Let Me Tell You!

Investigating the Effects of Robot Communication Strategies in Advice-giving Situations based on Robot Appearance, Interaction Modality and Distance

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ABSTRACT

Recent proposals for how robots should talk to people when they give advice suggest that the same strategies humans employ with other humans are effective for robots as well. However, the evidence is exclusively based on people's *observation* of robot giving advice to other humans. Hence, it is not clear whether the results still apply when people *actually participate in real interactions with robots*. We address this shortcoming in a novel systematic mixed-methods study where we employ both survey-based subjective *and* brain-based objective measures (using functional near infrared spectroscopy). The results show that previous results from observation conditions do not transfer automatically to interaction conditions, and that robot appearance and interaction distance are important modulators of human perceptions of robot behavior in advice-giving contexts.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

Keywords

Natural language, politeness, presence, interaction modality, human-likeness, functional near infrared spectroscopy

1. INTRODUCTION

Social robots capable of natural language-interactions with humans have to be sensitive to how humans use natural language in communicative situations. Being "sensitive to humans natural language use", however, is a complex multi-faceted problem that ranges from low-level algorithmic processing details (i.e., the incrementality of information integration [6]) to high-level pragmatic principles (e.g., social etiquette for how to respond to formulate and respond to requests in a polite manner based on social status [7]). Additional complications for understanding human communicative strategies and implementing them on robots arise from the fact that verbal communicative behavior is modulated by various aspects of the interaction scenario such as interaction distance (e.g., [38]), social role (e.g., [28]), and the nature and purpose of the interaction, among others. For example, humans frequently employ *indirect speech acts* [7, 16] together with various *politeness strategies* in their verbal communication modifications both to live up to and conform with social expectations and to mitigate threat and insult [9]. And while various attempts have been made to implement such strategies in robotic architectures (e.g., [7, 37]), it is currently unclear whether such strategies would work equally well in human-robot interaction (HRI) contexts.

Recent results regarding how robots should talk to people when they give advice suggest that the same strategies humans employ with other humans are effective for robots as well [33]. However, this evidence is exclusively based on people's *observation* of a robot giving advice to another humans, hence it is not clear whether the results still apply when people *participate* in *real* interactions with robots.

In this paper, we report results from a systematic evaluation of the question of whether robots should use indirect speech acts as a communication strategy when giving advice to humans. In addition to the effects of different *communication strategies* (direct versus indirect speech), we also investigated effects of *interaction modality* (participation versus observation), *interaction distance* (local versus remote interaction) and *robot appearance* (human-like versus machine-like) based on prior evidence that interaction modality and distance as well as robot appearance can be important modulatory factors in human-robot interactions (e.g., [2, 23, 14]). For the evaluation, we developed a novel mixed-methods study design where we employ both survey-based subjective *and* brain-based objective measures using functional near infrared spectroscopy [10] to evaluate the influence of the four dimensions on perceptions of the interactions and the robot. Our main finding is that all four dimensions have an important influence on human perceptions of robot behavior in advice giving contexts and that previous results about the preference of indirect speech acts from observations of human-robot interactions do not transfer to actual interaction contexts.

2. RELATED WORK

Politeness theory [9] describes universal ways in which speakers can modify their speech to avoid threat to interlocutors (see Table 1). In HRI, [24] examined situations in which

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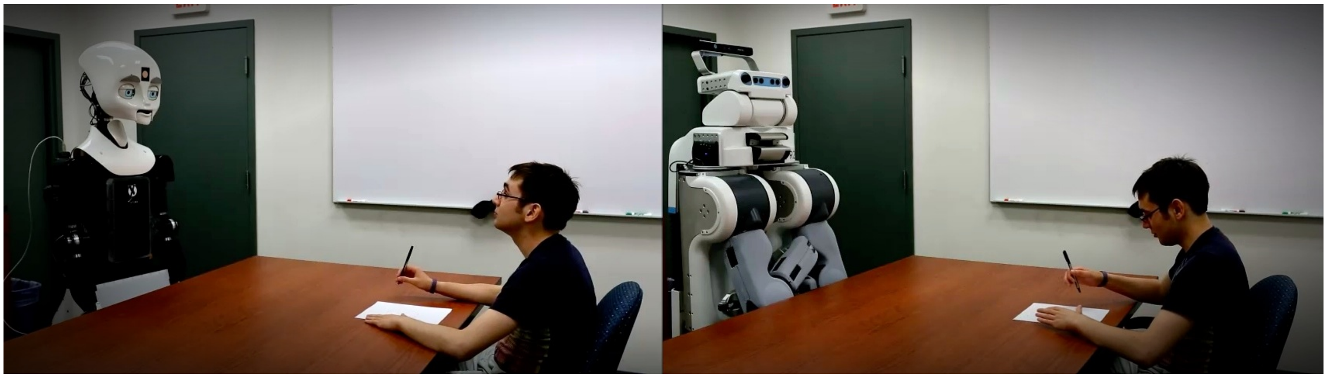

