What Makes a Good Robotic Advisor? The Role of Assertiveness in Human-Robot Interaction

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Abstract. The display of different levels of assertiveness by a robot can be an essential factor in determining the way it is perceived and the extent to which it can influence its users. To explore the persuasive abilities of social robots, we devised an interactive storytelling scenario, in which users had to make several decisions while being persuaded by two autonomous robots (each one displaying low, high or neutral levels of assertiveness). To evaluate how different levels of assertiveness affected the decision-making process, we conducted a user study (n = 61) in which we measured participants' perceptions of the robots, the valence of their emotional state and level of assertiveness. Our findings revealed that (a) the user's perception of assertive robots differed from their initial expectations about robots in general and (b) that robots displaying personality were more effective at influencing participants to change their decisions than robots displaying a neutral arrangement of traits.

Keywords: Human-robot interaction · Interactive storytelling · Personality · Persuasion · Autonomous robots

1 Personalization, Assertiveness and Decision-Making in Human-Robot Interaction

The personality of the user is an important factor to take into consideration when designing interactive technological artefacts. Rosenthal-von der Pütten and colleagues [23] demonstrated that the user's personality influenced their feelings

We would like to thank the National Council for Scientific and Technological Development (CNPq) program Science without Border: 201833/2014-0 - Brazil and Agência Regional para o Desenvolvimento e Tecnologia (ARDITI) - M1420-09-5369-000001, for PhD grants to first and second authors respectively. This work was also supported by Fundação para a Ciência e a Tecnologia: (FCT) - UID/CEC/50021/2019 and the project AMIGOS:PTDC/EEISII/7174/2014.

M. A. Salichs et al. (Eds.): ICSR 2019, LNAI 11876, pp. 144–154, 2019.
https://doi.org/10.1007/978-3-030-35888-4_14

towards robots, their evaluation of these agents and actual behaviour towards them. Moreover, Callejas and colleagues [7] observed that the similarity between the user's and the agent's personalities had a moderating effect on the user's satisfaction with the interaction. This is also demonstrated by the work of Nass and Lee [17], in which participants felt more attracted and evaluated more positively robotic voices that showed a similar personality to their own. Furthermore, a study conducted by Aly and Tapus [2] also suggested that interaction with a robot is perceived as more engaging and natural when the robot adjusts to the interaction style of the participant, thus lending further credence to the idea that personalised Human-Robot Interaction (HRI) has the potential to offer a number of benefits not present in traditional HRI.

Although previous work has extensively acknowledged the importance of certain personality traits, it left others mostly in the shadows in regards to their effects in HRI, such as assertiveness [14]. Assertiveness is a valuable trait that people develop throughout their lifetime and that facilitates the achievement of one's goals while considering the rights, needs and desires of others [1]. The currently existing work concerning the role of assertiveness in HRI has presented mixed results. For instance, a pilot study conducted by Xin and Sharlin [26] found that users assigned more trust to a robot displaying a high level of assertiveness than to a robot displaying a low level of this trait, however a further investigation by the same authors returned inconclusive results [27]. Congruently, Chidambaram and colleagues [8] found no significant association between the level of assertiveness displayed by the robot and the participants' willingness to comply with its suggestions. However, the level of assertiveness seems to affect participants' evaluations of robots. For instance, Woods and colleagues observed that there was an association between the assertiveness level of the female participants and those participants' evaluation of the assertiveness level of the robot [25]. This is in line with the results reported by other authors who have also observed that the level of assertiveness displayed by participants is a good predictor of their evaluations of the assertiveness displayed by the robot [8]. But, it remains unclear what the direction of this effect is. In the first study, the authors observed a positive relationship between the individual's and the robot's reported levels of assertiveness. In the second study, this association seemed to go in the opposite direction, with subjects who scored higher on assertiveness, rating the robot lower on this trait [8,25].

These mixed results can be partly explained by the complexity of persuasive communications. Indeed, communication among humans is a complex phenomenon that involves both verbal and non-verbal cues. Within the realm of nonverbal communication, the display of negative emotions coupled with assertive behaviour can increase the effectiveness of a persuasion attempt [14]. Besides, several studies have shown that despite personality being an instrumental factor in predicting decision-making (e.g. [6]), especially in group scenarios [22], individuals are more likely to be persuaded when the persuasive situation presents determined characteristics (see [12,14]).

