Gendered Voice and Robot Entities: Perceptions and Reactions of Male and Female Subjects

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Abstract— **There is recent evidence that males and females view robots differently, from the way robots are conceptualized, to the way humans respond when they interact with them. In this paper, we further explore gender-based differences in human-robot interaction. Moreover, we provide the first available evidence for sex-related differences in reactions to gendered synthetic voices that are either disembodied or physically embodied within a robot. Results indicate that physical embodiment and perceived entity gender may interact with human sex-related characteristics and pre-experimental attitudes in determining how people respond to artificial entities.**

I. INTRODUCTION

Does a person's gender influence how they think about and react to robots? Can the perceived gender of a robot determine how a person will interact with it? Surely, these are important questions in the field of human-robot interaction (HRI). Answers to these questions may guide both the design characteristics with which robots are developed as well as a robot's intended use.

There is ample theoretical reason to suspect that gender could be important to HRI. *Social Identity Theory* [18] predicts that human males and females are likely to think about and respond to one another in very different ways based on perceived similarities or differences in sex, personal characteristics, or other group affiliations that either establish or preclude common ground (i.e., shared backgrounds or experiences) among them. Women, for example, are likely to have more in common with other women than with men across many domains. These shared commonalities can lead females to interact with other females differently than they do with males. A similar pattern is true for men.

Hence, an important open question in the context of HRI is whether the predictions of *Social Identity Theory* for human-human interactions also apply to human-robot interactions, specifically, whether men and women are likely to identify socially in different ways with robots that are perceived to exhibit human-like, gender-related characteristics. In this paper, we will investigate aspects of this specific question.

II. MOTIVATION, BACKGROUND, AND RELATED WORK

The idea that the degree of human-likeness of a robotic (or other artificial) entity can evoke distinct social-psychological processes in humans is not new. Indeed, investigators have examined social presence effects with computers and artificial entities for some time [12], [13], [10]. The conjecture was that the more a computer, a robot or an other artificial entity is perceived to resemble a human, or is perceived to exhibit human-like characteristics, the more likely it is that the mere co-presence of that entity will evoke social-psychological processes in humans subjects similar to those triggered by real human companions. Thus, we may observe a social presence effect when humans socially identify with robotic or other artificial entities based on their perceived gender characteristics.

Another type of social presence effect might be related to social desirability. In the 1980s, it was discovered [6] that humans answered certain survey questions in a more socially desirable way on a paper survey that would be scored by another human than on an electronic survey that was administered by a computer. This apparent response bias was thought to be related to a general apprehension or anxiety humans possess about being evaluated or judged by other humans [6], [14]. However, the tendency to adjust answers to "save face" or "look better" might be stronger for some types of questions than for others. For example, being asked to agree or disagree with a character-related statement like "I don't let others get blamed for my mistakes" might evoke a more socially desirable response than a neutral statement like "I listen to music." The present study will examine this possibility in a context where both male and female humans are asked a series of questions by a gendered artificial entity. Combining the possibilities of gender-based social identity with evaluation anxiety, we might expect more socially desirable responding from human subjects when certain types of questions are asked by a same-gendered entity than when asked by one of the opposite gender. This could occur if subjects attach a greater personal importance to how they are viewed by others with whom they have a greater degree of gender identity [8]. This study also will test this possible interaction effect between humans and robots.

A. *Gender Effects*

There has been surprisingly little work done investigating the effects of subject or entity gender in HRI. One study [3] reports differences between male and female subjects with respect to how they prefer to be approached by a robot (more females were found to prefer a direct, head-on approach than males). The robot used in that investigation was, like the robot used in the present study, an ActivMedia PeopleBot. Another study [9] found gender differences in some physical preferences, such as the distance to which they would initially approach a robot. These researchers also found that females tended to score lower on a measure of negativity toward robots than did males, in particular with regard to emotion in robots, which is consistent with our own previous findings using a paper and pencil survey [15].

An examination of the perceptions of men and women of a gendered humanoid robot chatbox with minimal gender characteristics (pink vs. gray lips and a female vs. male synthesized voice) [11] found that subjects not only treat the robot differently based on its supposed gender, but male and female subjects interacted differently as well. In a task involving the discussion of dating norms, subjects spoke (i.e., explained) more to the male chatbox in general, with male subjects speaking more to the female chatbox and female subjects speaking more to the male chatbox.

