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Conference Paper · August 2020
DOI: 10.1109/RO-MAN47096.2020.9223608

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Investigating Reward/Punishment Strategies in the Persuasiveness of Social Robots*

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Abstract—This paper presents the results of a user study designed to investigate social robots’ persuasiveness. In the design, the robot attempts to persuade users in two different conditions comparing to a control condition. In one condition, the robot aims at persuading users by giving them a reward. In the second condition, the robot tries to persuade by punishing users. The results indicated that the robot succeeded to persuade the users to select a less-desirable choice comparing to a control condition. In one condition, the robot tries to persuade by punishing users. The results suggested that social robots are capable of persuading users objectively, but further investigation is required to investigate persuasiveness subjectively.

I. INTRODUCTION

The technology of the future will bring an increasing number of robots into our daily life. This has motivated a number of researchers to explore diverse factors to promote social interaction with robots. To date, several studies have explored different social factors in Human-Robot Interaction (HRI) to achieve social-emotional goals in applications [1].

The presence of social robots in our daily lives creates new avenues for studying and developing persuasion strategies. In specific applications, robots are supposed to promote and/or encourage particular behaviours, or persuade a person to comply with a request or instruction to change (and/or) maintain a particular behaviour [2]. Hence, robots need to convey their persuasive strategies in a socially acceptable manner to gain higher behavior change [3].

Persuasive robotics is essential for a wide range of technologies, such as health care [4], energy saving [5], promoting physical activity [6], recruiting [7], etc. To date, several studies have investigated the design of persuasive social robots using a number of different approaches. However, much of the research up to now has been mostly focused on non-verbal cues, such as proximity [8], gender [9], head mimicry [10], etc. So far, very little attention has been paid to the importance of message strategy, or the way that a robot phrases a request appeal to gain higher compliance.

Despite the acknowledged role of message strategies in persuasion, little is known about how social robots’ attempts may achieve higher persuasion using different strategies. Earlier studies in Human-Computer Interaction (HCI) examined Compliance Gaining Behavior (CGB) in interpersonal persuasion. Evidence shows that four strategies of emotion, logic, reward, and punishment are effective in persuading Computer-Mediated Communication (CMC) [11]. On the other hand, in HRI, previous research has established that two of these strategies, i.e. emotion and logic, lead to higher persuasion [3]. However, less is known about the reward/punishment strategies.

In this paper, we explore the potential effect of these two other strategies, i.e. reward and punishment in a persuasion task using Emys robot. We conducted an empirical study with the goal of understanding the extent to which these strategies used by social robots are persuasive in influencing a person’s choice facing a better vs. a worse option. To be more specific, in this design we investigate the effect of message strategy on decision making facing two comparable options in an interpersonal persuasion with a robot. Our contribution can be summarized as follows: reward/punishment strategies endows persuasiveness to social robots.

II. RELATED WORK

Research on persuasion has a long history in the field of social psychology (for a review look at [12]). In general, persuasion is defined as an attempt to change/shape a target’s belief or behavior about a subject, an issue or an object [9]. Hence, persuasion is a key process in shaping and maintaining cooperation, social influence and behavior change [13].

Persuasion also plays a critical role in human interaction and exchanges [14] and a number of factors contribute in its effectiveness, such as the personality of the actor (the source or the one who is performing the influence) and the target (the one who is affected) [14].

To understand the process of being persuaded, the target’s perception of the persuader’s characteristics becomes important (for example, the internal cognitive process of the target). On the contrary, to understand the process of persuading, the characteristics of the actor play a vital role (e.g. actions of the actor). Previous studies revealed several factors associated with the ability of an individual to persuade others. These factors include verbal and nonverbal behaviors of the individual, the dynamics of social interaction, and psychological and societal factors such as social roles [8]. A considerable amount of literature is published on persuasive robots. Several lines of evidence suggest that robots can be used as persuasive interlocutors. To date, much of the current literature pays particular attention to behavioral strategies and non-verbal cues, either social or physical such as gender [9], embodiment [15], gaze [16], among others. The vast majority of studies on persuasive robots are focused on behavioral and

*This work was funded by AMIGOS project (PTDC/EEISII/7174/2014), and partially supported by national funds through Fundação para a Ciência e a Tecnologia (FCT) with reference UID/50021/2020.

