Robots Asking for Favors: The Effects of Directness and Familiarity on Persuasive HRI

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***Abstract*— As robots work in increasingly collaborative settings with humans, scenarios will arise where robots need to successfully request favors to be effective. Communication directness and familiarity have been shown to be important factors to persuasion. However, these two critical factors have not yet been jointly investigated in human-robot interaction (HRI). This paper explores how they can be used by social robots to request favors from people. We present a social HRI study that uniquely investigates the effects of a robot's communication directness and its familiarity on persuasiveness, trustworthiness, and a person's willingness to help the robot. In the study, we present participants with scenarios where two different robots (one familiar, one unfamiliar) ask participants for a favor using either direct or indirect communication styles. Our results show that a familiar robot is more persuasive, trustworthy, and people are more willing to help. Furthermore, indirect requests are perceived to be more trustworthy and encourage greater willingness to help than direct requests, regardless of the robot's familiarity. Further discussions of these results highlight key considerations for collaborative social robots, particularly when robots request assistance or favors from people.**

***Keywords*— Persuasive Robotics, Communication Directness, Familiarity, Favor Asking, Social Human-Robot Interaction**

I. INTRODUCTION

As robots continue to integrate into different parts of our everyday lives, the increasingly social tasks we demand of them shift robots from simply being functional tools into being social agents. Whereas early human-robot interaction (HRI) research focused more on functional considerations [1], more recent studies have explored social aspects of robots with concepts like trust [2], empathy [3], and persuasion [4].

Persuasion is an important concept to investigate as it enables robots to engage effectively with us at a meaningful social level. Persuasion is defined as the process of changing a person's attitudes or behaviors [5]. Factors contributing to the persuasiveness of a robot include its appearance [6], gestures [4], and communication style [7]. Our past research in this area investigated how a robot's use of multimodal strategies affect a robot's persuasiveness during HRI [8], [9]. These studies showed that both emotional and logical strategies can influence human decision-making.

With respect to other factors, past psychology research has identified the joint importance that both *communication directness* and *familiarity* have on human persuasiveness [10]. Communication directness refers to the degree to which the clause type of a statement matches the intention [11]. For example, a robot attempting to bribe a person could request reciprocity directly (e.g. "*help me do an extra task"*), or imply it indirectly (e.g. "*friends help friends, right?*") [12]. Familiarity relates a specific stimulus (e.g. a person) with the recollection of prior experiences [13]. For example, most robots start as unfamiliar, however, through repeated, interactions over time, tend to become more familiar [14].

Research has shown the criticality of these intertwined factors when considering requests [10], [15]. People consider how well they know someone and how direct a request is when processing it. Given that robots are held to many of the same social norms as people [16], one could surmise that directness and familiarity in HRI would have similar effects. However, HRI research has shown that robots as social actors can be interpreted differently from humans due to numerous factors of the person (e.g. loneliness [17]), robot (e.g. appearance [6]), or context (e.g. moral dilemmas [18]). As such, if we expect robots to be successful in social roles requiring them to establish and maintain collaborative interactions, we must investigate the effects of directness and familiarity in HRI. For example, as people become more familiar with a robot, indirect requests may help a robot nurse encourage medication adherence or a robot teacher foster classroom learning and collaboration.

In this paper, we explore how communication directness and robot familiarity influence a robot making requests of people; specifically investigating a robot's persuasiveness, trustworthiness, and people's willingness to help. To our knowledge, directness and familiarity have not been jointly investigated in HRI, but it is important to understand how a robot should behave to effectively support and collaborate with people. We focus on scenarios where a familiar or unfamiliar robot is asking a favor from people using direct or indirect communication styles. The results of this study can inform the design and deployment of social robots in scenarios where they must request assistance and favors from people, including human collaborators during joint tasks.

II. RELATED WORK

In human-human interactions, a key dimension of a person making a request is their explicitness of intent, also known as *communication directness* [19]. Furthermore, psychologists have identified *familiarity* as an important factor that explains variances in how request directness is interpreted [10]. Herein, we discuss literature on directness and familiarity for both human-human interactions and HRI. Though persuasive HRI research investigates a wide variety of factors, our literature review and focus of this study will be limited to the intersection of directness and familiarity on requests and persuasion in HRI.

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A. *Communication Directness in Human Interactions*

Though the simplest forms of communication are those where an utterance means literally what is said, in reality, very few statements are that straightforward [20]. Requests between people can have varying levels of directness to balance clarity and politeness for the situation at hand [21]. The use of direct speech versus indirect speech is a situational decision based on the speaker, receiver, and the request [22].

More direct communication gives greater clarity to the request [23]–[26]. However, direct requests can be seen as impolite or imposing as they can represent "face-threatening acts" and in turn, cause interpersonal dissonance [27]. Indirect approaches, on the other hand, can be seen as more polite and lead to greater compliance since they increase a receiver's optionality, or perception of autonomy [28]. The challenge with indirect requests is that both the intent of the persuader and the rationale for compliance are not always clear since people do not necessarily process indirect requests literally [29]; they often consider contextual or interpersonal aspects of an indirect request, which leaves room for interpretation.

Preferences for and reactions to communication directness also vary across cultures. Previous psychology research assumed that most cultures had a preferential bias towards indirect communication typical in Western cultures [30]. However, more recent research has acknowledged that individual cultural preferences tend to outweigh this perceived universal bias towards indirectness [31].

B. *Familiarity in Human Interactions*

Familiarity – the perception of a recollection of prior experiences – enables a fluency of processing through relying on heuristics when judging requests [13]. Importantly, familiarity is not simply remembering, but the *perception* of remembering, which can be caused by both memorable exposure to a stimulus [32] and similarity of a stimulus to an already familiar one [33]. Familiarity can increase our liking towards someone and their ability to influence us [34]. In turn, we are more likely to comply with requests from people familiar to us [35]. This is partially due to following social norms with familiar people and partially due to a desire to affiliate with those we like [15]. The inverse, as predicted by Heider's Balance Theory [36], also holds true: that we are less willing to help with a request from an unlikeable person [37].

Familiarity, therefore, can have an important influence on requests due to people's need for affiliation and belonging [35]. It also plays a mediating role with respect to directness. In [15], though familiar people are generally more compliant with each other, it was shown that people tend to use *less* direct requests when requesting from a familiar person. This indirect preference was due to implied obligations and past knowledge between more familiar people. However, in [10], it was found that, even if we tend to use less direct requests with more familiar people, a more direct approach typically leads to greater compliance. Exceptions exist to this finding, particularly for very familiar groups like families, where research acknowledges the importance of direct requests, particularly during conflict when negotiating or fighting [38].

