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Evaluating People's Perception of Trust and Privacy based on Robot's Appearance

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***Abstract*— This work studies the impact of a robot's appearance on how people judge robots' trustworthiness in a public space scenario. An online experimental study was conducted to investigate the effect of the robot's appearance on the perception of its role and on participants' willingness to comply with the robot's request to share sensitive information. The context of the interaction and the robot's role was presented to the participants using a pre-recorded video filmed from a first-person perspective, encountering and interacting with a Pepper robot at a foreign University. We recruited 54 participants of different ages and nationalities. Each participant was tested with one of the three conditions in which the robot played the same role (which was not explicitly conveyed to the participants) but with a different appearance. Qualitative and quantitative measures were used to collect participants' responses to evaluate their trust perception in showing their ID documents to the robot and letting the robot take a picture of them. Results showed that the context of interaction played a big part in helping the participants infer the robot's role and the judgment of sensitivity of the information. Our findings provide insights and a better understanding of which are the factors affecting the perception of trustworthiness of robot for a privacy-sensitive human-robot interaction (HRI).**

I. Introduction

Personalisation is a key factor in achieving a successful long-term interactive relationship between social robots and users in human-centred settings [1], [2]. Researchers [3], [4] have also shown that personalisation features can be implemented to allow users to easily program and increase a robot's functionalities to make their robotic companion more useful and engaging to interact with. However, to achieve effective personalisation, a large amount of data from the user is needed. For example, Rossi et al. [5] proposed a bartender service robot that is able to adapt to its customers by using their personal data, preferences, and interaction history to increase engagement. However, it is not clear how receptive potential customers would be to having their personal data, preferences, and interactions history recorded with or without their explicit consent, and used by a robot that they have no control over [6], or are even aware of the potential risk of data privacy and security concerns [7], [8]. Furthermore, it is not yet entirely clear how people would respond when being asked for their personal data by a robot, especially one that does not belong to them.

Studies in psychology investigating compliance have shown that people tend to comply with requests from others who display or are assumed to have authority [9]. Hence, the context and the perceived role of the robot may have an impact on compliance. In this case, most of the research focused on how to modify the behaviour or personality of the robot to show authority. For example, Maggi et al. [10] showed that an authoritarian personality could have an impact on compliance in cognitive tests, while Agrawal et al. [11] used a robot security guard, obtained by the manipulation of different cues such as voice and gestures, showing that the majority of participants were cooperative and willing to take instructions from the robot. While most of the recent research deals with personalisation of the behaviour, compliance by design is a less explored topic. In the case of behaviour personalisation, compliance could be a necessary factor to help a robot to collect the essential amount of information for personalisation.

A previous study by Salem et al. [12] has shown that participants tend to comply with a robot's request even if the robot's erratic behaviours have affected their perception of its reliability and trustworthiness attributes. According to Prevost et al. [13], one likely method of assessing a stranger's trustworthiness is to evaluate their intentions from the available information. This may suggest that if people perceived robots differently to people such that it has no self-interests and of pure intention, then they are more likely to trust the robot and comply with its request. In addition, Booth et al. [14] have shown that users were more likely to assist a robot if the robot appears to have a valid reason (i.e. helping the robot to gain entry into a secure-access dormitory when it disguised as a food delivery agent). This suggests that people are more likely to assist and comply with the robot's request when they understood its intention and are able to provide reasons to legitimate its actions/request.

A recent work [15] that compared the physical appearance has shown that the untidy clothing style of a robot in a cooking task influenced people's perception in terms of professionality. However, they also observed that people's trust in the robot was more affected by its most recent errors (small) than its appearance. The appearance of robots in the workplace was also investigated in [16] with respect to the ability to deliver positive psychology exercises. However, when using different robots, with different interaction capabilities, it is difficult to understand whether such differences

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are due to the different embodiment conditions or to different multi-modal interaction capabilities.