The above findings highlight the importance of both subject gender and perceived entity gender as factors to be further examined and better understood in the context of HRI research. Moreover, they demonstrate for at least one domain (dating) that a match between subject sex and perceived entity gender will produce a different pattern of human-robot interaction than a mis-match.

B. Social Identification with Voices

Nass and colleagues [8] have shown that voices by themselves can exert a powerful influence on human perceptions and preferences in a variety of circumstances, even when those voices are synthesized. They also reported that characteristics of the voice, such as its apparent gender, can influence the listener differentially, depending on the gender of the listener. For example, females were found to be more persuaded in a choice-making task by a synthetic voice they perceived as female than they were by one perceived as male. In addition, women rated the female sounding synthetic voice as being more trustworthy and likable than the male synthetic voice. Interestingly, the opposite pattern of effects was found for males listening to these gendered synthetic voices whereby men gave higher ratings to male voices on the same dimensions. Nass also reported the same pattern of effects when recorded human voices (male and female) were used. These findings seem to demonstrate a form of social identification in which humans resonate more to communications delivered by a gendered voice that matches their own, rather than by an oppositely gendered voice, regardless of whether the voice is human or synthesized.

C. Our Previous Work

In [15], we showed differences in how male and female subjects answered questions on a paper survey when they were by themselves (*Alone* condition) compared to how they responded to the same survey questions asked verbally by a co-present robot (*Robot* condition). Three different categories of questions were used on the survey, *Robot* questions (e.g., "Robots should have rights just like pets or people"), *MC* questions containing a subset of items from the Marlowe-Crowne Social Desirability Scale (e.g., "I always try to practice what I preach,") selected to maintain comparability with the same items reported by [6], and *Neutral* questions (e.g., "I sometimes go out with friends").

Results indicated that the answers subjects gave to these surveys depended upon both condition and their gender. For example, for *Robot* questions, male subjects tended to respond more positively when alone than when with the robot, whereas female subjects exhibited the opposite tendency. Similarly, for *MC* questions, male subjects offered more socially desirable responses in the *Robot* condition than when responding *Alone,* while female subjects showed the opposite trend. We hypothesized that the differences in male and female response patterns were due to differences in the extent to which males and females perceived the robot as human-like: *males viewed the robot as more human-like than females*. And we concluded that the different perceptions of humanlikeness which gave rise to the social presence effects in male, but not female subjects, depended on differences in male and female pre-conceptions of robots. We shall call this the *Robot Pre-conception Hypothesis* or RPH, for short.

D. Open Questions

RPH implies that human pre-conceptions of robots are a critical factor in determining human attitudes towards and interactions with robots. Note that RPH is a general hypothesis about differences in pre-conception potentially causing differences in human-robot interaction, which, by itself, does not imply any gender-based differences. For example, it seems likely that a robot programmer who implements emotional responses in a humanoid robot will not believe that the robot has emotions, while a person who has never even interacted with a robot might be taken aback by the robot's emotional display. Consequently, RPH would imply that the fact that the "naive subject" is affected differently by the robot's emotional display compared to the "hardened robot programmer" is based on a difference in their pre-conceptions about robots. While RPH is a possible explanation for the results seen in [15], we can think of two alternative explanations, which would be implied by *Social Identity Theory* if it applies to robots as well as humans.

Alternative 1: the *Gender Alignment Hypothesis* (GAH). The male gendered synthetic voice we employed for the robot in our previous study, along with the typically male name we attached to it ("Rudy"), projected a more masculine embodiment. Hence, the alignment of the gender triggered social identification effects in our subjects. If GAH is true and accounted for our previous results – that males exhibited more socially desirable responding when the robot was present than when it was absent – then we should see a difference in male and female responses to entities with masculine vs feminine voices, regardless of the embodiment status of the voices.

Alternative 2: the *Voice-as-Agent Hypothesis* (VAH). Male and female subjects attended only to the voice itself, rather than to any sense of embodiment (given that the robot had no other gender features). Hence, the voice was sufficient (i.e., the actual physical presence of the robot was irrelevant) for the human perception of the presence of an agent, which triggered social identification effects in our subjects (following [8]). If VAH is true and accounted for our previous results – that males exhibited more socially desirable responding when the robot was present than when it was absent – then we should see no differences in male and female reactions to embodied and disembodied entities.