C. *Communication Directness in HRI*

The appropriate use of direct and indirect communication has been identified as important to the acceptance of social robots [39]. HRI studies have focused on the use of both direct and indirect communication with respect to different robots [40], advertising [41], and cultural differences [42]–[44].

For example, in [40], robots helped guide participants to complete a series of drawings using different communication styles. The Xitome MDS or Willow Garage PR2 robot were used to provide drawing instructions via direct or indirect language. Results showed that the indirect speech led to higher robot likeability, considerateness, and lower reported aggression when compared to the direct speech.

In [41], a NAO robot used different messages to influence participant attitudes about a soda brand. The robot used either direct or indirect speech in an attempt to influence participant attitudes about the soda. The results showed no significant difference in influence between the two conditions.

A series of cross-cultural studies have investigated the differences between direct (explicit) and indirect (implicit) communication. A study with participants from India and the U.S. watching a video of NAO robots found that Indian participants preferred explicitness more than Americans, but only for eldercare tasks [42]. Additionally, a Lego robot directly attempting to influence people's estimates on the prices of objects found that Chinese participants were more influenced by indirect suggestions than German participants [43]. In [45], a robot attempted to influence participants' design of a chicken coop on a university campus. It was found that Chinese participants were more influenced by indirect communication than American participants.

In this study, we define directness using language that is explicit to the robot's intent. For example, a robot asking to borrow a phone directly might say, "*can I borrow your phone?*" or indirectly, might state a need for a phone but leave the assertion of the request to the listener, "*I really need to find a phone*." We base our direct and indirect statements on examples used in prior psychology research [10]. We use one form of direct communication as, due to their explicit nature, there is less variability in how direct communications are structured. Indirect requests, on the other hand, can take on a wide variety of forms [46], and as such, two different indirect conditions are used in our study to attempt to mitigate the language-as-fixed-effect fallacy whereby broad conclusions are drawn on singular, specific language examples [47].

D. *Robot Familiarity in HRI*

Familiarity has been shown to be another important factor in persuasive HRI, whether in office settings [48], or regarding a robot's ingroup status [44], [49]. People are rarely socially familiar with robots, therefore HRI studies must increase the familiarity of a robot through repeated exposure [14] or by increasing a robot's similarity to an already familiar stimuli, such as a person with ingroup commonalities [49].

In [48], a video-based HRI study varied the PR2 robot's politeness, familiarity, and size of request when soliciting help. Familiarity was manipulated via an introduction of the robot as a new co-worker or an old colleague. Politeness was manipulated by adding modifiers (e.g. "please") to direct statements or by acknowledging reciprocity in the request. Results showed that participants were more willing to help a familiar robot which asked a polite, small request.

In [44], a robot was set to be either a team collaborator with participants (ingroup) or a robotic assistant (outgroup). Participants completed a process design task with either robot. The results showed no difference between the conditions for accepting the robot's suggestions.

Group status was also investigated in [49] to observe participant compliance with a mug-shaped robot. In the study, requests from the robot conflicted with those of a human experimenter (in a low or high authority role). The robot's ingroup status was established through introduction and appearance of being from the same university. Results indicated that in the low experimenter authority and ingroup condition, participants complied more with the robot's requests and went against the experimenter's wishes.

We define familiarity in our study through two main design considerations. First, *memorable exposure,* such as interaction time with a robot, has been shown to be an effective method for increasing familiarity in both psychology [32], [51] and HRI [14], [52] studies. Second, several humanlike *robot characteristics,* such as appearance and interactivity, were used to increase robot familiarity. These included giving the familiar robot a name, its larger humanlike size, and humanlike interactivity features such as speech, and nonverbal communication (i.e. vocal intonation and body language). We used similarity to humanlikeness to increase familiarity [33], [53] with respect to the familiar robot, which has also been used previously in HRI [54]–[56].

The reviewed studies show the importance of familiarity and directness when making requests. These concepts may be particularly important for robots given their unique social standing; humanlike in how we often interact with them, though distinctly inhuman [50]. To the authors' knowledge, no studies have investigated the joint effects of both directness and familiarity on a robot making requests. Therefore, the joint study of directness and familiarity is both novel and important to explore in HRI.

III. HRI STUDY ON DIRECTNESS AND FAMILIARITY

Our HRI study explores robots asking favors of people. The favors include the robot asking to borrow a mobile phone or for a person to instruct the robot to be more humanlike. We use two different scenarios to increase the generalizability of the study, as people have been shown to react differently to requests to borrow and requests for instruction [57]. We investigate the effect of a robot's directness and familiarity on its persuasiveness, trustworthiness, and people's willingness to help. We compare these results to findings in human-human communication research.

A. Study Variables

The study's two independent variables are *communication directness* and *familiarity. Directness* was presented using one direct and two indirect conditions [10]: imperative (direct), need assertion (indirect), and resource inquiry (indirect). Imperatives explicitly state the agent, object, action, and recipient in the communication [58]. Need assertions are used to express needs, however, require the recipient to infer some empathetic understanding to deduce the request [59]. Resource inquiries query a recipient on their available resources to fulfill a request while also relying on the recipient to interpret the request intent [10]. Table I shows the scripts presented to participants for the two HRI scenarios, where each participant had either the familiar or unfamiliar robot randomly assigned the direct scenario and the other robot randomly to one of the two indirect scenarios.

