The Power to Persuade: a study of Social Power in Human-Robot Interaction

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***Abstract*— Recent advances on Social Robotics raise the question whether a social robot can be used as a persuasive agent. To date, a body of literature has been performed using various approaches to answer this research question, ranging from the use of non-verbal behavior to the exploration of different embodiment characteristics. In this paper, we investigate the role of social power for making social robots more persuasive. Social power is defined as one's ability to influence another to do something which s/he would not do without the presence of such power. Different theories classify alternative ways to achieve social power, such as providing a reward, using coercion, or acting as an expert. In this work, we explored two types of persuasive strategies that are based on social power (specifically Reward and Expertise) and created two social robots that would employ such strategies. To examine the effectiveness of these strategies we performed a user study with 51 participants using two social robots in an adversarial setting in which both robots try to persuade the user on a concrete choice. The results show that even though each of the strategies caused the robots to be perceived differently in terms of their competence and warmth, both were similarly persuasive.**

I. INTRODUCTION

The future will bring robots into many aspects of our personal and work lives. To date, a considerable amount of new applications has been proposed in which robots and people accompany and interact with each other [1]. This gave a rise to the emergence of Social Robotics, which aims to develop robots capable of communicating and interacting with human users in a socio-emotional way [2]. The academic literature on Human-Robot Interactions (HRI) indicates that people are as sensitive to the social dynamics of power between people and robots as they are to the dynamics between people [3]. Social power, or for short power, is an important attribute of the influencing agent in an interpersonal influence situation [4] as it generates psychological states which influences how we feel, think and act [5]. Recent studies revealed that the higher is the sense of power, the greater is people's action orientation, level of abstract thinking and higher optimism in perceiving risk [5]. Thus, as robots are treated as social agents that can engage in social interactions with their users [6], they can benefit from being able to use social power in their interactions.

On the other hands, one recent trend in the field of Social Robotics is the rise of "Persuasive Robotics" which refers to the study of persuasion in HRI [7]. Persuasion also plays a critical role in human interaction and exchanges [8]. To date, a number of persuasive technologies using social robots is developed. For instance, persuasive robots have been applied to health-systems, learning and training, marketing, within workplaces, or in behavior change support systems leading to higher sustainability, safety, healthy living, etc. [9]–[11].

An important question regarding these technologies is how should robots behave in an interaction setting whose goal is to persuade? What strategies should they choose? Do such strategies work equally for everyone? We believe that unravelling these issues is central to HRI, leading to better persuasive robots. For instance, if specific personality traits favor specific persuasion strategies, personalized persuasive technologies may have higher performance in persuading subjects. Hence, in this paper we aim to address these questions by conducting a user study in a setting where two robots, making use of different social power strategies, to persuade users to choose one of three alternatives. As social power is recognized to be a motivating force central to human interactions [12] and given that recent studies acknowledge its relationship with persuasion [13], we aim to explore its effectiveness in robots that try to be persuasive. Also we make a comparison between robots using different persuasive strategies to test which of the two is most influential.

II. BACKGROUND

Research on social power has a long history and different theories exist in the literature of Social Psychology regarding this concept (for a short overview of the existing theories see [14]). To date, different definitions of social power have been defined in the field of psychology. For instance, in [15], social power is defined in terms of a relationship between people, as one's ability to influence the other one to do something which s/he would not do it without presence of such power. Another well-known theory of social power [12], indicates that power must exist in a dyadic relationship, i.e. a mutual dependence. The strength of this theory is its generality in covering a wide range of different social movements, such as internalization of social norms. Also, in [16], which is mainly intended for organizations, four primary sources of power are identified: ideological, economic, military, and political (IEMP). Each of these sources offer alternative organizational means of social control.

While a variety of definitions of social power have been suggested, this paper will use the definition from French and Raven [17], which is one of the most influential work in this field. This theory identifies different bases of power: reward, coercion, legitimate, expert and referent. As detailed later, two of these bases of power are selected to inform the different persuasive strategies (simply power strategies).

