Persuasive polite robots in free-standing conversational groups

Sahba Zojaji, Adrian Benigno Latupeirissa, Iolanda Leite, Roberto Bresin, Christopher Peters

Abstract

Politeness is at the core of the common set of behavioral norms that regulate human communication and is therefore of significant interest in the design of Human-Robot Interactions. In this paper, we investigate how the politeness behaviors of a humanoid robot impact human decisions about where to join a group of two robots. We also evaluate the resulting impact on the perception of the robot's politeness. In a study involving 59 participants, the main (Pepper) robot in the group invited participants to join using six politeness behaviors derived from Brown and Levinson's politeness theory. It requests participants to join the group at the furthest side of the group which involves more effort to reach than a closer side that is also available to the participant but would ignore the request of the robot. We evaluated the robot's effectiveness in terms of persuasiveness, politeness, and clarity. We found that more direct and explicit politeness strategies derived from the theory have a higher level of success in persuading participants to join at the furthest side of the group. We also evaluated participants' adherence to social norms i.e. not walking through the center, or *o-space*, of the group when joining it. Our results showed that participants tended to adhere to social norms when joining at the furthest side by not walking through the center of the group of robots, even though they were informed that the robots were fully automated.

Index Terms

Social robotics, Politeness, Persuasiveness, Social norms, Human-Robot interaction, free-standing conversational groups

I. INTRODUCTION

Politeness is a fundamental aspect of human social interactions, as it plays a significant role in influencing individuals' decisions and establishing positive relationships between individuals. According to Brown and Levinson's politeness theory [1], politeness is achieved through strategies such as positive politeness (e.g., compliments, expressions of appreciation) and negative politeness (e.g., apologies, hedging language) that help to mitigate potential face-threatening acts. Additionally, Goffman's theory of face [2] emphasizes the importance of preserving one's positive self-image and the positive image of others in social interaction. Designing polite behaviors for humanoid robots is important in the context of Human-Robot Interaction (HRI) to maintain a positive impression of robots on users.

When people gather to communicate, they form *free-standing conversational groups* [3]. If a newcomer wants to join an ongoing free-standing conversational group politely, they should consider the group [4] and individual spaces [5]. A group member usually invites a newcomer to join the group. The invitation to join a group may be perceived as a face-threatening act, and the choice of politeness strategies could impact how the invitation is executed and the level of persuasion and politeness in the invitation. While these aspects are understood for human groups, far less is clear about how groups of humans and robots can operate and collaborate together. In collaborations and long-term interactions with humans, it is especially important that robots maintain a good bond with humans while also clearly communicating their requests [6].

All authors are affiliated with the School of Electrical Engineering and Computer Science (EECS), KTH (Royal Institute of Technology), Stockholm, Sweden. Email: {zojaji, ablat, iolanda, roberto, chpeters}@kth.se.

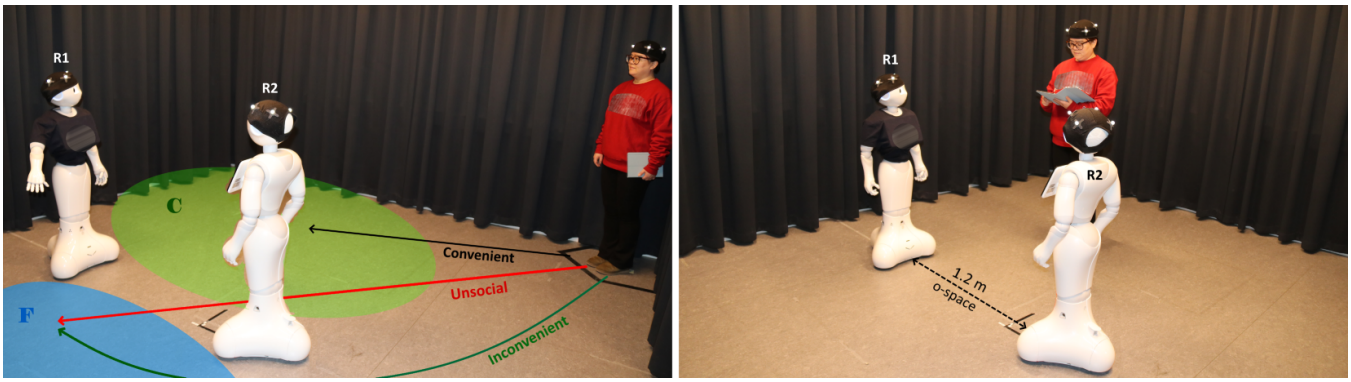

Fig. 1: **Experiment trial:** (left) a participant is standing at the initial location (L1) and R1 is inviting them to join the group at the *furthest* side *F* by conducting verbal and non-verbal behaviors (see Table II). Hypothetical routes to join the group at the *closest* side (green oval, *C*) or *furthest* side (blue oval, *F*) are marked; (right) a participant is providing feedback on the questionnaire after joining the group at the *closest* side *C*, representing an unsuccessful persuasion attempt by the robot.

This study examines the impact of politeness strategies used by a humanoid robot to invite a participant to join a free-standing conversational group of two Pepper robots. The main aim is to investigate the impact of politeness strategies, expressed via a combination of verbal and non-verbal behaviors (see Figure 1), on the ability of the robot to persuade participants to join at the *furthest* side and the consequential impact of those strategies on the effectiveness (persuasiveness, politeness, and clarity) of the robot and the degree to which participants adhere to social norms by avoiding walking through the center of the group.

The study has been designed to present participants with a dilemma in which they must choose between (1) expending more effort to join the group in a socially acceptable manner that conforms to the robot's request (i.e., by taking an *inconvenient* route around the group), (2) opting for a least effort but *unsocial route* (i.e., joining the group by walking straight through its center, violating the *o-space* of the group) that nevertheless conforms to the robot's request, or (3) by taking a *convenient* route to join the group at the *closest* side, thus balancing effort and social acceptance while violating the robot's request to join the group at the *furthest* side.

The main contributions of this study are as follows:

- A set of verbal and non-verbal behaviors based on five politeness strategies derived from the theory that vary in terms of their directness and perceived politeness;
- Our results show that participants tended to adhere to social norms even when this involved expending more effort to take an *inconvenient* route to join the group;
- Our results suggest a specific verbal and non-verbal behavior corresponding to a politeness strategy that was optimal across all three criteria of persuasiveness, politeness, and clarity.