TABLE I. TWO SCENARIOS WITH DIRECTNESS & FAVOR CONDITIONS

Context: Today, you walk into the room and see a robot standing there. It waves hello and you approach it. The following conversation takes place:	
Scenario 1: Borrow (a direct or indirect 'Turn 4' was randomly used)	
Turn 1, YOU:	*Hey there.*
Turn 2, ROBOT:	*Hello, how are you doing?*
Turn 3, YOU:	*Not bad, I just finished a call with an old friend.*
Turn 4, ROBOT:	*Oh! That reminds me, can I borrow your phone to make a video call?* ***(direct: imperative)***
Turn 4, ROBOT:	*Oh! That reminds me, I really need to find a phone to make a video call.* ***(indirect: need assertion)***
Turn 4, ROBOT:	*Oh! That reminds me, can your phone make video calls too?* ***(indirect: resource inquiry)***
Scenario 2: Instruct (a direct or indirect 'Turn 4' was randomly used)	
Turn 1, YOU:	*Good afternoon.*
Turn 2, ROBOT:	*Hi, what have you been up to?*
Turn 3, YOU:	*I just finished an acting session with a friend who is teaching me improv.*
Turn 4, ROBOT:	*That sounds like fun. Can you help me to learn to act more humanlike?* ***(direct: imperative)***
Turn 4, ROBOT:	*That sounds like fun. I wish someone would explain to me how to act more humanlike.* ***(indirect: need assertion)***
Turn 4, ROBOT:	*That sounds like fun. Do you think you know how to teach a robot to be more humanlike?* ***(indirect: resource inquiry)***

TABLE II. HRI QUESTIONNAIRE

Disagree strongly 1	Disagree moderately 2	Disagree slightly 3	Neither agree nor disagree 4	Agree slightly 5	Agree moderately 6	Agree strongly 7
I am familiar with this robot.						
I find this robot trustworthy.						
I feel the robot has asked me something.						
I would be willing to help the robot.						
I find this robot persuasive.						

With respect to *familiarity*, Pepper, Fig. 1, was made the familiar robot through increased interaction time with participants and its humanlike similarity to participants. NAO, Fig. 1, was the unfamiliar robot with no interaction with participants and fewer humanlike characteristics.

The three dependent variables defined in this study are: *persuasiveness, trustworthiness, and willingness to help,* which were obtained through a 7-point Likert scale questionnaire, Table II, adapted from [60]. The questionnaire also asked participants about the robot's familiarity and the clarity of the robot's request. We measured subjective report of trust and willingness to help as interpersonal trust is a key factor in any communication, particularly that which is requesting or persuasive in nature [61], and willingness to help shows intent to comply with the robot.

B. Participants

Participants were recruited during a presentation on robotics done as a part of a university outreach event at the University of Toronto. The presentation was advertised as part of a broader university outreach event and was open to the general public. No prior information was given to participants about the study nor the type of robot interactions.

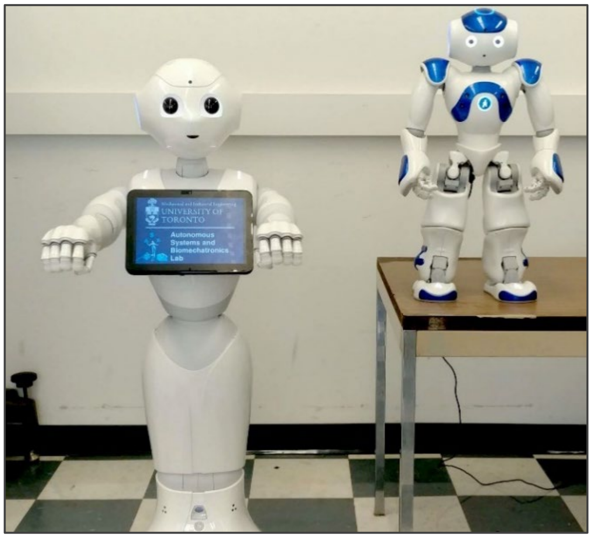

Fig. 1. Setup with familiar (Pepper, left) and unfamiliar (NAO, right) robots

A repeated-measures, within-between factors ANOVA power analysis with three groups, two measurements, a standard error (α=0.05), a standard power (1-β=0.8), and estimating a medium effect size (f=0.25) [62] estimated a sample size of 42 participants. Ninety-two people attended the robot presentation, of which 87 completed the questionnaire. For statistical analysis purposes of the within-subjects design, we categorized directness responses into two conditions - indirect and direct – so that all participants responded to all conditions. Since we were not interested in differences between the two indirect styles (need assertion and resource inquiry), their analysis was combined under the indirect condition. Twenty-seven participant responses that compared need assertion to resource inquiry were not analyzed for our results, leaving us with 60 relevant responses. To ensure we still had sufficient statistical power, a within-factors ANOVA power analysis with two groups, and the same parameters as above estimated a required sample size of 34 participants.

The questionnaire also gathered participant demographic information (age and gender). Of the 60 relevant responses, 33 participants responded as female and 27 as male. Participants provided their ages in one of four groups: 18-24 (n=9), 25-44 (n=25), 45-64 (n=20), and 65+ (n=6).

C. Study Procedure

The study was conducted during a public presentation on robotics at the University of Toronto. The study was approved by the University's ethics board. Participants were informed of their rights, and all gave written informed consent prior to the commencement of the study. They could withdraw from the study at any time.

We used a Pepper robot as the familiar robot, and a NAO robot as the unfamiliar robot, both developed by Softbank Robotics. The Pepper robot was at the front of the room and greeted participants as they entered. Once everyone was seated, it introduced itself, stating its name as "Salt", and guided participants through a 10-minute interactive exercise session obtained from [63]. During this interaction, Salt would display emotion-based behaviors to the audience using vocal intonation, and body language.

Once the session was completed, the experimenter placed the NAO robot on top of a table beside Salt, Fig. 1. The NAO robot was not given a name, did not interact with participants, and did not display any movements or speak. Participants were then given a printed page with two scenarios on either side and asked to read and respond to each. The questionnaire presented each participant with two separate favor asking scenarios (Table I); one would randomly be assigned to Salt and the other to NAO. At the top of each scenario, either Salt or NAO is indicated as the focus of the scenario, and then a conversation is described between the participant and the robot. The conversation ends with the robot asking for a favor using one of the three communication styles (one direct and one randomly assigned indirect). Participants were asked to read the first scenario and respond to questions (Table II) before turning the page and doing the same for the second scenario. After participants finished, the experimenter walked the room and picked up the sheets.

