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Abstract

Trust is an essential condition for accepting and relying on autonomous vehicles. One of the well-studied factors contributing to trust in automation systems is anthropomorphism. It is expected that anthropomorphism may also enhance trust in the field of autonomous vehicles. A study is presented that investigated the effect of anthropomorphic embodiment for information about the vehicle's maneuvers on people's trust in autonomous vehicles. In a driving simulator experiment deploying a between-subjects design, participants ($N = 39$) were exposed to varying amounts of information displaying upcoming actions of an autonomous vehicle (symbolic information or symbolic + anthropomorphic information). Each group rated trust and liking for the test condition against a reference condition where no information about the upcoming actions was provided through questionnaires. Symbolic + anthropomorphic information resulted in significantly more trust than symbolic information. Through one-sample tests, it was found that ratings for symbolic + anthropomorphic information were significantly different from no information, while symbolic information by itself was not. Ratings for perceived anthropomorphism were positively correlated with trust and liking. It is concluded that anthropomorphizing information may foster the perception of autonomous vehicles as social agents and enhance trust in those vehicles.

KEYWORDS
anthropomorphism, autonomous vehicles, human-vehicle interaction, information transparency, trust

1 | INTRODUCTION

Technology for autonomous vehicles has made rapid progress in recent years. According to the SAE J3016 information report, autonomous vehicles are classified from Level 0 (no automation) to Level 5 (full automation; SAE International, 2014). Industrial and academic fields are actively working on the development of fully autonomous driving systems (Level 5), and fully autonomous vehicles are becoming a reality (Carnegie Mellon University, 2015; Gannes, 2014; The Tesla Team, 2016). However, several studies indicate that people may not trust the new technology and believe that autonomous vehicles cannot drive as well as human drivers (Schoettle & Sivak, 2014b, 2014b). In another survey (Meister, 2015), more than half of the experts and social media followers expressed they had concerns about autonomous vehicles driving in everyday traffic. Yet another recent report found that acceptance of autonomous vehicles decreased as the level of autonomy increased (Schoettle & Sivak, 2016). On the other hand, the results of a test program (Teoh & Kidd, 2017) suggest that highly automated vehicles may perform more safely than human drivers. Human distrust is a big problem, slowing down the acceptance of autonomous systems (Stormont, 2008). Just as trust influences acceptance in interpersonal relationships, trust plays an important role in people's willingness to accept autonomous vehicles. In the near future, the successful use of autonomous vehicles depends on whether people adopt the new technology (J. K. Choi & Ji, 2015). Improving people's trust is crucial to the adoption of autonomous vehicles.

1.1 | Increasing trust

Various in-depth studies offer insights into trust in automation, indicating that trust plays a leading role in the use and acceptance of new technology (Hoff & Bashir, 2015; Jian, Bisantz, & Drury, 2000; J. D. Lee & Moray, 1994). When people think automated systems are less reliable than manually operated systems, they are likely to give up using it (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003), but they will rely on the automated system when it is believed to be more reliable (Mosier & Skitka, 1996). According to J. D. Lee and Moray (1992), trust in automation depends on four dimensions. i) Foundation is about persistence of natural laws, which we will leave aside in the current context. ii) Performance is about what the automation technology does (Is the behavior stable and consistent, and is the performance desirable?). iii) Process is about how the automation technology works (does the user understand the algorithms governing how the system behaves). iv) Purpose is about why the automation technology was developed (the designer's intention in creating the system). Thus, based on the theory, three dimensions for trust in autonomous vehicles are proposed: i) system transparency, ii) technical competence, and iii) situation management (J. K. Choi & Ji, 2015), of which the first two are of particular relevance to the current context. System transparency is about "the degree to which users can predict and understand the operating of autonomous vehicles" (J. K. Choi & Ji, 2015, p. 694). In other words, one factor for trust is that users can get information to assess whether an autonomous vehicle performs its task correctly. Trust requires whatever information could be available in order to evolve (de Vries, 2004). For example, giving information and sharing driving goals could increase trust and acceptability of smart systems in vehicles (Verberne, Ham, & Midden, 2012). Information explaining the vehicle's imminent autonomous actions may improve trust (Koo et al., 2015). In sum, system transparency may help users to gain trust in autonomous vehicles (Kraus, Althoff, Heißing, & Buss, 2009). "Technical competence refers to the degree of user perception on the performance of the autonomous vehicles" (J. K. Choi & Ji, 2015, p. 694). That means it is important to know how the user processes the information presented (Ekman, Johansson, & Sochor, 2016).

