Trusting Automation Technology for Safer Roads: The Effect of Shared Driving Goals

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Abstract. Automation technology can increase safety on the road, but only when it is trusted. As shared goals lead to social trust, and people exhibit social responses towards intelligent machines, we hypothesized that shared driving goals would also lead to increased trustworthiness and acceptability of Adaptive Cruise Control Systems (ACCs). In an experiment, participants (N = 61) were presented with descriptions of three ACCs with different automation levels which were described as systems that either shared their driving goals or did not. Trustworthiness and acceptability of the three ACCs were measured. Results indicated that participants judged ACCs sharing their own driving goals to be more trustworthy and acceptable than ACCs not sharing their driving goals. Furthermore, participants judged ACCs that took over driving tasks while providing information as more trustworthy and acceptable than ACCs that took over driving tasks without providing information. Thereby, these results help opening the road to safer driving.

Keywords: trust, acceptance, adaptive cruise control, automation

1 Introduction

More than 50 percent of all car accidents happen due to human error [1]. Intelligent automation technology in cars could increase driving safety. However, drivers have to trust the technology before they accept it [2]. The media equation hypothesis [3] suggests that people might trust automation technology in the same way as they trust humans. In the research on trust in humans, the model of salient value similarity states that people are more likely to trust other people and institutions that have values and goals similar to theirs [4]. Therefore, we expected that automation technology that shares the goals with its user would be judged more trustworthy and acceptable than automation technology that does not.

In a previous experiment [5], we confirmed this expectation and showed that automation level also influences trust and acceptability judgments of automation technology. However, safety was included as one of the driving goals in that study, leaving an alternative explanation for our results. That is, the results could be explained by automation technology being safe versus unsafe instead of by shared versus unshared goals. In the current study, we test the effect of shared goals while excluding the safety goal. Furthermore, in the current study we use a different, more widely used measure of acceptability. Finally, this study serves as a replication of our first study.

2 Method

2.1 Participants

Sixty-one participants (20 women and 41 men) were randomly assigned to the conditions of a 2 (goal sharing: shared versus unshared) x 3 (automation level: ACC_{info} vs. $ACC_{info+action}$ vs. ACC_{action}) mixed model design with goal sharing as a between-subject factor and automation level as a within-subject factor. The two dependent variables were trustworthiness and acceptability of Adaptive Cruise Control systems (ACCs).

2.2 Materials

We presented participants with descriptions of three ACCs that differed in their automation level. One ACC system (ACC_{info}) was described as a system that only provided information to the user about when and how hard the user needed to accelerate or brake to reach the driving goal of the ACC. A second ACC system ($ACC_{info+action}$) was described as a system that would take over accelerating and braking of a car to reach the driving goal it was made for, while giving information about when and how hard it would accelerate and brake. A third ACC system (ACC_{action}) was described as a system that would take over accelerating and braking of a car to reach the driving goal it was made for, without giving information. As we only used descriptions of ACCs, participants did not receive actual information of ACCs or get to experience actual ACC systems.

Trustworthiness was measured by seven seven-point Likert scale questions (1 = “totally disagree”, 7 = “totally agree”) which were based on a questionnaire that measures trust in automation technology [6]. Answers to these questions were averaged to form a reliable measure of trustworthiness (Cronbach’s alpha = .91). Responses were coded such that higher scores indicate higher trustworthiness.

Acceptability of the ACCs was measured with a questionnaire [7] consisting of nine five-point bipolar questions, ranging from -2 to +2. Scores to these questions were averaged to form a reliable measure of acceptability (Cronbach’s alpha = .97). Responses were coded such that higher scores indicate higher acceptability.

2.3 Procedure

Participants were seated in a cubicle in front of a computer and presented with three driving goals. The driving goals (with their framing in parentheses) were comfort (relaxed driving, no sudden braking and accelerating), energy efficiency (saving fuel while driving), and speed (reaching the desired destination in the least amount of time). Participants were instructed to rank the driving goals from one to three, one being the most important driving goal, three being the least important.