Our study emphasizes the importance that verbal and non-verbal politeness behaviors adopted by robots have, not only on the persuasive ability of the robots but also on how they are perceived by humans. In collaborations and long-term interactions with humans, it is especially important that the robot maintains a good bond with humans while also clearly communicating its requests. This has significant implications for the design and application of robots in contexts from customer service to healthcare and education, where robots are increasingly being used to interact with humans and provide advice and guidance.

II. RELATED WORK

Brown and Levinson [1] defined politeness as an effort to avoid or mitigate actions that could damage an individual's public self-image or face [2]. They identified five different strategies for communicating needs while minimizing face-threatening acts: not doing the act (`NOT`), *off-record* or *indirect* (`IND`), using indirect language; *negative politeness* (`NEG`), focusing on avoiding imposition; *positive politeness* (`POS`), emphasizing friendliness; and *bald on-record* or *direct* (`DIR`), using clear and direct language. These strategies formed the basis for our design of six different combinations of verbal and non-verbal behaviors in this study, which will be discussed in detail later.

The CASA (Computers Are Social Actors) paradigm, as shown in previous studies [7], [8], [9], reveals that people tend to attribute human-like qualities to computers and other technological devices. Consequently, they integrate elements that are relevant to human interactions, like politeness [10], into their engagements with these devices. Therefore, it is crucial to develop polite behaviors for robots in the realm of HRI to establish and sustain a positive user perception of robots.

When multiple individuals come together to communicate, they form a *free-standing conversational group* [3]. Several studies have explored how people manage the space around them when in a group, and Kendon's theory [4] describes this as *F-formation*, which depicts the organization of a group where all members have equal, direct, and exclusive access to the group space. An *F-formation* consists of three social spaces: *o-space*, *p-space*, and *r-space*, with *o-space* being a convex empty space surrounded by individuals in a social interaction exclusive to group members. The main concept in this study is how humans associate these with a group of robots and especially with respect to avoiding the *o-space* crossing while joining the group.

In recent years, there has been a growing interest in the study of social behaviors and norms, such as politeness, and interpersonal attitudes, such as friendliness, in the context of HRI. Several studies have explored these topics in various individual or group scenarios [11], [12], [13], [6], aiming to understand how humans interact with robots and how these interactions can be improved to enhance the user experience. These studies have examined the impact of social cues such as eye gaze, facial expressions, and body posture on users' perceptions of robots' social presence and their willingness to interact with them. Other studies have focused on investigating the role of robot behavior, such as politeness strategies, in shaping users' attitudes and behaviors towards robots [14], [15].

Overall, the research in HRI has shown that social behaviors and norms play a critical role in shaping the human-robot interaction and that incorporating such elements into robot design can enhance the user experience and promote positive attitudes towards robots [16], [17], [18], [19]. Moreover, similar studies have been conducted to investigate to impact of the politeness of virtual agents on the trajectories taken by human participants when joining a virtual conversational group and the persuasiveness of those strategies [20], [21], [22].

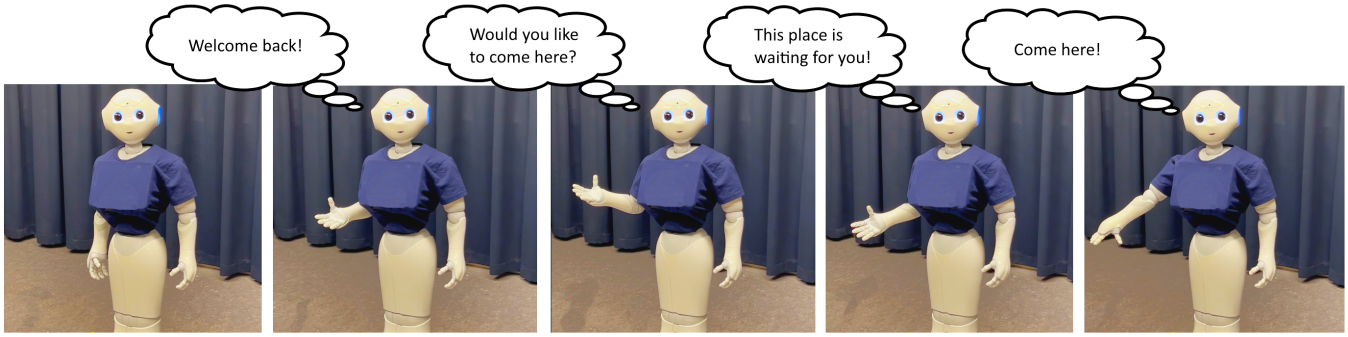

Fig. 2: **Main robot's (R1) behavior:** in each case R1 invites the participant to join the group by conducting verbal and non-verbal behaviors related to the following politeness strategies derived from the theory (see Table II), from left to right: (a) no face-threatening act (`NOT`); (b) indirect (`IND`); (c) negative face (`NEG`); (d) positive face (`POS`); (e) direct (`DIR`).

Routes	Persuasion	Social adherence	Effort
Convenient	No	Yes	Low
Unsocial	Yes	No	Medium
Inconvenient	Yes	Yes	High

TABLE I: Different alternatives and their trade-offs from the perspective of the participants (see Figs. 1 and 3).

This study examines the effect of direct and indirect politeness strategies employed by a humanoid robot to persuade a newcomer to join a group of two robots at the *furthest* side of the group, while simultaneously accounting for the impact of these strategies on the perception of the robot's request. It also investigates the degree to which humans adhere to the social norm of not walking through the center of a group, even when the group is composed of robots that the participants are informed are autonomous and not controlled by human operators.

III. Experiment

The experiment involved two Pepper robots[1] placed at the center of a Motion Capture (MoCap) room, 5.2*4.4 m (see Fig. 1). The main robot (R1) faced participants and invited them to join the group using a combination of verbal and non-verbal politeness behaviors (see Fig. 2). R1 maintained eye contact with the participant throughout the whole experiment. Also, when participants approached the group and were within the secondary robot's (R2) field of view, it maintained eye contact with them. The study was carried out in a MoCap room, enabling precise tracking and recording of both the participants' and robots' movements and trajectories during the entire study.