Figure 1: Robot helpers. Left – the MDS (Xitome Design), and right – the PR2 robot (Willow Garage).

natural language dialogue might be helpful for an assistive robot to have. A similar study looked at effects of adaptive dialogue on information exchange, which found that changing dialogue based on the listener's expertise (giving more info to the novices and less to experts) increased social cohesion with the robot [32]. One recent study investigated whether politeness universals for human helpers apply equally for robot helpers [33], which revealed that the presence of politeness modifiers in speech increased perceptions of considerateness and likability, and reduced perceptions of aggression – regardless of agency (whether the speaker was human or a robot). While this served as first steps towards understanding politeness universals for robotic assistants, it is not clear to what extent the results generalize. For instance, another study focused on applying error mitigation techniques drawn from politeness theory to improve perceptions of a robot in the event of an error; however, as to which technique (e.g., apology, compensation, etc.) worked best *depended on the participant's personality* [25]. In contrast, in a multi-social party setting, [15] found that *dialogue efficiency* and *task success* most affected the participant experience most. Hence, in those contexts ([25, 15]), the personality of the participant and as well as *task* success respectively were important in the perceptions of the robot helpers, rather than speech modifications alone.

Beyond natural language and politeness modifications of speech, however, a key aspect of HRI is the way in which the interaction occurs. For example, people are *more likely to perform a task when a robot is physically co-located* than when it is remotely communicating [2, 3, 12, 20, 22]. Moreover, people show more positive perceptions of co-located interactions than remote [4] and are more likely to profit from tutoring with greater levels of embodiment [14]. This suggests that perceptions of speech modifications may vary according to the manner of presentation (e.g., interacting with a physically present robot vs. by telepresence). Furthermore, holding the level of presence of the robot constant, people interacting with a robot from first-person perspective (direct interaction) may consider the interaction more seriously than from a third-person perspective (observing the interaction between another human and a robot) [33].

Finally, people seem to attribute more positive traits to attractive versus unattractive stimuli [8]. Both attractive people and robots are judged as warmer and more sociable than their less attractive counterparts [8, 19]. More importantly, unattractive robots which appear simultaneously very human-like can result in aversive behaviors in human observers [19]. This phenomenon is referred to as the *Uncanny Valley* [26], which posits a mismatch in human-likeness with non-human features results in feelings of unease towards the robot in question [5, 8, 19, 21, 26, 27]. While some have found that increased human-likeness can improve social perceptions of a robot [13, 8], many advise that human-like interfaces should be used with caution and within the appropriate contexts [5, 17, 21].

3. MATERIALS AND METHODS

To investigate the relative effects of communication strategy as modulated by interaction modality and presence as well as the robot's appearance, we conducted a mixed-design experiment. Specifically, speech and human-likeness manipulations were conducted within-subjects (to be consistent with [33]); however, to avoid bias from prior interaction, interaction modality (3rd-person vs. 1st-person remote vs. 1st-person co-located) was manipulated between-subjects.

Table 1: Some politeness strategies and examples.

	Strategy	*Example*
Positive	(a) give praise and	"good job"
	(b) rationale	"to make Y, do X"
	(c) be inclusive	"**we** will now do X"
Negative	(a) use markers,	"now"
	(b) hedges, and	"kind of"
	(c) indirect requests	"**could** you do X?"

Table 2: Example instructions in each communication condition for drawing a koala.

	Example
Direct	"Sketch a vertical oval extending from the space between the eyes down to the snout. This is the nose."
Indirect	"**Great**! **Now**, **to add a nose**, **let's** sketch a vertical oval extending from the space between the eyes down to the snout."

