Impacts of Robot Assistant Performance on Human Trust, Satisfaction, and Frustration

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INTRODUCTION

Trust is a parameter which usually takes time to develop and is important during interaction with any autonomous system. In general, there are many factors that might affect trust, for example, previous experiences interacting with autonomous systems. A lack of trust may negatively impact the task performance and impact the productivity of a human-robot team task.

The satisfaction level is one of the main factors when it comes to interaction with robotic systems, prosthetic limbs are prime examples of this, where high user abandonment rates are observed to be correlated with low satisfaction with the artificial limb. It is likely that limb absent people must first be satisfied with their prostheses before they are willing to use it long enough to develop a relationship of trust with the device.

There is no doubt a correlation between trust and satisfaction, but that is not well understood in human-robotic systems due to the substantial variations from one person to another, from one robot to another, and the myriad combinations of human-robot interactions that are possible. By adding the satisfaction and frustration measurements in this research, possible connections between the trust and satisfaction were explored to evaluate their effects on each other. End-user satisfaction is a crucial metric when evaluating assistive robotic devices such as prosthetic arms and surveys have shown that 30%-50% of upper limb-absent people abandon the use of their prostheses because they are not satisfied with the performance of the artificial limb. For users to trust autonomous systems, many factors might affect that trust as mentioned, and the satisfaction and frustration are among these factors.

EXPERIMENTAL METHODS

The purpose of this experiment is to implement a collaborative task through interactions with a robotic assistant. In this experiment, users conducted sets of interactions with the robotic assistant where each round consisted of three deliveries of water bottles. At the end of each case (three deliveries), the subject answered three questions regarding their levels of trust, satisfaction, frustration on a scale of -2 to +2.

A. Human Subjects

In this experiment, a task for an in-home robotic assistant to provide support to people in a daily task were explored. Specifically, the task of passing a bottle of water was examined. The human was asked to take the bottle out of Baxter's parallel gripper and place it on a shelf. 10 participants were recruited, all the participants' ages ranged from 20 to 40 years old.

B. Baxter Robotic Assistant

Baxter Robot (Rethink Robotics, Inc.) was used in this experiment; the robot was pre-programmed to pick up bottles of water and deliver them to the test subject. In our experiment, we used robot operating system (ROS) to establish a communication line to control Baxter and to record all the necessary information that is essential for our experiment. All the recorded data was synchronized with each other and have the same time stamp.

The user was asked to give a feedback rating their feeling of trust, satisfaction and frustration after each case (three deliveries).

C. Object Delivery Case Sequence

In this research, the sequence of 12 different delivery cases each with three bottle deliveries per case were followed by each of the 10 test subjects. The 12 cases of delivery modes were presented to the subjects sequentially in the order: 1, 2, 5, 5, 1, 4, 2, 4, 3, 1, 1, 1.

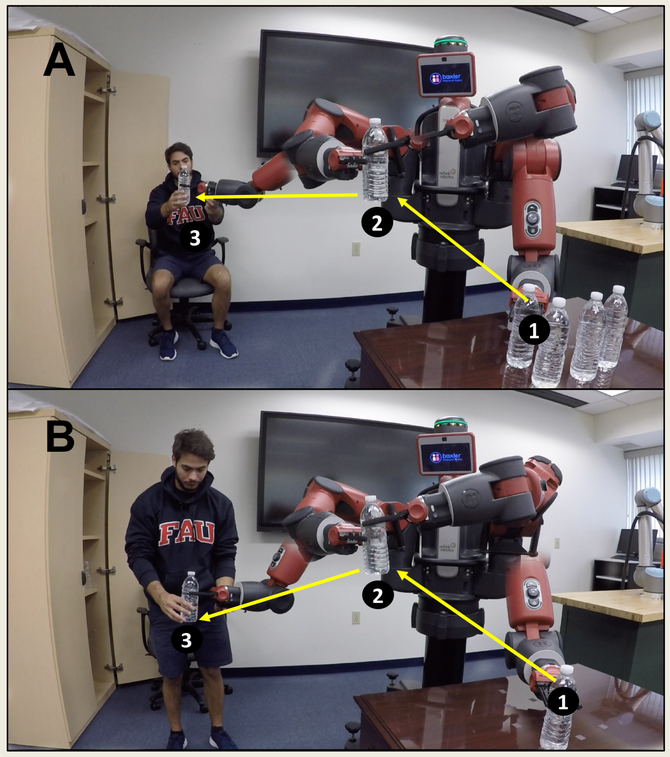


Figure 1.A. Successful delivery of the bottle of water.
Figure 1.B. Bottle Delivered to the Wrong Location.

RESULTS AND DISCUSSION

The data was plotted on three bar graphs showing the means and standard deviations to quantify the subjective ratings of trust, satisfaction, and frustration. To assess the statistical differences that occurred between any two cases of robot operation (listed in Table 1), a nonparametric Mann-Whitney U-test was performed on every combination of operational mode.