The aim of the present study is to test both GAH and VAH and investigate the extent to which they can provide an alternative explanation to RPH. Note that these two explanations are not mutually exclusive, but could be jointly accountable for the previous results. To test GAH, we needed a robot with a female voice in order to show that females display the same pattern of effects under this voice as males did in our previous study under the male voice; to test VAH, we needed a disembodied male voice in order to show that males displayed the same effect with the disembodied voice as they did with the embodied voice in our previous study. Accordingly, we employed two primary independent variables in this study: *Voice Gender* and *Entity Type*. The *Voice Gender* manipulation was used to test GAH and involved the use of either a masculine or a feminine synthetic voice. The masculine synthetic voice was the same one employed in our previous study. The feminine synthetic voice was a female version from the same synthetic voice generation software suite. The *Entity Type* manipulation was used to test VAH and involved either a disembodied voice condition in which subjects were exposed to a gendered synthetic voice presented through a table-top speaker, or an embodied voice condition, where an identical voice emanated from our autonomous robot. A third independent variable, *Subject Sex*, was completely crossed with the two manipulated variables, yielding a 2 × 2 × 2 between-subjects factorial design.

III. Methods

The experimental procedure consisted of five phases: 1) a computer-based distractor math task, 2) an entity-administered survey with Neutral survey items and Marlow-Crowne survey items [2], 3) a second distractor math task, 4) an entity-administered Attitudes survey and 5) a Post-experiment questionnaire administered by computer after the entity was no longer present. The purpose of the math "distractor" tasks and the attitudes survey was maintain consistency with the experimental conditions in our previous study as well as to disguise our primary focus in this study on just the first survey.

Participants. 44 subjects, 23 males and 21 females, were recruited from a pool of undergraduate students and given course credit for their participation in the experiment. They were randomly assigned to one of the four combinations of *Entity Type* and *Voice Gender* conditions: Male-Voice, Female-Voice, Male-Robot, and Female-Robot, each balanced for *Subject Sex* insofar as possible.

TABLE I

Respectively, the three categories of items below are the Neutral and Marlowe-Crowne items on the first Survey and the items from the Post-Experiment Survey. Subjects responded with 1 (for "Strongly Disagree") to 6 (for "Strongly Agree")

1	There are times when I have gone out with friends.
2	There are times when I have watched TV.
3	There are times when I have listened to music.
4	There are times when I have eaten some ice cream.
1	I am always careful about my manner of dress.
2	I always try to practice what I preach.
3	When I don't know something I don't at all mind admitting it.
4	I would never think of letting someone else be punished for my wrongdoings.
5	I never resent being asked to return a favor.
1	Rudy's/Mary's spoken language was clear and understandable to me.
2	Rudy/Mary seemed very capable to me.
3	Rudy's/Mary's voice sounded male/female to me.
4	Rudy/Mary seemed trustworthy to me.
5	Rudy/Mary seemed reliable to me.
6	Rudy/Mary seemed likable to me.
7	Rudy/Mary seemed pleasant to me.
8	Rudy/Mary seemed friendly to me.

Procedure. Subjects were greeted at the door of the experiment room and seated at a desk with a computer used for administering the Math Task and the Post-experiment questionnaire. Subjects completed a paper consent form and were given verbal instructions that the experiment consisted of five phases. The experimenter would be present at the start of each phase, give instructions about that phase and then leave the room. At the end of each phase, the subject was instructed to press a call button and the experimenter would return. Several experimenters participated and their roles were controlled for consistency with an explicit written script each person followed. Because of the multiple phases in the study, the experimenter's explanatory function at the start of each phase was important.

The survey phase began with the experimenter informing the subject that they were to be given a survey and briefly describing the survey-taking entity. In the Voice condition, the entity was a (disembodied) voice which emanated from a single, five inch diameter self-powered speaker located to the left of the computer monitor (which the experimenter powered on after referring to it). In the Robot condition, the survey-taking entity was an autonomous Robot with natural language capabilities (which self-navigated into the room from the same doorway as the experimenter after being announced by the experimenter). The Voice or Robot was introduced by the experimenter with a name which was appropriate to the gender of the synthetic voice of the entity-male entities were called "Rudy" and female entities were called "Mary." At the start of the first survey, both Voice and Robot again introduced themselves by name and informed the subject that they would be asking some questions. This was done in an effort to create a sense of social presence for the entity. The same software system was utilized to generate the synthetic voice emanating from either the Robot's speakers or the Voice's speaker. Prior to the experiment the Robot and Voice condition sound volumes were set to the same level using an audio meter at the subject's seated position.