The initial positions and angles of the group and the participant were chosen to facilitate a straightforward, least effort, and *convenient* path for the participant to join the group at the *closest* side. Nonetheless, the main robot (R1) typically invited them to the opposite side of the group, entailing twice the effort to get there which was *inconvenient* to reach.

The task for participants was to start at a distance from the group, *L1* or *L2* and join in by freely moving in the environment. In each trial, the starting location of the participant is alternated between the right-hand side (L1) and left-hand side (L2) of the group (see Fig. 3). The robot always invites the participant to join at the furthest point, either from L1 or L2 as appropriate. The participants were presented with a scenario on a paper that described a situation where they were expected to join a group of two robots that they were familiar with. They were instructed that the robots were fully autonomous. In reality, the robots were controlled by a human operator in a semi-automated manner according to a Wizard of Oz (WoZ) methodology [23]. At the end of the experiment, participants were debriefed about this.

The study has been designed to present participants with a dilemma in which they must choose between (1) expending more effort to join the group in a socially acceptable manner that conforms to the robot's request (i.e., by taking an *inconvenient* route around the group, approximately 10 steps), (2) opting for a least effort but *unsocial route* (i.e., joining the group by walking straight through its center, violating the *o-space* of the group, which took about 7 steps) that nevertheless conforms to the robot's request, or (3) by taking a *convenient* route (approximately 4 steps) to join the group at the *closest* side, thus balancing effort and social acceptance while violating the robot's request to join the group at the *furthest* side (see table I). However, participants were totally free to choose where and how to join the group.

The study consisted of six conditions, shown in table II, each representing relevant politeness strategies and derived verbal and nonverbal robot behaviors. Participants experienced all six conditions, with their order of presentation counterbalanced using a Latin Square design. Each of the six conditions was repeated three times, leading to a total of 18 trials for each

[1]https://www.aldebaran.com/en/pepper

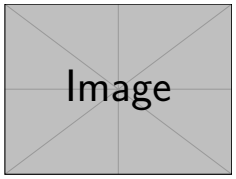

Fig. 3: **MoCap room schema:** *L1* and *L2* denote the initial locations of each trial. *Closest* (*C*) and *furthest* (*F*) sides of the group for joining from the L1 are denoted by green and blue ovals, respectively, along with three different possible hypothetical routes to joining the group, each indicated by a specific color - green: *inconvenient*; red: *unsocial*; and black: *convenient*. In all conditions (apart from `BSL`), R1 requested participants to join to *F*.

Condition	Strategy	Verbal behavior	Nonverbal behavior
1. Baseline (`BSL`)	NOT	None	None*
2. Indirect (`IND`)	IND	"Welcome back!"	Open palm up
3. Asking (`ASK`)	NEG	"Would you like to come here?"	Open palm sideways
4. Proposing (`PRO`)	POS	"This place is waiting for you!"	Open palm sideways and partly downward
5. Commanding (`CMD`)	DIR	"Come here!"	Pointing directly at a specific point with a straight arm
6. Pointing (`PNT`)	DIR	None	Pointing directly at a specific place with a straight arm

TABLE II: Experiment conditions and their associated politeness strategies, verbal and nonverbal behaviors derived from the theory. *Note: In all conditions, R1 always maintained eye contact with the participant. The verbal and nonverbal behaviors above were always conducted in exactly the same way by the robot (R1).

participant. The same order of the six conditions used in the first block was used in the following two blocks of the study. This allowed participants to familiarize themselves with the task and also to establish the progression of participants' responses over the course of the experiment e.g. in order to consider potential novelty or fatigue effects.

At the start of the study, participants were introduced to the MoCap room and the robots to get familiar with the environment and engaged in the informed consent process for the study. They were also provided with a tablet to provide their feedback at the end of each trial. They were instructed on the protocol for the study, which involved moving to the initial location (L1 or L2) at the beginning of each trial, looking at the group of robots in front of them, and starting their movement only after a beep signal was sounded. The beep signal ensured that the main robot R1 could completely perform its politeness behavior prior to the movement of the participant into the group.

The compliance of the participants with the robot's request to join the group at the *furthest* side in each trial was recorded, along with whether they crossed the *o-space* of the group by walking between the two robots. These two measures were used to calculate the rates of *persuasiveness* and *o-space crossing*, which served as indicators of the effectiveness of the robot's request and the participants' behavior towards it.

Once the participant had joined the group, they were requested to answer four 7-point Likert scale questions (ranging from "strongly disagree" to "strongly agree") on the tablet. These related to their perception of the politeness of the robot's behavior in that specific trial. "*The robot*" in all the following cases refers to R1 in the study.

1) **"I could precisely understand the robot's wants."** This question was intended to assess the *clarity* of the robot's requests.
2) **"I got offended by the robot's action."** This question was designed to measure the degree of *face loss* or *offensiveness* of the robot's requests.
3) **"The robot wanted to increase intimacy with me."** This question aimed to determine the level of *satisfaction of a positive face*, which relates to friendly or warm behavior.
4) **"The robot respected my freedom of action."** This question was designed to evaluate the level of *satisfaction of a negative face*, which relates to respecting the other's choice, freedom of action, or cold behavior.

At the end of the experiment, the participants were asked to respond to a post-study survey about their overall experience. The final section of the post-study survey evaluated their subjective effort in joining at the *closest* and *furthest* sides of the group. Before answering that section, they were instructed to join the group again at both sides from one of the initial locations (L1). They were interviewed and given information about the aim of the study and thanked for their participation.