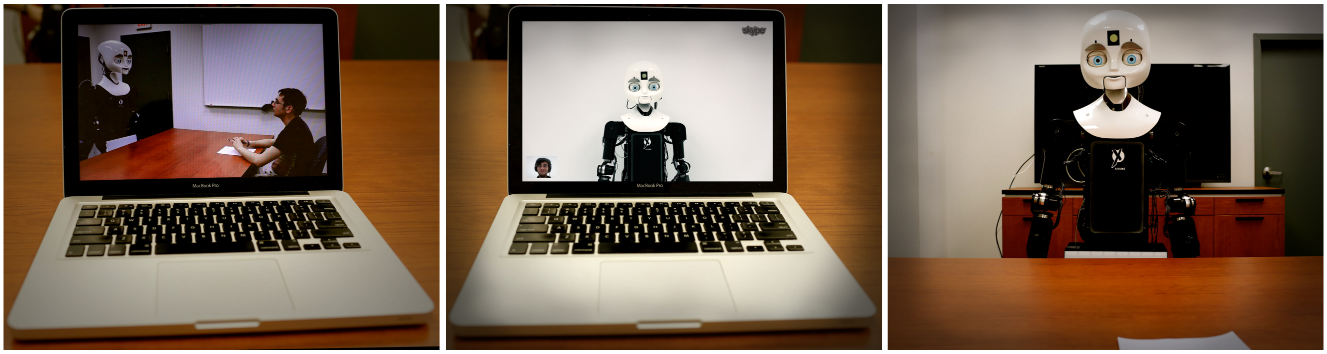

Figure 2: Left – the 3rd-person interaction (3PR) condition (directly replication of [33]). Right and center – the 1st-person protocols, with the robot helper co-located (1PC; right) and remote (1PR; center).

3.1 Design

Participants were informed the purpose of the study was to investigate different communication strategies for robots instructing humans on simple drawing tasks. To avoid habituation effects from repeated stimuli (i.e., the helpers advising on the *same* task), four distinct tasks involving the sketching of a simple object (tulip, koala, etc.) were created. To compare participants' impressions of robot helpers using politeness modifications in their instructions, we used two communication conditions (direct and indirect). Additionally, two robots were selected as representative "human-like" and "mechanical" robotic helpers to investigate how appearance of the helper could influence participant expectations and preferences. Lastly, to examine the effects of participant perspective and robot presence, three interaction conditions[1] were designed (see Figure 2).

Communication Strategies. The two communication conditions used here – *direct* and *indirect* – corresponded to the *no hedges/no markers* and the *hedges plus markers* conditions in [33]. As there was no evidence for additive effects of multiple politeness strategies [33], we expected that the presence of any *or* multiple politeness strategies (see Table 1) would elicit the same increases in liking and perceived considerateness of the helper. Thus we compared only the two communication conditions, where *direct* speech refers to an absence of any and *indirect* contains one or more of the above strategies (see Table 1).

Robot Helpers. Xitome Design's MDS and Willow Garage's PR2 robots were selected as the two helpers for their stereotypical robotic (PR2) and human-like (MDS) appearances. The selection avoided possible effects of height and girth of the helper, as they are nearly equal between the two robots. However, as the two are highly dissimilar in movement and affective capabilities, both robots were kept stationary and un-animated. Audio for the robots' speech was created using the Mac OS X native text-to-speech software, with the male voice, 'Alex', and female voice,'Vicki'. Subjects interacted with either Vicki-MDS/Alex-PR2 or Alex-MDS/Vicki-PR2, and the voice-robot pairing was counterbalanced. To avoid differences between subjects in speech recognition, the audio was controlled by wizard-of-oz: a behind-the-scenes researcher served as a 'human speech recognizer', and was trained to attend to three natural language indicators – *ready* (e.g., "okay, done"), *repeat* (e.g., "could you repeat that?"), or *back* (e.g., "what was the last instruction?"). All tasks were scripted so that the researcher could command the robot with the appropriate instruction immediately upon hearing an indicator. The pacing of the tasks were thus triggered based on these verbal cues.

Interaction Modalities. To measure effects of perspective (first-person vs. third-person) and the robot's presence (co-located vs. remote), three interaction modalities were created: (a) 3rd-person, remote (3PR); (b) 1st-person, remote (1PR); and (c) 1st-person, co-located (1PC) – see Figure 2. The 3PR condition corresponded to the experiment in [33]. Here participants observed video of the robot helpers instructing a human actor on the four tasks. Each video was approx. 2.5 minutes in length and was viewed on a 13" MacBook. The two first-person conditions – 1PR and 1PC – served as comparison for 3PR in order to investigate possible effects based on interaction modality (and distance, in the case of 1PC). They differed from 3PR both in that the participants performed the drawing tasks (rather than observing a video of someone else drawing) and that they interacted directly with the robot helpers.

3.2 Measures

A novel combination of subjective measures of the interaction as well as objective measures of the participants' reactions were used in this study. As human affect has a strong neurophysiological component [35, 36], in order to fully understand participants' unconscious or subconscious emotional reactions to robotic agents (e.g., feelings of unease in response to eerie, human-like robots), it is necessary to probe both conscious appraisal (subjective measures) as well as neurophysiological indicators [29, 35].

