Investigating User Perceptions of HRI in Social Contexts

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***Abstract*—In this paper, we present the results of a recent user study that investigates if user perception of HRI in social contexts may be affected by changing the interaction modality with the robot. Leveraging on Robot Social Attribute Scale (RoSAS) survey and on a statistical analysis, our results show that, in some interaction modalities, a greater feeling of *discomfort* is felt by users interacting with the robot. Interestingly, results also show the influence of users' gender on the user perception.**

***Index Terms*—User perceptions, gender, interaction modality, social context**

I. Introduction

In this paper, we explore if different interaction modalities and user attributes (e.g., gender) may influence the user perception during an interaction with a robot in a social context.

Specifically, we focus on investigating three aspects of user perception: *warmth of robot, competence of robot* and *discomfort of robot*. In order to collect users' feedback, we conducted a user study by adopting Robot Social Attribute Scale (RoSAS) [6] survey, due to its proven effectiveness when employed in social contexts. After analyzing the results of the study with two robust statistical tests for data analysis, named t-test and ANOVA, we found that, in some interaction modalities, a greater feeling of *discomfort* is felt by users interacting with the robot. Results also show that users' gender has an influence on many aspects of the user perception.

II. Related Works

Several HRI studies have investigated human's behavior in social contexts, e.g., human's attractiveness perceived at train station [7], collaborative attitude towards robot when robots ask for direction [8], social engagement increasing social cues such as voice, lips, facial expressions and gestures [9]. Also many aspects of user perception in HRI have been studied (e.g., attitude towards robots, companionship, trust etc.) [2] [3] [4] [5]. Differently from previous works, in this paper we focus on three specific aspects of user perception in HRI.

III. Experimental Setting

We performed our user study in the range of Maker Faire, a 3-days international event aimed at showcasing recent innovative technological solutions. The event was held in Rome in October 2018. We chose Pepper[1] as social robot. Pepper is a human-like service robot produced by SoftBank that can interact with users through spoken language or, alternatively, with a tablet linked to the robot that allows tactile interaction.

[1]https://www.softbankrobotics.com/emea/en/robots/pepper

A. Dependent and Independent Factors

We designed our user study by first carefully selecting the *dependent factors* to be measured and the *independent factors* to manipulate for producing many conditions for comparison.

We identified 18 dependent factors to be considered, reflecting the different user perceptions that can be captured during an interaction with a robot. According to RoSAS [6], any dependent factor can be associated with one of the three investigated aspects of user perception. Specifically, factors *happy, feeling, social, organic, compassionate, emotional* with warmth of robot; *capable, responsive, interactive, reliable, competent, knowledgeable* with competence of robot; *scary, strange, awkward, dangerous, awful, aggressive* with discomfort of robot.

Since the value of dependent factors is "dependent" on the changes made to the independent factors, we identified two of such factors: *interaction modality* and *gender*. Independent factors can assume many values. Gender assumes two values. Concerning the interaction modality, we identified four different values for such factor, which are thought to cover the majority of user interests in a social context:

- Funny modality (F): Robot tells a funny joke to the user in Italian language;
- Junior modality (J): Robot asks a short and easy question in Italian language, and the user selects one of the available answers on the tablet. Finally, the robot provides a comment on the user's answer;
- Senior modality (S): Robot asks a long and non-trivial question in Italian language, and the user selects one of the available answers on the tablet. Finally, the robot provides a comment on the user's answer;
- Foreign modality (E): Like the Junior modality, but questions and feedbacks are provided in English.

All of above interaction modalities are enacted by the robot with the aid of comprehensive (randomly selected) gestures, head-pose, gaze pattern, images shown on the tablet, and voice.

B. Experimental Hypothesis

We are interested in validating the following two experimental hypothesis in social contexts:

- User perception of a robot is influenced by user's gender.
- User perception of a robot is influenced by changing the interaction modality with the robot.

C. Participants, Interaction Flow and Evaluation Strategy

In social contexts, users are male or female, and usually have a broad range of age. Therefore, any user participating to the Maker Faire was representative for our study.