A power calculation was conducted for the study, indicating that 59 samples were required to achieve a power of 0.95 with an effect size of 0.25. Therefore, a total of 59 valid participants (32 females, 53%, and 27 males, 47%), between the ages of 19 and 63 (32 ± 10) and proficient in English were recruited from the general public in Sweden and compensated with a cinema ticket or a voucher. Out of the participants, 16 (27%) had no previous knowledge or familiarity with AI systems (robots, virtual agents, etc.), 32 (55%) with basic, and 11 (18%) had intermediate or advanced familiarity with AI systems. Data collected from each participant was anonymized, and written consent was signed by them before the start of

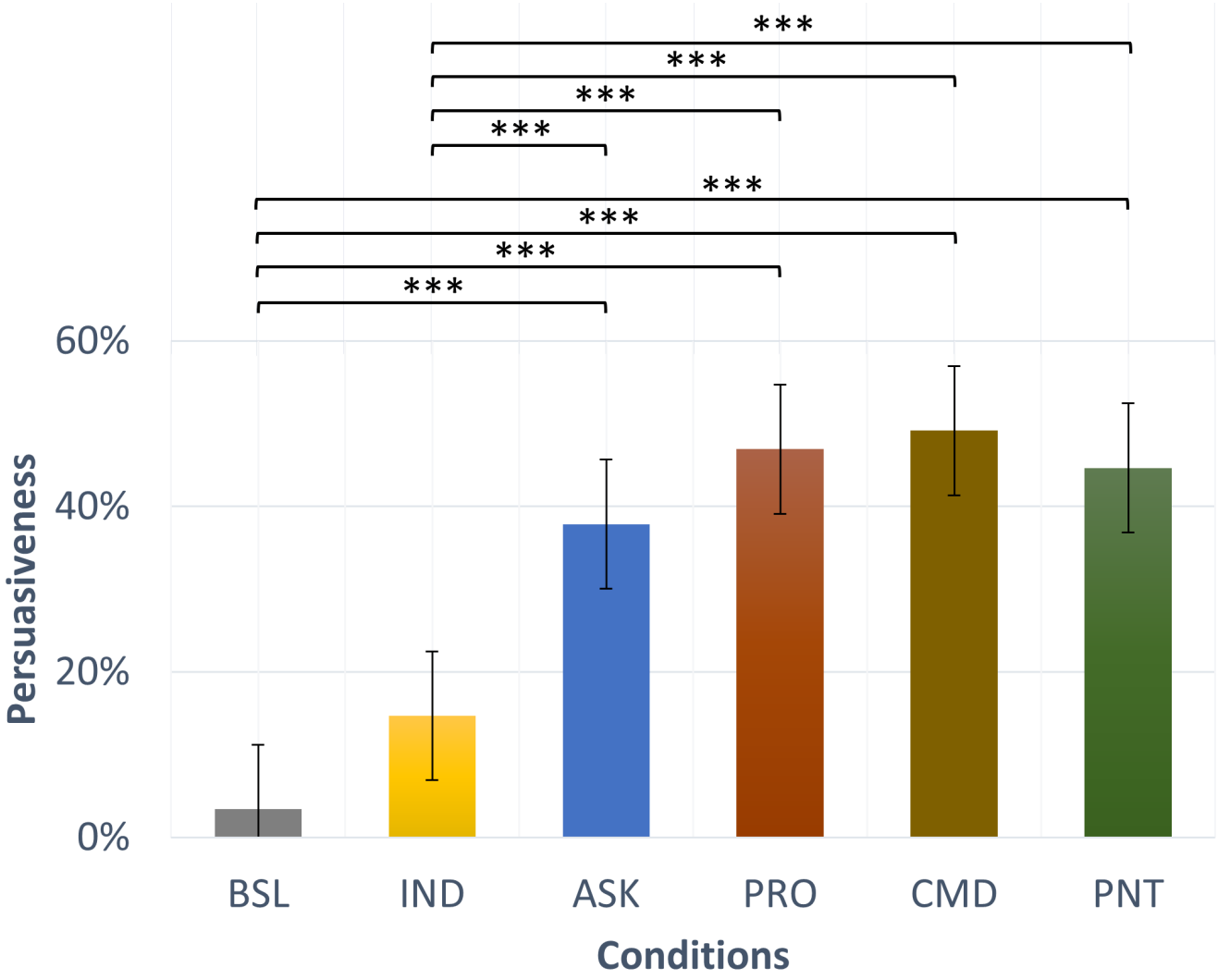

Fig. 4: *Persuasiveness*. Impact of politeness strategy on the participant joining the group at the *furthest* side *F*. The Y-axis displays the mean value of the *persuasiveness* Boolean across all individuals and trials. In all graphs, brackets denote the statistical significance of pairwise differences: ***, $p<.001$; **, $p<.01$; *, $p<.05$.

the experiment. Each participant experienced 18 trials. This resulted in 1062 trials being used in the final analysis.

IV. RESULTS

A repeated measures ANOVA was performed on the data obtained from the study, using *Condition* (which had six different levels, as specified in Table II) as a within factor. Dependent variables were *Persuasiveness*, *Clarity*, *Face loss*, *Positive face*, *Negative face* and *o-space crossings*.

A. Persuasiveness

The results for *persuasiveness* are illustrated in Fig. 4. Overall, there was a significant main effect of *Condition* on *Persuasiveness*, F (2.992, 173.525) = 33.758, p $<$ 0.001. A Bonferroni posthoc comparison suggested that direct conditions are more persuasive, with a significant difference between the conditions `BSL`, `IND` and the remainder of the conditions (`ASK`, `PRO`, `CMD`, `PNT`).

In general, more direct strategies tend to be more persuasive. `CMD` is the most persuasive condition (49% success rate) closely followed by `PRO` (47% success rate).

B. Politeness

1) Clarity: The results for *Clarity* are illustrated in Fig. 5. Overall, there was a significant main effect of *Condition* on *Clarity*, F (3.023, 175.354) = 197.950, p $<$ 0.001. A Bonferroni posthoc comparison suggested that `BSL` was perceived as least clear among all conditions and `PNT` was less clear among all other direct conditions. `CMD` and `ASK` was perceived

