The Effects of Social Gaze in Human-Robot Collaborative Assembly

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Research Questions

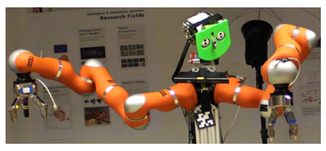
1) Did tutors look at the robot and perceive the robot's gaze towards them?
2) What effects does the robot's gaze have on initiating interaction?
3) What effects does the robot's gaze towards the human between tasks have?
4) What are the effects of robot's gaze behavior on tutors' perception of the robot's capabilities?

Method

Robot

The experiments were carried out using a robot torso at the Institute of Computer Science at the University of Innsbruck within the frame of the 3rd-Hand project [1].

- 2 Schunk hands (left hand only)
- KIT head
- Cameras mounted in eyeballs
- Kinect camera on top



Participants

- 36 University students and employees
- No experience with industrial robots
- Recruited by word-of-mouth

Ø 23,7 years

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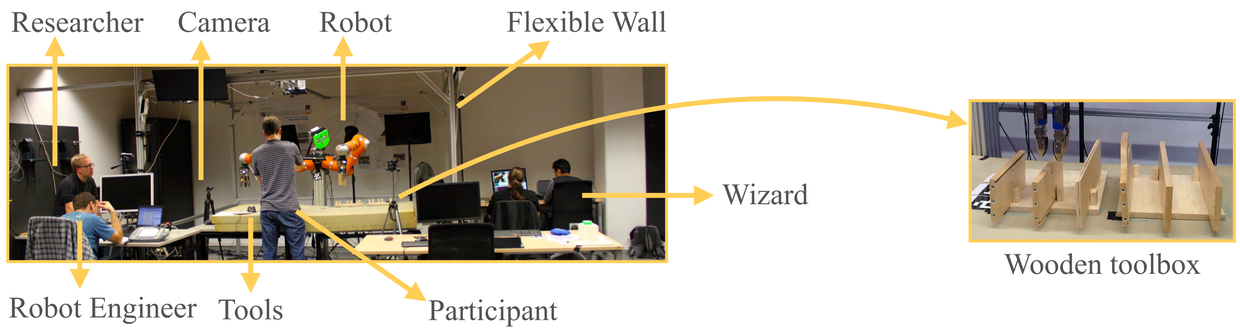
Set-Up



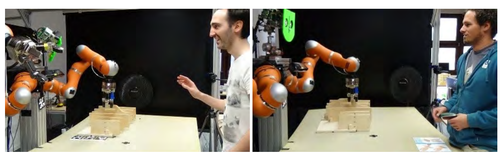
Task

Naïve human users were asked to instruct a robot to hand over the appropriate parts for the assembly of a wooden toolbox, which the user then had to assemble him- or herself.

Experimental Conditions

Social Gaze
- the robot's face is initially directed at the participant,
- during tasks, the robot changes its gaze to its hand
- then looks to the user again when it has completed its task

Simple Gaze
- the robot's gaze follows its own hand



Simple Gaze Social Gaze

Data Analysis

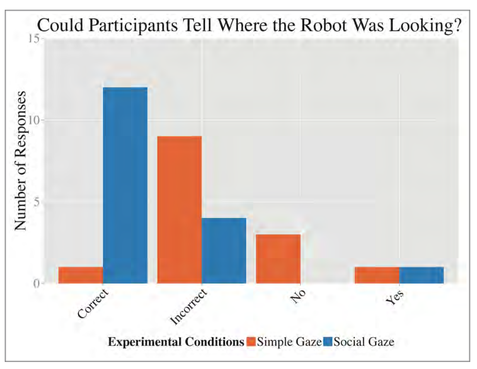
- Based on video recordings of the interactions, supplemented by field notes
- Quantitative: responses were coded and analyzed using single linear regression with the statistical software package R (v. 3.1.2)
- Qualitative: ethnomethodological conversation analysis [2]
- Analysis of questionnaire that participants filled out after experiment

Results

1) Did tutors look at the robot and perceive the robot's gaze towards them?

