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Robots Guiding Small Groups: The Effect of Appearance Change on the User Experience

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Abstract. In this paper we present an exploratory user study in which a robot guided small groups of two to three people. We manipulated the appearance of the robot in terms of the position of a tablet providing information (facing the group that was guided or the walking direction) and the type of information displayed (eyes or route information). Our results indicate that users preferred eyes on a display that faced the walking direction and route information on a display that faced them. The study gave us strong indication to believe that people are not in favor of eyes looking at them during the guiding.

1 Introduction

Social robots are designed to interact with humans in human environments in a socially meaningful way [3]. As a logical consequence, the design of robots often includes human-like features, e.g., heads or arms in order to generate social responses. It has been found that by using such anthropomorphic cues, people automatically have expectations of the robot's behavior [4].

However, the capabilities of robots differ from those of humans which allows them to use the anthropomorphic cues in different ways. For example, robot eyes can face the user while walking because the robot has other means (e.g., laser range finders) to detect the way to go. Thus, robots can walk backward. As eye contact has been shown to impact our image of others, and whether positive or negative, this being a sign of potential social interaction [6], robots facing users while guiding might actually be beneficial. On the other hand, literature indicates that people use a combination of head and eye movement to non-verbally indicate their direction [1] and users might expect robots to do the same.

Robots can also use non-anthropomorphic cues in different ways than humans, e.g. in the guiding context they can display route information rather than eyes. Related work found that visitors in historic places prefer a guide, as they would not have to worry about the route, or carry a map [2]. Therefore this could be beneficial for robots as well.

In the FP7-project SPENCER[2] we aim at developing a guide robot for a public place (airport) which will have a head and a screen. In this context, the questions arise which direction the head and screen should face when guiding a small group and what content should be displayed on the screen.

In related work, Shiomi et al. [5] conducted an experiment with the Robovie robot that drove either forward or backward while guiding participants in a mall (over a short distance). The overall finding in this experiment was that more bystanders joined when the robot moved backwards compared with frontwards, and that more people were inclined to follow the robot the entire time when moving backwards. In our work we are not so much interested in attracting people, but more in guiding people over a longer distance. Thus the question we pose here is how these design decisions impact the user experience in the process of guiding.

In this paper we present an exploratory study, in which we asked participants to follow a guide robot through a public lab space. This robot was equipped with a tablet (facing forwards, or facing the user) providing information to the participants. We were specifically interested in finding out which combination of tablet direction and type of information provided (eyes or route information) would yield the most positive user experience.

2 Method

In order to answer our research question, we designed an exploratory user study in which small groups of two to three participants were given a short guided tour by a robot.

2.1 Robot platform

For this study we attached a shell on top of a remote-controlled Robotino robot platform[3]. The height of the robot was 170cm and it drove at a speed of approximately 0.7 m/s. For purposes of this exploratory study, it was not deemed necessary to have the robot drive the path autonomously. Furthermore, the location of obstacles in the DesignLab changed from time to time (e.g. couches, chairs). As we were primarily interested in user experience ratings, the robot was remotely operated by an experimenter. Participants were not made aware of this before participating in the experiment.

2.2 Manipulations

We manipulated the direction of the tablet mounted on top of the robot and the information displayed on the tablet (Figure 1 and Table 1). In conditions A (Figure 1a) and B (Figure 1c) a set of blinking eyes was displayed on the tablet either facing the participants or the walking direction. In condition C we programmed the tablet to display route information, i.e., the remaining distance to the target (Figure 1e). A condition having the tablet mounted on the front of the robot, while displaying route information was deemed unnecessary as this would neither provide information for the participants following the robot, nor for other people present in the laboratory.