Subjective Measures. Immediately following each of the four drawing tasks, participants assessed (a) the interaction difficulty (two questionnaire items) and (b) several characteristics of the robot's communicative behavior (eight questionnaire items). Exploratory factor analysis with varimax ro-

[1]The fourth possible condition with the subject observer co-located with the confederate human interacting with the robot was left out because it was unclear whether minute differences in the live interaction between the confederate and the robot might have important effects on subjects' perception (as it is virtually impossible for human confederates to behave the same in all runs in the employed tasks).

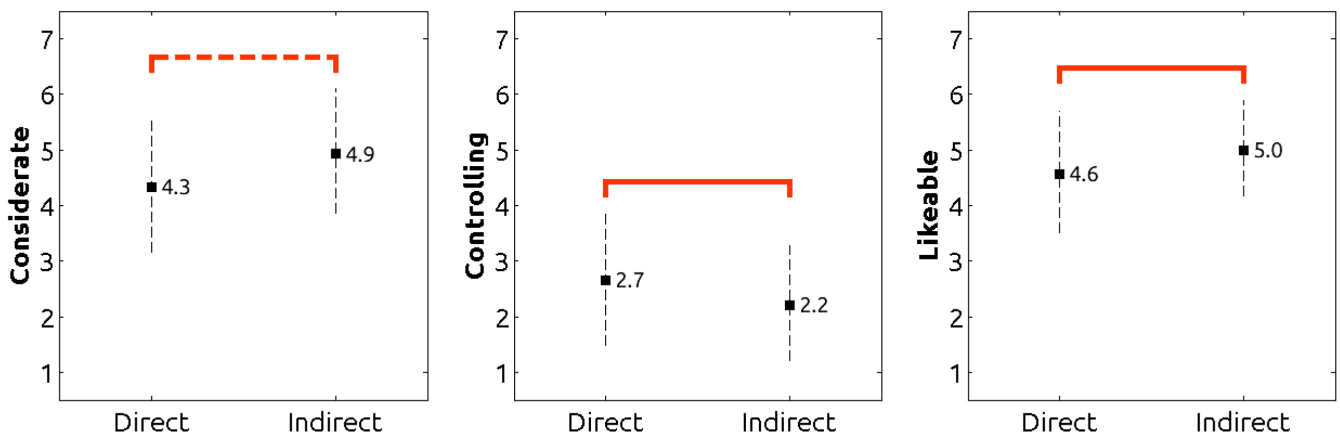

Figure 3: Main Effects of Communication Condition. The *indirect* communication condition significantly increased ratings of considerateness and likability of the robot helper. Moreover, the helper was rated as significantly less controlling in the *indirect* communication condition. *Dashed red comparisons indicate significant interaction effects with other manipulations (e.g., communication condition x interaction modality).

tation was conducted on these eight characteristics, yielding three underlying factors consistent with those found in [33]. Variance explained was used as the criterion for determining the number of factors. Table 3 shows the results of an orthogonal rotation of the solution. We interpreted the three-factor solution to reveal the following latent factors, responsible for 60.4% of the total variance: *considerate* (Cronbach's $\alpha = 0.77$), *controlling* ($\alpha = 0.80$), and *likable* ($\alpha = 0.80$). After participants completed all tasks, they answered a final survey regarding each robot (three items; based on indices by [19] for assessing a robot's appearance) and their preferences for future interaction (two items).

Objective Measures. Functional near infrared spectroscopy (NIRS) was used to measure participants' neural activity (indexed by hemodynamic changes) associated with attention, emotion regulation, and workload. A two-sensor NIRS instrument (ISS Imagent; TR=11Hz) was used to image participants' anterior prefrontal cortices (aPFC) bilaterally. This sensor placement captures the ventromedial prefrontal cortex which holds a key role in emotion regulation [30, 35].

3.3 Population and Procedure

Forty-five Tufts University students and staff were recruited via an affiliate University website and paid $10/hour for their participation. All subjects reported being healthy, right-handed, and having no history of brain trauma. The subject demographics mostly reflected those of the university, with a 60/40 female-to-male ratio (27 female/18 male participants) and average age of 21.3 years ($SD = 3.80$). Upon the receipt of informed, written consent, participants were fitted with the NIRS equipment, using a black cap to secure the two NIRS sensors on the left and right aPFC. A five-minute baseline measurement was then sampled for post-hoc conversion of the raw NIRS data into units of hemoglobin. Following, the participant performed the four drawing tasks sequentially (blocked by robot – e.g., first two with the MDS, then two with the other). Tasks were separated with the subjective questionnaires pertaining to the characteristics of communication and interaction difficulty. Lastly, to obtain NIRS measurements of participants' responses to only the appearance of the two robots (no auditory interaction), participants viewed a series of images of the MDS and PR2.