The interaction with the robot happened in a face-to-face fashion. Users selected one of the four available interaction modalities, and the robot activated the routine associated to the selected modality. Users were free to complete an interaction or leave it anytime. When a single interaction expired, the users could leave the "demo area" or start a new interaction with the robot. Hence, users could perform multiple interactions. Tactile user interaction (through the tablet) was preferred over speech due to the noise in the public event.

Once a user completed a (single or multiple) interaction with the robot, we collected her/his feedback through the RoSAS survey. Users had to fill age, gender, profession. Then, they provided a score from 1 to 9 to any of the 18 dependent factors to be measured. We performed our test using the *between-subject* methodology, i.e., each user was assigned to a different experimental condition, consisting of performing a single interaction or multiple interactions with a robot. We adopted t-test and ANOVA for data analysis.

IV. Results and Conclusion

145 users participated to the user study, and we collected 125 valid answers to the survey. Since only one user has selected the "foreign" interaction modality, we decided to exclude such modality from the analysis and focus on the other three. Gender distribution was as follow: 44% of male users, 53.6% of female users and 2.4% of users that did not declare their gender. Distribution of users in single and multi-interaction modalities are shown in Fig. 1.

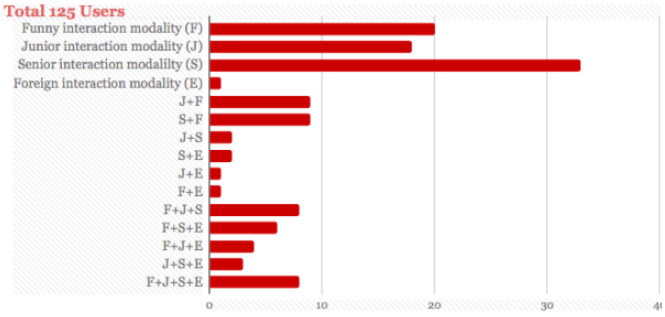

Fig. 1. Distribution of users in single and multi-interaction modalities.

A. Analyzing impact of gender on user perception

We analyzed gender information of each user that performed exclusively a single interaction with the robot. Then, we used t-test to check how male and female users perceived the interaction with the robot in the different interaction modalities. Significant results (i.e., $p<0.05$) have been found in any of the interaction modalities. For example, female users found the robot more *biologic*, *compassionate* and *capable* during the "Funny" interaction modality, and more *responsive*, *interactive*, *reliable*, *competent*, and *knowledgeable* (all aspects related to the *competence* perceived of the robot) in the "Senior" interaction modality. It is worth to notice that, even when the results are not statistically significant, the mean of the answers provided by female users is always higher than for male users, whose answers have often a larger variance.

We conclude that male users have more expectations in the competence of the robot when the interaction becomes more elaborated (i.e., during the "Senior" interaction modality). This confirms our first experimental hypothesis.

B. Analyzing impact of different interaction modalities on user perception

First of all, we analyzed only users that performed exclusively a single interaction with the robot. For any of the 18 dependent factors, we used ANOVA to check if there were statistically significant differences in the obtained scores related to the factor by varying the interaction modality (i.e., "Junior" vs "Funny" vs "Senior"). Only in one case – "scary" – we found a significant difference ($p<0.05$) between the collected scores. To precisely identify the source of the difference, we used t-test to compare the scores obtained for the "scary" factor evaluating interaction modalities in pairs. In this way, we identified that users perceived a greater feeling of *discomfort* (in particular, of scary) when the interaction with robot was more elaborated, such as in the "Senior" and "Funny" modalities, while this discomfort disappeared when the interaction happened exclusively in the "Junior" modality.

Secondly, we checked with ANOVA if performing multiple interactions (that always included the "Senior" and "Funny" modalities) could reduce the feeling of discomfort got during single interactions, but no statistical evidence has been captured. Hence, this allows us to conclude that our second experimental hypothesis is satisfied only for one dependent factor (i.e., *scary*) during the "Senior" and "Funny" modalities.

As a future work, we are designing a further user study to be performed with a larger sample of users. This will allow us to understand more about the implications on the discomfort of users in case of elaborated interactions with the robot.

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