Baxter's head LCD screen displays a neutral face and gazes down toward the table where the participant is building and blinks or glances up toward the participant randomly throughout the interaction. The neutral face was chosen since

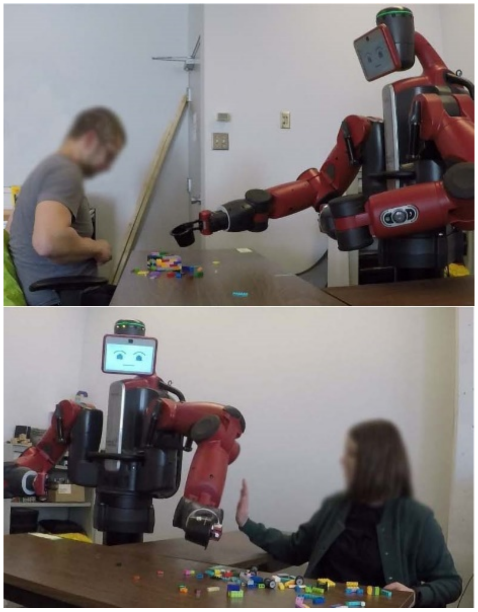

Figure 1. Personal space intrusion in the Across (top) and Beside (bottom) scenarios during a collaborative Lego-building task.

facial expression may affect the results [1], but we chose to focus only on depth and duration of personal space intrusion at this stage in our work.

In a pilot study we conducted, the reaches were counterbalanced using Latin Square. Each of the six reach states are repeated six times to obtain sufficient data, resulting in 36 reaches for each participant. The order of the scenarios is also counterbalanced between participants. After both scenarios are done, the participant fills out the Robotic Social Attributes Scale (RoSAS), found in [2]. We chose RoSAS because it contains items to measure discomfort.

Our testbed is based on evaluating the participants' comfort levels using qualitative and quantitative measurements. Our qualitative measurements include reflection on the participants' body posture and movements during the interaction which we captured on video, and on the RoSAS questionnaire. Our quantitative measures include heart rate data obtained during the task from the participant using a Xiaomi Mi Band 2 [12].

4 DISCUSSION AND FUTURE WORK

We conducted a pilot study using our testbed with 3 participants. Our observations showcased the potential of our testbed to uncover insight about comfort and invasion of personal space by robots, but we do not currently have enough data to draw conclusions.

In a full study still to come, the question we will aim to answer is: When a human's personal space is violated by a robot during collaboration on some task, how is the human's comfort affected by different levels of portrayed urgency and depths of intrusion? We hypothesize that decreased urgency, or greater duration of intrusion, as well as greater depth of intrusion, will elicit stronger reactions from participants.

Future planned work in this direction includes testing additional variables such as speed and facial expression. Collaboration with different robots will also be considered; Baxter's large arms and body size may be intimidating, which will likely affect the findings.

We believe that further investigation of the ways in which robots should intrude on people's personal space would provide insight into how robots should behave in social situations, particularly during collaborative tasks that require intrusion into people's personal space, for example, in the workplace or the intimate touch required during many healthcare tasks.

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