Can Robots Be Used to Encourage Social Distancing?

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Figure 1: Videotaping Pepper's persuasive strategies.

ABSTRACT

In this work, we explore whether robots can exert their persuasive influence to encourage others to follow new proxemic norms (i.e., COVID-19 social distancing guidelines). Our results suggest that social robots are not effective for this purpose, and, in fact, when some persuasive strategies are used, this approach might backfire due to novelty effects that encourage pedestrians to approach and cluster around such robots.

CCS CONCEPTS

• **Computer systems organization** → *Robotics*; • **Human-centered computing** → **Field studies**; *Natural language interfaces.*

KEYWORDS

Social robotics, persuasive robots, proxemics, COVID-19

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1 INTRODUCTION

COVID-19 has had a profound impact on the global population over the course of 2020, and on the field of Human-Robot Interaction itself [6]. Researchers have released a variety of guidelines for combating the spread of this disease, including guidelines to wear masks and maintain social distancing when around others. Unfortunately, many Americans have shown significant reticence towards following these guidelines, and there have been numerous instances of violence recorded against those following these safety guidelines. Accordingly, it is critical to identify strategies that might be deployed by institutions, businesses, and local governments to encourage compliance.

In this work, we examine how social robots might be used as part of this persuasion effort to swiftly build new social and moral

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norms without provoking additional violence. Social robots have been documented to wield significant persuasive power, including over humans' systems of social and moral norms. Moreover, social robots are designed to play friendly roles in society through social yet non-threatening and non-judgmental interaction.

Research has already demonstrated that telepresence robots might be able to motivate people to wear masks and can encourage them to maintain interpersonal social distance [21, 25]. In this work, we seek to investigate whether these benefits extend to language-capable social robots outside the context of telepresence, and, if so, what verbal communication strategies might be most persuasive.

To this end, we conducted an in-the-wild research study at a medium-sized US engineering university, in which a social robot (the Softbank Pepper) was positioned in a high-traffic outdoor area, giving periodic verbal comments encouraging social distancing and mask-wearing. Our results suggest that novelty effects prevent social robots from being effective at encouraging social distancing, as the very elements of their design that encourage engagement in fact *encourage* passers-by to congregate nearby one another despite the content of the robot's verbal messaging.

2 BACKGROUND

In this section, we first look at persuasive HRI, and then discuss robots' influence on human-robot proxemics and speculate as to how they might similarly influence human-human proxemics.

2.1 Persuasive Robotics

How much people comply with ideas and arguments presented by a speaker depends not only on verbal communication, but also on nonverbal cues, such as gestures and gaze [4]. In fact, Mehrabian et al. [17] found that peoples' perception of other individuals depended mainly on bodily cues and tone of voice, with verbal content accounting for only 7% of interpersonal perceptions. Similar perceptions of robots might affect robots' persuasive power. Chidambaram et al. [5] studied the role of verbal and nonverbal communication in persuasive robots. The results showed that participants more readily complied with robot suggestions when robots used nonverbal cues along with their verbal communication.

Prior work in HRI investigated the effect of the robot's persuasiveness in terms of human factors, such as trust and compliance [8], robot appearance and gender cues [23], and robot nonverbal behavior [10, 18]. For example, Baroni et al. [2] studied the importance of robot verbal and nonverbal cues to persuade children (8-9 years of age) to eat fruits and vegetables. Similarly, Briggs and Scheutz [3] found that a humanoid robot refusing commands and affectively communicating its distress successfully persuaded a human operator to abort an objectionable course of action. And Jackson and Williams [11] showed that a robot, through simple and common dialogue behaviors, can influence a human's moral norms (or application thereof). In this work, we are particularly interested in a robot's ability to influence human proxemic behaviors.

2.2 Proxemics

Hall [9] introduced the concept of proxemics, which refers to the space that people maintain around themselves. This space is divided into multiple zones: the intimate zone (reserved for embracing, touching, whispering), personal zone (reserved for friends), social zone (reserved for acquaintances and strangers), and public zone (reserved for public speaking). Various factors influence the human proxemics model, such as age, gender, individual personalities, the familiarity between people, and culture.