From an HRI perspective, studies on persuasion have focused mostly in explorations of the effectiveness of persuasive approaches using both verbal [3] and non-verbal cues [8] and in the role of the robot embodiment [15]; thus, paying little attention to contextual, task and user-related attributes. In this paper, we seek to fill that gap by taking into consideration a personality trait of the user (i.e., the level of assertiveness) and the role of the robots' emotional expression (in terms of its valence: positive or negative) in determining the effectiveness of the persuasion attempts.

2 Goals and Hypothesis

Our goal is to analyse how the display of different levels of assertiveness can affect people's responses to two robotic agents in the context of an interactive storytelling game. More specifically, we will analyse how the display of different levels of assertiveness (high, low or neutral) by a robot can influence (a) peoples' perception of the robot; (b) peoples' emotional state during the interaction and (c) participants' decision-making process.

To achieve this goal, we devised a mixed design study in which the level of assertiveness displayed by the robots was manipulated. As such, we had two conditions: (1) both robots presented a neutral level of assertiveness (henceforth, neutral or control condition) and (2) each robot presented different levels of assertiveness (high or low; henceforth, test or personality condition).

In this study, sought to test the following hypotheses:

- **H1:** Participants will change their decisions more often when being persuaded by a robot displaying a negative facial emotion than by one displaying a positive facial emotion.
- **H2:** Participants who report a high level of assertiveness will evaluate the robots as being more assertive than participants who score low on this trait. As an exploratory hypothesis, we will also analyse possible gender differences in this attribution effect.
- **H3:** We also expect to observe differences in the perception of robots displaying different levels of assertiveness both between robots displaying different levels of assertiveness and between each robot and the participants' general perception of robots prior to the interaction.

3 Research Methods

3.1 Participants

A sample of 61 participants (40 male) was recruited on the campus of a technological institute. Participants were on average 24 years old ($SD = 7.1$).

3.2 Materials

We conducted a quantitative study using two autonomous EMYS robots programmed to display different levels of assertiveness and act as advisers in an interactive storytelling scenario. A speaker was placed next to each robot to communicate its verbal utterances. A touchscreen was used to display the elements of the interactive story and to enable the user to chose her/his path in the story.

3.3 Manipulations

Four physical aspects of the robots' behaviour were manipulated to display different levels of assertiveness in accordance with a previous validation reported in [20]: (a) pitch (with values x-low, default and x-high), (b) rate of speech (values set as medium and +20%), (c) posture, and (d) eye gaze behaviour[1]. To ease the distinction between the two robots, they were given different names: *Emys* (high assertiveness) and *Glin* (low assertiveness). In the neutral condition, the names were assigned randomly (Fig. 1).

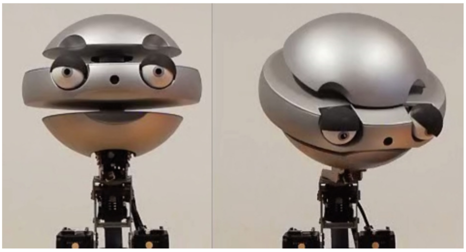

Fig. 1. EMYS robot with postures pride at left and shame at right.

3.4 Procedures and Measures

Pre-interaction. After signing the informed consent, participants were asked to answer to the Myers-Briggs Type Indicator (MBTI) [5] to assess their personality. Secondly, to determine their own level of assertiveness, they answered a personality scale from [9]. Thirdly, to measure participants perceptions and feelings towards robots, they responded to the Godspeed Questionnaire [4] and PANAS (Positive and Negative Affect Schedule) [11]. Because participants had not interacted with the robots yet, the items of these questionnaires were framed to refer to participant's perceptions of robots in general. Finally, they were asked to respond to a brief sociodemographic questionnaire.

[1] More details regarding the configurations of the robots for the display of assertiveness can be consulted in [20].