For both the Robot and Voice Entity Type conditions, the entity verbally presented a set of statements instructing the subject to respond verbally with a numeric response from "one" to "six." This survey consisted of the Neutral and Marlow-Crowne items (see Table I). After the survey items were complete, the entity indicated that the subject should press the call button to summon the experimenter. A hidden microphone captured the subject's responses and enabled a human observer in a separate control room to interact with the Robot or Voice survey software subsystem, thereby recording the subject's response and initiating the next item in the survey. The observer was different from the experimenter and was used primarily to eliminate the need to use the robot's own voice recognition system.

For the post-experiment survey, the subject was instructed by the experimenter to respond to survey items which were presented in text form on the computer screen on the desk. The experimenter reviewed the format of the survey items, including the use of a "slider" style response type, and had the subject complete two sample survey items using the survey software (also written in Java by one of the authors) for practice. The experimenter then left the room and the subject finished the on-screen questionnaire. At its completion, the subject was prompted to press the call button to summon the experimenter, who returned and debriefed the subject. The subject then left the experiment room.

Equipment. We used an ActivMedia Peoplebot (P2DXE) with two Unibrain fire-wire cameras mounted on a Directed Perception pan-tilt unit, a Sick laser range finder, a Voice Tracker Array Microphone, and two speakers. We employed our distributed integrated affect, reflection, cognition DIARC architecture used successfully in previous HRI experiments [17], [1], [16]. The subject's verbal responses to the Neutral and Marlow-Crowne surveys were recorded by a human observer.

IV. Results and Analysis

We computed average rating scores across all items in both the Neutral and the Marlow-Crowne survey items (Table I) as the primary dependent variables for the analyses reported below. In addition, ratings for the individual items in Table I on the post-experiment questionnaire were also analyzed.

A. Voice Understandability

The first step was to determine if the subjects perceived the different voices used in this study as equally understandable. One of the items on the post-experiment survey was intended to serve as a manipulation check in this regard. An *Entity Type* $\times$ *Voice Gender* $\times$ *Subject Sex* ANOVA of the ratings for the understandability item revealed a significant main effect for *Voice Gender* ($F(1, 36) = 4.90, p = .03$) as

Fig. 1. The robot used in the study. As can be seen from the image, the robot has no distinguishing gender features.

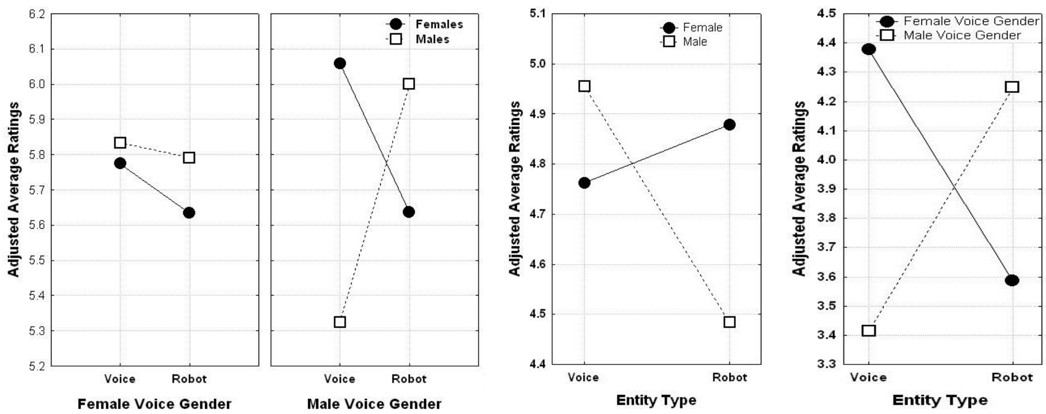
well as an interaction of *Voice Gender* with *Subject Sex* ($F(1, 36) = 5.82, p = .02$). No other main effects or interactions emerged as significant from this analysis. The significant interaction resulted from the fact that female subjects rated the understandability of the two Voice Genders differently while males did not. Fisher LSD follow-up tests ($MS\ Error = 1.93, df = 36$) confirmed that females subjects perceived the female synthetic voice to be significantly less understandable ($p = .002$) than the male voice.