Recent work in HRI has incorporated these unspoken proxemic rules into robot mobility to develop social navigation strategies [20] that comply with these important human social norms [1, 7, 13, 15, 22]. Human-robot proxemics has been shown to depend on a variety of human-centered factors, including interactant familiarity with robots, pet ownership, and gender [24], and robot-centered factors, such as robot anthropomorphism, gaze behavior [15], and height [19].

Research in human-robot proxemics also suggests that robots can persuade people to change their proxemic behaviors [7, 16]. Feil-Seifer and Matarić [7] modeled peoples' spatial behavior when following a robot and modified a navigation planner to enable the robot to exhibit socially-aware goal-oriented navigation behavior, producing robot behavior that effectively allowed humans to follow their robot teammates. Their results suggest that robots can influence human teammates to enter a much closer proxemic zone than they would otherwise. In other work, Mead and Matarić [16] found that people will naturally adapt their proxemic behavior toward robotic teammates to improve the performance rates of the robot's automated speech and gesture recognition systems.

The work described above suggests that robots can influence human behaviors, including their human-robot proxemic preferences. However, it not clear whether robots can influence human-human proxemic preferences. To the best of our knowledge, prior research in HRI only concentrated on influencing human-robot proxemics, and there is a gap that can be filled by studying the influence of robots in persuading people to change their proxemic preferences in human-human interactions. This new knowledge could help us better understand whether robots can be deployed in pandemic events to improve public health by encouraging social distancing. In the next section, we present the design of an observational in-the-wild study intended to assess whether robots could more effectively encourage social distancing than non-robotic solutions, and, if so, which persuasive strategies might be most effective.

3 METHOD

3.1 Experimental Design

A four-condition design was used in which different persuasive technologies were deployed adjacent to a busy university walkway over the course of four days. These four conditions consisted of three robotic conditions and one non-robotic condition. In the three robot conditions, a social robot (the Softbank Pepper) was placed next to a busy campus walkway and used three different persuasive strategies to encourage social distancing. The robot was fully autonomous for each of the three conditions.

Highlighting of In-Group Status In this strategy, the robot highlighted its status as an in-group member of the campus community: *"Hello there, my name is Pepper, and I am wearing a mask to keep our campus safe. Let's work smart and stay six feet apart!"*

Reminder of Norms In this strategy, the robot reminded community members of social distancing norms and of their prior agreement to comply with them: *"Please remember to social distance while on campus. Also, remember to keep your mask on at all times. Have a great day and stay safe!"*

Norm Sanction In this strategy, the robot issued a modest sanction expressing the importance of adhering to social distancing norms: *"Whoa! Please remember to keep a distance of six feet. Thanks for wearing your mask and have a safe day!"*

In addition, a non-robotic condition was used in which signs were posted stating, *"Please remember to keep a distance of 6 ft."* and *"Have a great day and stay safe!"*, providing a baseline condition that did not exploit the robot's embodied status, and the associated perceived community membership and persuasive advantage granted by the robot's anthropomorphic design [12] and its ability to gaze and gesture [10].

Each condition was deployed for an hour-and-a-half within a similar time period on a separate day. On the day in which the sign condition was performed, the signs remained up for the entire hour-and-a-half period. On the days in which the robot condition were performed, the robots were configured to play/speak their messages with accompanying gestures every 45 seconds.

3.2 Experimental Context

Our observational study took place on a busy walkway of a university campus. The physical space was selected because it has a high foot-traffic and only allows for people to walk in North and South directions; therefore, the people that entered the experiment were forced to walk parallel to one another. This prevented foot-traffic from coming in from other angles, and allowed us to easily trace pedestrian paths. This setting also allowed us to place notices at each end of the experimental area alerting pedestrians that the region was being recorded for experimental purposes.

3.3 Measures

The effectiveness of the robotic and non-robotic persuasive strategies were measured based on the density of pedestrians in the area in which the robot or signs were positioned. The density of pedestrians near the robot or signs was measured by videotaping the experimental environment and recording, at periodic intervals, the number of people in each of nine blocks of equal size arranged in a 3x3 grid on the ground in front of the robot or signs. Specifically, these density estimates were calculated 15 seconds after the start of each 45-second interval (15 seconds after the commencement of robot speech and gesture).