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Similarly, *Persuasion* has a long history in social psychology (for a review look at [18]). Persuasion is defined as an attempt to change/shape a target's belief or behavior about a subject, an issue or an object [7]. Hence, persuasion is a key process in shaping and maintaining cooperation, social influence and behavior change [19]. Moreover, central to every human interaction is the concept belief/behavior change playing an important role in Human-Human Interaction (HHI) or more interestingly human-robot interaction [7]. A number of factors contribute in its effectiveness, such as personality of the actor (or the one performing the influence) and the target (the one who is affected) [8].

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 vital role (e.g. actions of the actor). Previous studies revealed a number of factors associated with the ability of an individual to persuade the 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 [11].

Having defined what is meant by *social power* and *persuasion*, now we turn to consider the relationship between these two concepts. Over the past six decades, extensive research has shown that power and persuasion are entwined (for a recent review look at [13]). Early results shows that a powerful individual is more influential in persuading others [20]. However, it should be noted that the extent to which that the power is effective is dependent on the circumstances. In other words, under specific circumstances the same act may lead to short or long-term influence, as well as, to increase or decrease persuasion [13]. More recently, in [21] this relationship is investigated using an agentic-communal model. Interestingly, the authors have addressed how perception of warmth and competence of the persuasive actor affects persuasion outcome. To be more specific, there is a match between power level of audience/communicator and the use/acceptance of competence/warmth messages.

This link motivated us to investigate the effect of power on the persuasion ability of a social robot. With this aim, we propose the concept of "persuasion strategy" originating from sources of power. To be more specific, we argue that each base of social power leads to a channel of persuasion. Based on what Raven defines in [22], social influence is *a change in the belief, attitude, or behavior of a person*, resulted from the action of another person. In this case, social power is the potential for such an influence. And the level of influence performed is a function of the influencer's power. For instance, in correspondence to the reward power, a reward persuasive strategy refers to an attempt to persuade the target to comply with a request in response to a positive incentive. In turn, based on expert power, an expert persuasive strategy is an attempt to influence another one by making salient that the person has a superior knowledge about what is best under that specific circumstance.

In the scope of this paper, we explore the use of two persuasive strategies (reward & expert) that were previously defined and put the other three (coercion, legitimate and referent) for future work. We selected these two strategies because of their different nature, to explore two different kind of strategies in our study, and because they were the ones with best fit in the process of designing the task for the study, which is discussed in Section IV.

III. Related Work

The study of persuasive technologies is relatively new in HRI [23] and few studies have explored the persuasiveness of social robots [11]. In this section, we review a number of recent advances in HRI field. In a recent study presented in [24], the authors investigated the influence of social cues and gender of a social robot on psychological reactance and compliance toward it. The result of an *imaginary beverage making* task show that participants felt more reactance when interacting with a robot having less trustworthy related facial expressions. Also, the authors concluded that to have higher persuasiveness, facial expressions should be more similar to the ones recognized as being more trustworthy between human beings. Another study used a humanoid robot with different genders proposing persuasive messages to raise donations to deal with uneven distribution of technology around the world [7]. The results revealed that participants rated a robot in opposite sex as being more credible, trustworthy and engaging. Also, male participants tended to donate more interacting with a female robot. Finally, the effect of trust and engagement was significantly higher for male participants interacting with a female robot.

In [11], the authors investigated the use of vocal and bodily cues to enhance robot's ability to persuade within the imaginary task of solving the *Desert Survival Problem*. Specifically, they focused on 'proximity, gaze, and gestures' as bodily cues and on 'vocal tone and expressions' as vocal cues. The results show that compliance with the robots was significantly higher when the robot used nonverbal cues, compared to the lack of this ability. Also, in [25] the effectiveness of an embodied agent on behavior change (saving energy at homes) is investigated. With this aim, the authors explored the effect of social feedback vs. factual one, as well as, the effect of perceived agency of the robot. The results show that people are sensitive to social feedback they receive from a robotic agent. Also, persuasive robots are able to make behavior changes in humans. Further, this effect is stronger in case of using social feedback in an interactive setting in comparison to factual feedback.

When it comes to persuasiveness of recommendation, explainability of agents becomes important. In other words, the agent is required to provide an explanation of why humans should follow its persuasive advice. The goal of such explanation is to provide information and to obtain higher user engagement by generating confident and transparent information [26]. Recent studies investigated the role of persuasion in storytelling robots. For example, persuasiveness of a storytelling robot could be increased in case of using gaze and gestures [27]. In [28], the authors designed a social

robot as a storyteller in an interactive storytelling aiming at persuading the listener to make decisions in a subtle way.

