Pay Attention! The Effect of Attentional Behaviours by a Robotic Receptionist on User Perceptions and Behaviors

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Abstract— **Developing social robot attentional behaviours is critically important if robots are to be successfully employed in healthcare environments. The aim of this research was to examine the effect of robot voice pitch, robot self-disclosure, and robot forward lean on user perceptions of engagement, robot attention, robot empathy, as well as user behaviors. A randomised, between subjects, experimental design was employed.**

I. Introduction

The use of robots in healthcare environments is fast becoming a reality. While much research in social robotics is focused on developing the technical capabilities of a robot, developing the social behaviours of a robot is critical in achieving acceptable and comfortable human-robot interactions [1]. A fundamental social behaviour, in human social interactions, is the ability to engage, maintain and demonstrate attention. A number of different attentional behaviours are used by humans when engaging in social interactions. These behaviours, such as the use of mutual eye gaze, pointing, and facial expressions, have been studied in human-robot interactions (HRI), and have been found to increase human engagement, human attention, and human comprehension [2-5].

However, a number of other attentional behaviours are involved in successful human interactions but have not been researched in HRI. Self-disclosure, voice pitch changes, and forward lean, represent important human attentional behaviours that should be explored in relation to human-robot interactions. Examination of these behaviours represents an opportunity to test whether these simple behaviours can increase perceived empathy and attention, and impact the quality of human-robot interactions in addition to the already identified factors of eye gaze, pointing and facial expressions.

A. Self-Disclosure

Self-disclosure is an important aspect of human social interaction, with research demonstrating the effectiveness of self-disclosure in increasing mutual eye gaze, smiling, perceived friendliness, and in facilitating closeness and rapport [6, 7]. While a handful of studies have investigated the effect of robot self-disclosure on participant anxiety [8] and likability [9, 10], no study could be found that has investigated the use of robot self-disclosure on participant ratings of engagement, attention, perceived robot empathy, or perceived robot attention.

B. Voice Pitch

The use of voice pitch, is another important behaviour in attracting and sustaining attention in human interactions [11, 12]. Only one study to date has examined the effect of robot voice pitch on HRI [13]. Niculescu and colleagues found that participants rated a robot significantly better in terms of appearance, voice, social skills, and personality when a higher voice pitch was used, as opposed to a lower voice pitch. Participants also rated the interactions with the robot with the higher pitch as more exciting, enjoyable, and entertaining.

C. Forward Lean

The ability of a robot to demonstrate attention when interacting with a human is another important social behaviour, particularly in a health care environment. When considering patient-clinician interactions, leaning towards a patient is one way in which to demonstrate attention or 'active listening' [14]. In a literature review by Hall, Harrigan and Rosenthal [15] examining physician-patient interactions, physician leaning towards a patient was found to be associated with increased patient perceptions of physician empathy. No research could be found examining the use of forward lean by a robot during HRI.

II. AIM

The primary aim of this study was to investigate whether certain robot behaviours (i.e. self-disclosure, forward lean, voice pitch changes) would facilitate participant attention and positively influence user perceptions of robot empathy and robot attention. The secondary aim of this study was to investigate whether these same behaviours would positively influence user behaviors.

III. Method

A. Participants

180 participants were recruited via emails to the University of Auckland students and social media sites.

B. Procedure

A randomised, between-subjects, experimental study was undertaken in which participants engaged in a 5-minute (approx.) scripted interacted with a robotic medical receptionist. In the voice pitch condition, the robot altered the pitch of its voice at three separate times during the HRI. In the forward lean condition, the robot leant towards the participant each time the participant spoke. In the self-disclosure condition, the robot offered two self-disclosure statements during the HRI (i.e. "I'm a little nervous about this task" and "No problem, I forget things to sometimes"). In all conditions, the rest of the script for the HRI was identical. Following the interaction, participants completed questionnaires aimed at determining engagement, perceived robot empathy, and perceived robot attention.