Thus, a challenge for designing autonomous vehicles is to better understand how the system's information is best delivered to users (Koo et al., 2015). The information that users receive about the operation of the vehicle should be expressed in a manner in accordance with the cognitive process for users to develop trust (J. D. Lee & See, 2004). Especially when people lack prior interaction with the system, they tend to apply an anthropomorphic scheme to interpret the nonhuman agents' actions and create a mental model of nonhuman agents (Epley, Waytz, & Cacioppo, 2007), based on their experiences with similar systems (Li, Hess, & Valacich, 2008). For example, Eriksson and Stanton (2017) treat an autonomous vehicle as an intelligent agent and utilize the maxims of human–human communication to design information exchanges. In other words, information expressed in a human-like way is easier to understand and facilitates the interaction. Anthropomorphizing the information display may increase humans' trust, so that they are more willing to accept autonomous vehicles (J. G. Lee, Kim, Lee, & Shin, 2015).

1.2 | Anthropomorphism

Anthropomorphism can be defined as the "tendency to imbue the real or imagined behavior of nonhuman agents with humanlike characteristics, motivations, intentions, or emotions" (Epley et al., 2007, p. 864). It refers to the phenomenon that human beings tend to see human-like shapes in the environment and plays an important role in human behavior and choice (Złotowski, Proudfoot, Yogeeswaran, & Bartneck, 2015). People regularly make anthropomorphic attributions not only to the animals in their environment but also to technology and machines such as vehicles or computers (Chin et al., 2005; Nass, Moon, Fogg, Reeves, & Dryer, 1995). The tendency to make anthropomorphic attributions in the interaction with technology is enhanced by people's motivation to understand the environment and the nonhuman agents that inhabit it and to reduce uncertainty, as "anthropomorphism provides an intuitive and readily accessible method for reducing uncertainty in contexts in which alternative non-anthropomorphic models of agency do not exist" (Epley et al., 2007, p. 871).

Based on this common human tendency, anthropomorphism is already used in the area of robotic systems (Kuz, Mayer, Müller, & Schlick, 2013). Anthropomorphism offers benefits and opportunities for the design of robots (Duffy, 2003), as it facilitates human–machine interaction (Złotowski et al., 2015). As a format for information presentation, anthropomorphism enables untrained users to understand and predict the machine's behavior. Moreover, users are encouraged to observe and interact with the machine so that more training opportunities are available (Coradeschi et al., 2006). On the other hand, there are also problems related to anthropomorphic design, such as the uncanny valley phenomenon (Mori, MacDorman, & Kageki, 2012). This theory proposes that the likability of robots increases with increased degree of anthropomorphism, up to the point where robots appear almost like real human beings. That's when humans have a strong negative emotional reaction. Anthropomorphism is not always a good option to present information. For example, a highly human-like robot perceived as a person might not be the best choice for a medical robot, as patients feel less embarrassed with a machine-like robot (Bryant, 2010). Therefore, anthropomorphic design should appropriately match the task given to improve humans' acceptance with the robot (Goetz, Kiesler, & Powers, 2003).