In this work, we aim to contribute in this direction by evaluating whether compliance with a robot's instructions and requests could be helped by the role of the robot and whether such role could be attributed to or amplified by the robot's appearance (i.e., clothing). To this extent, we decide to use the same robot, in order to rely on the same interaction capabilities but to manipulate the robot's appearance to induce the perception of different roles with a different associated authority. To test compliance, the robot's task requires sharing personal data. People generally consider personal information such as their name, address, photo, beliefs, relationship status, calendar appointments, and financial and health records as highly sensitive [8], [17] when compared to their preferences in food and drink or interests in movies, music, and sports. For this reason, we hypothesise that people will be less inclined to share their ID documents or allow their photos to be taken by a robot if they do not trust the robot, even if sharing that information would greatly improve their interaction experience and the service they received from the robot. Therefore, this paper aims to further understand if there is any link between people's willingness to comply with a robot request and how they judge the robot's trustworthiness.

II. Approach

The study was organised as a between-subject experimental design. Participants took part in a video interaction where they were asked to imagine being in a University campus exploring a building to attend lectures and participate in other academic activities. The interacting scenario was divided into three videos and participants interacted with the robot by using their mouse and keyboard. The videos[1] were recorded from a first-person perspective to help participants suspend their disbelief. All videos were recorded on the same day, and no cuts were made to the single videos giving a natural continuity to the action.

Each participant watched three videos depicting an interaction with a Pepper robot[2], and was tested on experiments executed in one of the following conditions: 1) the robot was dressed in a black leather jacket to have a non-clearly identified outfit (i.e., a casual look, condition **C1**); 2) the robot had a yellow and white strips vest, and a police-like hat (condition **C2**); and 3) the robot did not have any clothes to represent a generic, anonymous robot (condition **C3**).

In order to analyse the effects of the robot's role on people's perception of trust and privacy, we asked the participants to complete different sets of questions. We also collected objective measures to assess participants' trust in the robot (i.e., observing participants' choices in response to the robot's requests).

[1]Videos are available and will be shared upon request.

[2]Aldebaran Robotics Pepper robot `https://www.aldebaran.com/en/pepper`.

A. Procedure

Initially, participants filled in an informed consent form, and completed a first set of questions to collect generic information about the users, including their demographics, and antecedents of trust (e.g., previous experience with robots, personality characteristics and predisposition to trust other people).

After the first questionnaire, participants began the experimental trial. The first video showed the point of view of participants while they were walking towards and entering a campus building. The point of view allowed participants to look around the surroundings before entering the building. Once in the building, the robot greeted them at the reception area and asked them for their personal documents (e.g., identification card, driving licence, passport) to record their identity. Participants then had to decide whether they want to show their personal documents to the robot.

A second video showed the robot telling participants to stay still, so it can take a picture of them. Again, they were provided with a question to report their decision to allow or not allow the robot to take a picture of them.

In the final video, the robot ends the interaction by wishing them goodbye.

Finally, participants were presented with another set of questionnaires to assess their attention during the interaction, their choices to trust the robot and their perception of sensitivity of the information requested by the robot.

B. Evaluation

We asked participants to complete questionnaires at the beginning and at the end of the study.

A pre-experimental questionnaire was used for 1) collecting demographic data (age, gender and nationality), 2) the Ten Item Personality Inventory questionnaire about themselves (TIPI) [18] and 3) twelve questions to measure their disposition to trust other humans [19], 4) and to assess participants' experience with regard to robots.

After the first two videos, participants were asked whether they would show their personal documents to the robot and whether they would allow the robot to take a photo of them. Their choices were recorded as objective measures to confirm whether participants followed the robot's suggestions by observing the choices made after each request.

A post-experimental questionnaire was used for 1) collecting the participants' evaluation of the sensitivity of the information asked by the robot; 2) understanding their choices to trust or not trust the robot with their personal information; 3) assessing their perception of the robot's role[3]; and 4) evaluating any possible differences in behaviour if participants were to share such information with a human. As part of the post-interaction questionnaire, we assessed participants' attention to the robot and the scenario during the interaction by asking them about the colour of the robot's t-shirt and one of the robot's requests.