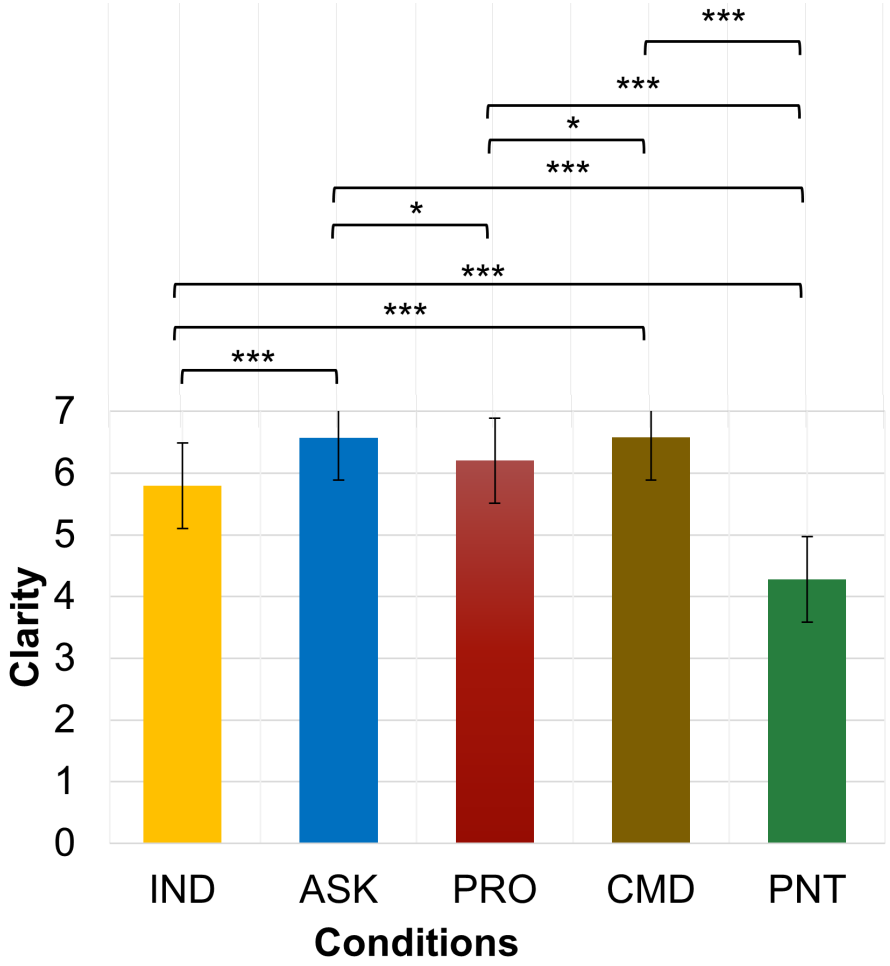

Fig. 5: *Clarity*. Impact of politeness strategy on the perception of the clarity of the robot's request. Note: For brevity, the BSL condition is not included in Figures 5-8.

as the clearest among all conditions. In general, CMD and ASK were perceived as the clearest conditions (6.58 out of 7) followed by PRO (6.20 out of 7).

2) Face loss: The results for *Face loss* are illustrated in Fig. 6. Overall, there was a significant main effect of *Condition* on *Face loss*, F (2.669, 154.796) = 51.245, $p < 0.001$. A Bonferroni posthoc comparison suggested that PNT and CMD were perceived to create the most loss of face for participants among all conditions and BSL was less than them but more than the remainder of conditions. In general, CMD and PNT were considered the most offensive, as they were associated with a high degree of loss of face. In contrast, IND and ASK conditions were seen as the most effective in minimizing the loss of face.

3) Positive face: The results for *Positive face* are illustrated in Fig. 7. Overall, there was a significant main effect of *Condition* on *Positive face*, F (3.204, 185.834) = 84.506, $p < 0.001$. A Bonferroni posthoc comparison suggested that BSL and PNT were perceived as the least friendly conditions, whereas ASK was perceived as the friendliest one.

In general, the conditions CMD and PNT were perceived as the least friendly among direct strategies due to their association with a lower degree of positive face. In contrast, the conditions ASK followed closely by PRO were regarded as the most successful in making a friendly request.

4) Negative face: The results for *Negative face* are illustrated in Fig. 8. Overall, there was a significant main effect of *Condition* on *Negative face*, F (3.114, 180.622) = 49.813, $p < 0.001$. A Bonferroni posthoc comparison suggested that CMD and PNT made the participants feel the most constrained in terms of their freedom of action, whereas, ASK and IND were perceived to give more freedom of action to the participants. In general, the conditions CMD and PNT restricted the participants in their ability to act freely, while they perceived that the conditions of ASK and IND allowed for more freedom of action.

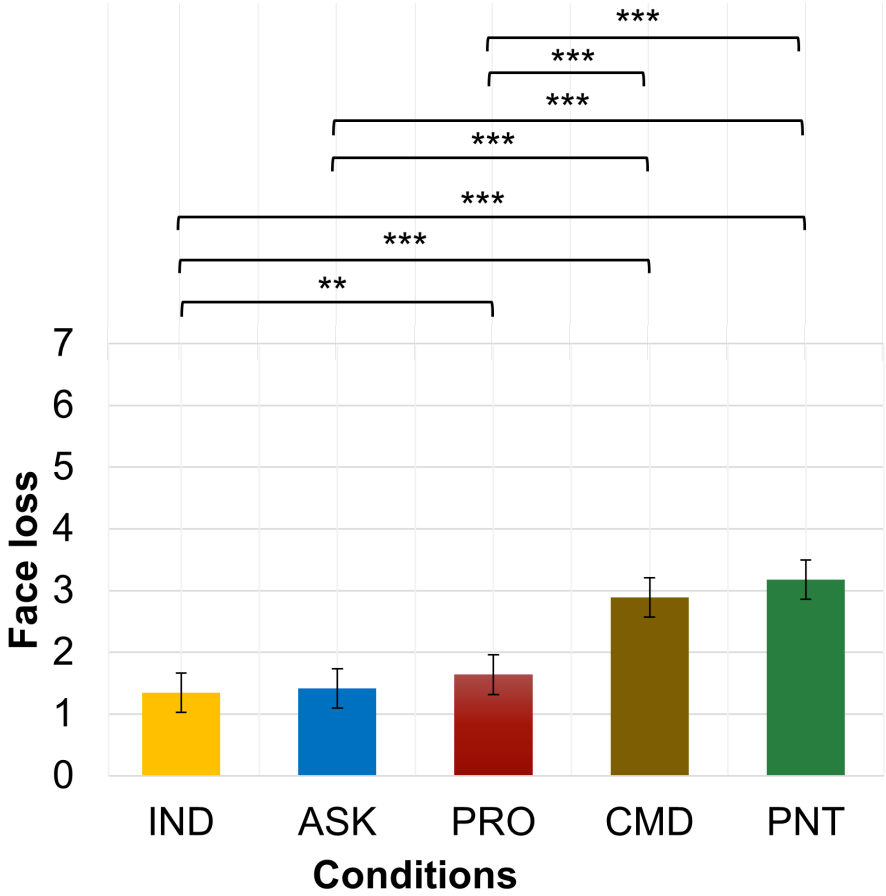

Fig. 6: *Face loss*. Impact of politeness strategy on the perception of the offensiveness of the robot's request. Note: Unlike other cases, lower values indicate less loss of face and are thus preferable.