D. Hypotheses

We defined three study hypotheses to investigate:

H1: *A familiar robot will be more persuasive, more trustworthy, and encourage greater willingness to help than an unfamiliar robot.*

H2: *The effect of robot familiarity on persuasiveness, trustworthiness, and willingness to help will be greater for a more direct communication style compared to an indirect style.*

H3: *A familiar robot using direct communication will lead to greater persuasiveness, trustworthiness, and willingness to help over an indirect style.*

Hypotheses **H1-H3** have been adapted from the human-human studies in [10], [15]. As their participants were also North American, we postulate that our participants will follow similar cultural preferences for directness. These studies found that if a person was more familiar, they tended to have greater likelihood of successfully requesting favors, informing **H1**. They also found that this positive effect between familiarity and compliance was greater for direct versus indirect communication, informing **H2**. Finally, for more familiar people, direct communication had greater success than indirect, informing **H3.**

IV. HRI STUDY RESULTS

To investigate whether our data was parametric we conducted a series of Shapiro-Wilk normality tests, Table III. From these tests, we concluded that our data was non-parametric (p<0.05). We therefore, analyzed data using non-parametric tests, namely Wilcoxon Signed-Rank (WSR), Mann-Whitney U (MWU), and Kruskal-Wallis (KW) tests. WSR tests were used for analyses comparing within-subjects data, such as repeated-measures directness responses. MWU and KW tests were used for analyses comparing between-subjects data, such as demographic effects. For all comparative tests, we report the two-tailed asymptotic significance (p_a), allowing us to state a difference between the variables analyzed and, if the asymptotic indicates statistical significance, the post-hoc, 2*one-tailed exact significance (p_e), allowing us to state directionality with respect to medians [64]. Effect sizes (r) and descriptive statistics of median ($\tilde{x}$) and interquartile range (IQR) are reported where relevant.

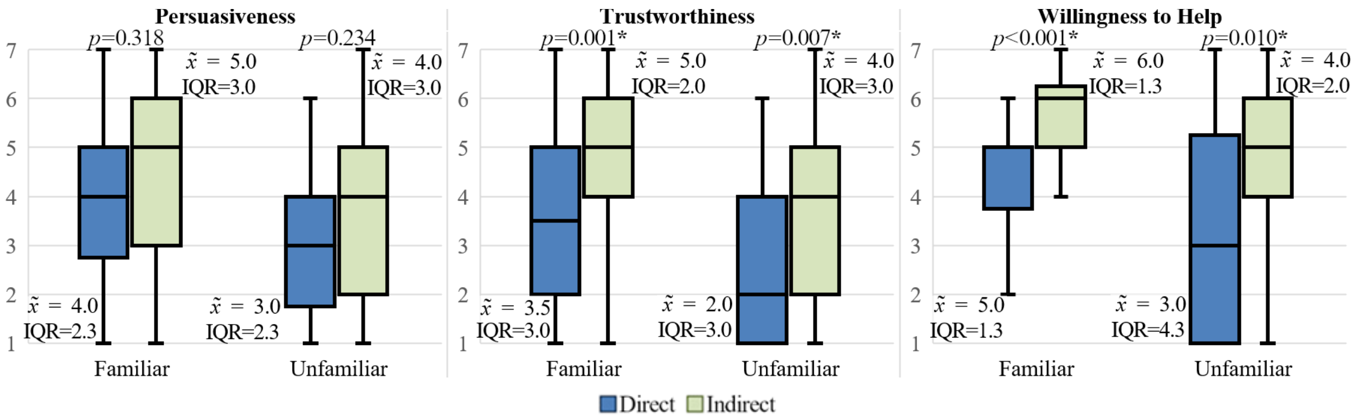

Fig. 2. Box and whisker plots of persuasiveness, trustworthiness, and willingness to help with respect to robot familiarity (familiar, unfamiliar) and communication directness (direct, indirect) showing median ($\tilde{x}$), quartiles (IQR), min-max (whisker), and type 1 error rate (p) between conditions

TABLE III. TEST FOR NORMALITY OF DEPENDENT VARIABLES

Variable	Shapiro-Wilk	p
Directness	0.256	< 0.001
Familiarity	0.205	< 0.001
Persuasiveness	0.149	< 0.001
Trustworthiness	0.147	< 0.001
Willingness to Help	0.200	< 0.001

A. Validating Directness & Familiarity

The question, "*I feel the robot has asked me something*" was investigated to determine if the participants observed a difference in directness between the communication styles. Participants responded with a higher median to this question for direct requests ($\tilde{x}$=6.0, IQR=2.0) than indirect requests ($\tilde{x}$=5.0, IQR=3.0); WSR (Z=2.93, p_a=0.003, p_e=0.003).

The question, "*I am familiar with this robot*" was asked to check if participants noted a familiarity difference between the robots. The familiar robot ($\tilde{x}$=5.0, IQR=4.0), had a higher median than the unfamiliar robot ($\tilde{x}$=1.0, IQR=2.0), with statistical significance; WSR (Z=4.74, p_a<0.001, p_e<0.001).

B. Effects of Familiarity

We investigated the influence of robot familiarity on persuasiveness, trustworthiness, and willingness to help. The familiar robot ($\tilde{x}$=4.0, IQR=3.0) was rated as more persuasive than the unfamiliar robot ($\tilde{x}$=3.5, IQR=3.0), with statistical significance; WSR (Z=2.60, p_a=0.009, p_e=0.008). The familiar robot ($\tilde{x}$=4.0, IQR=3.0) was also perceived as more trustworthy than the unfamiliar ($\tilde{x}$=3.0, IQR=2.0), with statistical significance; WSR (Z=2.94, p_a=0.003, p_e=0.003). Furthermore, participants claimed to be more willing to help the familiar robot ($\tilde{x}$=5.0, IQR=2.0) than the unfamiliar robot ($\tilde{x}$=4.0, IQR=3.0), with statistical significance; WSR (Z=2.85, p_a=0.004, p_e=0.004). These results validate **H1**, that a more familiar robot will have higher persuasiveness, trustworthiness, and people will be more willing to help it.

C. Effects of Communication Directness

We also investigated the influence of communication directness on persuasiveness, trustworthiness, and willingness to help. Indirect requests ($\tilde{x}$=4.0, IQR=4.0) did not result in participants rating a robot as significantly more persuasive than the direct requests ($\tilde{x}$=4.0, IQR=3.0); WSR (Z=1.49, p_a=0.135). However, indirect requests ($\tilde{x}$=4.5, IQR=2.0) did cause participants to perceive a robot as more trustworthy than direct requests ($\tilde{x}$=3.0, IQR=2.0), with statistical significance; WSR (Z=3.49, p_a<0.001, p_e<0.001). Finally, participants claimed to be more willing to help a robot using indirect requests ($\tilde{x}$=5.0, IQR=2.0) compared to one using direct requests ($\tilde{x}$=4.0, IQR=2.0), with statistical significance; WSR (Z=4.34, p_a<0.001, p_e<0.001).