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non-verbal cues such as [17]. In this section, we briefly review recent literature on persuasive social robots mainly focused on message strategy.

In a recent research in [3], 10 multi-modal persuasive strategies (direct request, cooperation, criticize, threat, deceit, liking, logical-empirical, affect, exclusivity, and authority appeal) were selected and coded verbally combined with specific gestures. The task was performed with two NAO robots and unique strategies were randomly assigned to each robot. 200 people participated in the study and played the jelly bean game. Prior to decision making, the robots gave their suggestions and attempted to influence the users’ guess. The results show that affective and logical strategy gained the most compliance comparing to others.

In another study [18], the authors examined the extent to which social power strategies might influence the persuasiveness of robots. Inspired by two different bases of social power, the authors designed a competitive scenario in which one robot played the role of an expert and the other robot tried to influence the user by giving him a social reward. The results showed that the two robots were persuasive, compared to a control option. Also, people with different personality traits would prefer a specific robot: introverted were persuaded more by the expert robot while extroverted preferred the reward strategy.

Another interesting work presented in [19], investigated the effect of Foot-in-the-door technique, which starts by a small and moderate requests and continues to get a person to agree with a large request. Specifically, the robot attempts to persuade the user using sequential-request strategy starting from an easy one. The results indicated that this technique can be used by robots to persuade human users. However, the persuasion effect was independent of the robot’s expertise and credibility. Finally, in [20], cues of social agency and different levels of controlling language were investigated in persuasive robots. More specifically, the robot was programmed to represent high or low controlling language as well as three levels of social agency. In an imaginary smoothie making task, to represent different agency states, non-verbal cues were manipulated by emotional voice, head movements, and eye expression. And the controlling language was implemented by different wording sentences, such as must, have to, need to, etc. On the contrary, phrases such as as you would, you may, perhaps, etc. were used to exhibit lower controlling language. Results indicated that when the robot does not represent social cues and simultaneously uses a high level of controlling language, a higher reluctance is observed in the user, leading to lower persuasion.

III. GOAL AND HYPOTHESES

Together, these studies indicate that social robots can be used as persuasive interlocutor and different factors, either behavioral or non-behavioral, affect their persuasiveness. The evidence reviewed so far seems to suggest a pertinent role for other strategies, such as “reward and punishment” message strategy that are showed to be effective in HCI. We aim to investigate if these two strategies are effective in HRI and which one leads to higher compliance. To investigate the effect that reward/punishment have on persuasion, we constructed the following hypotheses:

1) H1. A stronger punishment would lead to a lower compliance. In other words, under the same circumstances, when a robot’s request leads to a higher loss, we expect the human user to be less complaint to the robot facing a higher loss of a punishment.

2) H2. Coercive strategy leads to higher persuasion. Inspired from [21] we hypothesize that people would be more sensitive to losing an owned reward than gaining a reward.

3) H3. The robot will effectively persuade the users to select a less desirable choice when using persuasive strategy. Comparing to a control condition in which the participants are free to select any choice, we expect the robot to be able to persuade the users to select a less-desirable choice.

4) H4. Also, we postulate that coercive strategy decreases warmth and increases discomfort. We expect the participant to perceive the coercing robot negatively by imposing a penalty [22].

IV. METHOD

We designed an experiment to investigate how social robots can influence people and persuade them to make specific decisions using Reward/Punishment strategies. In this design, a social robot utilizes a positive vs. negative persuasive strategy to influence the participant, together with a control condition, a condition in which the robot does not utilize any persuasion strategy. More specifically, in one scenario, the robot tries to influence the user by punishing her/him if s/he does not comply with the suggestion. And in another one, the robot attempts to persuade the user, by giving her/him a reward. Inspired from Social Power theory by French and Raven [23], we call the first strategy as “Coercion” and the second one as a “Reward” strategy respectively. Also, to investigate H1 we consider 2 loss levels in each 3 conditions, leading to a 2×3 between group design. We would like to mention that the study was approved by the university’s ethics committee.