4. RESULTS

We first considered the effects of the interaction and robot helpers on the survey measures, followed by the objective measures of participants neural activity. The dependent measures were analyzed using a type-2 mixed design ANOVA with the following independent variables (IVs): interaction *Modality* (3PR, 1PR, 1PC; between-subjects), participant *Gender* (M, F; between), robot *Voice*-pairing (M-MDS/F-PR2, F-MDS/M-PR2; between), communication *Speech* strategy (indirect, direct; within), robot (PR2, MDS; within), and *Order* of exposure to the robots (1-MDS/2-PR2, 1-PR2/2-MDS; between). Post-hoc comparisons were conducted using Bonferroni-corrected pairwise t-tests.

Task completion. Based on the interaction logs, a 4-way ANOVA on Modality, Robot, Voice, and Gender showed 1PC participants spent significantly more time on the drawings compared to the 1PR condition; $F(1,39)=6.69$, $p=.0123$.[2]

[2]As the 3PR condition involved only observation of the task, it was not comparable in terms of time spent.

Table 3: Factor loadings for the measures of interaction showing a three-factor solution.

	Likable	*Controlling*	*Considerate*
Aggressive	-.324	.644	-.211
Considerate	.276	-.197	.938
Controlling	-.198	.969	-.127
Attentive	.395	-.134	.385
Likable	.667	-.215	.435
Annoying	-.742	.318	-.136
Comforting	.661	-.153	.178
Helpful	-.290	.102	-.127
Eigenvalues	3.82	1.027	.850
Variance	.237	.436	.604

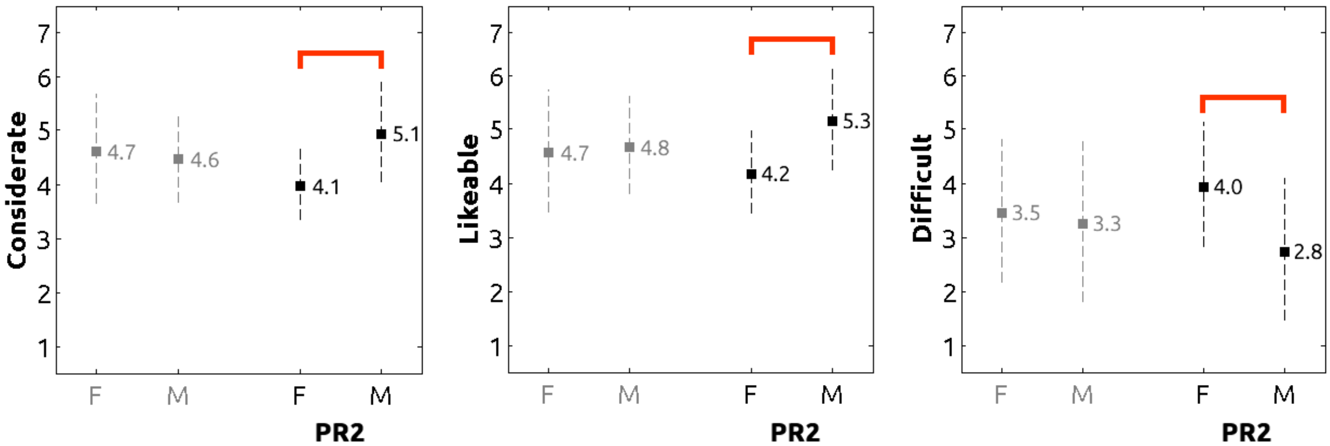

Figure 4: Robot*Voice interaction effects. A male (versus female) voice on the PR2 robot significantly increased ratings of considerateness and likability, and decreased the perceived difficulty of the interaction.

Considerateness, likablity, and aggression. These three factors were analyzed using a 5-way ANOVA with IVS: Modality, Gender, Voice, Speech, and Robot. Here, *indirect* speech significantly increased participants' ratings of liking (main effect; $F(1,33) = 8.56$, $p = .006$) and reduced ratings of control/aggression of the robot helper (main effect $F(1,33) = 12.49$, $p = .001$), see Figure 3. Indirect speech also increased considerateness, but only in the 3PR condition (see Figure 5); interaction $F(2,33) = 4.81$, $p = .014$. Ratings of indirect speech in the 1PC and 1PR conditions were significantly higher than *direct* speech in the 3PR condition ($p = .005$, $p = .024$ respectively), but there was no significant difference between direct vs. indirect within the first-person interaction conditions. Participant preferences also reflected these findings, with participants in the 3PR condition showing a strong preference for indirect speech (12/15) in comparison to the two first-person conditions, which showed instead a slight preference for direct speech (9/15 in both 1PR, 1PC).

