Empathy: Interactions with Emotive Robotic Drawers

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ABSTRACT

The role of human-robot interaction is becoming more important as everyday robotic devices begin to permeate into our lives. In this study, we video-prototyped a user's interactions with a set of robotic drawers. The user and robot each displayed one of five emotional states - angry, happy, indifferent, sad, and timid. The results of our study indicated that the participants of our online questionnaire preferred empathetic drawers to neutral ones. They disliked robotic drawers that displayed emotions orthogonal to the user's emotions. This showed the importance of displaying emotions, and empathy in particular, when designing robotic devices that share our living and working spaces.

Category and Subject Descriptors

H.5.m [Information Interface and Presentation]: Miscellaneous.

Keywords

Human Robot Interactions; Interactive Furniture; Interaction Design; Wizard of Oz Experiment; Video Prototyping.

1. INTRODUCTION

Autonomous robots have begun to permeate into various facets of our everyday lives. As they have come to share common spaces, these devices have consequently needed to interact with human users. However, both robots and users have traditionally treated each other more like obstacles rather than social figures with whom to collaborate [1]. Thus, designing robots to complement or enhance human users' lives still remains an important challenge. Our current research focuses on improving the engagement with interactive furniture and appliances, particularly in the study of human gestures and other forms of non-verbal communication. In this study, we explored the interactions with a set of robotic drawers that could assist human users in finding desired items. We found that the interactions between the user and the devices felt very much like a conversation, with greetings and a dialogue. This laid the foundation for the questions we wanted to ask. Based on the user's action and emotion, should the robotic drawers show empathy? Should the robot lead the interactions? How does the drawers' response affect the user's perception?

2. RELATED WORK

There has been extensive research of the social interactions between robots and their users. Osawa [2] showed that implementing of anthropomorphic frameworks for domestic robotic devices facilitated better communication with their users. Another branch of research focuses more on gesture and other forms of nonverbal communication. Sirkin and Ju [3] examined the importance of both on screen and off screen motions for telepresence robotics. The study found that the proxy motions displayed by the telepresence robots improved the understanding of messages and the sense of collaboration.

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Figure 1: A Set of Robotic Drawers Responded to the User.

3. METHODOLOGY

3.1 Design Improvisation

In the initial stage of this study, we conducted several exploratory improvisation sessions with interaction designers and motion experts. We utilized the basic Wizard of Oz techniques to make the gestures for a set of drawers that responded to the users' commands. A human operator stationed behind the drawers used handles to control each drawer's individual movements.

We observed how the drawers physically responded to the users and how the users perceived the drawers' movements. Through these sessions, the drawers appeared to be a prominent social figure in this study. From this, we decided to create working robotic drawers and a video prototype study.

3.2 Physical Prototype

We fabricated a set of robotic drawers that allowed us to perform consistent and reproducible motions. The drawers were actuated using a rack and pinion system. Appropriate DC motors were used to provide our drawers with the necessary acceleration and velocity to create more expressive motions. In addition to the motors, each drawer was also retrofitted with a linear position encoder built with reflectance sensors on a black and white track. The motors and encoders were fed into an Arduino microcontroller which itself was controlled by a computer running Processing software. We wrote a Processing application to perform Wizard of Oz style remote control on the drawers. It presented a basic button-based GUI and sent animation commands to the Arduino. The animations dictated the drawers' position and actuation speed.

Table 1: Mean responses for 7-point Likert scale response (7= Strongly Agree) for emotionally matched, emotionally mismatched and neutral conditions

Questions	Mean Mat.	Mean Mis.	Mean Neu.	Mat. Vs Mis. (t/p)	Mat. Vs Neu. (t/p)	Neu. Vs Mis. (t/p)
Q1: The dialogue between the person and the drawer felt natural .	4.68	3.66	4.19	3.11 / 0.004	1.14 / 0.21	1.84 / 0.07
Q2: I thought the dialogue was appropriate.	4.75	3.98	4.17	2.60 / 0.014	1.45 / 0.14	0.66 / 0.32
Q3: The person liked the behavior of the drawer.	4.43	3.46	4.11	3.07 / 0.004	0.72 / 0.31	2.29 / 0.03

The Arduino used its knowledge of time and position to carry out the animations. This system allowed the robot operator to easily execute pre-scripted and reproducible drawer motions at the simple click of a button.