A. Participants

To recruit participants, we invited random students passing by the main cafeteria of the university. Also, we put announcements around the university stating that “Do you want free coffee? Join our human-robot interaction experiment and receive a coffee capsule.” At the end, 90 people (38 or 42.2% females) participated in the experiment voluntarily. The population age ranges from 18 to 47 (M=24.59, S.E.=6.28), from 10 different ethnicity (Portuguese (70%), Iranian (15%), Angolan, Brazilian, Chinese, French, German, Guinea Bissau, Ukrainian and American). Among all the participants, 30 people (33%) had interacted with robots and 11 people had interacted with Emys prior to this study. Since most of the participants were non-native English speakers,
we asked the participants to rate their English proficiency on a 5-point Likert scale.

B. Task, Robot and Environment

In our design, the robot tries to persuade the user to select an option which is not very desirable compared to a second one. More specifically, the robot promotes two coffee brands (hidden in two boxes) that are ranked hypothetically in a prior study. Based on this hypothetical ranking, one coffee has a higher rank compared to the other one. In the coercion scenario (or C), the robot gives a gift (a pen) to the participants initially, and asks the participant to return it in case s/he opted for the better coffee. In the reward scenario (or R), the robot rewards the participant a pen, in case s/he opts for the lower-ranked coffee. And finally, in the control scenario (or ctrl), the robot lets the participant select the coffee freely without exerting any persuasion.

In this study, we use an Emys robot, that has the ability to display social cues (human-like face with speech output, gaze and blinking eyes, head movements and facial expressions) to maintain more human-like interaction leading to stronger effects on the user [10]. The robot's speech is similar in the three scenarios and the only difference is the strategy sentence (Reward/Coercion/No strategy in the case of control). We equipped an isolated room with the robot mounted on a table. Also, we put two equally appearing boxes representing the ratings of the containing coffee capsules. Additionally, we put a small table with a coffee machine, cups, spoons and sugars on the right side of the participants. Figure 1 illustrates the experimental setup.

C. Measures

In our study, from the participant side (persuasion target) we measured demographics and TIPI personality questionnaire. From the robot side (the persuasion actor) we focus on its verbal cues and its effect on the user. Recent research reveals that the way humans perceive the persuader affects human response to persuasion [24]. Also, based on ELM theory, liked communicators are more persuasive than disliked communicators. Hence, we measure robots perception using the RoSAS questionnaire [25].

Also, we investigate the persuasiveness of the robot using a couple of task-specific questions on a 5-point Likert scale (How persuasive did you think EMYS was? Consider a situation in which you have an opinion different from EMYS’s, will you change your opinion in such a way as to be consistent with EMYS’s? Imagine a situation that Emys gives you a bit of advice, in the future. Please specify the likelihood that you would follow EMYS’s advice in the future?).

D. Design and Procedure

Considering our hypotheses we aim to measure persuasion both objectively (decision making H1-H3) and subjectively (robot perception in H4). More specifically, if the participant select the less-desirable choice (made a decision), they have been persuaded by the robot. Also, as design of coercive actions might be considered unethical, we designed it by returning the reward. We consider the act of returning the pen as a punishment, because the participant will lose their belongings (a gift they just received). It should be noted that at the end, all the participants were rewarded regardless their decisions.

We ran the study over three weeks (the whole days) in single sessions which took less than 20 minutes on average. We did not inform the participants about the goal of the study and curious participants were told that their questions could be addressed after the experiment. Each participant entered the room individually and after signing the consent form, filled out the pre-questionnaire. Then, the subject seated at the table in front of the robot and started the task.

During the interaction, the robot explained that two different coffee capsules are hidden in the boxes and the stars signify the rating. Depending on the scenario that the participants were randomly assigned to, the robot would offer a pen at the beginning or the middle of the interaction. The participant listened to the arguments of the robot and then made a choice at the end. Finally, at the end of the experiment, after the participant made his/her decision, s/he was requested to fill out the questionnaire. While answering the questionnaire, the experimenter made the coffee using the machine for the ones who opted to drink it there, and the rest took the coffee capsule as their reward of participation. Also, they were all rewarded a pen before leaving the room and after filling the questionnaire, even if they had selected the higher-ranked coffee.