In the field of autonomous vehicles, several studies apply anthropomorphism to increase trust (e.g., Forster, Naujoks, & Neukum, 2017; Kraus et al., 2009). In one study (Verberne, Ham, & Midden, 2015), it was found that people were more likely to trust a virtual driver in a self-driving vehicle when he looked, acted, and thought like themselves. In another study (Waytz, Heafner, & Epley, 2014), an autonomous vehicle was given a name, a gender, and a voice. The results showed that participants believed the vehicle with anthropomorphic features would perform more competently. Another experiment (J. G. Lee et al., 2015) provided low and high autonomy of the agent, with two different levels of anthropomorphism: i) a humanoid robot was placed in the driver's seat as an artificial driving agent and ii) a smartphone was mounted on the car's dashboard as a driving agent of an autonomous vehicle. Participants' evaluations of trust in the autonomous vehicle, perceived safety, and intelligence were compared. The results indicated that the combination of a human-like appearance with high autonomy led to higher ratings of perceived trust, safety, and intelligence. Similar to the application of anthropomorphism in the field of robotic systems the human-like appearance is not the most important determinant of anthropomorphism for autonomous vehicles (Kiesler & Goetz, 2002), but the information presentation makes an autonomous vehicle more transparent to users in a natural way (Kraus et al., 2009).

1.3 | The current research

As mentioned before, J. K. Choi and Ji (2015) proposed three dimensions for trust in an autonomous vehicle: i) system transparency, ii) technical competence, and iii) situation management, which is about "the user's belief that he or she can recover control in a situation whenever desired" (J. K. Choi & Ji, 2015, p. 694). Since the current research focuses on fully autonomous vehicles that can take users from point A to point B fully unleashed, only the first two dimensions are relevant to the current context. Increasing levels of autonomy make transparency and trust of the system decrease (Norman, 1990; Schoettle & Sivak, 2016). A way to deal with this is to provide information to users that allow them to perceive the autonomous vehicle's state, understand it, and evaluate whether the actions are performed as desired. We assume that users of autonomous vehicles would like to receive information about the intention of the vehicle before it performs an action, so that they can anticipate the actions of the vehicle. Our research question is whether adding anthropomorphic characteristics to the information presentation will increase users' trust in the system.

Users' information needs change depending on the level of automation of autonomous vehicles, but information about the status of the system is always requested (Beggiato et al.,). In a driving simulator experiment, the effect of information about the vehicle's planned actions on trust was investigated. The effect of symbolic information about present and planned actions, consisting of icons presenting upcoming actions of the system, was compared with symbolic information that was supplemented with anthropomorphic visualizations, consisting of animated eyes. Eyes are one of the most significant visual features among all facial features (J.-G. Choi & Kim, 2009; Windhager et al., 2010). Our hypothesis is that information transparency, as established through the symbolic information condition, leads to increased trust and that adding anthropomorphism further enhances trust in autonomous vehicles.

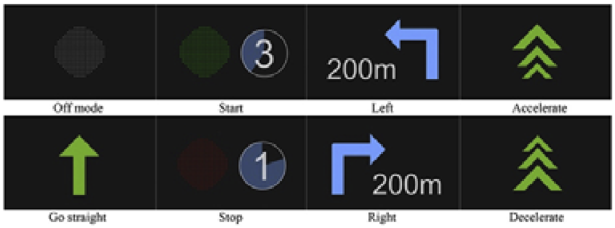

FIGURE 1 Contents of symbols. 'Start' and 'Stop' count backwards from 5 seconds to 0 (in the figure, snapshots are shown representing "still 3 seconds to go" and "still 1 second to go" for 'Start' and 'Stop' respectively). 'Left' and 'Right' count backwards from 200 meters to 0 with a step size of 50 meters. When the distance to the junction is less than 50 meters, the step size changes to 10 meters

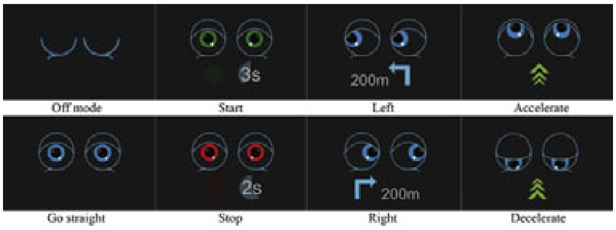

FIGURE 2 Contents of anthropomorphic representations. When the vehicle is off mode, eyes are closed; when the vehicle is in normal driving mode, eyes are blinking at a natural rate; when the vehicle is going to start/stop, the color of the eyes changes into green/red; when the vehicle is going to turn left/right, eyes look left/right; when the vehicle is accelerating/decelerating, eyes look up/down

