Preliminary Results: Humans Find Emotive Non-Anthropomorphic Robots More Calming

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ABSTRACT
This paper describes preliminary results of a large-scale, complex human study in HRI in which results show that participants were calmer interacting with non-anthropomorphic robots operated in an emotive mode versus a standard, non-emotive mode.

Categories and Subject Descriptors
I.2.9 Robotics, J.4 SOCIAL AND BEHAVIORAL SCIENCES – *Psychology,* G.3 PROBABILITY AND STATISTICS - *Multivariate statistics.*

General Terms
Measurement, Design, Experimentation.

Keywords
Human-Robot Interaction, Affective Computing, Affective Robotics, Experimental Design, Victim Management, Urban Search and Rescue Robotics, Doubly Multivariate Analysis.

1. INTRODUCTION
The focus of this study was to determine if humans interacting in close proximity with non-anthropomorphic robots would view interactions as more positively and calming when the robots were operated in an emotive mode versus a standard, non-emotive mode. Understanding human affective response is important because non-anthropomorphic robots represent the majority of field and service robots. Additionally, lessons learned in making non-anthropomorphic robots more affectively consistent through body language can be applied to other types of robots.

This study distinguished standard versus emotive modes of operation based on non-verbal and non-facial affect using the heuristics in [1]. These heuristics specify the appropriate body movements, postures, orientation, and the use of illuminated color based on the robot's proximity to a human (i.e., personal space). In the emotive mode the robots approached more slowly, lower to the ground, and remained oriented toward the 'victim' to demonstrate caution, attentiveness, and caring. A light blue illuminated light was placed on the undercarriage of the robots to provide better visibility in the darkness and to produce a calming effect. The standard robot had no additional lighting and the robots approached more quickly, raised to full height, would turn away from the "victim" to evaluate the surroundings, and moved erratically as the only concern was operator ease.

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2. EXPERIMENTAL DESIGN
The test domain for this study was victim management in urban search and rescue (US&R). In most cases, it takes 4 – 10 hours to extricate trapped victims once they are located and these non-anthropomorphic robots will need to stay with the victims until help can arrive [4]. From observations of victim management experiments [3, 4], robots have been operated so as to maximize the medical responder's assessment of the situation, leading to aggressive, fast, and erratic movements which could increase arousal and stress levels for victims already traumatized. Therefore, victim management provides an ideal test domain for exploring affect in non-anthropomorphic robots.

The design for this study used self-assessments, video observations, psychophysiological measurements, and follow-up interviews. The study involved a significantly larger participant pool than previous HRI studies. Based on a power analysis, 128 participants were selected for the study (79 females and 49 males ranging from ages 18 – 62) [5]. Each participant interacted with two robots (Inuktun Extreme-VGTV and iRobot Packbot Scout) that were modified to carry IR devices for operating and recording in the dark. Participants were randomly assigned to robots that were programmed to act in either a standard, impersonal mode or an emotive mode with robot order counterbalanced.

Figure 1: Confined Space Simulated Disaster Site with an Inuktun Extreme-VGTV.

The study was conducted in a high fidelity simulated disaster site constructed in a laboratory. It was conducted indoors to obtain temperature regulation for the psychophysiological measures. The robot interactions were conducted in the dark to simulate an actual disaster environment. Participants were placed in a confined space box during the interactions (See Figure 1).

Four different methods of measurement (self-assessments, psychophysiology measurements, video observations, and follow-up interviews) were used in order to obtain convergent validity for the study. Each participant was given multiple self-assessments; they were connected to five different psychophysiological sensors (EKG, abdominal and thoracic respiration, skin conductance response, and blood volume pulse) for obtaining physiological responses; observations were made using infrared night vision video cameras from four different camera perspectives (robot view, overhead view, participant view, and face view); and a follow-up interview was conducted to determine their feelings about the interactions and the study as a whole.

3. PRELIMINARY ANALYSIS

A doubly multivariate analysis of variance for the self-assessment data was conducted with robot (Inuktun, Packbot) as the within-subjects factor and operating mode (standard, emotive) and order (Inuktun first, Packbot first) as the between-subjects factors. The effects of these factors were examined based on participants' assessments of the robots using the Self-Assessment Manikin (SAM) [2] (See Figure 2) to measure participants' valence (positive to negative) and arousal (excited to calm) responses to the robots.

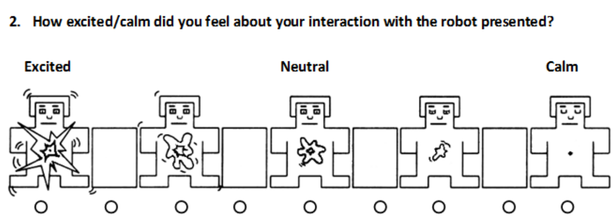

Figure 2: Example of the Self-Assessment Manikin (SAM) for measuring arousal.

Preliminary results of the SAM data indicate a statistically significant main effect ($\alpha = .05$) of operating mode on arousal $F(1,123) = 12.05$, $p = .001$. Participants exposed to robots in the emotive mode reported feeling calmer. The values for participants' arousal to robots in the emotive mode were higher ($M = 4.81$, $SE = 0.18$) than participants interacting with robots in the standard mode ($M = 3.95$, $SE = 0.18$). Lower scores indicate greater excitement. Additionally, preliminary results indicate statistical significance ($\alpha = .05$) for a three way interaction between robot, order, and operating mode on valence $F(1,123) = 4.50$, $p = .036$ (See Figure 3).

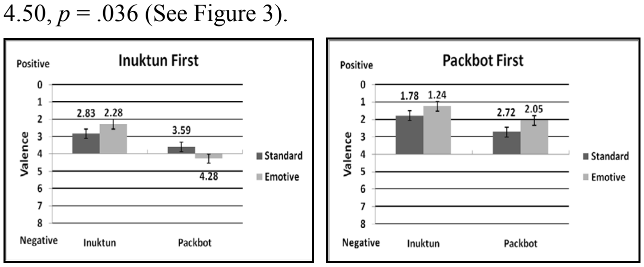

Figure 3: Graphs of three way interaction for valence.

4. PRELIMINARY CONCLUSIONS

Statistically significant results for arousal by operating mode clearly show that participants remained calmer when interacting with the robots operated in the emotive mode. There were no other factors that impacted these results. This indicates that using non-facial and non-verbal affect is a better way of operating these robots to reduce the stress and arousal levels of victims. Since the responses were apparent in a lab setting it is expected that the responses would be even more noticeable in an actual disaster environment. It is expected that the favorable reaction to emotive robots would transfer to other domains, such as healthcare, education, and entertainment, where robots operate in close proximity with humans.

The preliminary results related to participants' valence responses to the robots operated in the emotive mode are dependent on not only the robot itself, but also on which robot they interacted with first. In most cases, participants reported that they felt more positively about the robots operated in the emotive mode. However, if they received the Inuktun robot in the emotive mode first, their responses to the Packbot in emotive mode were more negative than expected, with valence scores for the emotive Packbot even more negative than the standard operated Packbot. Additionally, analyses are being conducted to determine the physiological responses of the "victims" during their interactions and correlational analyses will be conducted relating the self-assessment data to the psychophysiological data to determine if there is a correlation between these two types of measurements.

5. ACKNOWLEDGMENTS

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