An interaction effect was also observed between the Voice and Robot factors on considerateness ($F(1,33) = 7.44$, $p = .010$), liking ($F(1,33) = 11.63$, $p = .002$), and difficulty of the interaction ($F(1,33) = 5.34$, $p = .030$); see Figure 4: with the F-PR2 pairing resulting in significantly reduced ratings of considerateness and liking and significantly increased difficulty than the M-PR2 pairing ($p = .001$). In addition, a four-way interaction effect was found on ratings of aggression between *Interaction*, *Robot*, *Gender*, *Voice*; $F(2,33) = 3.32$, $p = .049$. Subsequent pairwise comparisons showed male participants in the 1PR *Interaction* condition rated the F-MDS as significantly more controlling.

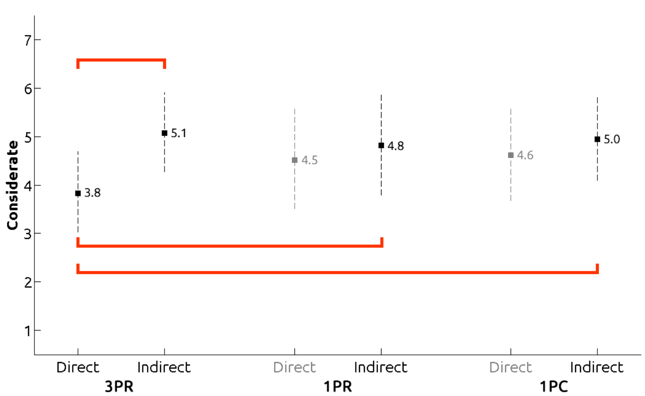

Figure 5: Interaction effect (*speech*, *modality*).

Human-likeness, warmth, and eeriness. The following three dependent variables were analyzed using a 4-way ANOVA with IVs *Modality*, *Robot*, *Gender*, and *Order*. As expected, the type of robot showed a main effect on ratings of human-likeness; $F(1,39) = 130.92$, $p < .0001$. The robot type (MDS vs. PR2) also showed a significant main effect on ratings of eeriness, $F(1,39) = 6.83$, $p = .013$, with significantly higher eeriness ratings for the MDS compared to the PR2 (see Figure 6). There was no significant effect of the robot on warmth; however, a marginal main effect of interaction *Modality* was observed, $F(2,39) = 2.73$, $p = .078$, with higher warmth ratings in the 1PR than the 3PR condition. Regarding preferences for robot helper, participants in the 1PC showed a strong affinity for the PR2 (10/15 participants) in comparison to the two remote-interaction conditions, which showed roughly 50/50 preferences between the two helpers (7/15 preferred the PR2 in both 1PR, 3PR).

Prefrontal hemodynamics. The NIRS data were preprocessed in the following manner: (1) conversion of raw light attenuation to changes in hemoglobin concentrations, (2) linear detrending to remove signal drift, (3) filtering of systemic artifacts (specifically, cardiac pulsations using a Savitzky-Golay low pass filter with degree 1 and cut-off frequency of 0.5Hz), and (4) correlation-based signal improvement ([11]) to correct motion based on common NIRS preprocessing and filtering techniques [10, 30]. Preprocessing yielded two signals – oxygenated hemoglobin for the left and right PFC – for each agent stimulus (MDS and PR2), for a total of four signals. To normalize the signals for between-subjects analysis, the respective signals for the MDS and PR2 were subtracted to yield one signal: difference in hemodynamic response.

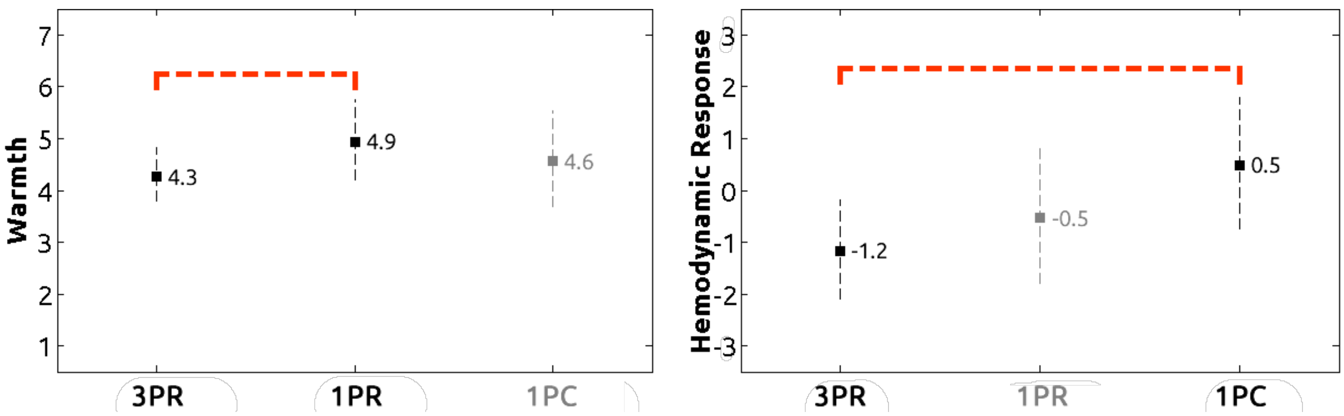

Figure 6: Main effects of Robot helper. As expected, the MDS robot received significantly higher ratings of human-likeness (as well as eeriness) than the PR2.

