INNOVATIVE EXPERIMENTAL METHODS IN HUMAN-ROBOT INTERACTION

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INTRODUCTION

Previous work in social robots commonly makes use of user studies, online studies, and surveys. All of these are fairly controlled, in which there are independent variables which are explicitly varied, and there are dependent variables (measures) that are tracked in response to these variations. We continue this pattern, but instead of recruiting people to observe and interact with programmed robots in a traditional way, we investigate the use of innovative methods in two different experiments. *The Actor Method*: Act something out rather than explicitly encode it. *The VR (Virtual Reality) as an HRI Design Tool*: Visualize what a robot could look like rather than build it.

Both of these are still user studies, but they are user studies with a twist applicable to early stage application design, in that they enable us to understand early what should be built and/or programmed.

HYPOTHESIS

Utilizing innovative experimental methods for social robotics can provide access to high-stakes social data not typically collectible with traditional user studies:

- The Actor Method provides access to data that would not typically be approved by the experimental research board.
- VR as an HRI Design Tool allows us to collect data about robot physical designs, without actually building all of the robot variants.

Fig. 1: A recreation photo of the In-Person Study. The actual study re-used the actor from the Online Study. Both studies utilized the same script, but the in-person study included the participant as a character in the scene.

Fig. 2: This experiment varied the apparent material and shape of a virtual robot whose motion was synced to that of a real robot. This robot approached and then collided with each participant (N=16). This sequence was repeated 12 times with 12 different apparent surface materials.

METHODS

The Actor Method: This experiment explored the impact of a robot barista's comment to two coffee shop customers after the two customers have had a brief conversation. To perform the role of the robot barista, we selected a NAO robot as it had an anthropomorphic face to relate to customers, and arms that could be used to make the coffee (Fig.1).

Robot Valence	Robot Data Use
Positive Comment	Body Language Analysis
Negative Comment	Conversation Analysis
Neutral Comment	Database Search
	Control
Robot Addressee	**Base Script Variants**
To One Person	Meeting Type
To One About the Other	Meeting Valence
To Both	

Table 1 (left): A summary of the experiment variables in the experiment carried out by using the Actor Method. There were 24 different robot comments.

Example: *"She has a clean criminal record, I think you should go for it!"* (Positive, Database Search)

The participant was an actor in the scene (Fig. 1). After each trial (total of 6), they were asked to Likert questions about the robot. At the end of the study, the participant was asked open-ended questions.

VR as an HRI Design Tool: This experiment explored the effects of a virtual robot's material (Fig. 5), path (Fig. 2) and shape (cube or cylinder) on a participant's interpretation of the interaction and collision. In between each trial (total of 12), participants were asked to answer Likert questions out loud since they were wearing the VR headset. After the completion of the study, they were asked open-ended questions about the virtual robot and their experience in the system.

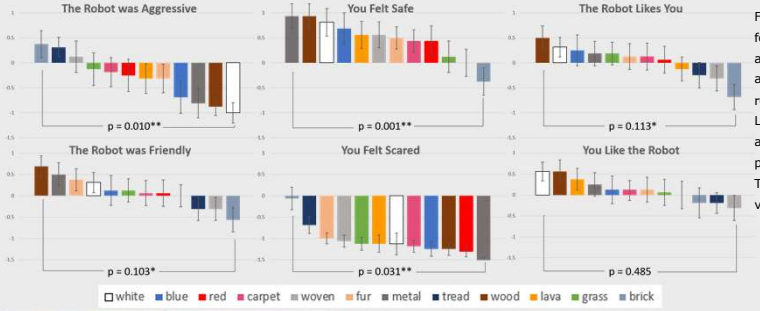

Fig. 3: The Material Means for the Six Survey Questions asked to each participant after each interaction. The responses were on a 5 point Likert scale and were analyzed using a non-parametric Kruskal Wallis Test to yield the indicated p values.

Fig. 4 (left): Participants experienced and expressed emotions in the in-person study. Snapshots (a) and (b) demonstrate reactions to a negative robot comment, while (c) and (d) are to a positive robot comment.

Fig. 5 (right): The 12 VR Materials: three colors, three materials associated with soft, three materials associated with hard, and three odd materials, uniquely available to VR.

RESULTS AND DISCUSSION

Actor Method: The in-person study that used the Actor Method found Comment Valence to be a significant predictor of the robot's comment being considered polite, considerate and appropriate and Data Type to be a significant predictor of the robot's politeness. Taking on the role of the character whose privacy was being violated as per the script helped participants feel vicariously through the characters (Fig. 4). For example, one participant said, "*I felt weird having one person telling me that I am fit for the job and the robot telling me that I suck, not cool*".

VR as an HRI Design Tool: As part of a design method check, we found that 3 out of the 12 materials (Woven, Fur and Metal) were misclassified by some participants. This points to the need for additional work to make the system render fibers and detailed textures properly. As shown in Fig. 5, the materials (namely, white, metal, wood and fur) were considered to be the least aggressive robots by the participants. In terms of mental models, many participants affectionately talked about pets, dogs, and children. One participant even greeted the robot directly with, "*hello random dog, what are you doing?*". The participant reemphasized the robot's doglike nature by saying, "*when it runs onto my foot it's like a puppy*".

CONCLUSION

The Actor Method enabled an investigation into the social privacy and data use revolving around human-robot interaction. Using this theater-inspired method allowed participants to experience a variety of scenes without putting their personal privacy at risk. In fact, in-person participants reported feeling real emotions during the scenes, demonstrating the credibility of the Actor Method (Fig. 4).

As a tool for conducting Human-Robot Interaction research, the VR as an HRI Design Tool method helped us survey the participant's attributions, participant comfort, and camaraderie, across all robot materials, shapes and paths. Multiple participants explored the interaction as the experiment went on: moving out of the way, asking to sit on the robot, letting the robot go through their legs, and one even jumping over it.

This thesis illustrates the rich potential of both these innovative experimental methods to gain access to typically inaccessible high-stakes data in user studies.

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