Table 1. Baxter Robot Operational Modes

Operational Mode	Robot Operation Mode	Robot Arm Speed
1	Successful placement	0.3 m/s
2	Successful placement	0.1 m/s
3	Successful placement	0.7 m/s
4	Bottle Dropped	0.3 m/s
5	Wrong Location Delivery	0.3 m/s

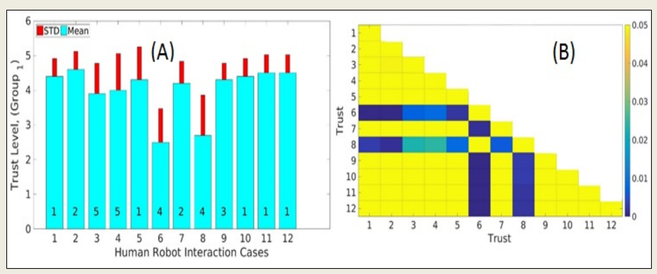
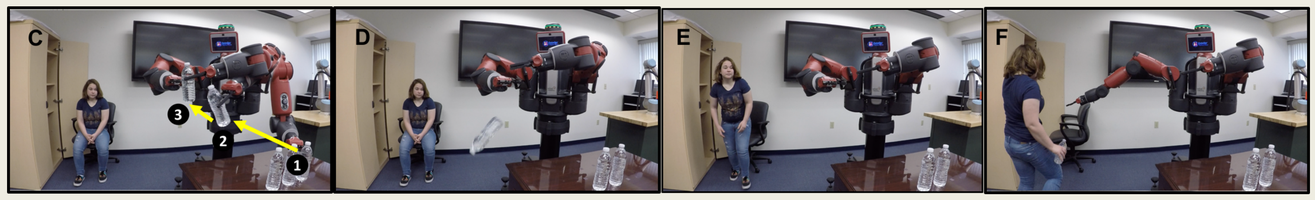


Figure 2. Trust Level, (a). Mean and Standard Deviation, (b). Mann-Whitney U test

The human trust clearly varied throughout the sequence of the operational modes Fig. 2(A). Fig. 2.(B) shows the statistical analysis of the comparison between any two cases of operational modes, which showed several significant findings. The blue blocks indicate which two robot operational mode cases are fundamentally different. The most significant change in trust happened in the dropping mode (mode 4) in cases 6 and 8. The wrong location mode (mode 5) also affected the trust level in comparison to modes 1-3. Also, as shown in Fig. 2(B) is that Case 7 is significantly different in comparison with case 6 and 8 because the trust level sharply rose from case 6 to case 7 then sharply declined between case 7 and 8 Fig. 2(A).

Figure 1.C - F. Drop Bottle Delivery.



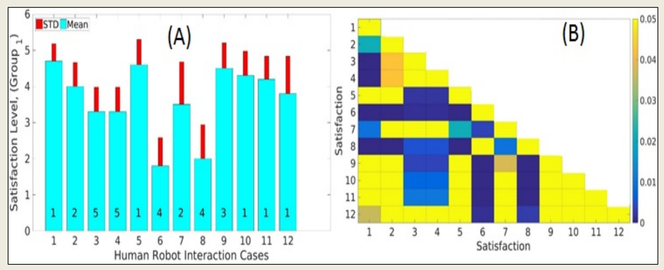


Figure 3. Satisfaction Level, (a). Mean and Standard Deviation, (b). Mann-Whitney U test

The satisfaction level showed a similar trend as the trust metric because the dropping mode (mode 4) was the lowest across all subjects. The satisfaction levels with the wrong location mode are also low when compared to other robot operation modes, Fig. 3(A). The satisfaction level of cases 3 and 4 are also significantly different than the rest of the cases except for case 7 and 12 (Fig. 3(B)).

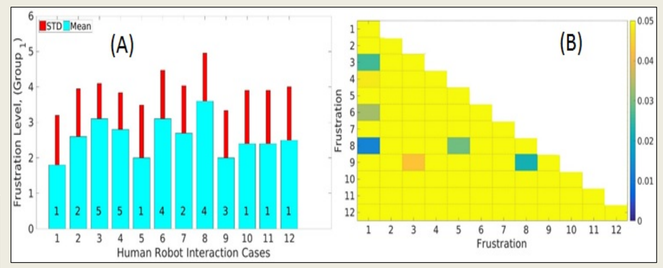


Figure 4. Frustration Level, (a). Mean and Standard Deviation, (b). Mann-Whitney U test

The self-reported frustration levels also changed with respect to the robot operational mode. The frustration level was high in operation mode 4 (dropping mode), Fig. 4(A). The wrong location modes are also had slightly higher frustration levels. The statistical analysis for frustration level showed a significant difference between cases 1, 3, 6 and 8. is completely different from case 8, 6, 3, and 4. Also, case 8 (the dropping mode) and case 3 (the wrong location mode) are different from case 9 (the fast delivery mode).

CONCLUSION

This work focuses on the interaction with a robot in daily life tasks like passing objects to disabled or elderly persons helping them with the daily routine. HRI feedback was measured for trust, satisfaction and frustration levels after interaction with Baxter robot. It was observed that the human trust, satisfaction and frustration levels changed depending on the interaction mode with Baxter robot. If the robot did the delivery task without any mistake the subjects had higher levels of trust and satisfaction with less frustration.