2 | METHOD

2.1 | Experiment design

The main variable, type of information, was manipulated through a between-subjects design with two conditions (symbolic only vs. symbolic + anthropomorphic). However, for both groups, the test condition was set off against a baseline condition of no information (within subjects) to neutralize individual differences in trust levels such as related to differences in dispositional trust (Hoff & Bashir, 2015). The reason for not using a full within-subjects design was that it would require balancing order of conditions across participants, which might result in carry-over effects from between conditions. Alternatively, a full between-subjects design would suffer from a lack of reference against which participants might evaluate the test condition. The current set-up allows making multiple comparisons: i) comparison between experimental conditions (symbolic only vs. symbolic + anthropomorphic) (between-subjects comparison); ii) comparison of experimental condition with the baseline (within-subjects comparisons). The baseline was always presented first, serving as a reference and avoiding potential carry-over effects from the test condition to the reference condition.

2.2 | Experimental conditions

The information to be displayed concerned present and future actions of the vehicle, including acceleration, deceleration, braking, turning left, and turning right. Existing traffic icons were employed where available to set up symbolic information, since their familiarity could reduce learnability issues and participants' recognition time. We chose the most well-known and frequently used icons, except for acceleration and deceleration, for which it was hard to find existing icons and which were therefore designed by ourselves. Figure 1 shows the icons employed in the experimental conditions. In the anthropomorphism part, the concept of using animated eyes to represent the vehicle and to interact with participants was based on the fact that eye contact is critical for better communication between humans and intelligent agents (Mukawa, Fukayama, Ohno, & Sawaki, 2001). Humans use their eyes to observe the environment outside of the vehicle, to express emotion, and to interact with humans. It turned out to be very hard to design animated eyes to express the future actions of the vehicle, so that the animated eyes were combined with the icons of the symbolic information condition, as shown in Figure 2, for what was termed the symbolic + anthropomorphic information condition.

2.3 | Materials

This study took place in a medium-fidelity, fixed-based driving simulator at Eindhoven University of Technology. The driving simulator system with software from Greendino consisted of a steering wheel, pedals, a seat, and three 42-in. screens, so that participants had a 180-degree field of view (see Figure 3). Since the experiment involved fully autonomous driving, participants did not have to use the steering wheel and pedals. During the experiment, the driving scenario was run on the lab computer in another room and displayed

FIGURE 3 Snapshot of a participant in the driving simulator. The symbolic information and anthropomorphic representation are shown on the small screen at the lower right corner of the middle screen inside the driving simulator

on the three screens. An 8-in. screen was mounted at the lower right corner of the middle screen, on which the information about the future actions of the vehicle was presented (as shown in Figure 3). All conditions (the baseline condition and the two experimental conditions) used the same scenario, lasting about 8 min. The scenario involved an urban section (5 min) and a highway section (3 min), featured traffic signals, and included a traffic jam and two hazards: i) slamming on the brakes because of a vehicle ahead and ii) a child rushing into the road. Apart from these, the urban and highway sections included normal traffic conditions and covered common traffic situations.

2.4 | Participants

Thirty-nine participants (24 men and 15 women, *M* = 27.21 years old, *SD* = 7.22) with valid driving licenses for on average 7.22 years (*SD* = 6.52) were assigned to one of two experimental groups, 12 men and 8 women for Group 1, 12 men and 7 women for Group 2. All participants were students or staff members recruited from Eindhoven University of Technology. They received a chocolate gift worth 1 euro for participation.

2.5 | Procedure

After arriving, the participant read and signed an informed consent form and read the instruction for the experiment. Then, the participant was seated behind the steering wheel of the driving simulator in the driver's seat, fastened the safety belt, was given a brief description of the procedure, and instructed to just experience the trip—without manual control of the vehicle, without touching the steering wheel, pedals, or any other devices at all during the experiment. When the participant was ready to begin, the trip with the no information condition was started, taking 8 min. Next, the participant received an explanation of the information visualizations that would appear in the second trip. After reading it, the second trip began, which also lasted 8 min. After completing the two trips, the participant filled out a questionnaire that requested judgments about anthropomorphism, liking, and trust. An interview was conducted when all the tasks were done. Last, the participant was paid and thanked for participating. The experiment lasted approximately 30 min.