A type-2 three-way ANOVA revealed a marginally significant main effect of *Modality* on the left prefrontal neural activity (F(2,39) = 3.12 (p = .057)) with a significant difference between 1PC and 3PR conditions. Specifically: in the first-person interaction condition, the MDS elicited greater overall PFC activity resulting in a net positive MDS-PR2 difference; whereas in the 3rd-person condition, the PR2 elicited greater activity resulting in a net negative MDS-PR2 difference. In the 1PR condition, the MDS-PR2 difference trended towards -.5, falling between the mean differences of the other two conditions (see Figure 7).

5. DISCUSSION

The polite communication strategy (indirect speech) improved ratings of likability and considerateness, and reduced ratings of aggression compared to the communication strategy without any politeness modifiers, consistent with the findings of [33]. However, the effect on considerateness (seen in the interaction effect with interaction modality) was only significant in the 3rd-person modality (3PR). This suggests the effects of politeness modifiers do not necessarily persist in 1st-person human-robot interactions. Participant preferences also substantiate this interpretation, showing affinity for indirect speech *only* in the 3PR condition. Moreover, the preferences for communication condition seem to reverse in the 1st-person interaction conditions, with a slight affinity for *direct* speech. Together, the results show that conclusions from HRI studies that use human subjects solely as interaction observers rather than interaction participants cannot be automatically applied to human-robot interaction scenarios. Hence, it is not only important, but necessary to conduct actual human-robot *interaction* studies as we are ultimately not so much interested in human perceptions as interaction observers, but as interaction participants.

Regarding the influences of appearance, the MDS robot helper was perceived as significantly more human-like but also significantly more eerie than the PR2, both as expected. The difference in human-likeness seemed primarily important when a female synthetic voice was used in combination with the less human-like PR2. The female-voiced PR2 reduced ratings of likability/considerateness and increased perceptions of difficulty. However, these effects might be due more to the mismatch in the relatively male or androgynous appearance of the PR2 with a female voice (e.g., [27]. Although human-likeness did not show effects on perceptions of politeness, the MDS received significantly higher ratings of eeriness which may influence the enjoyment/success of general HRI in other manners (e.g., preferences for future interaction) than measures assessing the agent's politeness. Participant preferences may be revealing of this effect, as 1PC participants strongly preferred the PR2 robot (10/15 participants) over the MDS, whereas the remote condition participants (1PR, 3PR) showed relatively equal preferences for both.

The significant differences in prefrontal hemodynamics in response to the two robots according to the interaction condition further underscores a possible effect of human-likeness and the corresponding perception of eeriness. In the 1PC condition, participants showed markedly greater activity in response to the MDS robot as compared to their level of neural activity in response to the PR2. As prefrontal hemodynamics have been shown to reflect negatively-valenced affect (i.e., [1, 18, 30, 31, 34]), this suggests an emotional response may have been evoked in participants directly interacting with the very human-like MDS. Whereas participants in the remote conditions (1PR, 3PR) showed activity differences closer to zero. Hence, in combination with the subjective responses, these findings suggest there may be emotion-regulatory mechanisms evoked when directly interacting with a co-located, humanoid robot. Whereas, in a removed context such as that of observing video of the two – much like viewing a movie – the fear or anxiety elicited by the MDS' eerie appearance may have been reduced or non-present. The implication here is the same as above: in the context of politeness, it is critical to evaluate modulatory dimensions like robot appearance in real HRI experiments where human subjects *participate* in interactions with co-located robots, for otherwise important effects of such dimensions might be missed or misinterpreted.

