Maintaining Trust While Fixated to a Rehabilitative Robot

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***Abstract*—This paper investigates the trust relationship between humans and a rehabilitation robot, the *RoboTrainer*. We present a study in which participants let the robot guide their arms through a series of preset coordinates in a 3D space. Each participant interact with the robot twice, one time where participants hold on to the robotic arm, and a second time where participants are fixated to the robotic arm. Our findings show that in general participants did not feel more insecure when fixated to the robot. However, when the robot arm moves close to participants and enter their intimate space, or when the robot moves out into an outer position participants display significantly more signs of fear opposed to when the robot arm is in a normal position.**

***Index Terms*—Trust, Robot Assisted Rehabilitation, Human-Robot Interaction, Extreme Human-Robot Interfacing, RoboTrainer**

I. Introduction

This paper investigates feelings of security and trust in a robotic system, the *RoboTrainer*. The *RoboTrainer* is designed to ease the burden of the practitioner in some phases of the rehabilitation treatment. Previous work on trust and insecurity in HRI have been studied by Ximenes et al. in a study to understand the discomforts of Extreme Human-Robot Interfacing [1]. They find that while 25% of their participants feared getting hurt, those who did not fear said that a reason for their lack of fear was due to them not being constrained. To put this to the test we set up an experiment where a robot arm guides a participant's arm through different preset coordinates in a 3D space, once unconstrained and once constrained. Our research question is thus: ***Does the user feel insecure if the robot has control of their arm and leads it in unaccustomed positions, and will the insecurity increase if the hand is fixated to the robot?***

II. Methods

We set up an experiment to investigate whether participants display feelings of insecurity when a robot arm guides their movement, and the extent to which (if any) these feelings are reinforced when participants are fixated to the robotic arm.

A. Participants

14 healthy participants (7 women, 7 men) took part in the experiment, ranging in age from 18 to 26 years (M=21.71, SD= 3.02). The height ranged from 158 to 183 centimeters (M=173 cm, SD=8 cm). Participants were recruited from the University of Southern Denmark. Participants were randomly assigned to start with one of these two conditions.

B. The Robot

The *RoboTrainer* is a *Universal Robots* robotic arm, which is configured to be used for rehabilitation purposes. The arm has a handle at the end, which can be utilized by either fixating a person, or having them hold on to it (see Fig. 1. The speed of the robot arm can be controlled through the RoboTrainer's software. During the experiment, the speed was set to 75% of its maximal speed.

C. Data Collection

1) Video Recording: Each participant was observed and video recorded. The video data along with our notes make out the foundation of our behavioural analysis. There is no distinction between the degree of reactions. A reaction was defined as a discomfort related facial expression such as nervousness, surprise, fear and pain. Each waypoint was evaluated with a score of one when a discomfort reaction was observed and zero when no discomfort reaction was observed. The evaluation was subjective, but done by two individual coders to minimize the subjectivity.

2) Open Ended Interviews: After the experiments participants were asked a sequence of questions related to their experience with the robot. This was to get the participants own view on the experience and their reactions [2].

III. Results

A. Interview

Of the 14 interviews one interview was discarded because the interview procedure was not comparable with the standard procedure, due to the questions being leading.

The most prominent tendency is that 80% of the participants feel safe with the robot and find the speed of the robot arm to be fine, no one expressed direct feelings of insecurity. 53.3% of the participants are not concerned with fixation while 13.3% of the participants are. The remaining 33.4% said neither that they are concerned with fixation or not.

Results of the interview study reveal four factors that increase participants' trust in the robotic system. These four factors are (1) previous experience or a short familiarization with the robot, (2) repetition of the route, (3) the speed of the

978-1-4673-8370-7/16/$31.00 © 2016 IEEE

Fig. 1. Illustrations of the workspaces: Yellow = intimate, Green = normal, Red = outer.

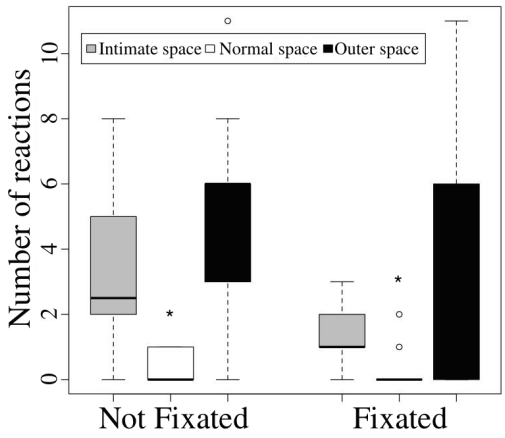

Fig. 2. Observed facial reactions summarized over the different work spaces. *The normal workspace is significantly different from intimate and outer normalized workspace in both cases.

robot allowed the participants to react and move if needed, and (4) to know that the experiment supervisor has an emergency stop button and that the participants themselves can stop the robot.

B. Behavioral Analysis

Of the 14 experiments four sessions were discarded due to missing video recordings. Each of the waypoints are sorted into one of the three groups (intimate, normal and outer workspace. See figure 1). The observations are summarized across the participants' reactions in these three groups. The reactions in the outer workspace were normalized with a factor 2.75 because of the non-equal amount waypoints in the three workspaces.

Analysis of the interview shows that none of the participants are insecure with the robot and that only 13.3% are concerned about being fixated, which was a contradiction of the expected result

1) Fixation in Each Work Space: First, we tested the effect of fixation in each of the three work spaces. This analysis is also seen in figure 2. Welch's T-test shows that there is no significant differences between not fixated and fixated, for Intimate workspace p=0.06, Outer workspace p=0.51 and Outer normalized p=0.47. The difference in p-values for outer workspace and outer normalized is due to rounding mistakes under normalization.

2) Fixation Across Work Spaces: Second, we tested what effect fixation had across work spaces on participants' displays of fear. This was done by performing a Kruskal Wallis test (non-normal distribution) across intimate, normal, outer and outer normalized workspace in interaction with the two fixation conditions. Results show no significant differences between the fixation conditions. However, they do show that participants display significantly more signs of fear when the robot moves into the intimate and outer work spaces than when working in the normal work space ($p<0.05$), regardless of fixation condition.

IV. Discussion

In this experiment, there were unwanted limitations, these were: (1) Distribution of waypoints (Intimate workspace = 11, normal workspace =10, outer workspace =4). (2) Spectators during experiments and interviews. (3) Trust towards the programmer may differ between target groups. (4) Subjective collection of data (video and interview).

The distribution of waypoints that, put together, made the robot's route, were not of equal size when looking at the three workspaces and therefore the direct comparison of the workspaces are not possible. An assumption was made, that the probability of a reaction for any outer position had the same characteristics as the four waypoints represented in our experiments. This is a rough assumption, but it made it possible to normalize the data from the outer workspace. This way, it was possible to perform statistical comparison between the three groups. The presence of experimenters and other technical personnel during the experiments and interviews may have caused an observer's paradox, and thus unwittingly influenced participants' reactions and responses. For example, during the experiment some participants looked to experimenters for confirmation of their actions. Our behavioral results showed only a mild degree of insecurity among the participants, which may also be the reason why none of them brought it up in the interviews.

The contribution of this LBR is that the participants accept to a high degree being fixated to a robot in a rehabilitation scenario. Furthermore, we show that it was easy to make the participants feel safe by letting them get familiarized with the robot, letting them try the emergency stop in a safe position in the normal workspace, and/or by having a supervisor to release the emergency stop.

References

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