There has been recent research exploring how robots can be more persuasive. Despite the promising findings of these studies, most of them have used imaginary tasks to explore persuasiveness of robots. Hence, the result might not be generalizable to an actual persuasion setting in which the participant really benefit/suffer from his/her decision. Also, despite the acknowledged role of social power in multitude social processes, few studies have investigated the concept of social power in robots. For instance, in [29], the effect of social (power) distance in task performance and rapport was investigated by assigning the same robot with either the role of a supervisor or a subordinate. The findings highlight the importance of consistency between the status and proxemic behaviors of the robot in fostering cooperation.

In this paper we aim to contribute to close the gap between social power and social robots research, focusing on persuasiveness. With this aim we designed a study to investigate the role of power on persuasiveness of social robots using the concept of "power strategy" defined previously. Also, in this study, we use "telling a joke" as a social reward. Social interaction is rewarding for social species and can drive individuals' behavior [30]. On the other hand, studies revealed that human beings perceive agent systems, such as virtual agents or robots, as social beings [31]. Hence, we can conclude that social rewards from such systems would positively affect our mental system in a similar way [32]. The concept of using social reward is not new and is used in a number of recent studies. For instance, positive facial expressions, such as smile and admire, have been used in prior studies targeting children or adolescents [33]. Inspired by such investigations in HHI, recent studies in HRI has investigated the role of social rewards. For instance, in [32] the authors investigated the relationships between the effects of social rewards and the number of robots. The results show that people who perceived the social reward performed better in the sequential finger-tapping task. Also, [33] shows that tangible and quantitative social reward had stronger incentive power than monetary reward among children and adolescents. Previous studies have investigated the concept of humor and telling a joke using computers or robots [34].

IV. Study design and procedure

A. Goal and Hypothesis

Our primary goal is investigating if the use of social power is effective for persuading people using social robots, or if personality differences affect the perceived persuasiveness of robots [35]. To examine these effects, we designed a persuasion task in which two robots try to convince participants to select a particular coffee brand by using different strategies. In this study, our control variables are: personality, Coffee Drinking Habit or CDH (how much they like/drink coffee), and an independent variable which is the power strategy used by the robot (rewarding the participant or giving him/her information). Further, we measure the following dependent variables: coffee selection (which coffee they select), robot preference (which robot they prefer to interact with in general), perceived persuasiveness of robots (how persuasive they find each robot with a specific power strategy), robot perception (how they perceive each robot in terms of warmth, competence, and discomfort), Future Compliance (FC) towards robot (the likelihood of following the robot's suggestions in the future). We constructed the following hypotheses:

- **H1**: We investigate the effect of different power strategies on the choice they opt for.
- **H2**: We explore people's preferences toward interacting with robots with different persuasive strategies.
- **H3**: We investigate how the two robots would be perceived considering the two different power strategies.
- **H4**: We inquire how different persuasiveness are perceived considering the two power strategies.
- **H5**: We explore if using different power strategies affects the likelihood of following future suggestions of the robots.
- **H6**: We inquire if people perceive the persuasiveness of robots differently based on their personality.

B. Task, Robots and Environment

To investigate these hypotheses, we designed a task in which two robots promote two different coffee capsules. To include a control condition, we added a third coffee option to control for random choice. If the robots have no effect the expected distribution of choices is 1/3 for each option. If the distribution is different, then the participants decision is due to the influence of the persuasive strategies. This third coffee could be promoted by a silent robot representing lack of a power strategy. However, this might cause a bias toward the other two robots having more dialogues with the user. To prevent such bias, we decided to place the control coffee option on the table, with no information, between the coffee capsules promoted by the two robots.

We programmed the robots in a scripted scenario with the two different persuasion strategies. In this scenario, one robot acts to persuade the user by giving information about the quality of his capsule (Expert Power Strategy). The other robot uses a reward to influence the user (Reward Power Strategy). As the reward, we programmed the robot to give the user "Social Rewards", by telling him/her a joke. We used two Emys robots appearing equally, however, differing in their voices and names (Emys and Gleen). The two robots represented the same instances of 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 [36]. In our study, from the participant side (the persuasion target) we focus on his/her personality, and from the robot side (the persuasion actor) we focus on its verbal cues.