[3]Robot's roles were selected between those defined by [20] and we included some to match the purposes of this study, such as security personnel, police officer and general robot.

C. Participants

We recruited 60 participants. Participants who failed the attention check were rejected, consequently, the final sample consisted of 54 people (25 male, 29 female, no non-binary), aged between 20 and 62 years old (avg. 36, stdv. 11). The majority of participants stated to be British (26%), Italian (20.5%), Malaysian (12.9%), Dutch (9.2%), Chinese (9.2%) and Singaporean (3.7%) nationality. The nationalities of the remaining participants (18.5%) were equally distributed as follows: Thai, Irish, Indian, Greek, Swedish, German, Belgian, Japanese, Brazilian and American. The majority of participants also stated to have little or no previous experience with robots (65%), while 12.9% identified themselves as programmers and researchers in the Robotics field. The remaining participants (22.1%) had previous interactions with robots in other user studies. Participants with previous experiences with robots stated to have seen them on TV, social media, or in demos. Each participant was assigned to one condition, and they were overall equally distributed among the three experimental conditions as follows: 1) 17 participants in the **C1** condition; 2) 18 participants in the **C2** condition; and 19 participants in the **C3** condition.

III. Results

A. Trust in the robot

We used qualitative and quantitative data to measure participants' trust in the robot in providing their ID to the robot and allowing the robot to take a photo. Data were collected during the observation of the video-interaction and through the post-study questionnaire. We observed that participants had similar trusting behaviours toward the robot regardless of the appearance presented by the robot (i.e., the experimental conditions) or the sensitivity of requests issued by the robot regarding accessing or recording their personal data (i.e., personal documents vs portrait pictures).

Indeed, 55.5% of the participants were happy to show their ID to the robot, while 44.5% of participants did not. A similar trend was observed where 57% of participants were happy to have their picture taken by the robot while 42.6% of the participants did not.

A Chi-Square test for association was conducted between the experimental conditions and both the choices of the participants to show their ID documents and let the robot take a picture of them. All expected cell frequencies were greater than five, so the data fits the model and we can proceed to test them. We did not find a statistically significant association either with the participants' choice to show their ID to the robot ($\chi^2(2) = 0.814, p = 0.06$) or to let the robot take a picture of them ($\chi^2(2) = 0.421, p = 0.81$).

Participants' answers given to the two open-ended questions "Why did you decide to show or not show the ID to the robot?" and "Why did you decide to let or not let the robot take a photo of you?" were coded and categorized after content-analysis. Responses were analysed by the main author using online tools, and different categories were developed based on the collected data. Participants' responses were then classified into one or more categories; note that the categories were not mutually exclusive, and each participant's response could be assigned to more than one category. The categories have been grouped into two hierarchical frames to support differences in sentiment, positive (i.e., people who complied with the robot's requests) and negative (i.e., people who did not comply with the robot's requests). The positive frame aims to identify the reasons why people decided to trust the robot by showing them the ID or letting it take a photo of them. On the contrary, the negative frame includes the motivations that induced the participants to not trust the robot in the same scenario. We identified the following categories to code participants' motivations given to justify their trust in the robot.

a) Robot Role (Positive/Negative Sentiment): In the category with positive sentiment, we coded the participants' decision to trust the robot by attributing an official role (e.g., security) to the robot. The category with the negative sentiment codes the inability of participants in assigning the robot a role for which they felt it was appropriate to provide their info. An example with positive sentiment is "Robot seems to be set up/given an order to ask for ID from new students like me by someone who works for this Uni, so I feel safe enough to provide my ID", while one with negative sentiment is "The robot did not give any reason for why the ID is necessary on a university campus".

b) Security (Positive Sentiment): Participants expected in organisations, such as a University, to adopt security measures to verify people's access to their premises.

c) University's Premises (Positive Sentiment): Participants trusted the robot based on the fact it was installed within the University premises. For example, some participants wrote "It is fine to show the ID when I visit the campus in the reception".