Interaction. Participants were told that they would be playing a game in which they would take on the role of the leader of a country that receives an invasion threat from an enemy country. Participants were also told that to defend their country, they would have to make some important decisions and that to do so, they would receive help from two robotic advisors. Participants were told that they would have to state their intention of a decision at each *Decision Point* (DP) and then, after hearing the advice of the robot, indicate their final choice. The narrative is a short story set in the medieval period, with approximately 30 min of duration.

Post-interaction. In this stage, participants were asked to assess their emotional state subsequent to the interaction and the assertiveness level that they displayed during the game. Afterwards, they evaluated their perceptions and feelings towards each one of the robots and the extent to which their decisions were affected by them. Participants received a cinema ticket as compensation for their participation.

3.5 The Platform

The platform was developed using the language *C#*, which allows the integration with the framework described in [24] and supports the communication with the robots. The flow of the system with the user intervention has: the Scene Generator, the Persuasion Module, the Robot Selection Function, the Personality Module, and the System Settings. For a visual representation of the system architecture, consult [18].

Scene Generator (SG). Determines the next scene of the story flow by taking into consideration the user's final decision. The story follows a parallel interactive storytelling structure where the user can go to different parts of the story and face different decisions depending on the choices made. In total, the story has 30 distinct DPs, and to reach the end, the user must pass through a minimum of 20. This way, the SG is responsible for: (a) showing the selected scene for each DP, (b) call the text-to-speech to process the corresponding utterance for the narrator and (c) present two decisions after the narration finishes. After this last point, the user must inform his/her intention of decision for the DP. In [18] it is presented a persuasion flow that depicts a small part of the scheme that represents the full story with the DPs and the MBTI dimensions that it measures (details in Subsect. 3.5 PEM).

System Settings (SS). It is responsible for storing the information related to the user's personality (collected in the pre-interaction stage) and the robots' characteristics (personality and congruence with the user personality). The robots features are updated every time the Sect. 3.5 RSF is called.

Persuasion Module (PM). It has in consideration information from the Sect. 3.5 SS and combines these settings and the user's intention to produce the corresponding persuasive gestures. As a result, the PM determines the type of persuasion (verbal and non-verbal) that the robot will make. The Non-Verbal Cues are associated with facial expressions and head movements (nodding yes or shaking the head for no); while the Verbal Cues are the utterances said by the robots after the user intention has been indicated.

After the players' final decision, this module is reactivated by the Personality Module (see Sect. 3.5 PEM), by sending information about the decision and the personality classification. This data will then define the final response of the robot based on whether the participants' decision was congruent (joy) or incongruent (anger) with his/her personality.

Robot Selection Function (RSF). During the story, each user will interact with the system and one of the two robots in each DP through a specific order. The process has into consideration that: (a) the story has DPs associated with the MBTI dichotomies pairs **EI** (Extroverted-Introverted), **SN** (Sensing-iNtuition), **TF** (Thinking-Feeling) and **JP** (Judging-Perceiving); (b) for each pair exists a maximum number of DPs (**K**) in the story and (c) the robot can act in **favour** or **against** the player's personality. For example, having into consideration the first DP (DP1), that measures the pair **EI**, and in all story, there are 5 DPs for this pair, **K** maximum is 5. This way, following the process in Fig. 2, the random robot selected was the less-assertive one; $K = 1$, so $K\%2 \neq 0$ (remainder of 1 per 2) which means the robot will be performing the advice against the user personality; finally, K is incremented. This process will be repeated until each dichotomy pair has reached their limit ($K = max$) or the user has finished the game. The flow for the selection of traits and the scheme of the story flow can be consulted in [18].

Personality Module (PEM). It does a real-time classification of the user personality based on the dichotomy associated with the DP received. This classification was generated through a parallel mechanism based on the findings presented in [19], which shows that each DP in this game is "connected" to one of the dimensions of the MBTI questionnaire. In this sense, we devised a story that considers all MBTI dimensions and follows the same principles of [19]. After the user final decision in each DP, the PEM will activate the PM again by sending the user's personality classification for the DP and the final decision that was selected. With the features described above, at the end of the interaction, the system presents information about both (a) the game outcome (victory or defeat) and (b) the MBTI dimensions score for each user.