We equipped an isolated room with the two robots, mounted on a table. Also, we put three equally appearing boxes (in randomized order) containing coffee capsules, two in front of each robot and one between the two robots (control condition). To avoid confusions we put the name of

each robot on the corresponding box, but we did not add any information on the third box. Further, we put a small table with a coffee machine on the left side of the participants, together with cups, sugar, and spoons. Furthermore, we put two cameras, one in front of the participant to record gestures or facial expressions and one on the back to record postures.

So in this study, we tested the robot's persuasiveness in a scenario where participants have to make a real choice, rather than an imaginary one (Table I lists the dialogues). Depending on the response of the participant, the researcher, acting as a Wizard of Oz, selected some of the sentences based on the user's dialogue choices (dialogue 4 and 15).

C. Procedure

We designed a within-subject study and ran for two weeks in single sessions which took less than 15 minutes. Each participant entered the room individually and seated at the table with the two robots. Participants were given the consent form and were briefly introduced to the task. We did not inform them about the goal of the study and curious participants were told that their questions could be addressed after the experiment. During the interaction, the robots explained that they are promoting different coffee capsules. One of the robots interacted in a more funny way by telling jokes, whereas the other robot was more serious and interacted based on facts and information. The funny robot (*Joker*), works to persuade the user by giving a social reward, as telling a joke. On the contrary, the Expert robot tries to influence the participant by highlighting the impressive characteristics of the coffee he has. We emphasize that the participants were unaware of the contents of the boxes. The participant should listen to the arguments of the robots and then make a choice, and at the end, had to fill out the questionnaire. While filling in the questionnaire, the experimenter made the coffee for the ones who opted to drink, and the rest took the coffee capsule as their reward of participation. To overcome potential biases towards the voices, we randomly assigned Expert/Joker role to the robots and counterbalanced the data to have an equal number of participants in each assignment.

D. Measures

The questionnaire is divided in 4 parts: 1) Demographics (gender, age, occupation, prior interaction with robots, coffee drinking habits); 2) TIPI personality Questionnaire [37], 3) the RObotic Social Attribute Scale (RoSaS) [38], 4) Finally, in the last section we added a number of questions to measure task-specific factors listed in Table II.

E. Sample

To gather the data, we put announcements around the university stating that "Do you want free coffee? Join our human-robot interaction experiment in 'Faculty of X, room X' and receive a coffee capsule." At the end of the experiment, 51 people (17 females, 34 males) participated in the experiment voluntarily. The participants' age ranges from 20 to 55 years old with a mean of 29.45 ± 6.4. Among these 51 participants, 23 people (54.9%) stated that they have already interacted with a robot, while the rest did not have any interaction with any kind of robot before this study. Among these 23 people who had prior interaction with a robot, 14 people (60.87%) had interacted with Emys type robots.

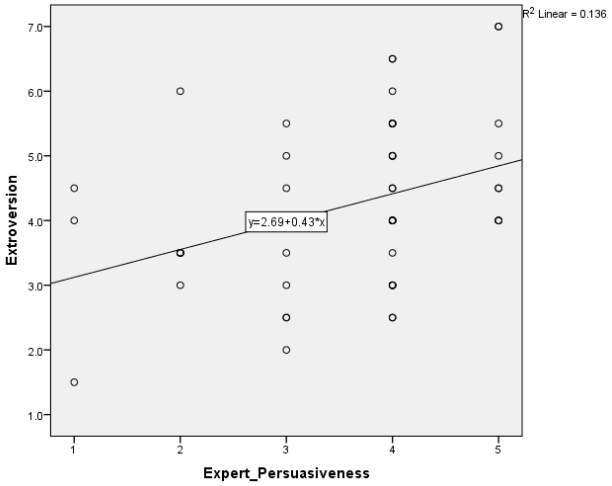

Fig. 1. Scatter plot of Expert's Persuasiveness X Extroversion

The result of Fisher tests show that a prior interaction with robots (either Emys type ($p = .332$) or any robot ($p = .364$)), had no influence on decision making of the participants. Also, we checked if Coffee Drinking Habits (CDH) of the participants alter their coffee selection. Considering the first two items in Table II, results of Chi-square tests (Liking-Coffee: $X^2(4) = 1.958, p = .743$; CoffeeTimes: $X^2(4) = 3.942, p = .414$) revealed that no significant association exists between either of the two variables measuring CDH and robot preference/coffee selection.