C. Adherence to social norms

The percentage of crossing the *o-space* while joining at the *furthest* side is illustrated in Fig. 9. Overall, there was a significant main effect of *Condition* on *o-space crossing*, $F\ (2.530, 146.712) = 10.563$, $p < 0.001$. A Bonferroni posthoc comparison suggested that participants crossed the *o-space* more, with a significant difference between the conditions `BSL`, `IND` and the remainder of the conditions (`ASK`, `PRO`, `CMD`, `PNT`).

V. DISCUSSION

In general, the study indicates that using more clear and direct strategies (`ASK`, `PRO`, `CMD`, `PNT`) is more effective in persuading participants to join a group at the *furthest* side. This may be because they provide clearer guidance for participants to follow. Even though the indirect (`IND`) condition initially appeared to have similar clarity to most direct strategies, it is possible that participants only thought they understood what the robot wanted them to do. This is supported by the lower persuasiveness scores for the `IND` condition compared to the explicit strategy conditions.

A. Evaluation of politeness strategies

Based on the results of this study, three following politeness behaviors from the theory have emerged as potentially effective for application to social robotics for making requests to users or persuading them.

Among the top three strategies, `ASK` condition (which is based on the negative politeness strategy) is considered the least effective in terms of persuasion. However, it stands out as the most friendly and respectful towards the participants' freedom of action, while also avoiding any potential offense. Moreover, in terms of clarity, it ranks second among the three strategies. This strategy might be useful in a retail setting. A social robot acting as a sales assistant [24] may need to persuade customers to purchase a specific product, while also respecting their freedom of choice and maintaining a friendly and respectful demeanor to ensure that the customer has a positive experience.

The `PRO` condition which is related to the positive politeness strategy ranks as the second most persuasive and also one of the most friendly and respectful strategies towards participants' freedom of action while avoiding offense, among the top three strategies. However, it is the least effective in terms of clarity when compared to the other three. This approach can

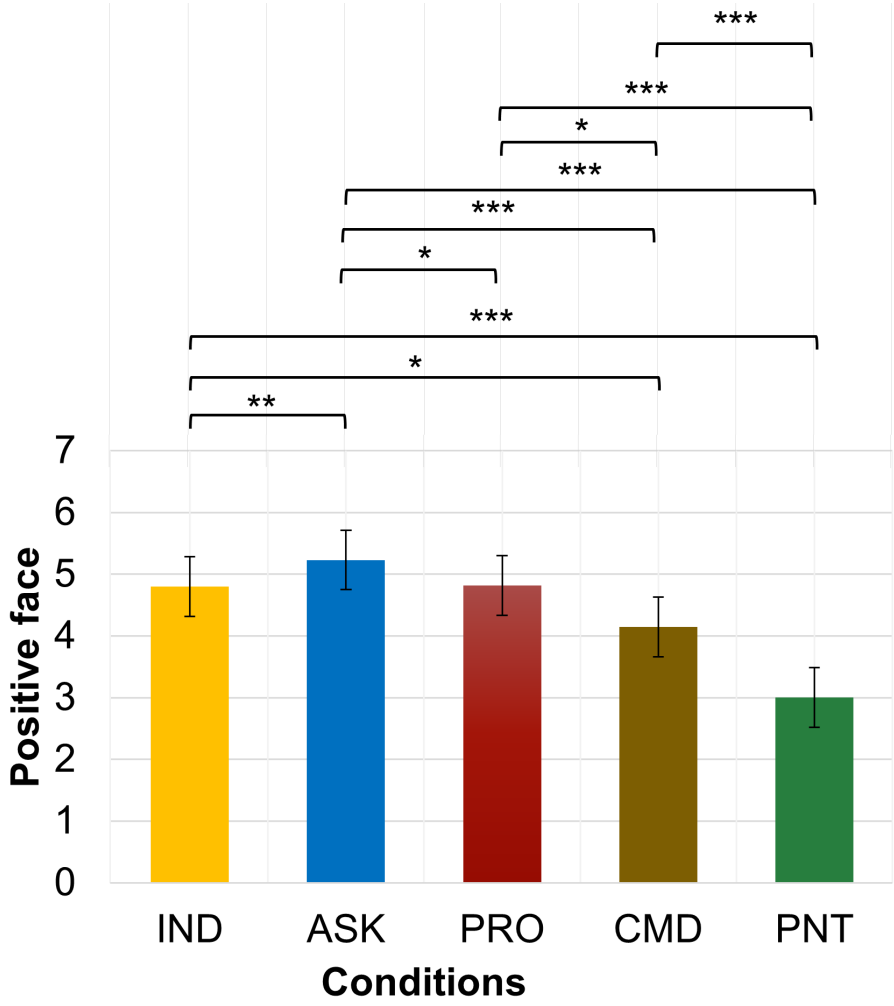

Fig. 7: *Positive face*. Impact of politeness strategy on the perception of the friendliness of the robot's request.

be especially effective in situations where there is a need to strike a balance between persuasion and maintaining a positive impression on the user. For example, a social robot designed to assist individuals with disabilities in a workplace environment [25]. In this case, the robot's main goal is to persuade the user to follow specific workplace safety and accessibility guidelines, while also maintaining a friendly and supportive relationship with the user. This approach could help the robot to build a stronger rapport with the user and encourage them to follow the guidelines voluntarily, rather than feeling pressured or forced to comply.

