Riding In Cars With Robots: Opportunities for Exploring Group Interactions with Robots in Cars

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Abstract
As social robotics become more imbued in everyday life, situations will surely arise when robots will interact with groups of people. Given this, interaction designers should begin to consider how robots can influence interactions with and between multiple people. One area for future exploration of group interactions with robots will be the autonomous vehicle. In this workshop paper, I review my previous work exploring how robots can interact with teams of people and suggest that work in human-robot interaction can be transferred to and help explore robots mediating interactions with groups in cars.

Author Keywords
Human-robot interaction; interaction design, automotive interaction

ACM Classification Keywords
H.5.3. [Group and Organization Interfaces]: Computer-Supported Cooperative Work

Introduction
As robots enter into our everyday environments, be it at work, at home, or in the car, designers will need consider interactions at both the individual and the group level. While we often think about dyadic interaction, real-world scenarios have the potential for groups of people interacting with

a robot (or robots). Previous work around group interactions with robots has shown that social cues can change group behaviors [3]. For example, robot eye gaze has been shown to influence the role that team members take during a task [8]. Non-verbal robot behaviors have also been shown to improve team performance while working on a problem solving task [2]. In another study exploring two robots interacting with one person, robot gaze was shown to improve the person's levels of stress and cognitive load [5]. These positive cognitive benefits may also transfer to teams of people working with a single robot and can have a positive impact within teams working together with the robot on a shared goal.

In my previous work, I have explored how robot behaviors such as attempting to verbally repair a negative comment made by a team member can impact team interactions. More recently, I have begun to explore how interactive agents within cars can influence the interactions in the vehicle. One opportunity for this work it to extend my previous work around robots regulating team dynamics to explore how robots in cars can help regulate driver-passenger dynamics. This could have possible implications for things such as co-navigation, emotion regulation during stressful driving, and interactions among family members during road trips.

Using repair to support team dynamics

In my prior work with collaborators Malte Jung and Pamela Hinds, we explored how a robot might aid in regulating team dynamics during a stressful problem solving activity [6]. During the study, a team of three people worked with one robot to "diffuse a bomb" by completing a puzzle. One member of the team was a confederate and delivered a negative comment, or trigger, toward either the task or another team member. We then had the robot, who was

Figure 1: A robot repairing a negative comment given by a team member.

helping with the task directly, attempt to repair the negative comment by verbally acknowledging the comment and making a statement to remain positive, or ignoring the trigger. Participants reported that the robot's repairs heightened their awareness of the team's conflicts. Although this may not seem productive, this could potentially help teams to acknowledge and work through their issues together, potentially improving their overall interactions with each other [9].

Moderating group dynamics in cars with robots

While my previous work looked at group dynamics in relation to teams solving a fictional problem, there are many real world environments where teams work together with the aid of technology. One such place is the car. For example, research has been done to explore the design of collaborative navigation apps and show how the technology can mediate interactions between the passenger and driver [4]. With more attention on interactive agents and autonomous capabilities in vehicles, there is potential for interactive, social robots to mediate interactions among groups of people in a car. For example, an extension of prior work could see how an in-car robot could assist a passenger and driver navigating in an unknown area.

This type of on-the-road team dynamics work has been challenging in the past. My current work exploring in-car prototyping and observation systems can now allow for designers and researchers to ride along and control in-car interactive agents remotely [7]. While I have currently only explored interactions between a driver and robot, I am now interested in realizing the potential of remote interaction prototyping to study groups of people in the car.

Robots could help to regulate the emotions of the people in the car. Previous work has shown that emotion regulation can improve team dynamics [1] and the same may be true for regulating interpersonal dynamics in the car. For example, the robot could aid in regulating stress of the driver and/or of the passenger (who is in the stressful position of not being in control of the vehicle) during challenging driving scenarios. An in-car robot could also be used to help regulate communication between people in different locations of the car during long drives, such as mediating communication between children in the back and parents in the front during a family road trip.

Conclusion

As cars become more autonomous there are open design opportunities for how in-car robots will interact with multiple people in the vehicle. The car presents an interesting real-world environment to explore how robots can influence various group behaviors, from stress management to collaboration. With new remote prototyping and observation capabilities, it is now possible to explore real-world interaction between interactive robots and groups in the car. The potential impacts of this work may help designers to better understand how robot behaviors can influence group dynamics in other scenarios such as team problem solving at work or relationship management within the home.

REFERENCES

1. Sigal G Barsade and Donald E Gibson. 2007. Why does affect matter in organizations? *The Academy of Management Perspectives* 21, 1 (2007), 36–59.

2. Cynthia Breazeal, Cory D Kidd, Andrea Lockerd Thomaz, Guy Hoffman, and Matt Berlin. 2005. Effects of nonverbal communication on efficiency and robustness in human-robot teamwork. In *2005 IEEE/RSJ International Conference on Intelligent Robots and Systems*. IEEE, 708–713.

3. Thomas Fincannon, Laura Elizabeth Barnes, Robin R Murphy, and Dawn L Riddle. 2004. Evidence of the need for social intelligence in rescue robots. In *Intelligent Robots and Systems, 2004.(IROS 2004). Proceedings. 2004 IEEE/RSJ International Conference on*, Vol. 2. IEEE, 1089–1095.

4. Jodi Forlizzi, William C. Barley, and Thomas Seder. 2010. Where should I turn: moving from individual to collaborative navigation strategies to inform the interaction design of future navigation systems. In *Proceedings of the SIGCHI conference on human factors in computing systems*. ACM, 1261–1270.

5. Malte F Jung, Jin Joo Lee, Nick DePalma, Sigurdur O Adalgeirsson, Pamela J Hinds, and Cynthia Breazeal. 2013. Engaging robots: easing complex human-robot teamwork using backchanneling. In *Proceedings of the 2013 conference on Computer supported cooperative work*. ACM, 1555–1566.

6. Malte F Jung, Nikolas Martelaro, and Pamela J Hinds. 2015. Using robots to moderate team conflict: the case of repairing violations. In *Proceedings of the Tenth*

Annual ACM/IEEE International Conference on Human-Robot Interaction. ACM, 229–236.

7. Nikolas Martelaro and Wendy Ju. 2017. WoZ Way: Enabling Real-time Interaction Prototyping and On-road Observation. In *Proceedings of the 2017 Conference on Computer Supported Cooperative Work (CSCW '17)*. Portland, OR. DOI: http://dx.doi.org/10.1145/2998181.2998293

8. Bilge Mutlu, Toshiyuki Shiwa, Takayuki Kanda, Hiroshi Ishiguro, and Norihiro Hagita. 2009. Footing in human-robot conversations: how robots might shape participant roles using gaze cues. In *Proceedings of the 4th ACM/IEEE international conference on Human robot interaction*. ACM, 61–68.

9. Laurie R Weingart, Kristin J Behfar, Corinne Bendersky, Gergana Todorova, and Karen A Jehn. 2015. The directness and oppositional intensity of conflict expression. *Academy of Management Review* 40, 2 (2015), 235–262.