V. Results

Table III lists the descriptive statistics of the collected data[1]. Results did not provide evidence supporting our first hypothesis (H1). Around half of the participants (22 out of 51 or 43.1%) selected the coffee promoted by Joker, 21 people or 41.2% chose Expert's coffee, and a minority of the participants picked the middle box, the one that was not promoted by neither of the two robots (8 people or 15.7%). From a statistical point of view, there was no dominant preference in the *coffee choice* in regard to the used power strategy (H1: $X^2(1) = .023, p = .879$).

Regarding H2 or the robot preference (Item 4 in Table II), 18 people opted for Expert, and 29 people selected Joker, and four participants declared that they do not favor any of the two robots. From a statistical viewpoint, there was no dominant preference in the *robot choice* when considering all of the participants (H2: $X^2(1) = 2.574, p = .109$).

To investigate H3, we analyzed the perception of the robots based on three different social attributes (RoSAS):*Warmth*: A significant difference exists between the level of perceived warmth of the two robots, and the higher mean of the Joker's

[1]Full data: https://github.com/mojgan1987/SPinHRI

TABLE I

ROBOT DIALOGUE - IN THIS SCENARIO, GLEEN IS EXPERT AND EMYS IS JOKER.

#	robot	Dialogue
#1	Expert	<Gaze(person)>Dear + namePlayer + , my name is Gleen. Welcome to our coffee testing program!
#2	Joker	<Gaze(person)>Hello + namePlayer +, my name is Emys. Glad to see you here <Gaze(person3)>
#3	Expert	<Gaze(person)>Hey + namePlayer +, do you like coffee? <Gaze(Joker)>
#4a	Joker (Positive)	<Gaze(person)>Great, I also like coffee. That's why I am working here. Hih hih!
#4b	Joker (Negative)	<Gaze(person)>Oh, you don't? But I do love coffee. That's why I'm working here. Hih hih!
#4c	Joker (Neutral)	<Gaze(person)>Well, you might like our coffees here. But I love coffee. That's why I work here. Hih hih!
#5	Expert	<Gaze(person)>+ namePlayer +, I would like to explain what we are doing here <break strength='medium'>. <Gaze(Joker)>My robot colleague and I <Gaze(person)>are testing three different coffee brands. You see these three boxes on the table?
#6	Joker	<Gaze(person)>namePlayer +, I don't know if you have ever participated in a coffee testing program, but I think It's really fun. You can drink coffee as much as you like. It's the best experience I had in my life!
#7	Expert	Yeah. But, unlike other coffee testing programs, here, at the end of the experiment, you can only select one of the coffees we have <break strength='medium'/>. Either mine, Emys's or the third one, in the middle.
#8	Joker	When you decided which one you want to choose, take the box, open it and take your coffee. But don't take the box. Only the coffee!
#9	Expert	<Gaze(person)>I'd also like to add, you can take the coffee capsule with you and drink it when you were in the mood. Or drink the coffee here, using the machine you see on your left, on the red table.
#10	Joker	<Gaze(person)>Hey + namePlayer ! If you used that coffee, make one for me too. But wait, I cannot drink, hih hih!
#11	Expert	<Gaze(Joker)>Emys! let's get back to our work. <Gaze(person)>namePlayer +! My capsule is perfect. It has been made of fresh geisha seeds from Ethiopia. Each seed has been carefully roasted and dried <break strength='weak'/>. Then has been professionally ground. Therefore, this professionally processed coffee is very crispy and balanced. <break strength='weak'/>You will love this exotic and aromatic coffee.
#13	Joker	<Gaze(person)>But, + namePlayer ! If you select my capsules, I will tell you a funny joke about robots. I bet you have never heard a joke from a robot. Come and take mine!
#14	Expert	Now please select the coffee you want to test among these three options
#15a	Joker (if selected)	<ANIMATE(joy4)><Gaze(person)>Great, now listen to the joke <break strength='medium'/>. What would a man say to his dead robot? <break strength='strong'/><ANIMATE(joy4)><Gaze(person)>Rust in peace! <ANIMATE(joy4)>Ha ha ha ha!
#15b	Expert (if selected)	<ANIMATE(joy4)><Gaze(person3)>Great! You made the best decision. Hope you enjoy your coffee.
#15c	Expert/Joker	Under the case that None of the robots are selected, the two robots perform sadness gestures and facial expressions.