Participants were then presented with descriptions of three different ACCs. Each description included the ranking of the three driving goals both *for the participant* and *for the ACC system*. In the shared goals condition, all ACCs had the *same ranking* as the participant. In the unshared goals condition, all ACCs had the *reversed ranking* to that of the participant (e.g. if the participant ranked speed as the most important driving goal, speed would be the least important driving goal for the ACC system).

For each ACC system, trustworthiness and acceptability were measured using the questionnaires described above. After the experiment, participants were thanked, paid for their participation, and debriefed.

3 Results

3.1 Trustworthiness

A two-way mixed ANOVA was conducted on trustworthiness with goal sharing and automation level as factors.

Goal sharing. Results revealed a main effect of goal sharing, $F(1, 59) = 3.48$, $p < .05$ (1-tailed), $\eta_p^2 = .06$. In the shared goals condition, ACCs were judged more trustworthy ($M = 4.40$, $SD = 1.05$) than in the unshared goals condition ($M = 3.95$, $SD = 0.86$).

Automation level. Mauchly's test indicated that the assumption of sphericity had been violated ($\chi^2(2) = 32.16$, $p < .001$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.70$). Results revealed a main effect of automation level, $F(1.40, 82.77) = 25.15$, $p < .001$, $\eta_p^2 = .30$. Planned contrast analyses showed that ACC_{info} was judged as more trustworthy ($M = 4.78$, $SD = 1.15$) than ACC_{action} ($M = 3.65$, $SD = 1.35$), $F(1, 59) = 33.44$, $p < .001$, $\eta_p^2 = .36$. Furthermore, $ACC_{info+action}$ was judged more trustworthy ($M = 4.10$, $SD = 1.16$) than ACC_{action}, $F(1, 55) = 16.27$, $p < .001$, $\eta_p^2 = .23$. Lastly, ACC_{info} was judged more trustworthy than $ACC_{info+action}$, $F(1, 59) = 15.95$, $p < .001$, $\eta_p^2 = .21$. There was no significant interaction between automation level and goal sharing, $F(2, 58) = 1.67$, *ns*.

3.2 Acceptability

A two-way mixed ANOVA was conducted on acceptability with goal sharing and automation level as factors.

Goal sharing. Results revealed a main effect of goal sharing, $F(1, 59) = 7.95$, $p < .01$, $\eta_p^2 = .12$. In the shared goals condition, ACCs were judged more acceptable ($M = 0.58$, $SD = 0.74$) than in the unshared goals condition ($M = -0.10$, $SD = 0.80$).

Automation level. Mauchly's test indicated that the assumption of sphericity had been violated ($\chi^2(2) = 33.13$, $p < .001$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.70$). Results revealed a main effect of automation level $F(1.39, 82.22) = 4.67$, $p < .05$, $\eta_p^2 = .07$. Planned contrast analyses showed that acceptability of $ACC_{info+action}$ ($M = 0.22$, $SD = 0.94$) was higher than acceptability of ACC_{action} ($M = -0.13$, $SD = 1.00$), $F(1, 59) = 26.10$, $p < .001$, $\eta_p^2 = .31$. No other differences between the automation levels were signficant. There was no significant interaction between automation level and goal sharing, $F(2,58) = 1.01$, *ns*.

4 Discussion & Conclusion

The current research investigated the influence of goal sharing (shared versus unshared) and automation level on the trustworthiness and acceptability of an ACC system. We presented participants with descriptions of three ACCs: one that only provided information (ACC_{info}), one that took over driving tasks and provided information ($ACC_{info+action}$), and one that only took over driving tasks, without providing information (ACC_{action}). For half of the participants, these ACCs did not share their own driving goals, for the other half, these ACCs did share their driving goals. For every ACC system, trustworthiness and acceptability were measured.

The current research replicates and expands the findings of our previous study [5]. That is, results again suggest that shared goals lead to increased trustworthiness of ACCs, even when the safety goal is omitted. Furthermore, using a more widely used measure of acceptability, the current results suggest that shared goals also lead to increased acceptability of ACCs. Lastly, for both shared goals and level of automation, this study replicates the findings of [5]. This study suggests that to increase safety on roads by introducing automation technology, sharing goals with the driver might increase the trustworthiness and acceptability of automation technology. Thereby, the current results help opening the road to safer driving.

5 References

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