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C. Measures

Participant Engagement. In order to measure participant engagement, a 'Participant Engagement Tool' was created which utilised both a Likert scale and pair-choice items. The Likert scale was developed using an adaption of the 'stimulation' items from the McGill Friendship Questionnaire [16], along with an adaption of the engagement items used in the human-robot engagement study by Snider, Kidd, Lee and Lesh [17], was used. An adaption of the McGill Friendship Questionnaire was used previously in HRI research [18]. Cronbach's alpha for the Likert items was .86, showing excellent reliability. Therefore, the scores from these items was added to create a total score. The pair-choice items were developed using an adaption of the 'stimulation' (paired) items from the Attrak/Diff User Experience Tool [19] was used, and items were analysed separately. The Attrak/Diff questionnaire has been used previously in HRI research [13].

Perceived Robot Attention. No measure could be found in order to measure human perceptions of robot attention. Therefore, in order to measure perceived robot attention, an adaption of the 'stimulation' items from the McGill Friendship Questionnaire [16] was used along with an adaption of the engagement items used in the human-robot interaction study by Snider, Kidd, Lee and Lesh [17]. The scores from all items were added to create a total score. Cronbach's alpha was .89, showing excellent reliability.

Perceived Robot Empathy. Finally, in order to measure perceived robot empathy, an adaption of the McGill Friendship Questionnaire [16] was used, along with an adaption of the Consultation and Relational Empathy measure (CARE measure) [20]. The CARE measure assesses patient perceived empathy in relation to clinical encounters and has been found to be both valid and reliable across clinical settings (Bikker, Fitzpatrick, Murphy, & Mercer, 2015; Wirtz, Boecker, Forkmann & Neumann, 2011). An adaption of the McGill Friendship Questionnaire was used in research investigating perceived robot empathy by Leite et al (2012). Cronbach's alpha was .82, and after removal of one item: "I think Nao had fun during this interaction", increased to .89. The scores from all remaining items were added to create a total score.

User Behaviours. Video recordings were used in order to determine participant time spend (seconds) looking at the robot. Recordings were also coded in order to determine if participants smiled, laughed, and/or leant towards the robot during the interaction

D. Analysis

One-way ANOVA analyses were used to analyse the total Participant Engagement and total Perceived Robot Empathy scores. Fishers exact tests were used to analyse results of the (pair-choice) items in the 'Participant Engagement Tool'. A Kruskal-Wallis Test was performed to analyse total Perceived Robot Attention, due to data being found to violate normality. All analyses were performed using the Statistical Package for Social Sciences (SPSS), version 22.

IV. Results

A. Descriptives and Frequencies

In total, 181 participants took part in the study. Most participants identified as female (n=112, 61.9%). In regards to ethnicity, participants identified as NZ European (n=57), Chinese (n=37), Indian (n=29), Korean (n=5), Maori (n=4), Samoan (n=3), Tongan (n=1), and 'other' (n=49). Completed education level ranged from PhD or Masters level (n=26) to secondary school level (n=93). Most participants were students (n=139), followed by part-time employees (n=20), full time employees (n=19), and unemployed (n=4).

B. Participant Engagement

A one-way ANOVA of Participant Engagement (F (3, 177) = 1.420, p = .239) found no significant difference between the means of the neutral (M = 26.96, SD = 5.800), forward lean (M = 27.38, SD = 5.87), self-disclosure (M = 28.22, SD = 5.387), and voice pitch (M =25.84, SD = 5.261) conditions.
A Fishers Exact test found that participants in the voice pitch condition were significantly more likely to rate Nao as boring (as opposed to interesting) compared to the neutral, self-disclosure, and forward lean groups. χ^2 (3, n =179) = 10.255, p = .002). Participants in the voice pitch and neutral conditions were significantly more likely to rate Nao as unstimulating (as opposed to stimulating) compared to the self-disclosure and forward lean groups (χ^2 (3, n = 176) = 8.775, p = .029).