3.3 Video Prototype / Experimental Setup

3.3.1 Study Design

We decided to conduct a controlled video prototype study to investigate how people interpreted the robotic drawers' motions. We were interested in studying the interactions along two dimensions: initiator and empathy. To this end, we engineered a video prototype where we varied the initiator of the interaction (either drawer or user), the emotion the user displayed and the apparent emotion the drawer displayed. Matching the last two variables resulted in scenarios where empathy could be examined.

The video prototype scenario had a simple storyline with two scenes. In the establishing scene, the user displayed an emotion as she entered an office, sat down at a desk next to the drawers, and started working. In the interaction scene, the user stopped working, showed a need for something and interacted with the drawers to get it. The interaction followed the format of greeting, drawer selection, then a closing gesture. The initiator was varied by which entity started the greeting interaction and the apparent emotion of the drawers was varied both by the types of animations the drawers performed and the speed at which they performed it.

3.3.2 Study Implementation

To facilitate this study, we designed an online Qualtrics Survey with participants recruited from Amazon's Mechanical Turk crowdsourcing service (N=40). The participants were randomly placed into one of five categories where the constant was the user's emotional state (angry, happy, sad, timid, and indifferent). Participants were first shown the establishing scene to prime them of the situation. Next followed 10 survey pages, one for each of the 5 emotions the drawers could display multiplied by 2 for varying the initiator. Each survey page had an interaction video and a set of statements based on the apparent conversation between the user and robotic drawers. The participants were asked how much they agreed with these statements based on a seven point Likert scale. Afterwards, they were also asked to interpret what mood the user had displayed and how confident they were with their interpretation as a manipulation check for our interpretation of emotions.

4. ANALYSIS / RESULTS

First, the sets of responses were grouped into three categories: robot displaying matching emotion, robot displaying mismatching emotion, and the robot displaying neutral (indifferent) emotion. We then combined every set of responses in each category to find the mean of that category. Our analysis focused on Q1-Q3, the most relevant questions on appropriateness of the interaction.

We then performed a single tailed t-test on the questionnaire responses. Our null hypothesis for category A vs B was H_0: $\mu_A = \mu_B$ and we wanted to test the following- H_1:$\mu_{Mat} > \mu_{Mis}$, H_2:$\mu_{Mat} > \mu_{Neu}$, H_3:$\mu_{Neu} > \mu_{Mis}$. The mean Likert ratings between the emotionally matched and mismatched conditions were statistically significant for all three of the questions [$t(160)=3.11$, $p<.01$], [$t(160)=2.60$, $p<.05$], and [$t(160)=3.07, p<.01$] respectively. In other words, people were significantly more likely to agree that the interaction was natural / appropriate / liked when the user-robot emotions matched than when they were mismatched. In addition, there was a statistically significant difference in mean response between the neutral and mismatched condition for Q3, [$t(160)=2.29, p<.05$]. However, we could not reject the null for matched vs. neutral, though the matched mean appeared greater. This implied that the matched emotions between user-robot were generally perceived as the best / preferred interactions by the online questionnaire participants, while interactions with mismatched emotions were taken as the worst interactions. This was reminiscent to a study done by Nass [4] in which the emotional pairing of the voice of a car to a driver had a significant effect on performance. Interestingly, the mean for the neutral emotion category was somewhat close to the mean of the matched category for many questions. When looking at each individual user emotion, we found similar results in all the emotions except for one: Happy. For the happy emotion, the neutral category was the most preferred interaction.

5. CONCLUSION / FUTURE WORK

We have found a significant relationship between the matching of emotions for the user-robotic drawers' interactions and the perception of these interactions by the online questionnaire participants. They found the interactions most favorable when the emotional states of the drawers matched those of the user. The second best scenario was when the drawers remained neutral with regard to the user's emotions. This showed the importance of displaying emotions, and empathy in particular, when designing robotic devices that share our living and working spaces.

We are currently implementing additional sensors to create a fully autonomous drawer system. We are also interested in using devices, such as the Kinect, to capture the gestures and commands that a user performs to elicit an action from the robotic drawers. In the future, we plan to further explore the appropriateness of emotional displays by interactive furniture and deploy a fully autonomous version of the drawers to conduct live experiments.

6. REFERENCES

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