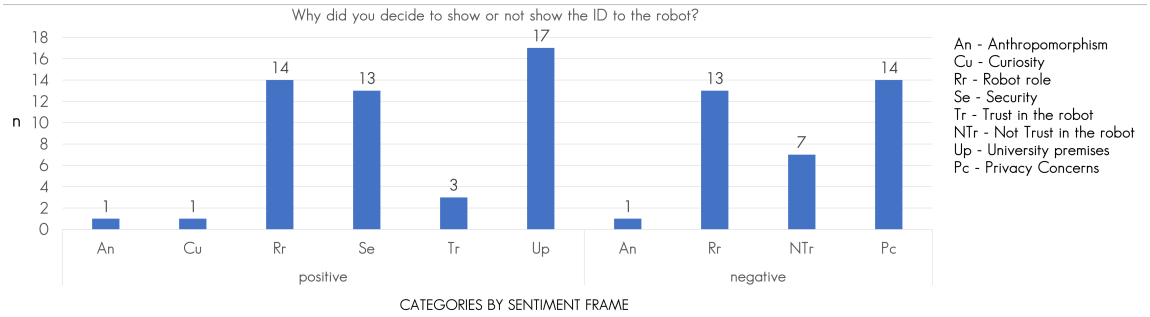
d) Trust/Not Trust in the Robot (Positive/Negative Sentiment): In these categories, we coded participants' general extent to rely on and not rely on the robot. For example, they wrote "I didn't feel I trusted to give my details to a robot" and "It looks trustworthy".

e) Anthropomorphism (Positive/Negative Sentiment): We coded in the positive category the attribution of positive human traits, appearance and behaviours to the robot. For example, "the robot had a really good and reassuring voice". We coded in the negative category, the people's negative perception of the robot behaviours and appearance. For example,"he was not polite".

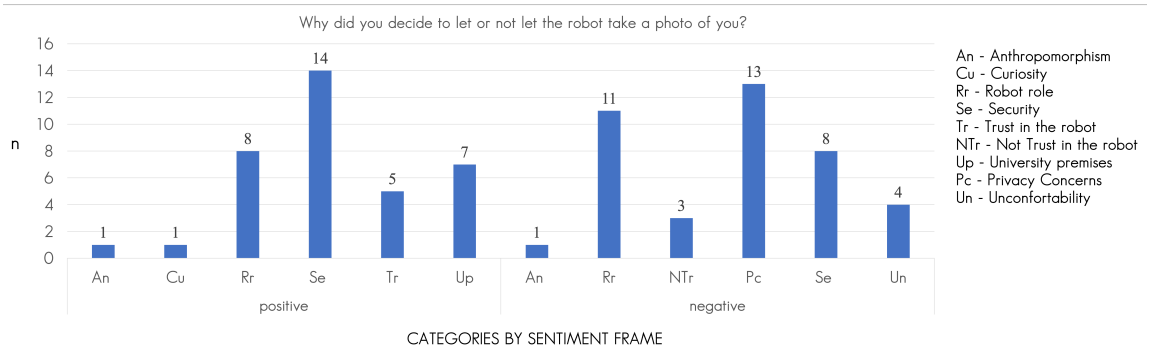
f) Curiosity (Positive Sentiment): In this category, we coded the participants' desire for the robot's behaviours. An example is "I wanted to see how the robot took photos".

g) Privacy Concerns (Negative Sentiment): Participants were concerned about how the data were stored and used. For example, some stated "I do not want [to show my ID] or [my picture taken] without knowing how it will be used and stored".

h) Uncomfortability (Negative Sentiment): Some participants felt uncomfortable in having a picture taken. For



(a) *Showing the ID to the robot.*



(b) *Letting the robot take a photo.*

Fig. 1: The qualitative analysis of participants' responses for the reasons why they did or did not trust the robot. Categories are divided by differences in trusting response, positive and negative.

example, "I'm not comfortable with that" and "I don't like others taking pictures of me".

i) Security (Positive/Negative Sentiment): In this category, we coded the participants' lack of concerns about having their pictures taken by a robot. For example, they stated "I see no harm in a robot taking a harmless picture".