4 RESULTS

As previously described, we measured the effect of different robotic and non-robotic communication strategies on pedestrians through post-communication pedestrian density in subsectioned regions of the experimental area, at 15-second offsets from each 45-second-interval measurement point. Time points that contained fewer than two people in the entire area were discarded. For remaining data points, the number of people in each sub-region was determined, and the average number of people per nonzero block was calculated,

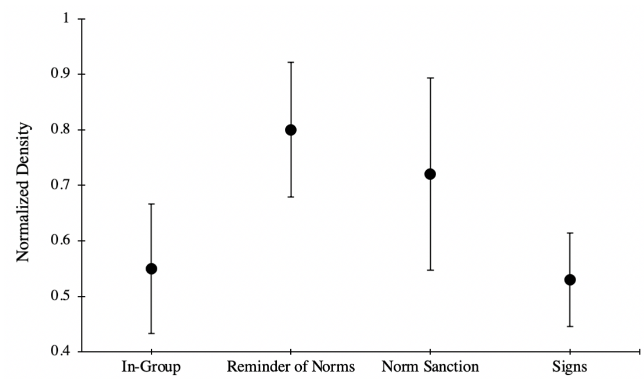

Figure 2: Normalized pedestrian density at $t + 15$ measurement points.

and normalized by dividing by the number of visible people at that time point, to account for day-to-day differences in traffic. Post-normalization, a value of 1 meant all pedestrians could be found in a single sub-area. These normalized data were then analyzed in JASP [14] using a Bayesian analysis framework.

A Bayesian ANOVA revealed moderate evidence of an effect of condition on normalized pedestrian density (BF=7.624), which led us to conduct a series of pairwise post-hoc Bayesian t-tests between conditions. These t-tests revealed strong evidence (BF=23.196) in favor of a difference between the non-robotic intervention (M=0.537, SD=0.177) and the Norm-Reminder condition (M=0.800, SD=0.254), moderate evidence of a difference (BF=5.273) between the Norm-Reminder condition and the Highlighting of In-Group Status condition (M=0.551, SD=0.261), anecdotal evidence (BF=2.092) for differences between the non-robotic intervention condition and the Norm Sanction condition (M=0.718, SD=0.275), anecdotal evidence (BF=1.028) for differences between the Highlighting of In-Group Status and Norm Sanction Conditions, and anecdotal to moderate evidence against effects for the other two pairwise comparisons (Highlighting of In-Group Status vs. non-robotic intervention, and Reminder of Norms vs. Norm Sanctions). These results are visualized in Figure 2.

5 DISCUSSION AND CONCLUSION

There are several main conclusions that can be drawn from these results. First, in many cases, the use of social robots actually *discouraged* pedestrians from social distancing between one another. Examining the recorded videos, we observed pedestrians frequently congregating around the robot. In this experiment, the use of a social robot, especially one that attempted to exert pressure on others to follow norms (rather than merely stating its own adherence to such norms) might indeed have better attracted pedestrian attention, but this gathering of attention paired with the novelty effect of seeing a social robot "in the wild" appears to have backfired by encouraging pedestrians to collectively interact with the robot. It is possible that this effect would go away if a longer-term longitudinal study were performed, but it is also unclear whether such a study could be ethically performed given the findings of this brief experiment.

Figure 3: Students congregating around the robot.

Second, this negative effect was not observed in all conditions. In the Highlighting of In-Group Status condition, the robot did not perform significantly worse than the non-robotic intervention. However, while the mean normalized participant density in that condition was indeed lower than in the non-robotic intervention condition, our experiment actually provided moderate evidence *against* a difference between that strategy and the non-robot intervention, suggesting that the robot using that strategy was no more effective than using no robot whatsoever.

This experiment does have a number of limitations. First, perhaps ironically, due to COVID-19, we were only able to collect a limited number of days worth of footage, resulting in a relatively small dataset. Second, the robot used in this experiment communicated on a set schedule rather than communicating when actually approached, which might have broken immersion or caused passersby not to take the robot seriously. Third, it is unclear whether these findings would replicate with other embodied and/or robotic technologies; for example, it could be the case that a non-anthropomorphic robot (e.g., a simple mobile base) might be able to give persuasive directives while not attracting crowds. Finally, it is unclear if these findings would replicate with other, purely non-verbal persuasion strategies; for example, future work could investigate whether robots that physically move away from incoming pedestrians might be able to discourage approaches from such pedestrians.

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