As a result of this difference in understandability, it was necessary to adjust the statistical analyses for this factor by using understandability ratings as a covariate in the ANOVAs applied to the Neutral Survey and Marlow-Crowne ratings. In these Analyses of Covariance (ANCOVAs), all main effects and interactions with $p \leq .05$ will be considered significant.

B. Neutral Survey Items

An *Entity Type* $\times$ *Voice Gender* $\times$ *Subject Sex* ANCOVA (using understandability ratings as the covariate) applied to these ratings revealed a significant two-way *Entity Type* by *Subject Sex* interaction ($F(1, 35) = 5.37, p = .02$) as well as a significant three-way interaction of *Entity Type* with *Voice Gender* and *Subject Sex* ($F(1, 35) = 3.79, p = .05$). None of the other main effects or interactions were significant.

Fig. 2(a) illustrates the three-way interaction, which resulted from a clear two way interaction among the *Male Voice Gender* groups (right panel), but not among the *Female Voice Gender* groups (left panel). Fisher LSD follow-up tests ($MS\ Error = .177, df = 35$) revealed that the difference in *Voice* and *Robot* groups for male subjects in the right panel was highly significant ($p = .009$), while the same



(a) (b) (c)

Fig. 2. (a) average ratings on the neutral survey items adjusted for voice understandability displayed a function of *Entity Type*, *Voice Gender*, and *Subject Sex* conditions. (b) average adjusted ratings on the Marlow-Crowne Survey items for both Male and Female subjects in the *Voice* and *Robot* conditions. (c) average adjusted reliability ratings as a function of Entity Type and Voice Gender conditions, collapsed over Subject Sex conditions.

comparison was not significant on the left. In contrast, none of the other *Voice-Robot* comparisons in either panel reached significance. These findings show that, when adjusted for understandability, males rated Neutral Survey items higher with the robot present than under the disembodied *Voice* condition when a male gendered voice was employed, but not when a female gendered voice was used. In contrast, females offered arithmetically lower ratings in the presence of the *Robot*, regardless of *Voice Gender*, though not significantly so. These results indicate that, at least for males, the embodiment of the entity, and not the gender of the voice, is responsible for the difference in ratings of the neutral items.

C. Marlow-Crowne Survey Items

An *Entity Type* × *Voice Gender* × *Subject Sex* ANCOVA of these ratings revealed only a significant interaction of *Entity Type* with *Subject Sex* ($F(1, 35) = 3.94, p = .05$). No other main effects or interactions approached significance in this analysis. Fig. 2(b) shows this significant interaction, which seems to have occurred because males responded to these survey items with lower ratings in the *Robot* than in the *Voice* conditions, whereas, if anything, females displayed the opposite trend. Fisher LSD follow-up tests for this interaction ($MS\ Error = .232, df = 35$) showed that the male subjects' responses differed significantly in the *Voice* and *Robot* conditions ($p = .02$) – even though this effect did not depend on *Voice Gender* as with the Neutral Survey items in Fig. 2(a) – while female subjects showed no difference. Thus, these findings confirm that the embodiment of the voice is the cause for the differences in male ratings.

D. Post-experiment Survey

This survey contained additional items beyond voice understandability designed to assess the same perceived entity characteristics examined by Nass and his colleagues [8]. These characteristics included "gender appropriateness of the voice" (e.g., female entities seemed feminine; male entities seemed masculine), as well as "entity trustworthiness", "capability", "reliability", "pleasantness", and "friendliness" (see Table I). Significant effects were found on these measures only for the "reliability" and "friendliness" (note that higher ratings denote greater subject agreement that the specified characteristic is present in the target entity).