C. Perceived Robot Empathy

A one-way ANOVA of Perceived Robot Empathy (F (3,175) = 1.889, p =.133) found no significant difference between the means of the neutral (M = 41.95, SD = 6.38), forward lean (M = 44.23, SD = 6.716), self-disclosure (M = 43.83, SD = 7.325), and voice pitch (M = 41.33, SD = 6.925) conditions.

D. Perceived Robot Attention

A Kruskal-Wallis Test of Perceived Robot Attention (χ^2 (3, n = 181) = 1.081, p = .782 found no significant difference between the mean rank scores of the neutral (MR = 84.82), leaning forward (MR = 94.44), self-disclosure (MR = 94.63), and voice pitch (MR = 90.02) conditions.

E. User Behaviours

Eye Gaze. There was a significant difference between groups in regards to user eye gaze ($F_{3,173}$=8.13; P<.001), with participants in the forward lean (mean 78.80, SD 8.98) condition spending significantly more time looking at the robot compared with those in the neutral (mean 69.14, SD 10.96) and voice pitch (mean 73.30, SD 9.88) conditions. Participants in the self-disclosure (mean 76.30, SD 8.78) condition also spent significantly more time looking at the robot compared to those in the neutral condition.

Forward Lean. There was a significant difference between groups in regards to user forward lean behaviours (χ^2_3=22.1; P<.001; n=174), with significantly more participants in the forward lean condition leaning towards the robot, 67% (31/46), compared to those in the self-disclosure, 47% (20/42), voice pitch, 39% (17/43), and neutral, 18% (8/43) groups.

Smiling. No significant differences were found between groups in regards to participant smiling behaviors ($F_{3,173}$=0.801; P=.50).

Laughing. There was a significant difference between groups in regards to user laughing behaviours (χ^2_3=12.0; *P*=.01; n=174), with significantly more participants in the self-disclosure group laughing, 47% (20/42), compared to those in the forward lean, 21% (10/46), voice pitch, 20% (9/43), and neutral, 18% (8/43) groups.

V. Discussion and Conclusion

The main results of this study were that participants in the forward lean and self-disclosure conditions spent significantly more time looking at the robot, compared to those in the neutral condition. Participants in the forward lean condition were also more likely to lean towards the robot, while participants in the self-disclosure condition were more likely to laugh during the interaction with the robot. These user behaviours arguably demonstrate increased user attention and engagement in the forward lean and self-disclosure conditions.

Those who interacted with the robot in the forward lean or the self-disclosure conditions also found the robot more stimulating that those who interacted with the robot in the voice or the neutral conditions, while those in the forward lean, self-disclosure, and neutral conditions found the robot more interesting compared to those in the voice pitch condition. Together, these results suggest that forward lean and self-disclosure are worth further investigation in the area of social and healthcare robotics.

Research investigating the use robot voice pitch changes in human-robot interactions may need to focus on using more distinct and/or frequent voice pitch changes in order to see positive effects.

There were no significant differences between the self-disclosure, forward lean, or voice pitch groups in regards to participant engagement, perceived robot empathy, or perceived robot attention. A potential explanation for these results may be found in the use of a between-subjects study design. This design may have resulted in a lack of comparison for participants when rating the robot. For the majority of participants (n=148/180), this was the first time they had interacted with a robot.

It is recommended that further research utilizes a within-subjects design, comparing forward lean, self-disclosure, and neutral conditions during a human-robot interaction, measuring participant perceptions of engagement, robot empathy, and perceived robot attention. Use of a natural environment, rather than a lab setting, may also provide context to participants interacting with the medical robot receptionist.

Acknowledgment

This work was supported by the Technology Innovation Program (10077553, Development of Social Robot Intelligence for Social Human-Robot Interaction of Service Robots) funded By the Ministry of Trade, industry & Energy (MI, Korea).

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