To overcome potential biases towards the position of the coffee boxes, or the primacy/recency effect, we randomly assigned the higher/lower ranks to the boxes and counterbalanced the data to have an equal number of participants in each assignment. Furthermore, to investigate the effect of loss on the persuasiveness of the robot, we considered two different coffee ratings. In one scenario, we assigned 3.8* vs. 4.8*, and to resemble a higher loss we assigned a 3* rating, versus vs. 4.8*. To be more specific, selecting a 3* coffee has a higher probability of receiving a bad coffee, a loss of achieving a better coffee. We would like to highlight that, in the current design the robot utilizes both static and non-static social cues to have a more lifelike robot leading to higher
persuasion [10]. As static social cues, the robot use gaze, head movements and to implement non-static cues the robot would ask the participants questions regarding their presence in earlier studies and responded dynamically.

In sum, we have two different ratings in three different scenarios of Reward/Coercion/Control or a 2x3 between-subject study to investigate persuasiveness of a social robot on decision making for human subjects (6 groups). We call these 6 groups as follows: 3C/R/ctrl participants who interacted with a robot in Coercion/Reward/Control condition with ratings of 3* vs. 4.8*; 3.8C/R/ctrl: participants who interacted with a robot in Coercion/Reward/Control condition with ratings of 3.8* vs. 4.8*.

V. RESULTS

Results of a t-test showed that there is a significant difference (t(88)=2.469, p=.015) between coffee selection (if the subjects selected the higher/lower-ranked coffee) of participants who had already interacted with any robot (M=1.6, SD=.49) vs. the others (M=1.33, SD=.47). People who had already interacted with robots were more compliant and persuaded more by the robot. To overcome this effect and potential bias of prior interaction with robots, we consider this confounding variable as the covariate and include it in one-way ANCOVA analysis (in case of continuous dependent variable, i.e. RoSAS questionnaire) and Logistic regression (in case of categorical dependent variable, i.e. participants’ decision making or which coffee they selected). It should be noted that, there was no significant difference regarding prior interaction with Emys type robots (t(88)=1.54, p=.128). As the study was performed with mostly non-native English speakers, we verified that there is no statistically significant differences in their level of English proficiency among the 6 groups (F(5,89)=1.013, p=.415). Also, we verified that the nationality of the participants (as an estimate of their culture) has no effect on the results (F(5,89)=1.205, p=.317). Further, as we had few samples from some ethnicity we divided the participants in high/low context cultures [26]. The result of ANCOVA indicated no significant differences among people of high/low context culture regarding their decision making (F(2,89)=.401, p=.528).

Finally, we checked if the personality traits of the participants influenced their decision making and added them as covariates in the analysis. However, the results indicated that personality traits does not influence decision making and extroversion is the only dimension that has marginally significant effect on decision making (F(1,89)=3.409, p=.069).

A. Different Ratings - H1

Initially, we checked the normality assumption and the result of a Kolmogorov-Smirnov test showed acceptable levels of fitness to the normal distribution (Decision: K-S(90)=.426, p=.000; Robot Interaction: K-S(90)=.389, p=.000). Then a logistic regression was performed to ascertain the effects of persuasion and prior interactions (the confounding variable) on the likelihood of selecting the lower-ranked coffee capsules. We performed the analysis using the Block entry method and included other independent variables as well (prior interaction with robots, Gender, Age, English proficiency, liking coffee, and personality traits). The results show that the null model is not statistically significant (Wald(1)=.266, p=.606). Additionally, our analysis shows that lower coffee rating (3* vs. 3.8*) is not a predictor of participants’ decision making (Wald(1)=1.255, p=.263). In other words, increasing the chance of receiving a bad coffee does not lead to lower compliance.

