Robot Etiquette: How to Approach a Pair of People?

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ABSTRACT
Research has been carried out on robots approaching one person [1, 3, 4]. However, further research is needed on robots approaching groups of people. In the study reported in this paper, we studied participants who were paired up for a task and assessed their perception and behaviors as they were approached by a robot from various angles. On an individual level, participants liked the frontal approaches, and they disliked being approached from the back. However, we found that the presence of a task-partner influenced participants' comfort with a robot approaching (i.e. when the robot approaches and one is standing behind the task-partner). Apart from the positioning of the individuals, the layout of the room, position of furniture and doors, also seemed to influence their experience. This pilot study was performed with a limited number of participants (N=30). However, the study offers preliminary insights into the factors that influence the choice for a robot approach direction when approaching a pair of people that are focused on a task.

Categories and Subject Descriptors
H1.2 [**Information Systems**]: User/Machine systems – *Human factors*

General Terms
Human Factors, Experimentation

Keywords
Human robot interaction; approach direction; multiple people; task oriented; comfort.

1. INTRODUCTION
In the EU FP7 FROG project, a robotic tour guide is being developed for indoor and outdoor places of interest (such as zoos and castle grounds). A main goal of the project is to guide small groups of visitors through parts of a site and provide a unique interactive engaging experience. The visitors will either actively approach the robot, or the robot will approach visitors who seem to be interested in the site. The current study described in this Late Breaking Report intends to shed light on the approach directions a robot could take when approaching small groups of people who want to be actively engaged with (aspects of) their environment.

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Previous research by Walters et al. [4] showed that people who were sitting or standing in a room preferred a robot to approach from either front-left or front-right directions. A direct frontal approach was not preferred, especially not when the people were seated or standing in front of a wall. Rear approaches were always regarded as least comfortable. Dautenhahn et al. [1] added to these findings that a robot that serves a human should always have its motions in the human's field of view, so that a human can see the robot approaching, which is strengthened by the fact that humans do not like the rear approaches. As previously mentioned studies only report robots approaching a static (standing or seated) person, the work of Satake et al. [3] also gives guidelines for approaching people that are walking around. They found that approaching people on the move in a straight line is not effective, but that the robot should approach the moving person from the front, actively predicting and reacting to the person's changes in direction.

While the previously mentioned studies are valuable, we require solutions for approaching groups of people who are focused on something other than the robot or who are walking together. When a robot approaches a pair or a group, it will not be able to approach each person from their preferred approach direction. Furthermore, the studies of Walters et al. [4] and Dautenhahn et al. [1] were carried out in the context of the home or office. When people visit (semi) public environments such as outdoor settings of cultural heritage, this offers a more crowded environment where people are not focused on the robot, but on the objects of interest such as an exhibit.

2. METHODOLOGY
Based on the work of Walters et al. [4] and Dautenhahn et al. [1], the following hypothesis was formulated: "When people are doing something together in pairs, in various formations, they prefer to be approached by a robot from a frontal position. This is the position where the robot is in the field of view for both persons."

The study was carried out in a controlled environment. Participants in the study were 30 students and staff from the University of Twente in the Netherlands, who participated in 15 randomly combined pairs. Average age of the participants was 21.4 (*SD*=1.92). Of the participants 27 were male and 3 were female, leading to 12 male-male pairs and 3 female-male pairs. The robot used for the study was a Giraff (http://www.giraff.org). For this study, the screen of the Giraff was equipped with two digital robot eyes. The robot was controlled remotely.