TABLE II

QUESTIONNAIRE. X REFERS TO JOKER/EXPERT AND THESE PARTICULAR QUESTIONS REPEATED FOR BOTH ROBOTS.

Section	Item#	Variable Name	Question	Scale
CDH	1	LikingCoffee	How much do you like coffee (In General)?	5-point Likert
	2	CoffeeTimes	How many times a day you drink coffee on the average?	5-point Likert
Final Remarks	3	Satisfaction	Are you satisfied with your selection?	5-point Likert
	4	RobotPreference	In general, which robot do you Prefer?	-
	5	Persuasion_X	How persuasive did you think X was?	5-point Likert
	6	FC_X	Specify the likelihood that you would follow X in future?	5-point Likert
	7	SP_X	In you opinion, does X have social power?	5-point Likert
	8	Joke	How funny was the joke? (What would a man say to his dead robot? Rust in peace!)	5-point Likert

TABLE III

DESCRIPTIVE STATISTICS OF THE COLLECTED DATA. IN THIS TABLE, "E" REFERS TO EXPERT AND "J" REFERS TO JOKER

Factor	Avg	SD	Min	Max	Factor	Avg	SD	Min	Max	Factor	Avg	SD	Min	Max
Extroversion	4.25	1.28	1.5	7	PowerSense	3.82	0.48	2.63	5	J_Competence	4.56	1.09	1.67	7
Agreeableness	3.49	0.94	1.5	5.5	FutCmplience_E	3.75	0.87	1	5	J_Discomfort	2.25	1.16	1	5.17
Conscientiousness	5.15	1.18	1	7	FutCmplience_J	3.29	1.24	1	5	E_Persuasiveness	3.61	1.1	1	5
EmotionalStability	3.32	1.48	1	6.5	E_Warmth	4.1	1.16	1.5	7	J_Persuasiveness	3.43	1.19	1	5
Openness	5.43	1	3	7	E_Competence	5.32	1.06	2.5	7	SocialPower_E	3.39	0.85	2	5
LikingCFE	3.82	1.23	1	5	E_Discomfort	2.28	1.17	1	6.33	SocialPower_J	3.51	1.1	1	5
CFE_Times	2.76	1.07	1	5	J_warmth	5.04	1.3	1	7	Satisfaction	4.06	0.88	2	5

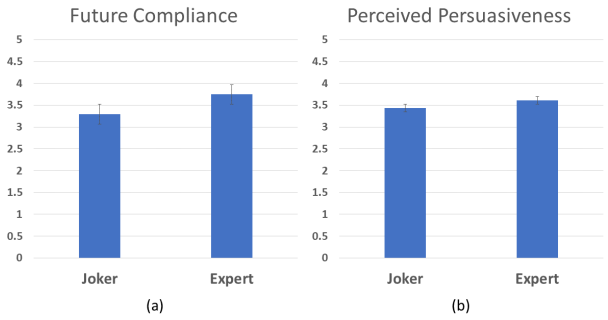

Fig. 2. Persuasion Scores

scores signifies that people perceived Joker to have higher warmth (Z=-4.409, p=.000). *Competence*: The results show that people found significantly higher competence in *Expert* comparing to the Joker (Z=-4.286, p=.000). *Discomfort*: No significant difference found between the scores of discomfort comparing the two robots (Z=-.199, p=.842).

Hence, we can infer that Joker scored higher on warmth, while the Expert robot was perceived to be more competent. However, no difference exist regarding the discomfort dimension, so from this point of view, the participants perceived the two robots similarly. Hence, the third hypothesis is verified.