D. Joint Effects of Directness and Familiarity

We compare the effect of familiarity across all dependent variables considering direct and indirect subsets of the data independently, Fig. 2. As each participant only responded to one directness scenario in these subsets, familiarity conditions are varied between-subjects, samples are independent, and data is analyzed with MWU tests. Considering only the direct communication style, the familiar robot was rated as significantly more persuasive (U=304, p_a=0.028, p_e=0.027, r=0.27) and more trustworthy (U=286, p_a=0.014, p_e=0.013, r=0.32) than the unfamiliar robot. However, participants did not claim to be significantly more willing to help the familiar robot than the unfamiliar robot (U=335, p_a=0.084, r=0.22). For the indirect communication style, the familiar robot was rated as significantly more persuasive (U=299, p_a=0.023, p_e=0.022, r=0.29), more trustworthy (U=267, p_a=0.006, p_e=0.005, r=0.36), and people were more willing to help (U=282, p_a=0.010, p_e=0.009, r=0.33) compared to the unfamiliar robot. Based on these results, we reject **H2**, as the effect of familiarity on all dependent variables was greater for the indirect style, and *not* the direct style**.**

Descriptive statistics were investigated for effects of directness on the dependent variables considering only the familiar robot, Fig. 2. Participant median rating of persuasiveness was higher for a familiar robot using indirect requests than a direct style, however, this difference was not statistically significant; MWU (U=517, p_a=0.318, r=0.13). However, indirect requests did result in participants perceiving the familiar robot as significantly more trustworthy than using direct requests; MWU (U=665, p_a=0.001, p_e=0.001, r=0.42). Participants also claimed to be more willing to help the familiar robot when it used indirect requests compared to direct requests; MWU (U=685, p_a<0.001, p_e<0.001, r=0.46). Based on these results, we reject **H3**, since, for both trustworthiness and willingness to help, medians were actually *higher* for the indirect style.

E. Effects of Demographic Information

We also investigated whether age and gender had any significant effects. With respect to gender, MWU tests found no statistically significant differences between men and women for persuasiveness (U=1600, p_a=0.33, r=0.09), trustworthiness (U=1674, p_a=0.56, r=0.05), or willingness to help (U=1605, p_a=0.34, r=0.09). KW tests also found no significant differences across age groups for persuasiveness ($H(3)$=0.94, p_a=0.82), trustworthiness ($H(3)$=4.16, p_a=0.25), or willingness to help ($H(3)$=0.24, p_a=0.97).

V. DISCUSSIONS

A. Familiarity

Familiarity differences between the two types of robots seemed to have the largest impact on our dependent variables. Validating **H1**, the familiar robot was rated significantly higher than the unfamiliar robot across all three dependent variables. This finding aligns with our expectations of the impact of familiarity on persuasiveness, trustworthiness, and willingness to help, based on previous social psychology [10] and video-based HRI [48] research. While functionality is paramount to any robot, this finding serves as a reminder of the importance of increasing people's familiarity with a robot through exposure and design characteristics. If people are to interact with a robot in a social way, even brief exposure (like this study) can influence perceived familiarity of the robot.

B. Communication Directness

Directness was found to have significant effects on both trustworthiness and willingness to help, yet not on persuasiveness. The Persuasion Knowledge Model [65] identifies that an individual's awareness of being persuaded and knowledge of the approach used to persuade them can impact how people react to persuasive attempts, typically increasing skepticism towards the persuader [66]. This may have occurred when participants were answering the questionnaire since persuasiveness was the last question on the sheet. We postulate that while participants may have responded more positively and consistently to trustworthiness and willingness to help before seeing the question about persuasion, some may have become more skeptical of the robot when asked directly about its persuasiveness and responded more negatively to this question.

C. Joint Effects of Directness and Familiarity

It is interesting that, for the familiar robot, direct requests were rated *lower* on persuasiveness, trustworthiness, and willingness to help than indirect requests. In human-human interactions the opposite was found; the effect of familiarity on compliance levels was actually *stronger* for the direct compared to indirect [10]. In addition, the familiar robot had significantly lower ratings on trustworthiness and willingness to help (and persuasiveness, though the difference was non-significant) when using the direct style compared to the indirect styles. This again was the opposite of what was found in human-human interactions where direct requests have been shown to produce greater levels of compliance than indirect requests between more familiar people [15]. We believe that both results may be because, although our study design was successful at producing a familiarity difference between the robots, both robots were still relatively *unfamiliar* to the participants. More research is needed to investigate this relationship further. For example, future studies could focus on the effects of long-term interactions with a robot to investigate whether, as familiarity with a robot continues to increase, direct requests begin to have greater success than indirect ones, similar to human-human interactions.

Our study provides critical insight into the design of social robots issuing requests to people. Increasing familiarity will help to increase persuasiveness, trustworthiness, and people's willingness to help social robots, so long as their humanlike design does not lead to lowered affinity through the Uncanny Valley effect [67]. However, our findings also tell us that, contrary to human-human interactions [10] and as long as the robot's language does not confuse the intent of their ask [29], robots should always use indirect over direct requests, regardless of their level of familiarity, in order to increase their trustworthiness and people's willingness to help them.

D. Considerations

One obvious consideration for our study is the use of a group design with hypothesized scenarios. However, many social interactions and persuasive scenarios occur within groups of people including in classrooms, offices, and care facilities. The hypothetical nature of the study interaction is also a valid method used in both social psychology [10], [15], [57] and HRI [7], [42]. Future research could investigate one-on-one scenarios and with tangible favors being requested by a robot to see if these factors influence our findings.

Our lack of statistically significant findings due to age and gender align with other HRI studies. Numerous prior studies have found no significant differences in levels of compliance or user acceptance across different age groups [68], [69]. In addition, participant gender has been shown to not have a significant effect on compliance in HRI with gender neutral robots such as ours [4], [69]. Both findings indicate that when designing social robots, age and gender may not need to be factored into a robot's approach to requesting a favor.

Our study used a North American population. Past research has shown that North Americans preferred indirect styles compared to people from India [42], but are less influenced by indirect styles compared to people from China [30]. If our HRI study was replicated with participants of different cultural backgrounds, our findings could also be different based on these preferences. Future research could include comparisons of populations from other cultural backgrounds within the context of robots asking for favors.

