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Perception of Power and Distance in Human-Human and Human-Robot Role-Based Relations

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***Abstract*—The use and interpretation of social linguistic strategies such as politeness is influenced by multiple factors, e.g., the speaker-hearer relation. Such relations influence an interlocutor's expectations regarding the interaction and thus also its perception. This makes speaker-hearer relations constituting a partner model highly relevant for the user experience in human-robot interaction as well. This paper presents a questionnaire-based study on the perception of human-robot relations in comparison to human-human relations across different roles (e.g., colleague, assistant) and spaces of interaction (home, work, public). It was found that participants perceive robots differently based on space, as they do for human-human relations in corresponding roles. Overall, humans were evaluated to have more power over and more distance to a robot interaction partner compared to another human. Our results provide insights into an intuitive interaction-initial partner model based on roles.**

***Index Terms*—human-robot interaction relationship, partner model, social influences, politeness, face**

I. Introduction

Interaction between humans is highly complex and includes many linguistic and non-linguistic phenomena that have yet to be fully understood and researched. One is *politeness*, a social linguistic phenomenon which is often defined as strategies used to preserve or enhance the public self-image of a person, called 'face' [1], [2]. In conversation, humans use such 'face work' to build and strengthen social relationships. Interestingly, humans have been observed to use politeness when interacting with artificial agents as well – even though these agents lack social sensibility [3], [4]. In addition to the user's behaviour, user expectations of a robot regarding these social strategies are relevant for robot development [5] as well as they are related to several issues, such as the benefits and risks of humanization of robots [3], [6], their scope and capabilities [7], and the user's *mental models* of them [8].

Research on politeness has found that the relationship between speaker and hearer influences the choice of politeness strategy as well as its interpretation [1], [9], [10]. It is therefore relevant that the relation between a human and a robot has been described as unequal in previous research [5], [11], [12]. Further, based on effects such as *uncanny valley* [13] and other similarly undesirable user experiences, it has been questioned, whether robots should use human social linguistic strategies, such as politeness, at all [6]. It can be observed that politeness in human-robot interaction (HRI) is difficult to model, as it appears that there is a discrepancy between the *desired* [14], [15] and the *expected* social language strategy that robots should use [16] – as well as the politeness used by users [4].

This paper presents a questionnaire-based study that contributes to politeness research in HRI by gaining further insights into the differences between human-robot and human-human interaction (HHI), based on the perception of roles before an interaction (which contribute to the conversational expectations). The aim of the study is to capture human evaluations of perceived relationships between interlocutors in HRI and HHI. These evaluations can be interpreted as a part of a human's partner model of a robot (or another human), build before an interaction and solely based on the role that the robot (or human) has [17].

II. Background

As politeness strategies are used in conversation to build and reinforce interpersonal relations they can be considered social linguistic strategies [1], [12]. The choice of politeness strategy is socially motivated as it depends on the relation between speaker and hearer. Brown and Levinson [1] proposed this relation to be defined by the *power* (*P*) of the speaker (*S*) over the hearer (*H*) as well as the social *distance* (*D*) between the interlocutors. A third influence, the *rank of imposition* of a conversational act (*R*), is situationally and culturally dependent. Brown and Levinson [1, p. 76], describe politeness using a simple formula, $W_x = D(S,H) + P(H,S) + R_x$, according to which the weightiness W of a face threatening act x is computed using situation specific values for power, distance and rank. Even though the concept of face and the influences of *P*, *D*, and *R* are being challenged [18]–[20], this model remains the most influential one in politeness research [10], [21] and has been adopted in HRI (e.g., [22]) and human-agent interaction research (e.g., [23], [24]).

Several studies have found evidence for the positive influence of politeness use by robots and artificial agents on likeability [14], persuasiveness [25], compliance [26], and willingness to help [22]. Other studies, however, found that these strategies can be perceived as inappropriate [6], [16]. Such negative user experiences caused by social linguistic strategies were named 'verbal uncanny valley' [12] – referring to the uncanny valley effect [13] which describes a feeling of unease when an object is anthropomorphized, but in an imperfect way. The main explanation given for the verbal uncanny valley effect is that general social rules underlying interactions, which determine the use of social linguistic strategies, are not automatically transferable to human-computer interaction [12, p. 325]. This includes the concept of face as well as the influence of the social role that the system has. Different roles may lead to different levels of power, which then influence the use and interpretation of social linguistic strategies [12, p. 327]. Overall, the relation between a user and a robot has been evaluated to be unequal in distance, as found by Clark and colleagues [16], where interviews showed a mostly task-oriented – rather than social – relation perception to robots.

Given these results, it is of interest to analyze how humans perceive relations to robots vs. humans in different roles – in terms of power and distance (a caregiver robot, for instance, might be expected to use more and different social linguistic strategies than a robot at a check-in counter [12, p. 327]).