Regarding Persuasiveness variable (H4 or item #5 in Table II), the result of a Wilcoxon test shows that no significant difference exists between the perceived persuasiveness of the two robots (Z=-.944, p=.345). It means that the participants found the two robots persuasive (see Figure 2 (a)). Thus, we cannot verify the fourth hypothesis.

Turning now to H5 or item 6 in Table II, we checked whether they are willing to follow future suggestions by any of the two robots. For this item, there is a significant difference between participants' idea about following suggestions of Expert versus Joker's (FutCompliance: Z=-2.363). In this case, the higher mean of the Expert's score (3.75 vs. 3.29 and 2.92 vs. 2.51 respectively) signifies that people are more willing to follow Expert's suggestion in future, comparing to Joker. Thus, the 5th hypothesis is verified (Figure 2 (b)).

Finally, regarding H6, to investigate the potential association between personality traits and perceived persuasiveness of the robots, we performed a linear regression with a forward selection procedure. We used all the five dimensions of personality to examine the relationship between each factor and the perceived persuasiveness of the two robots. Regarding the Expert robot, the obtained model ($F(1, 49) = 7.69, p = 0.008, R^2 = 0.136$) ended up with only one predictor, namely, the Extroversion dimension ($\beta = 0.37$). Figure 1 shows a scatter plot of the existing correlation. In case of the perceived Joker persuasiveness, the forward selection returned an empty set of predictors, indicating that none of the personality dimensions, nor their linear combination, are correlated with Joker's persuasiveness. Turning to the 7th item in Table II, perceived Social Power (SP) of the robots, there is no significant difference between the power level of the two robots (Z=-1.099, p=.272) although Joker was scored higher on the average.

VI. Discussion

The scores of RoSAS questionnaire revealed that the Joker, succeeded in presenting himself as being more kind and funny, as it scored significantly higher on Warmth. On the other hand, the Expert succeeded in showing himself as being knowledgeable, skilled, and informative, as it scored higher on Competence (H3). Considering the perceived persuasiveness of the two robots, no statistically significant differences found between this score corresponding to Joker or Expert (H4). Also, our results show that the third coffee (the control option) is much less common. This finding indicates that the two power strategies are effective and the two robots were able to persuade people, although they were perceived differently with regards to competence and warmth. It should be noted that the mean score corresponding to the two robots is higher than medium, which endorses their ability to persuade and influence the participants. This fact, could be due to the use of persuasive strategies inspired by social power bases (Reward and Expert). Results also show that there is a correlation between perceived persuasiveness of the expert and Extroversion dimension (H6). The positive correlation indicates that higher extroverted people are more likely to be persuaded by the Expert robot. However, no other similar correlation was found regarding other personality dimensions or regarding the perceived persuasiveness of Joker. Although previous studies have found positive correlations between persuasive strategies and agreeableness as well as emotion stability [39], we could not confirm them in this study. This might be attributed to our limited sample size or due to the nature of the persuasion task. Also, we hypothesized that personal characteristics play a vital role in being persuaded by one specific type of power strategies, however, this difference was not standing out in the results. A potential reason to this might be a number of hidden factors other than what we measured in this study, such as Need for Cognition. We aim to investigate these factors in future.

As stated earlier, although Joker was perceived to have higher power (SP) on the average, this difference is not statistically significant. This finding should be interpreted carefully since the mean score of the two robots lie around the middle score of the Likert scale. To be more specific, measuring social power of the robots might not be truly reflected using a single question. One potential reason for this might be misunderstanding in interpretation of "social power" expression. It should be mentioned that the experimenter was asked about the meaning of "social power".

Finally, regarding Future Compliance (FC), which supports the effectiveness of persuasion strategies, there was no significant differences between persuasion of the two robots (due to the use of power strategies); However, people are more eager to follow Expert's suggestions. This could be due to the expertise of the Expert and the fact that he stated more logical and rational statements. On the other hands, this finding also highlights the role of "reward power strategy" in

persuading people: although people found the Expert more trustworthy to be followed in future (H5), the Joker was also similarly successful in persuading them to choose his coffee (H1). In other words, we can infer that people found the Expert more reliable to be followed in future. So we can conclude that, the Joker was also persuasive, however, his persuasion was based on the effect of the reward strategy, not the information. In other words, some people are persuadable more easily by means of rewards.