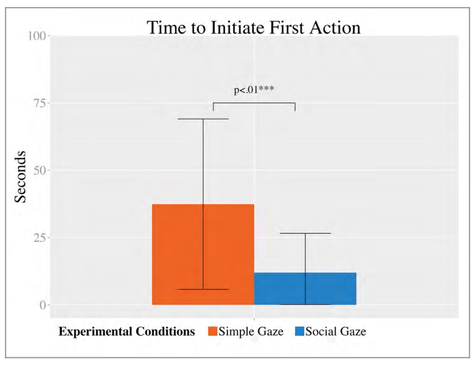
Did participants actually perceive the robot's gaze?

- Initially, all participants in the social gaze condition looked at the robot and perceived its gaze towards them. However, during the experiment, they often did not look up at the robot.
- During 43 of the 90 handovers in the social gaze condition, the respective participant did not glance towards the robot.

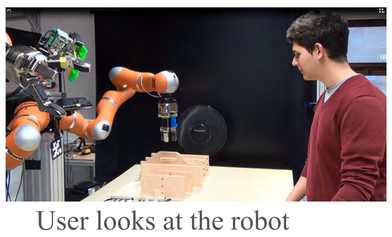


2) What effects does the robot's gaze have on initiating interaction?

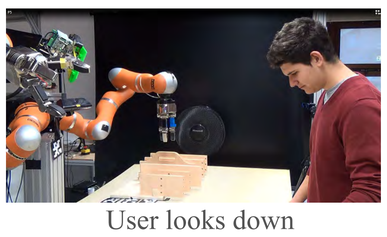
- Participants in the social gaze condition needed less time to initiate their first action (instruction) than participants in the simple gaze condition.
- No significant results on age or gender as predictor variables and no significant interactions can be found.
- Using visual inspection of boxplots, we eliminated one extreme outlier from the analysis.



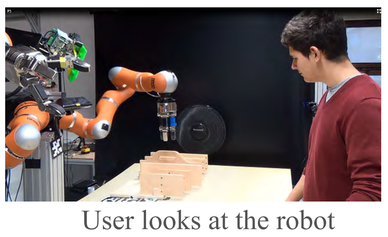
With simple gaze, the participant does not know how to start



User looks at the robot



User looks down

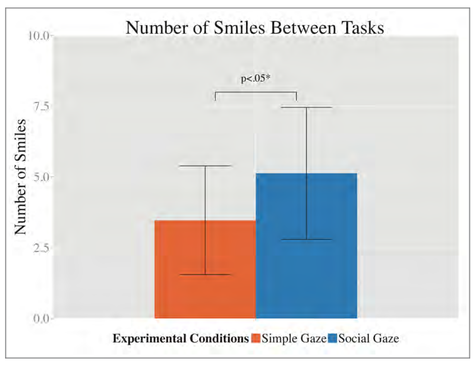


User looks at the robot

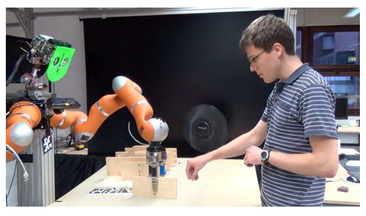
Results

3) What effects does the robot's gaze towards the user between tasks have?

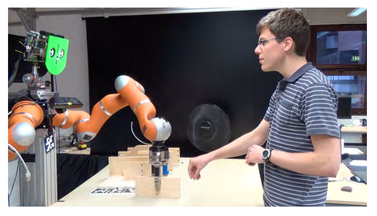
- In 75.6% of the cases in which users looked up to see the robot's eye gaze, they responded to the robot's gaze with a smile.
- The robot's eye gaze can be understood as a straightforward social signal.