III. Research expectations and hypotheses

Our study's evaluation of role-based relations is grounded on previous research on power and distance that used similar relationship designations (e.g., 'close friends', 'new colleague') to analyze the influence of the relation on politeness [18], [27]–[29]. Even though relationships change over time and during interaction [18], we assume that a basic evaluation is possible based solely on an agent's role forming the relationship designations.

For the evaluation of power and distance we expect to see differences between human-robot and human-human interaction: in HRI we expect to see a higher power evaluation for the human and a greater distance to the robot compared to corresponding roles in HHI [16], [30]. We expect, however, that relationships suggesting low frequency of interaction (e.g., relationships formed in a public space) are perceived to have greater distance than those with higher frequency of interaction (e.g., close friends) [29] – both in HRI and HHI. Based on these expectations, we formulated the following hypotheses:

H-1: Power and distance: Role-based relationships between actors can be estimated without context influences.

H-2: Power and distance HRI: Power and distance of a robot's user differ depending on the use-cases and different spaces the robot is used in.

H-3: Power: Relationships suggesting dependencies between actors are evaluated to have higher power.

H-4: Distance: Relationships suggesting frequent interaction are evaluated to have lower distance than those suggesting less frequent interaction.

H-5: Power HRI vs. HHI: Overall, the power of a person is perceived to be higher over a robot than over a human in a similar role.

H-6: Distance HRI vs. HHI: Overall, the distance to a robot is perceived to be higher than to a human in a similar role.

H-7: Power and distance: Power and distance are correlated and hence not independent variables.

IV. Methods

The study consisted of two conditions – human–robot interaction (HRI) and human–human interaction (HHI) – and

TABLE I
Overview of relationships by space and condition.

Space	**Relationship** HRI condition	HHI condition
home	user: family member user: young adult user: elderly user: child	friend (close) housekeeper (long-time) housekeeper (new) friend (distant) parent-child
work	robot: colleague (long-time) robot: colleague (new) robot: assistant (long-time) robot: assistant (new)	colleague (long-time) colleague (new) assistant (long-time) assistant (new)
public	robot: parking inspector robot: restaurant admission controller	parking inspector restaurant admission controller

was set up in a between-subject design. Questionnaires for both conditions had the same structure and similar items and differed in whether two fictional human actors were involved (HHI condition) or whether one of the actors was a robot (HRI condition). The questionnaire consisted of three parts, of which only the first is relevant for this paper.

Both conditions comprised a set of different *relationships* set in three different *spaces* (at home, at work, in public), see Table I. Relationships between actors were illustrated by describing the role-based relation and the time of acquaintance (e.g., new vs. long-time assistant), or their closeness (e.g., close vs. distant friend) – as in [22]. In the spaces work and public, corresponding role-based relation are used across conditions (e.g., colleague vs. robotic colleague). This, however, was not possible in the home space, so that here the role-based relations differ between conditions and will hence not be immediately compared in the evaluation. Additionally, in the at home items, a perspective change was required as the relationship is manipulated by varying the human user (e.g., child vs. elderly) and the robot is described as a social robot with the generic abilities to converse and to assist the human. In contrast to this, the items set at work or in public manipulate the relation through a change in the robot's role.

Figure 1 shows an example item, (translated from German), which queries the relationship evaluation for a social robot (condition: HRI) in a home setting (space: home) for a 10 year old child (relation: user is a child) who grew up with this robot (time of acquaintance).

For each item, participants were asked to evaluate relationships in terms of power (P) and distance (D). Power was evaluated with two questions: (i) the authority of one actor over the other, and (ii) the similarity in social status. Distance was also evaluated using two questions: (iii) closeness, and (iv) perceived social distance between the actors. Of these items (ii) and (iv) served as control questions. Participants responded to each question using a fine grained slider (with 100 steps). Due to their abstract formulation ('status', 'social distance') the two control questions (ii, iv) were seen as potentially

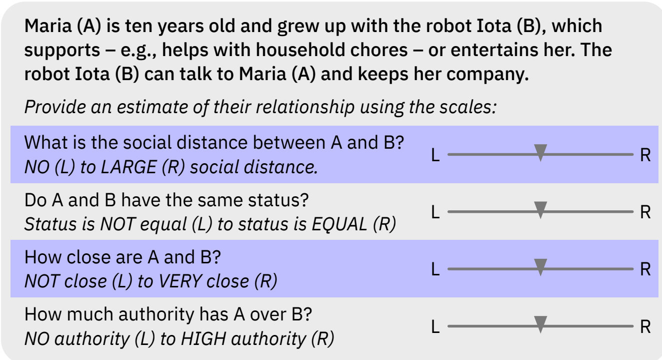

Fig. 1. Example question for power and distance evaluation (condition: HRI, relationship: user is child, space: home; question translated from German).

representing different and more difficult concepts. We thus controlled for differences to the main *P* and *D* questions of 'authority' (i) and 'closeness' (iii), computing Cronbach's α of the results for each question. We found that main and control questions did not yield similar responses and thus excluded the controls and based the evaluation of *P* and *D* on the responses on authority for power (i) and closeness for distance (iii).