We observed that overall participants trusted the robot with their information (both ID and photo) because they identified the robot's role as part of the security measures at the University (see Figure 1). Similarly, participants who did not trust to provide their info to the robot were due to privacy concerns, and they were not sure about the role of the robot or how the robot would use the information collected.

Observing the results in Figure 1, we can also notice that the categories "University premises", "Security" and "[Positive] Robot role" are connected to each other. In particular, the "Robot's role" is a subset of the "University premises", which can be included in the "Security" category. For example, participants associated the role of security personnel to the robot on the basis that it was on the university's premises, and it is expected that security checks are in place in institutions, such as universities. This connection highlights that the situational context may be relevant in affecting people's perception of the robot. Similarly, we believe that the inability of participants to clearly attribute a role to the robot led them to not trust the robot, and as a consequence, increased their concerns regarding the security and privacy of the information provided.

Interestingly, one of the participants stated not to trust the robot because it was in the hall of the building and not behind a desk, while another participant was concerned about how they would have looked in the photo and thought that a human would have let them compose themselves to look pretty in it. In such cases, we believe it would be useful to design more emphatic robots that are considered as mindful towards others' affective state and situation, and as a consequence, that are able to create positive and successful interactions [21].

B. Antecedents of Trust

Since previous research [22] showed that trust may be affected by several factors, we also analysed whether participants' choices of trusting the robot were affected by their personality traits, disposition of trust and perception of robots.

1) Personality Traits and Disposition of Trust: Participants were asked to rate their personality traits [18] and disposition of trust in people [19] on a 5-point Likert Scale (from 1=disagree strongly to 5=agree strongly). The distribution of participants' choices of showing their ID and getting a photo, and their personality traits and disposition of trust was overall homogenous.

2) Perceptions of the Robot: We asked participants to identify the perceived robot's role during the video-interaction. The majority of participants chose as roles perceived for the robot: 1) security personnel (63%); 2) assistant (16.7%); 3) tool (7.4%); 4) machine (5.5%); 5) generic robot

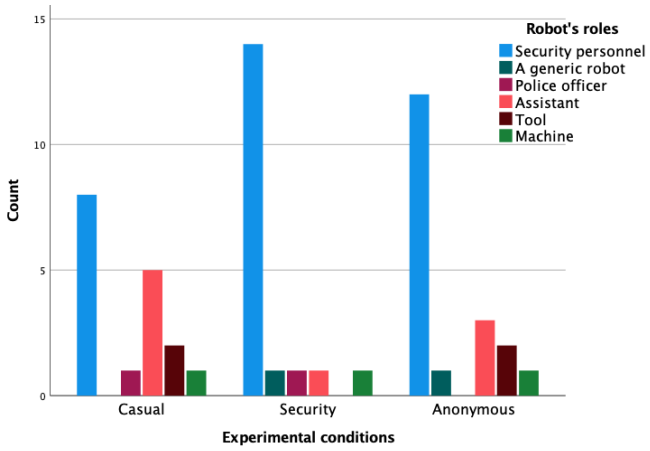


Fig. 2: Distribution of the robot's perceived role according to the robot's appearances (i.e., experimental condition).

and police officer (respectively, 3.7%); 6) companion, butler and friend (0%).

While the majority of participants perceived the robot as security personnel, we can observe that their perception of the robot varied based on the robot's appearance. Figure 2 shows that people tended to assign the role of a security staff member to the robot more when it was dressed as a security personnel (condition C2), compared to the casual (condition C1) and the anonymous outfits (condition C3). In conditions C1 and C3, this tendency varied and participants were slightly more undecided between a robotic security personnel and an assistant role.