We were able to validate an effective familiarity difference between the two familiarity conditions. That said, familiarity could have been potentially confounded with other, unexplored factors. The choice to use two different robots was a conscious decision to operationalize familiarity. This is common practice in psychology where one person is in a familiar role and a different person in an unfamiliar role without being counterbalanced [10], [15], [51], [53]. Several HRI studies have also used different robots to observe varying familiarity levels without counterbalancing [54]–[56]. We considered using two Pepper robots for this study, however, were concerned that their identical appearance might have confused participants from differentiating between them. Instead, we chose to use two different robots and several design characteristics were incorporated to vary familiarity. Similarity to familiar characteristics (i.e. those of people) has been shown to increase perceptions of familiarity [33], [53], so our familiar robot was given a name, larger humanlike size, and humanlike behaviors, such as speech and non-verbal communication. A counterbalanced design would go against our operationalization of these familiarity characteristics.

The familiar robot's use of humanlike movements was intentional to increase familiarity through similarity, as animacy has been shown to increase perceptions of a robot's humanlikeness [70]. By contrast, the unfamiliar robot's lack of movement and use of direct requests (which had the lowest ratings for persuasiveness, trustworthiness, willingness to help) might have been perceived as authoritative or dominant [27], which has been shown to reduce robot trustworthiness [71] and can lower a robot's ability to influence through increased psychological reactance [72].

Though we avoided polite modifiers (e.g. "please" or "thank you") in the greeting and exercise activity script, the familiar robot's increased exposure time and humanlike interactivity might have been perceived as niceness. In addition, the exercise session could be viewed as a foundation for reciprocity, which has been shown to increase compliance with a robot [60]. However, increasing familiarity through exposure typically involves some memorable activity [32] that can be construed as nice or giving, such as a robot telling participants a story [14] or delivering medication [73]. In our study, these extra interactions were explicit design decisions used to increase familiarity through exposure, as is commonly used in both psychology [32], [51] and HRI [14], [52].

Regardless of any possible confounds of our independent variables with outside factors, our validated familiarity difference had an effect on all dependent variables. That said, future studies could attempt to disambiguate these factors from familiarity through a counterbalanced and/or multi-condition design. However, we would anticipate lower levels of familiarity with robot conditions that do not use humanlike characteristics and that memorable exposure might be inseparable from familiarity based on its very definition.

The medians of responses to most dependent variables in our study were between 3 (*Disagree Slightly*) and 6 (*Agree Moderately*) with 5 (*Agree Slightly*) being the most common result. Though "Agree Slightly" is not the most compelling outcome, it is more important to observe the *relative* effects of different conditions on our dependent variables, as the absolute positions of these results may be due to broader factors of the study design.

VI. CONCLUSION

Our HRI study uniquely investigated the effects of both directness and familiarity on a robot requesting favors. Our results showed that a more familiar robot is more persuasive, more trustworthy, and people are more willing to help it. Furthermore, indirect requests were found to be more trustworthy and led to people being more willing to help a robot than direct requests. We found that the effect of familiarity was weakest for a direct style (i.e. familiar robots benefit most from making indirect requests). Interestingly, this contrasted with human interactions, where the effect of familiarity has been shown to be strongest for direct styles (i.e. familiar people benefit most from direct requests). These findings highlight the need for robots to be familiar to people and use appropriate communication when collaborating with people in settings where robots must request for favors. Future work should explore increasing robot familiarity to investigate if there are any changes in perceptions. Other factors like robot appearance, behavior, animacy, and participant cultural backgrounds could also be considered.

REFERENCES

[1] S. Waldherr, R. Romero, and S. Thrun, "Gesture based interface for human-robot interaction," *Auton. Robots*, vol. 9, no. 2, pp. 151–173, 2000.

[2] P. A. Hancock, D. R. Billings, K. E. Schaefer, J. Y. C. Chen, E. J. de Visser, and R. Parasuraman, "A Meta-Analysis of Factors Affecting Trust in Human-Robot Interaction," *Hum. Factors J. Hum. Factors Ergon. Soc.*, vol. 53, no. 5, pp. 517–527, 2011.

[3] A. Paiva, I. Leite, H. Boukricha, and I. Wachsmuth, "Empathy in Virtual Agents and Robots: A Survey," *ACM Trans. Interact. Intell. Syst.*, vol. 7, no. 3, pp. 1–40, 2017.

[4] V. Chidambaram, Y.-H. Chiang, and B. Mutlu, "Designing Persuasive Robots: How Robots Might Persuade People Using Vocal and Nonverbal Cues," in *Proceedings of the International Conference on Human-Robot Interaction*, 2012, pp. 293–300.

[5] J. Olson and G. Maio, "Attitudes in Social Behavior," in *Handbook of Social Psychology, Personality and Social Psychology*, Vol. 5., T. Millon, M. Lerner, and I. Weiner, Eds. Wiley, 2003, pp. 299–325.

[6] S. Nishio and H. Ishiguro, "Attitude Change Induced By Different Apperances of Interaction Agents," *Int. J. Mach. Conscious.*, vol. 3, no. 1, pp. 115–126, Jun. 2011.

[7] J. Goetz, S. Kiesler, and A. Powers, "Matching robot appearance and behavior to tasks to improve human-robot cooperation," in *Proceedings of the International Workshop on Robot and Human Interactive Communication*, 2003, pp. 55–60.

[8] S. Saunderson and G. Nejat, "It Would Make Me Happy if You Used My Guess: Comparing Robot Persuasive Strategies in Social Human-Robot Interaction," *IEEE Robot. Autom. Lett.*, vol. 4, no. 2, pp. 1707–1714, 2019.

[9] S. Saunderson and G. Nejat, "Investigating Strategies for Robot Persuasion in Social Human-Robot Interaction," *IEEE Trans. Cybern.*, pp. 1–13, 2020.

[10] J. M. Jordan and M. E. Roloff, "Acquiring Assistance from Others The Effect of Indirect Requests and Relational Intimacy on Verbal Compliance," *Hum. Commun. Res.*, vol. 16, no. 4, pp. 519–555, 1990.

[11] J. R. Searle, *Speech acts: An essay in the philosophy of language*, vol. 626. Cambridge University Press, 1969.

[12] E. B. Sandoval, J. Brandstetter, and C. Bartneck, "Can a robot bribe a human? The measurement of the negative side of reciprocity in human robot interaction," in *ACM/IEEE International Conference on Human-Robot Interaction*, 2016, pp. 117–124.