Specifically, an *Entity Type* × *Voice Gender* × *Subject Sex* ANCOVA of the "reliability" ratings revealed a significant interaction of *Entity Type* with *Subject Sex* ($F(1, 35) = 6.08, p = .01$), see Fig. 2(c); no other main effects or interactions approached significance in this analysis. This interaction shows that all subjects, regardless of their gender, perceived a disembodied female gendered voice as *more reliable* than an embodied female voice, while a disembodied male voice was perceived as *less reliable* than an embodied male voice. Fisher LSD follow-up tests ($MSError = 1.16, df = 35$) for this interaction revealed that the difference between the groups in the Voice Gender groups in the Robot condition was significant ($p = .009$), as was the difference between Robot and Voice groups in the female Voice Gender condition ($p = .05$). Moreover, an *Entity Type* × *Voice Gender* × *Subject Sex* ANCOVA of these Friendliness ratings revealed a significant main effect of *Entity Type* ($F(1, 35) = 3.82, p = .05$) with the robot being rated as more friendly overall than the voice; no other main effects or interactions approached significance in this analysis.

V. Discussion

The aim of the present study was to test both the *Gender Alignment Hypothesis* (GAH) and the *Voice-as-Agent Hypothesis* (VAH) as alternative explanations for previous results showing that male subjects responded differently in the presence of a robot than females [15], which we had earlier attributed to differences in robot pre-conceptions of male vs. female subjects (the *Robot Pre-conception Hypothesis*). To disentangle potential conflations associated with the previous findings (e.g., the robot had a male name and a masculine sounding voice), we explicitly manipulated two critical factors in the present experiments: *voice gender* and *embodiment status* of the entity. If humans identify socially with artificial entities along perceived gender lines (GAH), then the response patterns of male subjects in the presence of masculine and feminine entities should have been opposite to that of female subjects in the present study. If voice rather than physical embodiment was the primary factor operative in our previous study as implied by VAH, then subjects in the present study should have responded the same way in the presence of the disembodied voice as in the presence of the robot. Note that both hypotheses predict differences in male and female response patterns along gender lines but irrespective of embodiment, albeit for different reasons.

The above results provide evidence against either GAH and VAH, while all are consistent with RPH. For example, neither gender alignment (GAH) nor voice-as-agent (VAH) can explain the fact that, irrespective of voice gender, male subjects offered significantly lower ratings in the presence of the robot than in the presence of the disembodied voice for the Marlow-Crowne Items Survey, while female subjects showed the opposite pattern of ratings, a result in support of RPH. Interestingly, these results suggest that males responded in a less socially desirable way with the robot than with the disembodied voice. Moreover, the facts that (1) subjects generally rated the robot as being significantly more friendly than the disembodied voice entity and that (2) for the Neutral Items Survey, male subjects offered significantly higher ratings in the presence of an embodied male voice compared to a disembodied male voice, are inconsistent with the predictions of VAH, but consistent with RPH. Similarly, the facts that (1) on the Neutral Items Survey male and female subjects did not differ with respect to female voices, regardless of entity type, and that (2) differences in ratings were obtained only for male subjects for embodied male voices compared to disembodied male voices, but not for any other male voice condition, are also inconsistent with the predictions of GAH, but consistent with RPH. Finally, the most direct evidence against both GAH and VAH, but in support of RPH, are the results from the post-experiment survey that subjects, regardless of their sex, rated (1) the masculine embodied and female disembodied entities as *more reliable* than both the masculine disembodied and feminine embodied entities, and (2) found the robot *friendlier* than the disembodied entity, regardless of voice gender.

We have suggested above that embodiment may play a role in the present results. Unfortunately, we are not yet ready to offer a definitive explanation for the ways in which embodiment may act to influence how humans perceive agents or are affected by their presence. However, there are at least three promising lines of work that might well converge on such an explanation. First, considerable research reported in the mediated communication literature (see [20] for a review) has shown that certain visual cues (e.g., non-verbal behavior, gaze, etc.) emanating from conversation partners influence various cognitive aspects of the communication process (e.g., turn-taking). Since many of these identified cues are likely correlated with embodiment, these stimuli represent a potentially important source of influence whereby the presence of a body may contribute to any social effects engendered by a co-present embodied agent. Second, a recent study [19] has begun to unravel the complexities of embodiment in showing that it interacts with voice location (i.e., whether an entity's voice emanates from its own body or from a remote location) in determining a human partner's attitudes toward the agent as well as their performance on a collaborative task. More work along these lines will be needed to better understand how embodiment may exert any social presence influence it may have. Similarly, other work has shown that people who are not given detailed information about a robot will construct mental models for the robot similar to what they would construct for a person [7]. Hence, their perceptions of the robot may be shaped by features of the interaction or the environment in addition to possible preconceptions. Finally, it is very interesting to consider that embodiment may act as part of a broader complex of psychological processes whereby under certain circumstances humans exhibit a tendency to perceive humanlike qualities in non-human agents, entities or objects, a phenomenon known as anthropomorphism [4]. A recent psychological theory of anthropomorphism [5] posits that people are more likely to exhibit this tendency when relevant anthropocentric knowledge is available, when other factors increase their motivation for social engagement, and when they are somewhat socially isolated. We need to better understand whether and to what extent these factors operate in concert to influence the psychological consequences of embodiment and the other visual or auditory cues.