The study was conducted online. Participants were recruited on the crowd-sourcing platform 'Prolific' and received a compensation of the German minimum wage for 15 minutes. Filters ensured that only German native speakers could participate. A total of 99 participants took part in the study, eleven of which were excluded from the evaluation as they failed at least one of the three attention check questions (based on [31]). This resulted in 44 participants per condition. Participants were somewhat older in the HRI ($M = 26.8$ years, $SD = 10.6$) than in the HHI ($M = 24.6$ years, $SD = 8.6$) condition, gender balance is reasonable (HRI 24m/19f/1d, HHI 17m/25f/2d).

V. Results

Data analysis consists of three steps: to compare the relations within and between conditions descriptive and visual analyses as well as inferential statistical analyses were conducted. Further, correlations were calculated between power and distance for all relationships.

A. HRI condition

Due to the large response scale, we begin with an analysis of median scores. Figure 2 maps the median power and distance values for each relationship (HRI relationships are plotted as red squares). As can be observed, different relationships yielded different evaluations of power and distance. Overall, the relations and their power and distance evaluations can be grouped based on the space they are situated in. We can observe that participants evaluated humans in public space (data points with a dashed outline) to have the highest distance to and smallest power over a robot – as in the restaurant admission control and parking inspector robot. Relations occurring at home (data points with a gray outline) were evaluated to have the smallest distance between robot and user. Overall,

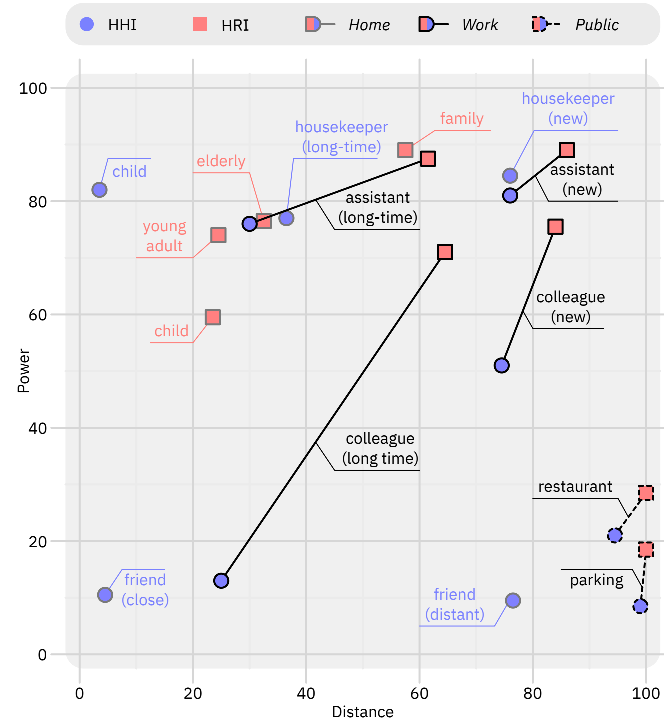

Fig. 2. Mapping of power and distance values of relationships in HRI (red squares) and HHI (blue dots).

apart from relations situated in the public space, participants evaluated the users to have relatively high power over the robot, while the distance differs based on the space (home vs. work) and time of acquaintance (long-time vs. new). An analysis of the relationships which can be compared within each space, yielded no statistically significant differences (Mann-Whitney-U tests with a Bonferroni-corrected alpha level of $\alpha = 0.05/10 = 0.005$). No high correlation between power and distance for any of the relationships were found either.

B. HHI condition

Figure 2 also shows the mapping of the median power and distance evaluations for each HHI relationship (plotted as blue circles). As in the HRI condition, relationships occurring in public (data points with dashed outline) were evaluated with the highest distance and those including work relations (data points with solid black outline) or dependencies (i.e., assistants and housekeepers) with the highest power, as expected (H-3). Similar to the HRI condition, participants evaluated the distance to be smaller for relations where employees had worked for a long time, compared to those involving a new assistant or a new housekeeper. Participants evaluated the relation to differ significantly in power ($W_P = 348, p < 0.001$) and distance ($W_D = 99, p < 0.001$) to a long-time colleague compared to a new colleague. Further, for the assistant ($W_D = 224.5, p < 0.001$) and housekeeper ($W_D = 213.5, p < 0.001$) participants evaluated the distances to be significantly different between a long-term employee and a new one. A further significant difference in distance was found for the evaluation of the close vs. distant friend relationships ($W_D = 2, p < 0.001$) When comparing colleagues and assistants for both long-time ($W_P = 95.5, p < 0.001$) and new ($W_P = 350.5, p < 0.001$) the power over the assistant was evaluated significantly higher compared to the power over the colleague. An analysis of the other relationships yielded no statistically significant differences (all tests conducted were Mann-Whitney-U tests with a Bonferroni-corrected alpha level of $\alpha = 0.05/14 = 0.00357$). As in the HRI condition no high correlations were found between power and distance for any of the relations.