The `CMD` condition, which is based on the direct politeness strategy, is the clearest and most persuasive among the top three strategies. However, it is also the most offensive and shows the least respect for the participants' freedom of choice, making it the least friendly of the three. Therefore, this strategy could be particularly suitable for use in critical situations where the robot must convey a clear and decisive message that the user is required to follow. For example, in a medical emergency situation, a social robot might need to persuade the user to take a specific action that is essential for the patient's well-being, such as administering a particular medication or performing a particular medical procedure. This finding contrasts with studies such as Saunderson et al. [26], in which indirect robots were found to be more persuasive than direct robots.

Overall, the `ASK` condition was the most optimal across all three criteria of persuasiveness, politeness, and clarity. However, if the main aim is a persuasive robot, the `PRO` condition outperformed `ASK`, but with lower politeness and clarity. As such, these strategies could be considered for incorporation into the design of future persuasive social robots, with appropriate testing and refinement as necessary in different contexts. These insights may be valuable in the ongoing development of social robots that exhibit more polite behavior to persuade users or make requests.

B. Adherence to social norms and effort

Previous psychological research [27] has shown that humans tend to avoid options that require more work or effort when given similar choices. These findings align with the study's results, as participants who were not given clear instructions

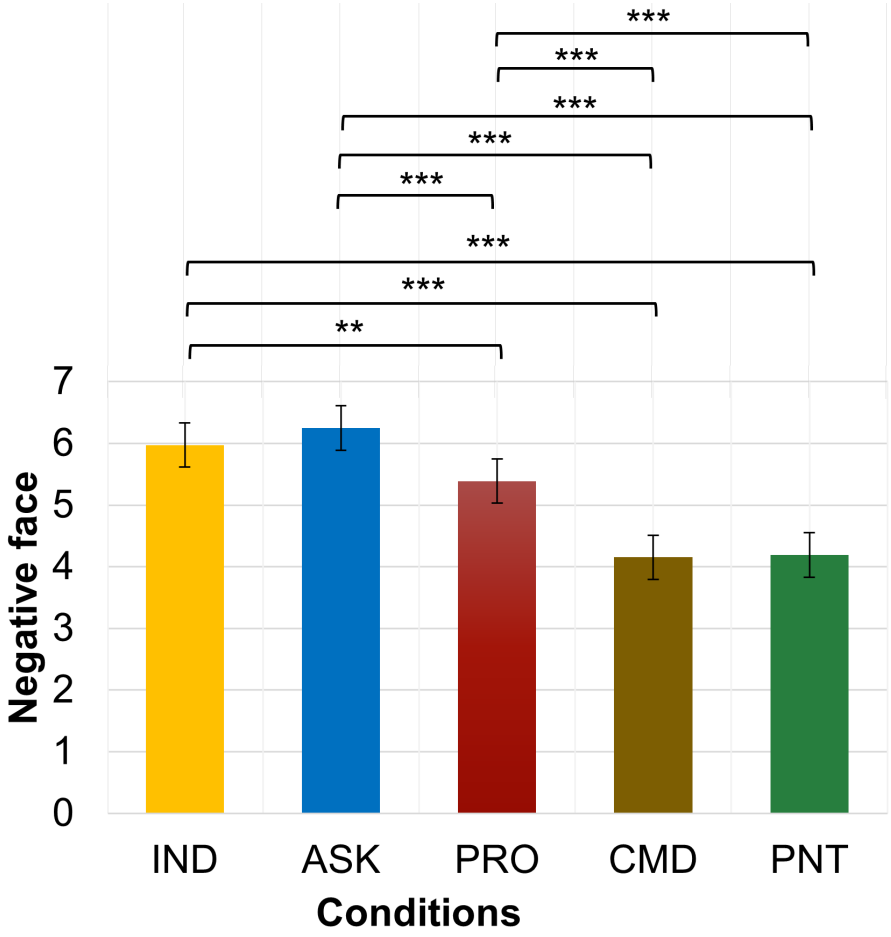

Fig. 8: *Negative face*. Impact of politeness strategy on the perception of freedom of action of the participant. Higher values indicate a greater perception of freedom of action.

about the joining side (`BSL` and `IND` conditions) tended to take the least effort approach and join the group at the *closest* side. Providing clearer requests about the side that the robot wanted the participants to join (the remainder of conditions), they may adhere to the requests of the robot to join the group at the *furthest* side of the group but may take a route through the center (i.e. *o-space*) of the group. Their social adherence was measured via the number of *o-space* crossings. The results showed that participants tended to adhere to social norms even when this involved expending more effort to take an *inconvenient* route to join a group of robots. As Table III shows, in most cases (64%), participants tended to value adherence to social norms over the savings in effort implied by taking the *unsocial* route through the *o-space* of the group of robots. Additionally, Table III shows that as the experiment advanced, there was a notable *increase* in adherence to social norms by participants (from 58% in block I to 70% in block III). This observation aligns with the concept of the effort paradox [28], which proposes that exerting effort can enhance perceived value, leading individuals to be more motivated to engage in tasks that require greater effort.

C. Eliciting social bonds

Participants were interviewed after the experiment in relation to perceived robot attributes. Many participants mentioned the robot's "cuteness," admiring its "lovely smile," and possibly forming an emotional attachment by considering it as their "kids" or "pets". Remarkably, some participants expressed that "they would have exhibited the same social behaviors towards humans" as they did towards the robots, even in the case of walking through the *o-space* of the group, perhaps highlighting the level of anthropomorphism [29] they attributed to the robot. These comments align with our research findings, which demonstrated that as the experiment progressed with participants exposed to each condition three times (a total of 18 trials), their adherence to social norms consistently increased. This suggests that the participants' interactions with the robot not only elicited feelings of fondness but also influenced their social behavior, reinforcing the significance of our study in the realm of HRI.