Limitations. These results suggest that indirect speech acts – in the context of help-giving – are most appropriate when *observing* human-robot interactions. Whereas in *direct interactions*, although indirect speech improves perceptions of likability and aggression, speech efficiency (directness) and the human-likeness of the robot help-giver are of greater importance. There are several limitations to this study and

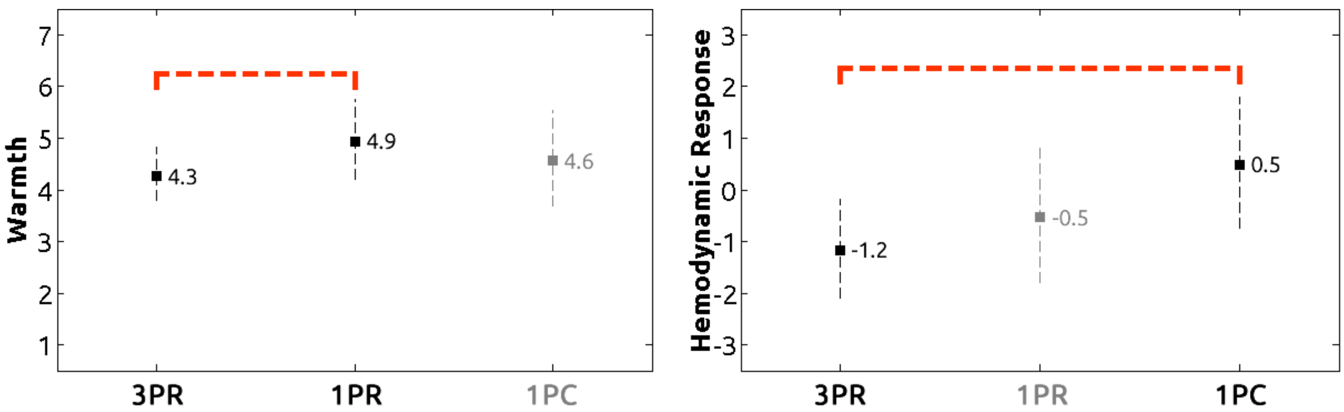

Figure 7: Main effects of *Interaction* modality. Left – the first-person perspective significantly increases ratings of warmth compared to the 3PR condition. Right – a net positive hemodynamic change is observed in the 1PC condition and (significantly lower) net negative change is observed for 3PR (units are micromolar).

its applicability, however. For instance, in situations in which the robot is not giving advice, but rather, receiving it, indirect speech may be more appropriate so as to reflect the superiority of the human help-giver. Whereas, in tasks in which both participants (robot and human) are equally knowledgeable, indirect speech may facilitate collaboration.

Moreover, the lack of nonverbal cues and affective displays (and as a result, the pacing of interactions based solely on verbal cues), as well as unsampled factors of the interactions are considerable limitations of the present work. For instance, the perception of the robots as gendered could indeed influence several of our dependent variables. In particular, it offers an explanation for the effect arising from the female voice-PR2 pairing (that the PR2 may have been perceived as being male in gender). We did not sample this factor here (as to whether the robots or their voices appeared gendered), which does not impact the comparison with the results of [33]; however, it may be an another important modulatory factor. Additionally, it is likely that the results are affected to some extent by the pacing of the interactions, which were triggered solely based on verbal cues (rather than some verbal and nonverbal combination). The observed difference in preferences between 1PC and 1PR conditions despite equal pacing as well as the lack of one between 1PR and 3PR, suggest it is not a major confound when considering differences between interaction modalities. Given the range of nonverbal behaviors and differences in the two robots abilities to execute them, we chose here to keep the robots stationary in order to standardize interactions across the two helpers, but this exclusion warrants further investigation using a combination of verbal and nonverbal behaviors to disentangling their potential contributions.

6. CONCLUSIONS

The aim of this study was to investigate the effects of robot communication strategies such as direct versus indirect speech on humans in advice-giving contexts. Here we specifically included three additional factors – robot appearance, presence, and interaction directness – as they have been shown to modulate the effectiveness of human-robot interactions. The results demonstrate that all four dimensions can have an important influence on perceptions of robot behavior in advice-giving contexts and that prior results regarding indirect speech acts obtained from experiments with human observers watching videos of human-robot interactions do not transfer to actual interaction contexts. Specifically, our results are consistent with prior findings that showed that, from the third-person perspective, a robot's use of polite speech seemed more considerate and likable, and less controlling. But we also found that preferences for indirect speech are not present in first-person interactions. In addition, increasing the presence and human-likeness of the robot engages greater neural activity and severely decreases preferences for future interactions. Lastly, a mismatch in voice and robot appearance results in decreased ratings of liking and increased perceptions of task difficulty. These findings confirm that while politeness modifications (as expressed via indirect speech acts) are important in observational settings of advice giving, other situational factors such as robot appearance and interaction distance might be of greater relevance to the design of effective robotic helpers. Finally, our experimental results also have methodological consequences for the field of HRI in that they suggest that at least for some tasks and contexts actual human-robot interaction experiments, rather than studies with human observers watching pre-recorded human-robot interactions, are necessary for untangling the complex interactions among the many important modulatory factors.

7. ACKNOWLEDGMENTS

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