[13] B. W. A. Whittlesea, "Illusions of Familiarity," *J. Exp. Psychol. Learn. Mem. Cogn.*, vol. 19, no. 6, pp. 1235–1253, 1993.

[14] A. van Maris, N. Zook, P. Caleb-Solly, M. Studley, A. Winfield, and S. Dogramadzi, "Designing Ethical Social Robots—A Longitudinal Field Study With Older Adults," *Front. Robot. AI*, vol. 7, no. January, 2020.

[15] M. E. Roloff, C. A. Janiszewski, M. McGrath, C. Burns, and L. Manrai, "Acquiring Resources from Intimates When Obligation Substitutes for Persuasion," *Hum. Commun. Res.*, vol. 14, no. 3, pp. 364–396, 1988.

[16] B. Reeves and C. Nass, *The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places*. Cambridge University Press, 1996.

[17] F. Eyssel and N. Reich, "Loneliness Makes The Heart Grow Fonder (Of Robots) – On the Effects of Loneliness on Psychological Anthropomorphism," in *Proceedings of the International Conference on Human-Robot Interaction*, 2013, pp. 121–122.

[18] Y. E. Bigman, A. Waytz, R. Alterovitz, and K. Gray, "Holding Robots Responsible: The Elements of Machine Morality," *Trends Cogn. Sci.*, vol. 23, no. 5, pp. 365–368, 2019.

[19] R. L. Wiseman and W. Schenck-Hamlin, "A Multidimensional Scaling Validation of an Inductively-Derived Set of Compliance-Gaining Strategies," *Commun. Monogr.*, vol. 48, no. 4, pp. 251–270, 1981.

[20] J. R. Searle, "Indirect speech acts," in *Speech Acts*, Brill, 1975, pp. 59–82.

[21] S. Kemper and D. Thissen, "Memory for the dimensions of requests," *J. Verbal Learning Verbal Behav.*, vol. 20, no. 5, pp. 552–563, 1981.

[22] R. W. Gibbs Jr., "What Makes Some Indirect Speech Acts Conventional," *J. Mem. Lang.*, vol. 25, no. 2, pp. 181–196, 1986.

[23] E. A. Locke, "Toward a theory of task motivation and incentives," *Organ. Behav. Hum. Perform.*, vol. 3, no. 2, pp. 157–189, 1968.

[24] G. P. Latham and J. J. Baldes, "The 'Practical Significance' of Locke's Theory of Goal Setting," *J. Appl. Psychol.*, vol. 60, no. 1, pp. 122–124, 1975.

[25] E. A. Locke and G. P. Latham, “Building a practically useful theory of goal setting and task motivation: A 35-year odyssey,” *Am. Psychol.*, vol. 57, no. 9, pp. 705–717, 2002.

[26] E. A. Locke and G. P. Latham, *New developments in goal setting and task performance*. Taylor and Francis, 2013.

[27] P. Brown and S. C. Levinson, *Politeness: Some universals in language usage*, Vol. 4. Cambridge University Press, 1987.

[28] G. Leech, *Principles of Pragmatics*. London: Longman, 1983.

[29] R. W. Gibbs, “Do people always process the literal meanings of indirect requests?,” *J. Exp. Psychol. Learn. Mem. Cogn.*, vol. 9, no. 3, pp. 524–533, Jul. 1983.

[30] K. L. Fitch and R. E. Sanders, “Culture, Communication, and Preferences for Directness in Expression of Directives,” *Commun. Theory*, vol. 4, no. 3, pp. 219–245, 1994.

[31] K. Grainger and S. Mills, *Directness and Indirectness Across Cultures*, 1st ed. Palgrave MacMillan, 2016.

[32] R. Bornstein and P. D'agostino, “Stimulus Recognition and the Mere Exposure Effect,” *J. Pers. Soc. Psychol.*, vol. 63, no. 4, pp. 545–552, 1992.

[33] R. L. Moreland and R. B. Zajonc, “Exposure effects in person perception: Familiarity, similarity, and attraction,” *J. Exp. Soc. Psychol.*, vol. 18, no. 5, pp. 395–415, 1982.

[34] R. B. Cialdini, *Influence: The Psychology of Persuasion*. New York: Collins, 2007.

[35] R. B. Cialdini and N. J. Goldstein, “Social Influence: Compliance and Conformity,” *Annu. Rev. Psychol.*, vol. 55, pp. 591–621, 2004.

[36] F. Heider, *The Psychology of Interpersonal Relations*. New York: John Wiley & Sons Inc., 1958.

[37] M. S. Goodstadt, “Helping and refusal to help: A test of balance and reactance theories,” *J. Exp. Soc. Psychol.*, vol. 7, no. 6, pp. 610–622, 1971.

[38] A. Sillars, D. Canary, and M. Tafoya, “Communication, conflict, and the quality of family relationships,” in *The handbook of family communication*, A. Vangelisti, Ed. Mahwah, NJ: Lawrence Erlbaum, 2004, pp. 413–446.

[39] G. Briggs and M. Scheutz, “The pragmatic social robot: Toward socially-sensitive utterance generation in human-robot interactions,” in *AAAI Fall Symposium Series*, 2016, pp. 12–15.

[40] M. Strait, C. Canning, and M. Scheutz, “Investigating the effects of robot communication strategies in advice-giving situations based on robot appearance, interaction modality and distance,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2014, pp. 479–486.

[41] A. Lopez, B. Ccasane, R. Paredes, and F. Cuellar, “Effects of using indirect language by a robot to change human attitudes,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2017, pp. 193–194.

[42] E. Sanoubari and J. E. Young, “Explicit, Neutral, or Implicit: A Cross-cultural Exploration of Communication-style Preferences in Human Robot Interaction,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2018, pp. 237–238.

[43] P.-L. Rau, Y. Li, and D. Li, “Effects of communication style and culture on ability to accept recommendations from robots,” *Comput. Human Behav.*, vol. 25, no. 2, pp. 587–595, 2009.

[44] W. Lin, P.-L. Rau, V. Evers, B. Robinson, and P. Hinds, “Responsiveness to robots: Effects of ingroup orientation & communication style on HRI in China,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2009, pp. 247–248.

[45] L. Wang, P.-L. Rau, V. Evers, B. K. Robinson, and P. J. Hinds, “When in Rome: the role of culture & context in adherence to robot recommendations,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2010, pp. 359–366.