To test the hypothesis a quasi-experiment was designed in which participants rated their experience of different approach directions of the robot. Participants entered the experiment room in pairs, and were asked to stand in a predefined formation (defined with markers on the floor). The three different formations, taken from Kendon's F-formations [2], were standing next to each other, standing in V-formation and standing opposite to each other (see

Figure 1, respectively white pair, gray pair and black pair). Formation was manipulated between-subjects. The participants stood near a table and played a game of Mikado together. While the participants played the game, the robot drove in circles around them and drove towards them from eight different directions (the order of the approach directions were randomized for each session). After each trial, the participants were asked to fill in one question of the questionnaire. The questionnaire used for each of the approaches consisted of eight 5-point Likert-scale questions (one for each trial), on a scale from 1 (uncomfortable) to 5 (comfortable). After the robot had approached the participants eight times, the participants were asked to fill out a general questionnaire. From the general questionnaire we used for this paper two questions here for most and least preferred approach directions (for both questions participants could choose from: front, left front, left, left back, back, right back, right, right front). The participants filled out the questionnaire based on their own orientation and how the robot approached them, however, for the analysis, their answers were transcribed to absolute approach directions (as numbered in Figure 1).

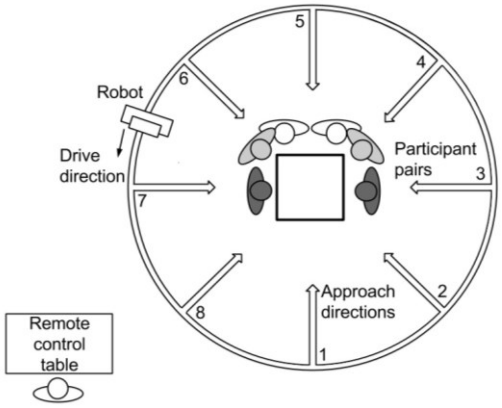

Figure 1: Experiment setup: the robot would approach each pair from eight directions. The directions are numbered from 1 to 8, however the participants were not aware of these direction numbers. They filled out the questions based on their own orientation to the robot.

3. RESULTS AND DISCUSSION

In general, our findings for the participants on an individual level are in line with the findings of Dautenhahn et al. [1] and Walters et al. [4]. We found that individuals preferred to be approached from the right front, left front and direct front, and that they did not like to be approached from the back. However, in this paper we focus on the implications of being there as a pair and standing in various formations.

For participants standing next to each other (Figure 1: white pair), a significant difference in preference for approach direction was found ($F(7,71)=4.73$, $p=0.00$): participants rated approach direction 8 as most comfortable ($M=4.4$, $SD=0.52$) and approach direction 4 as least comfortable ($M=2.6$, $SD=1.17$). For the participants standing opposite to each other (Figure 1: black pair), no significant difference was found in preferences for approach: approach direction 5 scored highest on comfort ($M=3.9$, $SD=0.6$). For the participants standing in a V-formation (Figure 1: gray pair), we did not find a significant difference either: the approach direction 8 scored highest on comfort ($M=4.3$, $SD=0.82$).

Most likely, when participants stand next to each other, the frontal approach is a frontal approach for both participants and both have a more positive experience of the approach. As the spreading of individual preferences in the other two formations was larger, no significant result for combined best preferred approach direction was found, which stresses the importance of finding a suitable way for a robot to approach a group of people.

As the participants were in pairs during the study, the position of the other person influenced the experience. When the other person was between the participant and the robot, the participant rated the approaches as slightly more comfortable than when the other person was not in between. A non-significant trend showed that participants gave the highest score for comfort when the robot approached from the individual left or right front and when the task-partner was closest to the robot ($M=3.9$, $SD=0.88$). The average lowest scores were given for the robot approaching from the individual left or right back when they were closest to the robot ($M=2.6$, $SD=1.22$).

The layout of the room might have influenced the results. Participants preferred the robot to approach from the window-side of the room. The entrance/exit was on the opposite side of the room, so probably people liked to keep the route to the door free. These are interesting observations, as in public spaces not only the formation of the group of visitors may influence the preferred approach direction, but also the layout of the environment.

4. LIMITATIONS AND FUTURE WORK

As described this is a quasi-experiment with a limited number of participants for the number of variables. However, our results are in line with previous research and we offer some preliminary suggestions on how to approach pairs of people with a robot.

Future work on this topic will include larger groups (up to 5 people), and research in real life settings. We will work on approach of groups of visitors who are focused on the exhibitions and are standing in various formations.

5. ACKNOWLEDGMENTS

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