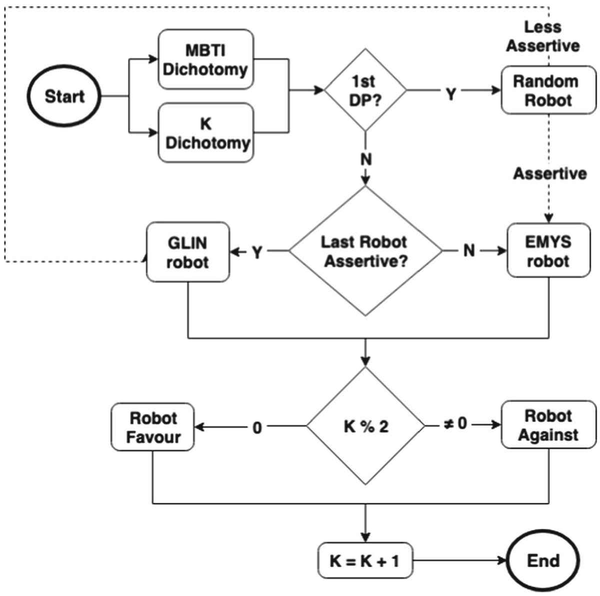

Fig. 2. Flow for the selection of traits for the assertive and/or less-assertive robot acting in favour or against the user's personality.

4 Results

H1. In order to examine the relationship between the valence of the facial emotion displayed by the robot (positive or negative) and the participants' final decision (congruent or incongruent with their initial intention), we conducted a χ^2 test. This test yielded that the relation between these two variables was significant (χ^2 (1, $N = 1220$) = 547.06; p <.01). Although most participants did not alter their decisions ($n = 756$), they were more likely to make a choice that differed from their initial intentions when the robot displayed a negative emotion (*i.e. anger*; $n = 290$) than when the robot displayed a positive emotion (*i.e. joy*; $n = 174$). On the other hand, participants were more likely to maintain their decisions in the game, when the robot displayed joy ($n = 737$), than when it displayed anger ($n = 19$).

H2. We computed the average score of participants' self-reported level of assertiveness (pre-interaction) and the average score given to each robot and then categorised them as being high or low assertive depending on weather their scores were above or below the middle point of the scale. We then performed a χ^2 test, which revealed no significant difference in the distribution of these two variables, neither for the high assertiveness robot (χ^2 (1, $N = 60$) = .43; p = .51) nor for the low assertiveness robot (χ^2 (1, $N = 60$) = .90; p = .34). Moreover, we also analysed the relation between the evaluation of the level of assertiveness displayed by the robots by participants and the participants' gender. In this regard, we observed a significant difference in the evaluation of the high assertiveness robot (χ^2 (2, $N = 60) = 19.45$; $p <.01$), suggesting that male participants rated this robot higher in assertiveness ($N = 37$) than female participants ($N = 20$). However, no differences were found in the evaluation of the low assertiveness robot according to the gender of the participant (χ^2 (3, $N = 60) = 4.03$; $p = .26$). Furthermore, we also did not observe any differences in the level of self-reported assertiveness between female and male users (χ^2 (2, $N = 60) = 1.09$; $p = .58$).

H3. To test this hypothesis, we analysed the answers of the Godspeed Questionnaire given by the participants in the pre and post stages of the study. Because our data did not present a normal distribution, we opted for a non-parametric test (Wilcoxon). Results suggest that participants had a different perception of the high assertiveness robot (Emys) after interacting with it than they had about robots in general (pre-interaction) in terms of appearance ($Z = -2.612; p = .009$), consciousness ($Z = -3.03; p = .002$) and friendliness ($Z = -3.28; p = .001$). Furthermore, the low assertiveness robot was also found to differ in terms of appearance ($Z = -2.44; p = .015$), consciousness ($Z = -2.98; p = .003$), friendliness ($Z = -2.68; p = .007$) and its ability to display emotions ($Z = -2.06; p = .039$) (see Fig. 3), in comparison to the perception of participants about robots in general before the interaction. Regarding the robots that did not present an assertive trait (neutral robots), participants also perceived them differently after interacting with them when compared with their general perceptions of robots. Our results revealed that both neutral robots presented sig. differences in impression (Emys ($Z = -1.96; p = .050$), Glin ($Z = -2.57; p = .01$)) and, only Glin was sig. difference in competence ($Z = -2.31; p = .021$). Concerning the statistical dif-