2.6 | Data collection

Questionnaires consisted of nineteen 7-point items that were drawn or adapted from other sources: Seven of the items measured participants' perception of anthropomorphism (Cronbach's α = .809; Waytz et al., 2014; Waytz, Cacioppo, & Epley, 2010): the car is smart; the car can feel what is happening around the car; the car can anticipate what is about to happen; the car decides about its action; the car has intention; the car has a mind of its own; the car experiences emotion. Four items pertained to the degree to which participants liked the system (Cronbach's α = .835; Waytz et al., 2014): my driving was enjoyable; I felt comfortable driving the car; I would like to own a car like this one; I would like most of cars to be (autonomous) like this one in 2020. Eight items pertained to trust in the system (Cronbach's α = .798; Jian et al., 2000): the car is misleading; I am suspicious of the car's intent, action or output; I have confidence in the car; the car provides security; the car is dependable; the car is friendly; I can trust the car; I am familiar with the car. Questionnaire items were rescaled such that scales ranged from −3 to 3. The midpoint ("0″) was labeled "First driving." This point referred to the first trip, in which the participant experienced the no information condition. Participants were instructed to respond to each question (choosing a negative versus positive rating value) in relation to this reference point at the midpoint of the scale ("0″). If the participants felt their judgment for a certain question was the same for the two trips, then "0″ would be the correct value to select. When their judgment for the question was better for the second trip than for the baseline condition, they were requested to select a positive value (more extreme as the difference in opinion was larger). When their judgment for the question was worse for the second trip than for the baseline condition, they were requested to select a negative value (more extreme as the difference in opinion was larger). The reasoning for using this approach to collect relative judgments was that research has shown that there are remarkable differences in the initial trust level of people because of individual differences (Pop, Shrewsbury, & Durso, 2015), especially because people do not have experience riding in autonomous vehicles. Not providing a reference might induce high intragroup variance, which might potentially overrule the often small differences found with absolute questionnaire judgments.

In addition, qualitative opinions were collected through interviews.

3 | RESULTS

3.1 | Quantitative results

Independent samples analyses of variance were conducted with information condition (symbolic information vs. symbolic + anthropomorphic information) as the independent variable and trust, liking, and perceived anthropomorphism as the dependent variables, respectively

TABLE 1 Results of one-way ANOVA showing the effects

Measured variables	Mean (*SE*) Symbolic information	Mean (*SE*) Symbolic + anthropomorphic information	*F*	*p*
Perceived anthropomorphism	.40 (.20)	1.00 (.15)	5.56	.024
Liking	.01 (.29)	.74 (.21)	3.88	.056
Trust	.20 (.19)	.66 (.11)	4.20	.047

Note: Means, standard errors (*SE*), *F* values, *p* values effect sizes. ANOVA = analysis of variance.

(where the scores represented judgments relative to the baseline condition). The result showed that information condition had significant effects on perceived anthropomorphism and trust (see Table 1). Participants perceived the vehicle with symbolic + anthropomorphic information to be more anthropomorphic, $F(1, 37) = 5.56$, $p = .024$, $\eta^2 = .131$, and trustworthy, $F(1, 37) = 4.20$, $p = .047$, $\eta^2 = .102$. The effect of information condition on liking was not significant, $F(1, 37) = 3.88$, $p = .056$, $\eta^2 = .095$.

Furthermore, one-sample *t*-tests were conducted to evaluate whether the experimental conditions (symbolic information and symbolic + anthropomorphic information, respectively) were significantly different from the baseline condition (no information). While rating the anthropomorphism, liking and trust of the system for the experimental conditions, participants were asked to rate these aspects relative to the baseline condition, which was represented by the middle of the scales (value "0″). Thus, the one-sample *t*-test tests whether the actual scores obtained are significantly different from 0. For the symbolic information condition, it was found that there was no significant effect for any of the dimensions: for perceived anthropomorphism, $t(19) = 1.953$, $p = .066$; for liking, $t(19) = 0.42$, $p = .967$; for trust, $t(19) = 1.016$, $p = .323$. For the symbolic + anthropomorphic information condition, it was found that the scores were significantly different from the baseline condition for all dimensions: for perceived anthropomorphism, $t(18) = 6.794$, $p = .000$; for liking, $t(18) = 3.441$, $p = .003$, for trust, $t(18) = 5.752$, $p = .000$.