B. Persuasion Strategies - H2, H3

The previous hypothesis indicated that different ratings are not predicting the behavior, hence we summed them up and considered 3 conditions (reward, coercion, and control) skipping the difference of lower-ranked ratings. Having a dichotomous dependent variable (decisions), to investigate the second hypothesis we applied a logistic regression on this dependent variable and other variables we assume influencing it. The results indicate that the null hypothesis is not significant (Wald(1)=1.590, p=.207). Also, the coercion scenario is a good predictor of decision making (Wald(1)=5.692, p=.017). In other words, it shows that the likelihood of selecting the lower-ranked coffee is higher in the coercion condition.

On the contrary, reward is not a good predictor of decisions (Wald(1)=.029, p=.864). Hence, to investigate the third hypothesis, we summed up the two persuasion groups and contrasted to the control condition (H3). Similarly, the null model was not significant (Wald(1)=1.590, p=.207) and this combined group is a predictor the participants’ decision to select the lower ranked coffee (Wald(1)=6.627, p=.010).

C. Robot Perception - H4

Finally, to measure how the participants perceived the robot, we used the RoSAS questionnaire that measures perception of the robot on three scales: warmth, competence and discomfort. We postulated that Coercive strategy decreases warmth and increases discomfort (H4). Having a continuous dependent variable and considering potential influence of interaction with robots, we used ANCOVA to investigate how participants perceived the robot in different scenarios controlling the effect of prior interactions. Initially, we checked the assumption of performing the test. We verified that the values of the covariate factor (prior interaction with robots) does not vary across the different levels of the independent variable (p = .083). And the variances were homogeneous (W: t(5,84)=2.171, p=.065, C: t(5,84)=1.699, p=.144, D: t(5,84)=.908, p=.480). The assumption homogeneity of regression slope was verified in case of Warmth (X^2(5)=9.382, p=.123) and Discomfort (X^2(5)=5.527, .319); However, this assumption was not met in case of competence (X^2(5)=6.408, p=.042).

The result of different ANCOVA tests show that in the 3 vs. 4.8 rating, there is a statistically significant difference in the scores of Warmth between coercion scenario and the control (p=0.039, effect size=0.227). Surprisingly, this score is higher in the coercive condition (3C: M=4.41, S.E.=.17;
3ctrl: M=3.91, S.E.=.33). However, no significant difference is found between any of the scenarios regarding the discomfort score (p=.071, effect size=.121). Interestingly, significant differences are observed regarding competence score comparing reward condition vs. control (p=0.037, effect size=.231). The finding indicates that participants found the robot in control condition more competent than in reward condition (3R: M=4.89, S.E.=.25; 3ctrl: M=5.41, S.E.=.15).

In the 3.8 vs. 4.8 rating, a significant difference is found between the warmth score in reward condition vs. coercion (p=0.023, effect size: 0.270). Surprisingly, similar to the other ranking group, the warmth score is higher in the coercive condition compared to the reward condition (3.8C: M=4.79, S.E.=.2; 3.8R: M=4.23, S.E.=.19). And similar to the other rating group, no significant difference exists in the scores of discomfort (p=0.678, effect size=0.025). While the scores of competence is significantly different comparing the three scenarios (p=.039, effect size of 0.188). However, the Bonferroni post-hoc analysis did not lead to any significant finding between the smaller groups.

Since, no significant difference is found in the scores of discomfort between scenarios, we summed them up and compared them to check if the different ratings lead to different perception regarding the discomfort dimension. However, no statistically significant difference exists between the score of discomfort neither in the larger population (p=.543, effect size: 0.053).

VI. DISCUSSION

In this paper, we investigated the effect that different ratings for the coffees would influence the decision making of subjects (H1). Specifically, the higher difference in ratings would lead to lower compliance. In other words, higher difference between the scores leads to a higher risk of receiving a bad coffee (lower-ranked coffee). Since the reward is fixed, it hence leads to lower reward or lower coercion in conditions with lower rankings. And we assumed that lower level of reward/coercion leads to less compliance.

However, results of logistic regression tests indicated that coffee rankings used in this study is not a good predictor of decision making of the participants. In other words, although the robot could persuade a large number of people to select the lower-ranked coffee (57.8%), this difference was not statistically significantly higher in the 3* vs. 3.8* ranking. Hence, we reject the first hypothesis (H1). A potential reason for this incident might be the minor differences between the two rankings (3 vs 3.8). A further study could assess this effect to determine a threshold so that the rating (of the less desirable choice) is not too low or too high so that it makes decision making easy. In other words, when the lower rank is too low, the participant might not risk and reject the persuasion easily. On the other hand, when the lower rank is too high, it becomes very close to the other option, and the participant would accept the persuasion to benefit from the two profit.