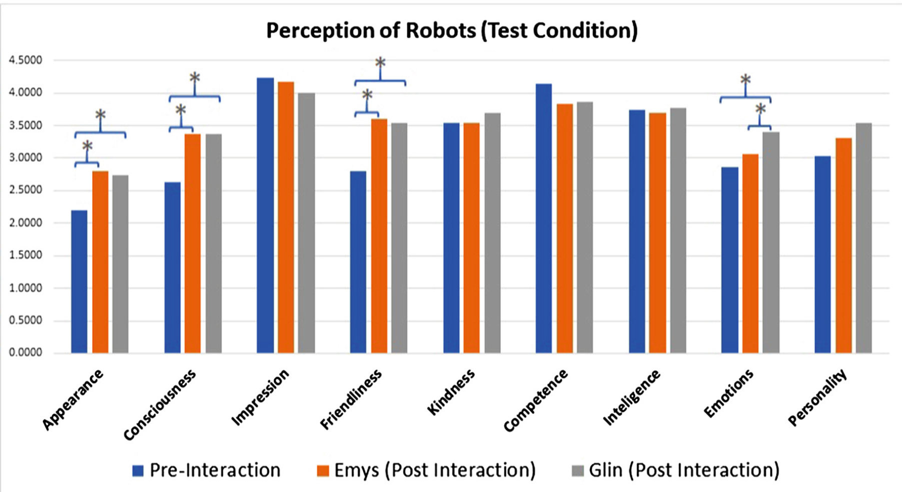

Fig. 3. The x-axis is the mean of the answers and Y-axis is the features measured for the Assertive and less-assertive robots (test condition).

ferences between both robots after the interaction, only the capacity of expressing emotions was perceived differently by the participants for the test condition ($Z = -2.500; p = .012$). Regarding the control condition, no statistical differences were found among the two robots.

5 Discussion

5.1 The Role of Emotions (H1)

Our results suggest that robot's persuasion attempts were more effective when the robot displayed a negative facial emotion, than when it displayed a positive facial emotion. In this instance, the negative emotion displayed by the robot might have emphasised the importance of the decision requested of the participant (and the potential negative consequences that would result of a wrong decision). This is congruent with previous literature that suggests that the perceived importance of a decision to the individual's self construct and attitudes presents a negative relation to the likelihood that the same individual has to be persuaded to take a course of action that is incongruent with his self-concept [10]. Moreover, in the specific context of HRI, some authors have speculated that negative emotions (in particular anger), can facilitate persuasion by easing the individual to make a concession [28].

5.2 The Role of Assertiveness (H2-H3)

Congruently with the results presented by Chidambaram et al. [8], we observed no relationship between the level of assertiveness of the participant (high or low) and the evaluation that participants made of the robots for this trait. This is contrary to H2, which stated that there would be an association between these two variables and warrants further research. Indeed, despite a trend in the literature suggesting that personalised interactions can foster a better HRI, this effect might be moderated or mediated by other variables. In particular, we observed that male participants rated the high assertiveness robot as being more assertive than the female participants, although no differences in assertiveness between female and male participants were observed in this study. This suggests that the sex of participants can have an important role in determining their perception of robots, which is congruent with the conclusions (but not with the results) drawn by Woods and colleagues [25].

In our scenario, the participant's assessment of the robots varied according to their level of assertiveness, which was in line with H3. Despite both robots with personality being evaluated similarly in terms of appearance, consciousness and friendliness, the less assertive robot was able to convey emotions better than the high assertive robot. Past research has revealed that empathy is a key factor when working with robots [13,21] and the fact that the less assertive robot had a more evident display of vulnerable emotions (shyness) might have contributed towards this effect [16].

Overall, our results offer valuable insights regarding the role of assertiveness in the context of persuasive HRI.

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