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[2] http://www.spencer.eu

[3] http://www.festo-didactic.com/int-en/learning-systems/education-and-research-robots-robotino/

(a) Condition A front (b) Condition A back (c) Condition B front (d) Condition B back (e) Condition C front (f) Condition C back

Figure 1: The appearance of the robot in the three conditions, showing the front and back side of the robot

Table 1: Overview of study conditions and number of participants

Condition	A	B	C
Tablet direction	Front	Back	Back
Tablet display	Eyes	Eyes	Time to destination
N	9	8	8
Group distribution	3x 3-person	1x 2-person 2x 3-person	1x 2-person 2x 3-person

2.3 Measures

In the post-experiment questionnaire user experience was assessed using a variety of measures.

All questions (except demographic- and open questions) were formulated as 5-point Likert-scaled items. General experience was assessed with eleven questions measuring among others if participants trusted that the robot knew where it was going, if it was clear where the robot was going and whether or not the robot was helpful in guiding someone. In this set of questions also the speed of the robot and volume of the audio messages were evaluated.

Five questions related to the physical appearance assessed the design, and specifically the height of the robot. Usability questions included questions related to users' expectancies of system capabilities and whether or not they were satisfied with the overall performance of the robot. Depending on the condition, this section included 5 (condition A), 6 (condition B), or 7 (condition C) questions.

Eight questions were included related to demographic information (age, gender, educational background) and familiarity with robots, social robots, and the premises where the test was conducted. A control question about the position of the tablet was included, and finally, we were interested in knowing whether or not the instructions provided were clear. Overall, this resulted in 30-32 questions

2.4 Procedure

Small groups of participants were recruited to participate in a guided tour of the DesignLab, a recently-opened lab of the University of Twente. Participants were given a briefing, after which they were given a tour of about five minutes through the lab. Participants were requested to follow the robot. No specific instructions were provided regarding the distance they should keep to the robot (Figure 4). The tour went past two points of interest (Figure 2, point B and C) where the robot provided a brief statement about the purpose using a text-to-speech engine. For example, when arriving at waypoint A, participants would see a tray with kinetic sand, and the robot would state that "The kinetic sand is made up of 98 percent sand, and 2 percent polyminethyl siloxane which gives it its elastic properties."

Afterwards the robot returned to the starting position where participants were requested to fill out the post-experiment questionnaire (Figure 2 point A). Following debriefing, participants were provided some candy as reward for their participation.

2.5 Participants

A total of 25 participants (14 males, 11 females) participated in the user study, with ages ranging from 17 to 40 (M=23.76, sd=5.93). All participants were students and staff from the University of Twente, primarily of Dutch (68%), German (8%) and Greek (8%) nationality. Participants had average experience with robots in general (M=2.84, sd=.90) and little experience with social robots (M=2.12, sd=1.09).

2.6 Data analysis

We calalculated means for all items. To compare between conditions, the data were first tested for normality. In case of normally distributed data, we report ANOVA's and T-tests in the results section, otherwise Kruskal-Wallis and post-hoc Mann-Whitney tests are reported.

3 Results

Overall, participants indicated they were quite satisfied with the robot: they believed the robot was helpful (M=4.47, sd=0.78), it

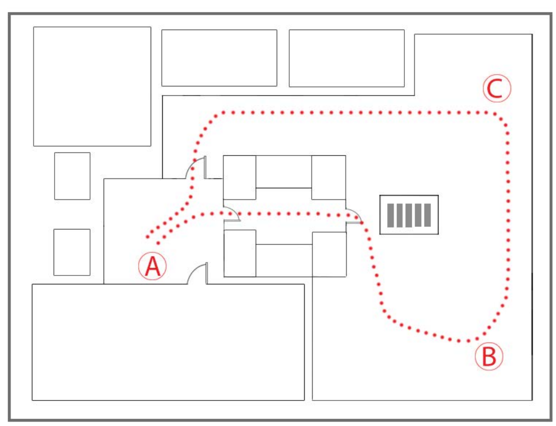

Figure 2: Layout of the laboratory showing start/end position (A) and two points of interest (B and C)