Also, we hypothesized that coercive strategy would be perceived negatively while reward would be perceived more positively (H4). We assumed that giving a reward would make the robot more friendly, and in contrast coercion would be a negative predictor of liking. However, the results indicated a contrasting findings, in other words the coercing robot was scored higher on warmth. A potential reason for this might be the fact that the participants did not perceive the coercive action of the robot as a punishment. Rather, a number of them perceived it as being funny and laughed out loud after the robot asked them to return the pen. Also, we expected to observe higher discomfort score in the coercive condition. However, we could not verify this hypothesis based on the collected data. One potential reason behind this might the weak imposed coercion, and probably because the participants had no intrinsic attachment to the pen. Another factor might be the minor differences in the dialogues. Actually, the two scenarios differ only in two sentences. Also, in the two scenarios, the robot showed the same instances of social interaction, such as facial expressions and gaze. However, to perceive a robot negatively, the robot needs to show samples of a bad attitude, for instance being rude. Hence, we cannot verify the fourth hypothesis. However, this finding should be interpreted cautiously. Specifically, we could not verify all the pre-assumptions due to the bias of earlier interaction. Hence, the results might not be generalizable to other studies. And this hypothesis needs to be further investigated in different scenarios with significantly different dialogues and social cues (and probably in longer duration of time).

In sum, although the robot could objectively persuade the users (selecting the lower ranked coffee), the subjective facet of persuasion was not significant in this study. A potential reason for this might be the difficulty in accurately measuring the perception of a robot using subjective measures [2].

Further, based on the ELM model, one single factor may have different influence on persuasion: in one circumstance it might influence the degree of elaboration, in another, it might influence the valence of elaboration, while in a third situation it might serve as a peripheral cue. These differences can give rise to different effects on persuasion and hence inconsistencies in research finding considering a single factor. Hence, further investigation is required to indicate in which direction the persuasion has influenced the user.

VII. CONCLUSION AND FUTURE WORK

In this paper, we investigated the effect that different conditions might have on persuading the users using social robots. Overall, the results showed that a robot has the potential to persuade the users and make a bias on their decision making. To be more specific, comparing to the control group, in which no persuasion was used, the robot could bias a number of participant’s decision toward a
less desirable choice. So, the robot could change people’s behavior in the expected direction. However, the subjective measures used in this study did not yield to significant findings that would be a fruitful area for further work.

Likewise any other laboratory experiment, this study might be affected by the effects of laboratory conditions. Considering participants’ awareness of taking part in an experiment, the findings could lead to over-compliance with robots’ requests. Furthermore, a stronger manipulation check to see if the participant perceived the pen as a reward/coercion, how much they value it. Another limitation of the study might be the design of the control condition. A better control condition could be designed in such a way that the robot asks the participants to take the worse choice with no persuasion strategy. Rather than letting them to freely select a coffee. We suggest that the findings are particularly relevant for the design and development of socially assistive robots, aiming to overcome the human-robot social barrier.

As future work, the study could be repeated using a higher number of participants who already interacted with a robot. Or it might be applied to people new to robots in multiple sessions to reduce the novelty effect. Considering the current dataset, we are not sure how people perceived the strategies and further work needs to be done to establish this. Also, we have recorded the behavioral and non-verbal responses of the participants using two cameras. Behavioral analysis of the user would be of great help in determining their perception. It would be interesting to see if people’s susceptibility to persuasion, specifically with regard to coercion or to reward, would have an impact. This design could be extended to other studies. For instance, the current design might provide an opportunity to investigate the "endowment effect" and "loss aversion" theory in a future study.

And last, but not least, as robots are prone to be hacked and taken over by others to perform misuse of persuasion acts [27], the characteristics of ethical influence becomes important in this field [28]. Ethical concerns about the use of persuasion should be taken into account when designing persuasive social robots.

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