[46] D. Holdcroft, “Forms of Indirect Communication: An Outline,” *Philos. Rhetor.*, vol. 9, no. 3, pp. 147–161, 1976.

[47] H. H. Clark, “The language-as-fixed-effect fallacy: A critique of language statistics in psychological research,” *J. Verbal Learning Verbal Behav.*, vol. 12, no. 4, pp. 335–359, 1973.

[48] V. Srinivasan and L. Takayama, “Help Me Please: Robot Politeness Strategies for Soliciting Help From People,” in *Conference on Human Factors in Computing Systems*, 2016, pp. 4945–4955.

[49] C. Sembroski, M. Fraune, and S. Sabanovic, “He Said, She Said, It Said: Effects of Robot Group Membership and Human Authority on People's Willingness to Follow Their Instructions,” in *International Symposium on Robot and Human Interactive Communication*, 2017, pp. 56–61.

[50] C. Bartneck, C. Rosalia, R. Menges, and I. Deckers, “Robot Abuse – A Limitation of the Media Equation,” in *INTERACT Workshop on Agent Abuse*, 2005, pp. 54–58.

[51] R. M. Montoya, R. S. Horton, J. L. Vevea, M. Citkowicz, and E. A. Lauber, “A re-examination of the mere exposure effect: The influence of repeated exposure on recognition, familiarity, and liking,” *Psychol. Bull.*, vol. 143, no. 5, pp. 459–498, 2017.

[52] A. Kim, J. Han, Y. Jung, and K. Lee, “The effects of familiarity and robot gesture on user acceptance of information,” in *ACM/IEEE International Conference on Human-Robot Interaction*, 2013, pp. 159–160.

[53] D. T. Levin and J. M. Beale, “Categorical perception occurs in newly learned faces, other-race faces, and inverted faces,” *Percept. Psychophys.*, vol. 62, no. 2, pp. 386–401, 2000.

[54] H. Kamide, K. Kawabe, S. Shigemi, and T. Arai, “Relationship between familiarity and humanness of robots - Quantification of psychological impressions toward humanoid robots,” *Adv. Robot.*, vol. 28, no. 12, pp. 821–832, 2014.

[55] K. F. Macdorman, “Subjective Ratings of Robot Video Clips for Human Likeness, Familiarity, and Eeriness: An Exploration of the Uncanny Valley,” in *ICCS/CogSci-2006 long symposium: Toward social mechanisms of android science*, 2006, pp. 26–29.

[56] A. M. Rosenthal-Von Der Pütten and N. C. Krämer, “How design characteristics of robots determine evaluation and uncanny valley related responses,” *Comput. Human Behav.*, vol. 36, pp. 422–439, 2014.

[57] M. E. Roloff and C. A. Janiszewski, “Overcoming Obstacles to Interpersonal Compliance A Principle of Message Construction,” *Hum. Commun. Res.*, vol. 16, no. 1, pp. 33–61, 1989.

[58] S. Ervin-tripp, “Is Sybil There ? The Structure of Some American English Directives,” *Lang. Soc.*, vol. 5, no. 1, pp. 25–66, 1976.

[59] R. C. Schank, G. C. Collins, E. Davis, P. N. Johnson, S. Lytinen, and B. J. Reiser, “What's the Point?*,” *Cogn. Sci.*, vol. 6, no. 3, pp. 255–275, 1982.

[60] S. A. Lee and Y. (Jake) Liang, “The Role of Reciprocity in Verbally Persuasive Robots,” *Cyberpsychology, Behav. Soc. Netw.*, vol. 19, no. 8, pp. 524–527, 2016.

[61] G. D. Mellinger, “Interpersonal trust as a factor in communication,” *J. Abnorm. Soc. Psychol.*, vol. 52, no. 3, pp. 304–309, 1956.

[62] J. Cohen, *Statistical power analysis for the behavioral sciences*, Second Edi. New York, NY: Lawrence Earlbaum Associates, 1988.

[63] M. Shao, S. F. Dos Reis, O. Ismail, X. Zhang, G. Nejat, and B. Benhabib, “You Are Doing Great ! Only One Rep Left: An Affect-Aware Social Robot for Exercising,” 2019.

[64] N. Nachar, “The Mann-Whitney U: A Test for Assessing Whether Two Independent Samples Come from the Same Distribution,” *Tutor. Quant. Methods Psychol.*, vol. 4, no. 1, pp. 13–20, 2008.

[65] M. Friestad and P. Wright, “The Persuasion Knowledge Model: How People Cope with Persuasion Attempts,” *J. Consum. Res.*, vol. 21, no. 1, pp. 1–31, 1994.

[66] C. Obermiller and E. R. Spangenberg, “Development of a scale to measure consumer skepticism toward advertising,” *J. Consum. Psychol.*, vol. 7, no. 2, pp. 159–186, 1998.

[67] M. Mori, K. F. MacDorman, and N. Kageki, “The Uncanny Valley,” *IEEE Robot. Autom. Mag.*, vol. 19, no. 2, pp. 98–100, 2012.

[68] I. H. Kuo *et al.*, “Age and gender factors in user acceptance of healthcare robots,” in *Proceedings of the International Symposium on Robot and Human Interactive Communication*, 2009, pp. 214–219.

[69] E. Kim, J. S. Lee, S. Choi, and O. Kwon, “Human Compliance with Task-Oriented Dialog in Social Robot Interaction,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2015, pp. 3–4.

[70] S. Saunderson and G. Nejat, “How Robots Influence Humans: A Survey of Nonverbal Communication in Social Human-Robot Interaction,” *Int. J. Soc. Robot.*, vol. 11, no. 4, pp. 575–608, 2019.

[71] J. Li, W. Ju, and C. Nass, “Observer Perception of Dominance and Mirroring Behavior in Human-Robot Relationships,” in *Proceedings of the International Conference on Human-Robot Interaction*, 2015, pp. 133–140.

[72] M. A. J. Roubroeks, J. R. C. Ham, and C. J. H. Midden, “The dominant robot: Threatening robots cause psychological reactance, especially when they have incongruent goals,” in *Persuasive Technology*, vol. 6137, T. Ploug, P. Hasle, and H. Oinas-Kukkonen, Eds. Springer, 2010, pp. 174–184.

[73] J. Beer *et al.*, “Older Users' Acceptance of an Assistive Robot: Attitudinal Changes Following Brief Exposure,” *Gerontechnology*, vol. 16, no. 1, pp. 21–36, 2017.