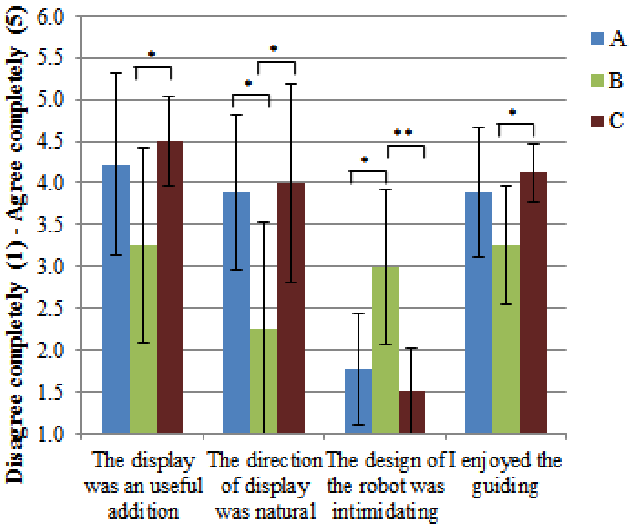

Figure 3: User experience ratings in the conditions; * indicates significance at the 0.05 level, ** at the 0.01 level

moved at a comfortable speed (M=3.12, sd=1.37), and participants trusted that the robot knew where it was going to (M=4.47, sd=0.78). These ratings did not differ significantly between conditions. Participants were moderately positive about the usability of the system: they felt comfortable using it (M=3.67, sd=1.05) and were satisfied by its performance (M=3.56, sd=0.77). No main effects or correlations were found including gender, age, robot experience and/or educational background.

Between conditions, Kruskal-Wallis tests indicated there were significant differences which were mostly due to the location of the tablet, thus between conditions A and C, versus condition B where the tablet was mounted on the front of the robot.

Post-hoc Mann-Whitney's indicated participants felt the direction of the screen was more appropriate in condition A (M=3.89, sd=.928) compared with B (M=2.25, sd=1.28), U=11.5; Z=-2.459, $p<0.05$. A similar effect was found between conditions B and C (M=4.0, sd=1.20), U=10.0, Z=-2.36, $p<0.05$ Furthermore, the design in condition B was more intimidating (M=3.00, sd=.97) compared with condition A (M=1.78, sd=.68), U=11.5, Z=-2.51, $p<0.05$ and condition C (M=1.50, sd=.54), U=6.00, Z=-2.885, $p<0.01$. Participants in condition C enjoyed the guiding more (M=4.13, sd=.35) compared with those in condition B (M=3.25, sd=.71), U=10.5, Z=-2.62, $p<0.05$.

With respect to the robot's appearance, participants felt that the body design matches the robot's function (M=2.71, sd=0.94). One of the interesting findings was that participants indicated the height was appropriate (M=4.21, sd=0.82). Informal sessions with participants indicated the robot would be too tall for a guiding robot, but in the end this was not the case. One of the reasons for this could be that participants' own average height was 177cm (sd=8.5cm), thus, most of them being taller than the robot.

4 Discussion & Conclusion

In this paper we presented an exploratory study into the effect of a robot's physical appearance on usability and user experience. Small groups of people were provided a short tour by a guide robot. Our results indicate that the location of the screen can be either forward

Figure 4: A small group of participants being guided by the robot

or backward, depending on the information displayed. In the case of eyes facing participants, our results showed that this was considered to be very unnatural and intimidating. On the other hand, when the tablet faced participants and route information was provided this was again evaluated as more useful. This might seem to be in contrast with the results of Shiomi et al. [5] who found that eyes facing participants are more effective to attract bystanders. However, we think this could be explained because in our setup the participants had already been introduced to the robot and asked to follow it.

Neither gender, age or experience with robots influenced the evaluation of the robots significantly, which could be due to small sample size.

Our future work will include a more interactive setup (e.g. provide participants some choices) during the tour. A second area of interest would be robot speed, and to investigate whether or not the speed of a guiding robot could be slower when guiding small groups compared with individual people. To conclude: the appearance of a guide robot can greatly influence user experience, something subtle as two eyes facing participants significantly decreases a robot's evaluation. Hence, more research is needed to even better understand how to design acceptable guide robots.

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