C. Comparison between conditions

Comparing the two conditions visually – Figure 2 shows comparable relations between conditions with a connected line – it can be observed that power and distance evaluations were more diverse in the HHI than in the HRI condition, where participants evaluated the power of the human to always be relatively high over the robot as well as the distance to it. As mentioned, the relations in the home space are not directly comparable as they differ between conditions. However, similarities in role-based relations, e.g., between an elderly robot user and a long-time housekeeper, can be observed. The two relations that were evaluated to be most similar between conditions were those in the public space: an analysis found no statistically significant difference. Statistically significant differences between conditions could, however, be found for the relationships long-time colleague, new colleague and long-time assistant. Analyses of these yielded statistically significant differences for either power (new colleague: $W_P = 526.5, p < 0.001$) or distance (long-time assistant: $W_D = 387, p < 0.001$) – or both (long-time colleague: $W_P = 94, p < 0.001$; $W_D = 273.5, p < 0.001$). As before, all tests conducted were Mann-Whitney-U tests, here with a Bonferroni-corrected alpha level of $\alpha = 0.05/12 = 0.00416$.

VI. Discussion

Overall, participants were able to evaluate power and distance for both human-human and human-robot relationships – based on the described roles and without context information. Hypothesis H-1 can therefore be accepted. Additionally, hypotheses H-3 and H-4 can be accepted, as the actor interacting with roles suggesting dependencies (e.g., over an assistant or housekeeper) were evaluated to have higher power. Further, relationships with frequent or longer interactions were evaluated to have lower distance, as for example the long-time assistant or colleague in contrast to the new assistant or colleague in both conditions. By comparing the two conditions, it was found that participants evaluated the power of a robot user to be higher compared to human-human relations in corresponding roles. Hypotheses H-6 for distance and H-5 and H-2 for power can therefore be accepted. This evaluation of distance can be interpreted as a relationship to a robot that is perceived to be rather task-oriented than social, which is in line with previous research [12]. The evaluation difference in power is also in line with previous research and with the assumption of a power imbalance in HRI [30]. Both results together are in line with the Moore's unequal partner theory [11]. The final hypothesis (H-7), that power and distance are correlated and therefore not independent from each other, has to be rejected, as overall in both conditions, no correlations between power and distance were found between relationships – apart from a few exceptions with low correlations. In future research we aim at finding further evidence for this indication of independence between the two variables, for example, by analyzing their dependence and influence on politeness choice.

The results have to be interpreted as first insights for robot partner models since participants evaluated fictional relationships and were third-party observers rather than actual interactants [6]. It also needs to be considered that human-robot relationships change over time in conversation [5], as well as with increasing exposure and contact due to higher availability of robots [3]. This study, nevertheless, provides insights into human-robot relationships in comparison to human-human relationships based on different roles of the robot or human interaction partner. It is useful to have such an evaluation based on roles as users will probably encounter robots in public spaces. With little or no interaction experience with the specific robot, users will likely base their first impressions and expectations on the role that the robot embodies.

VII. Conclusion

The questionnaire-based study presented in this paper collected evaluations of perceived speaker–hearer relations for human-robot in comparison to human-human interaction. It explored the perception of robots in different roles and the comparability to human roles regarding power and distance in different spaces. Using a between subject design for HRI and HHI, we found that participants were able to evaluate the perception of speaker–hearer relations based on corresponding roles in HRI and HHI. Similar to human-human relationships, the relation to a robot changes in power and distance based on the role this robot embodies. With increasing frequency of interaction, the distance to the other actor diminishes, and the power increases with increased hierarchy and dependence. Further, as expected, participants evaluated humans to have, generally, more power over a robot compared to another human, as well as overall more distance. This differed for the relations set in a public space, where participants perceived a human to have low power over the robot, similar to the corresponding human-human roles. Overall, these findings are in line with previous research. The higher distance indicates the mostly task-oriented – and not social – perception of a robot [16] and the high power of the user depicts the imbalanced relation between user and robot [30] which leads to conversational partners being unequal [11].

The study contributes to the research on robot perception and expectations in HRI. It provides insights into the partner models that humans builds of a robot before an interaction and based only on the role a robot or human is in.

All items of the questionnaire and more detailed results are available in the supplementary material:

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