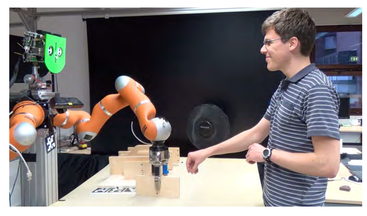
Spontaneous smile in response to mutual gaze



Robot and user look up

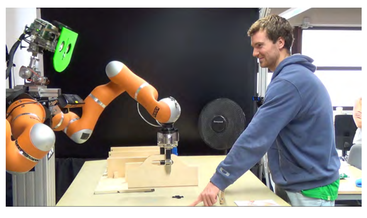


User looks at robot



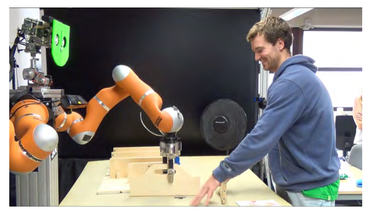
User starts smiling

User directs the robot's gaze back to his hand



Robot and user look up

User raises finger



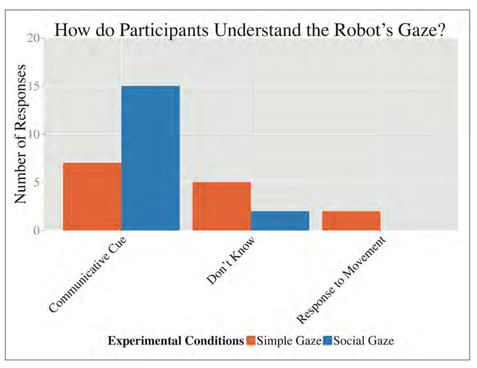
User instructs robot

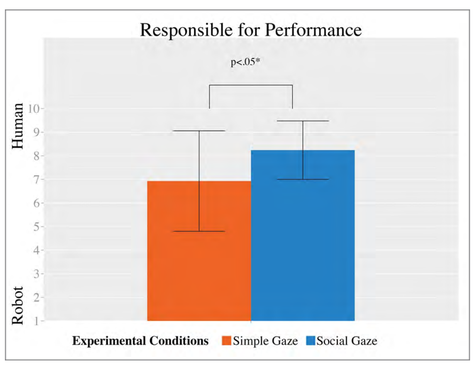
4) What are the effects of robot's gaze behavior on tutors' perception of the robot's capabilities?

Who did participants think was most responsible for the performance of that task?

(1=robot, 10=participant)

- Tutors in the social gaze condition thought that the tutors themselves were more responsible for performance of the task than the tutors in the simple gaze condition thought

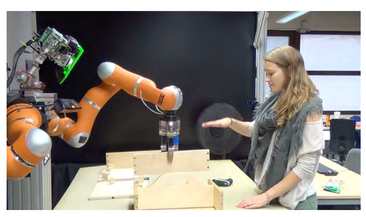




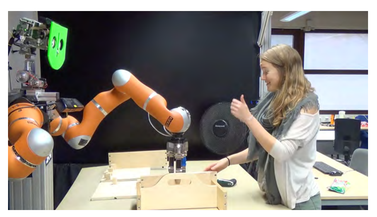
Participants' understanding of the robot's gaze behavior:

- The qualitative analysis of the handovers shows that participants interpret the robot's gaze towards them as an invitation to provide feedback:

Robot's social gaze as invitation for feedback



User says: "and now down"



Robot looks up. User looks up, says "perfect"

User takes piece and smiles

Conclusion

- People in the social gaze condition are significantly more quick to engage the robot, smile significantly more often, and can better account for where the robot is looking.
- Allowing the user to establish mutual eye gaze during the initiation of interaction by having the robot look towards the participant does not only serve ‚to break the ice'[3], but also provides users with a necessary indicator of the robot's "entry point" for the interaction since people interacting with the robot in the social gaze condition are significantly quicker to engage the robot.
- People in the social gaze condition feel more responsible for the task performance.

Acknowledgements

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References

[1] R. Lioutikov, O. Kroemer, J. Peters, and G. Maeda, "Towards a third hand," in 1st international workshop on intelligent robot assistants, 2014.

[2] Sacks, H., E. A. Schegloff, and G. Jefferson (1974). A simplest systematics for the organization of turn-taking for conversation. Language 50 (4), 696–735.

[3] Bee, N., André, E. & Tober, S. (2009). Breaking the Ice in Human-Agent Communication: Eye-Gaze Based Initiation of Contact with an Embodied Conversational Agent. In Zs. Ruttkay et al (eds.), Intelligent Virtual Agents 2009, pp. 229-242. Berlin/Heidelberg: Springer.