between explainer and a female robot leads to more efficient communication, whereas conversely, more detail is given to a male robot with less shared knowledge. The authors briefly acknowledge small effect sizes.

Nomura and Takagi study the effect of a male and female named anthropomorphic robot on politeness, mildness, ambitiousness and assertiveness perceived by 17 male and 22 female students, some studying science and some studying social science [20]. They did not find main effects for robots’ gender, subjects’ gender, or educational background, but did find an interaction effect between gender and educational background: men with science backgrounds rated the robot as more polite, with a moderate effect size.

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