Who Should Robots Adapt to within a Multi-Party Interaction in a Public Space?

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***Abstract*—Robots in public environments are challenged with socially appropriate interactions with previously unseen users: they need to offer appropriate services and shape their interaction style according to the particular individual's needs and preferences, for example the elderly and children. In addition, interactions in public spaces are not limited to merely two parties, but often involve multi-party situations with changing numbers of participants. The research question of this work is to investigate what rules should a socially competent robot follow in order to adapt to such complex social situations in real-world scenarios.**

Keywords—Human-Robot Interaction; Multi-Party Interaction; Public Spaces; Social Robotics

I. Introduction

Recent progress in all areas of service robotics, including works which seek to integrate speech, sensing, acting, and networking, have resulted in increasingly versatile and reliable service robots. One of the most promising application domains for such robots is to be deployed in public environments, for example as reception and information desks attendants, museum and city guides, servants in bars and restaurants, healthcare, rehabilitation and therapy assistants in hospitals, whimsical educators and learning companions in educational institutions.

In such public environments, robots must necessarily deal with situations that demand them to engage humans in a socially appropriate manner. Similar to human-human communication, if a robot does not adjust its communication style to the interlocutor or situation at hand, this can lead to confusion and misunderstanding. This can also cause annoyance, displeasure, dissatisfaction with the service, ultimately leaving a feeling of disengagement with a robot. Adaptive human behavior reflects an individual's social and practical skills to meet the demands of society. Thus, a socially competent robot needs to behave according to the contemporary conventional norms regularly accepted within the society, social class, or user group [1].

Social environments are complex and ambiguous in terms of task ownership, responsibilities and accountability [2]. Many queries to the robot are collaborative and do not have an assigned addressee, for example a family. In contrast, in cases of conflicting queries, social robots need to participate in value decisions and in negotiating multi-party settings. This paper portrays a study that aims to explore what people's preferences are in such situations and what is the most appropriate solution to mediate such conflicts.

Past work [3] suggests that adaptive robots do not only have advantages in terms of information exchange and efficient communication, but add social advantages as well. Our work aims to address a minimally explored issue of who robots should adapt to within multi-party interactions. In particular, the focus of this work is to investigate what adults and children have to say about robot's adaptivity, and to create such an adaptive robot that can address these requests.

Fig. 1: Experimental Setup

This paper presents an HRI study conducted at a local shopping mall with a group of adult-child participants. The goal of the study is a) to investigate whether people prefer the robot to adapt to children or to adults within multi-party interactions, and b) to analyze whether these responses are different according to the relationship of an adult-child pair.

II. HRI Experiment

The experiment took place at the food court of a shopping mall on Sunday throughout the day, where people were approached and asked to participate in the experiment with the robots. A parent-child group of participants were asked to sit in front of robots at the specifically allocated area for about 10-15 minutes and watch robot's self-presentations. The setup of the experiment is depicted in Figure 1.

We used mixed-subject design, in which all of the participants experienced two robot demonstrations. In attempt to prevent order effects we counterbalanced the order of the demonstrations: the child-friendly robot presented first for half of the participants followed by the adult-friendly robot. Second half of participants interacted with an adult-friendly robot first followed by the child-friendly robot. At the end of the interaction, adult and child participants were interviewed by the researchers.

There were two humanoid Aldebaran NAO robots of the same blue colour: a child-friendly robot and an adult-friendly

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robot. The differences between conditions were in wording of the robot's utterances such as greetings, self-introduction, and goodbyes. The self-introduction script of the robot's speech included a demonstration of the NAO's technical features and functionality. For example, a child-friendly robot described its vision capabilities as "I see the world around me with my eyes" in contrast to an adult-friendly robot stating that "my vision consists of two embedded cameras". Verbal content delivered by two robots was the only difference manipulated for adaptation. All non-verbal behaviours such as waving, gesticulating, eye gaze, and other robots' movements were the same across both conditions. The same pre-recorded male voice was used in both conditions.

Adult-child paired participants were invited to take part in the experiment, where adults' gender as well as relation to the child were varied. A total of 33 groups participated in the study: 14 male adult-child and 19 female adult-child groups. Among these groups, 20 were related and 13 were unrelated. In parent-child groups, there were cases where a parent had more than one child with them, and cases where some of the children had both parents with them. In the first case, multiple children were mapped to one parent, and in the second case, both parents were interviewed individually, thus creating two distinct groups. There were also children without their parents, that watched the robots presentations for multiple times. In these cases, random adults were asked to participate in the study by joining these children. These cases were considered as unrelated adult-child groups. Demographic information about gender and age of adults and children were collected during post-interview sessions.

III. Results and Discussion

First it should be noted that all children gave positive responses to the robots and the majority of them correctly replied to post-interview about the robot. Since there were no differences in conditions of how children rated the robots, adults' responses are discussed in detail.

We conducted a series of one-way ANOVA tests on the collected data of adults' responses. First it was tested how the adults rated the robots from 0 to 100 using Funometer scale [4]. There was a statistically significant difference between the ratings of parents and strangers $F(1,31) = 5.982$, $p = .020$. In comparison of unrelated adults (70.23 ± 22.5) to related adults (88.20 ± 19.3), Funometer scale values were significantly lower in the interaction of unrelated adults. These findings suggest that parents rated the robots much more positively seeing their child(ren)'s enjoyment. Similarly, the Pearson Chi-square test revealed a significant difference ($p = .022$) in what adults compared the robots to: options were toy, electrical appliance, computer, pet, or human. Unrelated adults were significantly more likely to compare the robot to a toy in contrast to parents whose most popular comparison was to a computer.

Finally, a one-way ANOVA was conducted to compare the opinions of related and unrelated adults on whether robots should adapt to adults or to children in cases of multi-party situations. Majority of related and unrelated adults replied that the robot needs to adapt to children in such situations. Then, the question was whether they would change their opinion if it were a different setting such as a hospital, bank or police station. For this question, some adults did change their opinion and claimed that the robot should ignore the child and adapt its verbal content to the adult. However, the change in the opinion significantly differed according to the relationship with the nearby child. The Pearson Chi-square test showed statistically significant ($p = .023$) differences: strangers do not want the robot to adapt to the unknown child in other public environments in service/business related domains. In contrast, the majority of parents would still prefer the robot to adapt itself and its content to their children (i.e. they did not change their opinion).

These findings motivate to further the research by developing a dynamically adaptive robot, which is able to detect whether a particular group of people is related to each other or not. The robot would need to estimate age and gender groups of children and adults (for example, based on 3D body metrics [5]), detect their relationship/non-relationship status (for example, based on social cues such as proxemics) to be able to switch to a non-child language once a non-parent adult is detected in a non-entertainment context.

IV. Conclusion

Taken together, these results suggest that the relationship within specified group of participants has a significant effect on people's opinion about the robot's need for adaptation. Specifically, parents express an opinion that regardless of the environment, robots should always adapt to their children. This justifies their opinion with the fact that it is important that the child understands the content of the robot's speech regardless of whether it is an entertaining or a service robot delivering important instructions. On the other hand, although unrelated adults agree that robots should adapt to children within the settings of the conducted study (i.e. shopping mall), they believe that adults need to be addressed and the robot's speech needs to be adapted to adults in non-entertainment settings (i.e. airports). In summary, adaptation of the robot should be context-specific and should take into the account the relationship between children and adults interacting with the same robot.

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