What seems to emerge from the present study is the likelihood that causes for the observed differences between male and female subjects cannot be attributed merely to factors like gender alignment or voice-as-agent. Rather, the results suggest various interactions among those dimensions that lead to a more differentiated picture. Collectively, our findings demonstrate that male and female subjects do not respond to embodied and disembodied masculine and feminine sounding voices in the same way. While neither the *Gender Alignment Hypothesis* nor the *Voice-as-Agent Hypothesis* can explain the present findings, they are consistent with the proposed *Robot Pre-conception hypothesis* that male and female subjects have different attitudes that can cause them to be affected differently by the presence of robots, regardless of the gender of the voice. One possible preconception that might offer at least a partial explanation for some of the specific findings in this study is that robots seem to be viewed as somehow "inherently masculine entities".[1] Unfortunately, we know of no empirical evidence establishing this.

[1]It seems that robots have been viewed as male agents from the very origin of the masculine-gendered Czech term "robotnik" ("worker") to popular portrayals of robots, such as the humanoid C3PO in Star Wars or the spaceship-robot-computer HAL in 2001, Space Odyssey. In this context, it is also interesting to note that even though the native English-speaking American subjects in the current study were likely not subject to potential influences from grammatical gender, the word "robot" has masculine gender in many (all?) gendered languages, including those where grammatically neutral forms exists (e.g., German or Slavic languages), pointing again to particular cultural constructions of robots as male-like.

VI. Conclusion

The present study was aimed at further exploring potential differences between males and females in their attitudes toward robots. Results from human-robot interaction experiments showed that male and female subjects responded differently to survey questions when these questions were presented by a robot with a male or a female voice compared to presentations by a disembodied entity also with a male or female voice. Since the factorial experimental design we employed allowed us to eliminate gender alignment and voice-as-agent effects as possible explanations for the present findings, the results provide further evidence for the hypothesis that the response patterns we observed in this study were caused by important differences in human preconceptions of robots.

In summary, we found that male subjects reacted differently to neutral survey items vocally administered by a robot with a male voice compared to the same male voice in disembodied form, while female subjects did not show a significant difference in responding to the robot or a disembodied voice, regardless of the voice gender. Similarly, male subjects showed less response bias on Marlowe-Crowne survey items when administered vocally by a robot than when administered by a disembodied voice, regardless of voice gender. In contrast, female subjects reacted in a similar way to Marlowe-Crown items under all administration conditions. Interestingly, neutral items took longer to process when presented by the robot than when presented by the disembodied voice. Moreover, males and females respond faster to opposite sex voice on the Neutral Survey. Subjects also found the female voice to be more reliable for the disembodied voice condition, but the male voice more reliable for the robot. Finally, subjects rated the robot as being more friendly than the disembodied voice, regardless of the gender of the subject or the voice. What we take to be the most important lesson from these results is that the interactions between gender and embodiment of an artificial entity and human gender are highly complex and cannot be reduced to a few simple dimensions or explanations. Rather, a fuller understanding of gender-based differences in attitudes and behavior towards robots will require substantive follow-up investigations with carefully controlled experimental conditions across a variety of different tasks.

Future work (in response to reviewers' comments) will examine in more detail exactly what aspects of the robot (e.g., embodiment, perceived gender) are most important to subjects identifying with the robot. Similarly, evaluating the context in which the interaction takes place may have an effect on how subjects view the robot by conducting similar studies in more natural (or even task-oriented) scenarios. Finally, we would like to explore the effect of using more explicitly-gendered robots (i.e., robots that really do have distinguishing gender features, unlike the PeopleBot used in the present study).

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