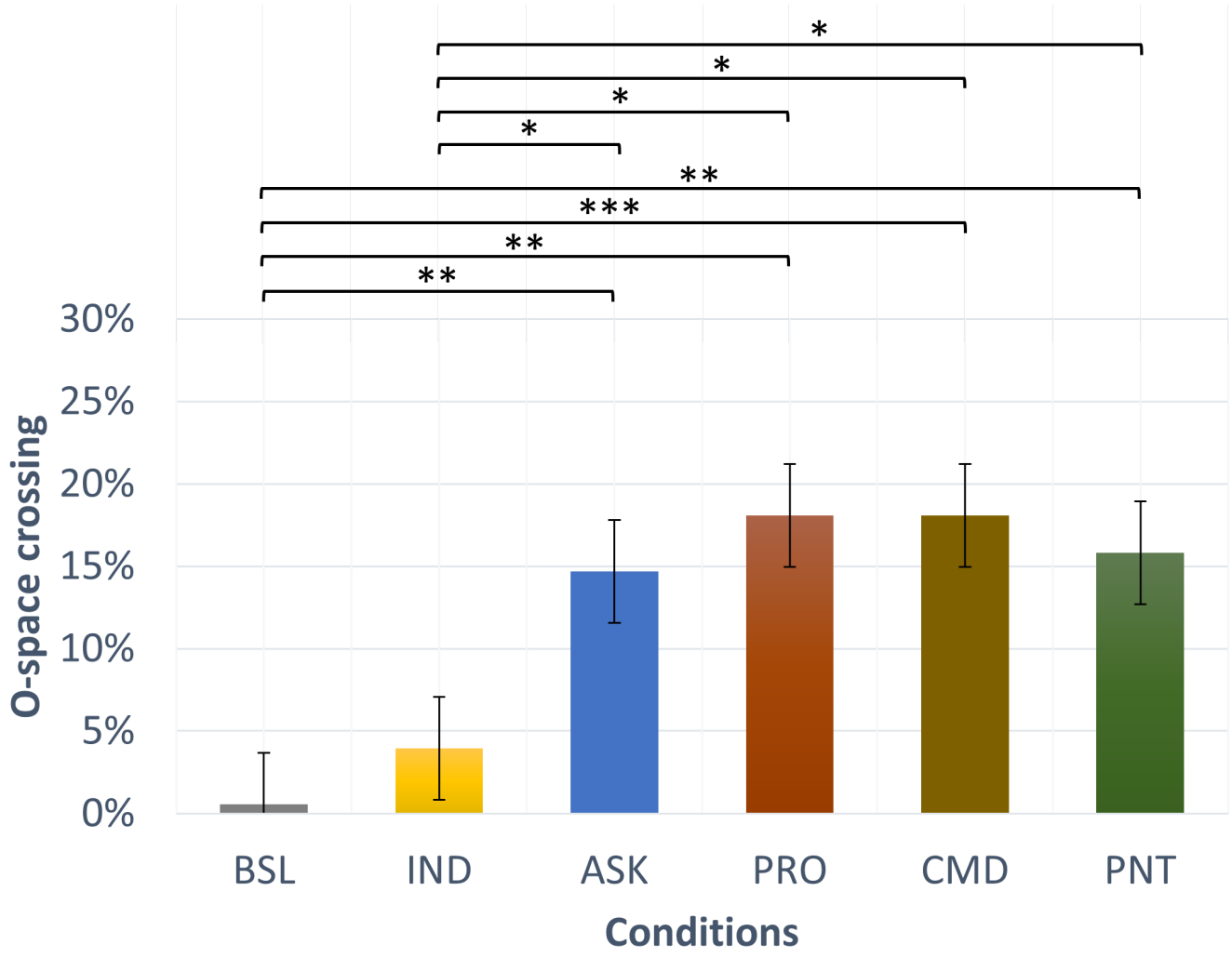

Fig. 9: *O-space crossing*. Impact of politeness strategy on the participant joining the group at the *furthest* side *F* by crossing through the center of the group. The Y-axis displays the mean value of the *o-space* Boolean across all individuals and trials. **Note:** overall, participants tended not to violate the *o-space* of the group of robots.

Block (trials)	I (1-6)	II (7-12)	III (13-18)	Total
Requested	295	295	295	885
Successful	99	122	121	342
Success rate	34%	41%	41%	39%
O-space crossings	26	30	19	75
Social adherence rate	58%	62%	70%	64%

TABLE III: Breakdown of the number of trials per block in which the robot (R1) requested and successfully persuaded participants to join the group at the *furthest* side, and of the related number of trials in which participants walked between the *o-space* of the robots. In total, participants were successfully persuaded to join the group at the *furthest* side in 39% of the trials. Among these cases, participants refrained from crossing the *o-space* in 64% of the trials overall. Note: That calculation excludes the `BSL` condition because the robot did not make any requests to participants in those instances.

D. Limitations and future work

The findings of this study may vary across cultures due to differences in defining politeness. For instance, in some cultures, walking through the center (or *o-space*) of a group may be perceived as less impolite than walking behind individuals when taking a route around the outside of the group. Social context could also impact participant perception, and future studies could explore this further. Additionally, more detailed studies on the relationship between politeness behaviors and trajectories could support the development of social-aware navigation algorithms for humanoid robots. Conducting a similar study in a human-human interaction setting can help further validate and generalize the findings of this study. It can also provide insights into how humans perceive and respond to these politeness strategies used by other humans in the scenario. Since direct strategies are more persuasive, they might seem more dominant. This could be another future investigation.

In this study, we used Pepper and the embodiment and voice of Pepper might have an impact on its perceived dominance. Furthermore, the use of only one type of robot, Pepper, may limit the generalizability of the findings of this study to other robotic platforms, which have their own distinct characteristics and behaviors. Additionally, although this study does not directly investigate the impact of anthropomorphism [29] in HRI, its potential role should be noted in shaping participants' responses and adherence to social norms during interactions with the robot (i.e., Pepper). Furthermore, the specific formation of two robots might restrict the applicability of results to scenarios with different spatial configurations. Future research could address these limitations by replicating the study with multiple robot types, exploring various spatial configurations and social distances, and conducting experiments in more diverse cultural settings.

VI. Conclusion

The study found that using more direct and explicit politeness strategies is more effective in persuading newcomers to join a group of humanoid robots (Pepper), especially when it requires extra effort to do so. However, participants perceived direct strategies as less friendly and more offensive, leading to less freedom of action. Also, in most cases, participants tended to adhere to social norms over the savings in effort implied by taking the unsocial route through the *o-space* of the group of robots. The negative politeness strategy was found to be the most effective in achieving persuasive success and maintaining a positive impression of the robot. These results can be useful for designing and modeling human-robot interaction systems.

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