Furthermore, we would like to highlight that the obtained results are independent from Coffee Drinking Habits (CDH) of the participants. Results of Chi-square tests revealed that no significant association exists between CHD and robot preference/coffee selection. Moreover, no association exists between CDH and satisfaction nor perceived social power of any robots. We hypothesized that people who like the coffee might be more sensitive to the quality of the coffee, and would opt for the coffee advertised from the Expert, but the results obtained did not confirm this. Another potential reason for this might be Expert's arguments which addresses the flavor, hence people who do not like coffee flavor might opt to go with one of the other two options instead. Hence future studies could usefully consider this.

In a nutshell, based on French and Raven theory, power arises from different sources. In this study, we equipped robots with two different sources, i.e. reward and expertise and designed them in such a way to generate persuasive strategies based on their power sources. Overall, this study shows that using different sources of power, and hence power strategies, appear to be equally viable solution to design social robots capable of persuading people. Also, we argue that the result of this study shows that Social Rewards can be effective at persuading users and, unlike material rewards, they are unlimited and always available.

VII. Conclusion and Future Work

In this article, we investigated the influence of two different persuasive strategies in an adversarial setting. To do so, we performed a user study in an actual decision making process within a persuasion setting. Our main goal was to examine the effect of different persuasion strategies that are based on social power. The second purpose of the study was to investigate the perception of such persuasive strategies from people with different personalities. To the best of our knowledge, the use of social power as a persuasive strategies have not yet been explored before this study.

Together the results of this study provide important insights into persuasion in HRI. First of all, this study has identified two different persuasive strategies that were selected and preferred equally. However, these strategies lead to different perception of robots and personal characteristics of each user, such as their personality also affect which strategies are deemed to be more effective. The second major finding was that using social reward is effective. To be more specific, in the two persuasive settings, the user was rewarded ultimately by receiving a coffee capsule, by either selecting any of the two promoted coffees or selecting none of them. However, selecting the Joker's coffee yielded to another dimension of reward, hearing the joke, as an example of a social reward. Undoubtedly, Social Rewards are cheaper and easily applicable in any type of Social Robots. The result of this study not only shows its effectiveness, but also it applicability in persuasion. These findings suggest that, in general, robots are capable of persuading people, however, personal differences should be taken into account. It should be noted that, only two bases of power have been tested here, and the rest have yet to be examined in future attempts. The result of the current study indicated that the two strategies used here were preferred equally, however, it should be noted that different power strategies might lead to different outcome. Also, the level of power exerted might influence the results. For example, a stronger reward strategy might be preferred higher. In other words, the comparability of such power strategies is inherently problematic because the power of an implemented strategy depends to a large extent on its implementation.

A potential question raised by this study might be that if combining the two strategies would lead to higher persuasion which worth investigating in the future. Further research could usefully explore the participants' social responses towards robots' persuasive messages, using behavioral cues and body language of the participants, their facial expressions, gesture and postures, to further investigate their decision making process facing these two power strategies. Finally, another factor influencing the likelihood that an individual yields to others' persuasive attempts, is the Plausibility of the Target [8]. Further work needs to be done to establish whether this characteristics of the participant plays a role in HRI setting. Recent studies found correlation between ostensible gender of the robot and perceived persuasiveness [7], [24]. Although Emys does not clearly appear to be either female or male, the two voices we assigned to them were both males. A potential future work worth performing is using voices with different genders to see weather its combination with persuasive strategies leads to higher effect. Finally, when people are subjected to strong persuasive attempts, they may respond negatively towards the attempt, with a behavior that is known as psychological reactance [36]. A future study could assess this by measuring the strength of the perceived persuasiveness message of the robot from the perspective of the participants. Also, participants' culture and background may affect how they perceive the over-the-top language used by the expert. A further study could also assess the effect of subjects' trust regarding such arguments [40].

A further study could assess the long-term effects of several persuasive interactions. The study should be repeated with a more homogeneous (gender balanced) sample and using more specific questions about the perception of the joke and either if the subjects find it as a positive reward, or even if they really find the other robot as an expert. More specifically a social power scale is required to implicitly measure the perceived level of social power, or a validating the dialogues by experts/judges criteria may resolve this issue. Moreover,

a better counterbalancing could be achieved by randomizing the location of the control coffee.

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