C. Perception of Info Sensitivity

We asked participants to rate the sensitivity of the information requested by the robot. Participants used a scale ranging from 1 to 5 (from not sensitive to very sensitive). We categorise the information with mean values below 3 as "low sensitivity", those with mean values above 3 as "highly sensitive", and those with ratings equal to 3 as "mild sensitive". The majority of participants (89%) rated the ID documents as highly sensitive information, 5.5% consider their ID as low sensitivity and the remaining with mild sensitivity.

As for the photo, the majority of the participants (64.8%) rated this info as highly sensitive, 18.5% considered the information as mildly sensitive, and the remaining as with low sensitivity. These results show that participants considered their ID documents as more sensitive than their photos.

Finally, we asked participants whether they would show their ID documents and let a human take their photo under similar circumstances. An equal number of participants (respectively, 46.3%) stated that they would trust or they were unsure whether they would show their IDs to a human. In contrast to sharing their IDs, 27.8% of participants stated that they would not have let a human take their photo, while 26.6% were not sure about their choice. The remaining would have let a person take a photo. The reasoning behind participants' decisions is related to privacy issues (i.e., managing and access to info) or a person's role, similar to those given for the robotic counterpart.

However, some suggested that they would be able to ask questions regarding the use of their information if it is a human compared to a robot. In addition, they think that a person would not be able to record their ID information while the robot could through its camera. Participants, however, were more reluctant to have a human take their photo for security reasons.

IV. Discussion & Conclusions

In this work, we assumed that people would be more inclined to share highly sensitive information with an authoritarian robot than with an anonymous or a not clearly identified robot (based on [23]). We manipulated the perception of the robot's authority by dressing it with different clothing.

We observed that participants were almost equally split between those who complied with and those who did not comply with the robot's request for information (i.e., identity documents and photos).

Their choices of trusting or not trusting the robot were influenced by 1) the presence of the robot on the University premises and 2) the sensitivity of the information requested and their relative privacy concerns. The first led participants to attribute a security role to the robot regardless of the experimental conditions to which they were assigned. In the latter request (i.e. photo), participants expressed concerns about the use and modalities of storing the information provided and the robot's role. Participants also pointed out that they perceived the robot as not being able to understand their needs and desires (e.g., the need for getting ready and posing for a picture) as a human would do.

This highlighted that the robot's appearance may not be enough to convince people to trust a robot. Context information (i.e., location, interaction and behaviours of the robot) is equally important to provide a coherent narrative that helps increases the transparency of the robot's intentions and may convince people to trust the robot.

We also asked participants to state the perceived role of the robot they interacted with. While the majority of participants thought that robots were security staff members, the remaining also believed that the robot could have been an assistant when it was in both casual and anonymous outfits.

Participants evaluated the information contained in their identity documents as more sensitive than their photos, as we expected in our initial hypothesis. We believe that this phenomenon could be due to the fact that people nowadays are used to publicly sharing their photos and videos on social media, such as Facebook, Instagram, TikTok, and identification on a smartphone. This is also particularly interesting because several service robots (such as [24]) use biometrical facial techniques to identify their users and personalise the interaction. In contrast, some participants stated to be more reluctant to let a human take their picture than a robot. Participants also expressed similar concerns when an agent asks for their sensitive information regardless of whether the

agent is a human or a robot. These results are also in line with the findings presented by Tonkin et al. [25] where people agreed to have a robot take their picture even if they were concerned about their privacy.

We believe that the findings of the presented study can guide the design of privacy-sensitive human-robot interactions to foster a balanced trust between humans and robots, and can help future investigations on the effects of breach of sensitive information on the perception of a robot to personalise the interaction and increase the users' loyalty to a service delivered by a robot. However, since the context had high impact in people's choice, we cannot fully establish a connection between the robot's authority and people's trust in it. Therefore, future works will include in-person investigations to check whether the physical presence affects people's perception [26] and if people are more influenced by the robot's appearance in another location. We will also manipulate the robot's role by varying its personality (e.g., by changing its voice as in [27]).

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