In addition, correlations were computed between perceived anthropomorphism and trust and liking, respectively. Perceived anthropomorphism was positively correlated to trust, $r = .527$, $p < .001$, and liking, $r = .491$, $p < .001$.

3.2 | Qualitative results

Subjective opinions were collected through interviews at the end of each participant's second trip. Two questions were asked to all participants: i) Did you think the information was helpful to you? ii) Was there other information you wanted to know during the journey, and if so, which information? One additional question was asked to participants in Group 2 (symbolic + anthropomorphic information): What did you think of the eyes displayed on the small screen? The answers to the questions were grouped in terms of the possible answers (see Table 2). When the answer was elaborated (e.g., about what information people wanted to know), the information was listed. Ten participants, equally divided over the different conditions, found the information sufficient. Twenty-seven participants, again equally divided over the different conditions, considered the information helpful but would have preferred more information, especially warnings and explanation about hazardous situations in the experimental scenario: braking because of the vehicle ahead and a child rushing into the road. Because the vehicle did not give information to predict and explain the hazardous situations, seven participants pointed out that they felt uncomfortable, and gave negative evaluations on liking and trust in the questionnaires. Interestingly, the negative effects were different between the two experimental groups. According to the questionnaires and records of the interviews, in Group 1 (symbolic information), eight participants mentioned that the vehicle should provide more information on the hazardous situations, and six of them gave negative evaluations in the questionnaires; in Group 2 (symbolic + anthropomorphic information), five participants made a similar proposal, but only one of them gave negative evaluations in the questionnaires.

Furthermore, remarks about the anthropomorphic information were insightful in Group 2. Nine participants accepted the concept of eyes and thought the eyes could express information by their nature. Seven participants proposed that the eyes should observe the road condition outside of the vehicle instead of looking at the passengers inside the vehicle. In particular, one participant commented that although the eyes were cute and helpful, having them look down during deceleration could make one nervous as it suggested that the vehicle was not paying attention to the road. Three other participants preferred symbolic information or no information to the eyes, feeling uncomfortable to be stared at by eyes and distracted.

4 | CONCLUSION AND DISCUSSION

In this study, we investigated whether anthropomorphism may increase the trust of people in autonomous vehicles. We presented the experimental conditions symbolic information or symbolic + anthropomorphic information to participants, where the information was about upcoming actions of the vehicle (accelerating/decelerating, braking, turning left, or turning right) and measured their opinion about the vehicle, in comparison with a baseline without such information. To assess their opinion about the vehicle, we had participants complete questionnaires about perceived anthropomorphism, liking, and trust. Also interviews were conducted to get qualitative feedback. Results

TABLE 2 Main qualitative opinions of interviews

Questions	Main opinions	Group 1	Group 2
Did you think the information was helpful to you?	Yes, it was helpful.	5	5
	Yes, but the information was not enough.	14	13
	No, the information was a distraction in autonomous vehicles.	1	1
Was there other information you wanted to know during the journey, and if so, which information?	The precognition and the explanation of hazardous situations.	8	5
	The explanation of vehicle's decision.	5	2
	The information outside of the vehicle.	4	7
What did you think of the eyes displayed on the small screen?	The eyes were interesting and cute to express information.	×	9
	The eyes were expected to observe the road condition outside of the vehicle.	×	7
	It was uncomfortable to be looked at by eyes.	×	2
	Icons were more directed than eyes.	×	2

revealed that symbolic + anthropomorphic information was judged more positively, increasing the trust of autonomous vehicles, compared to symbolic information only.

The findings may be discussed in two parts. On the one hand, it may be concluded that the results are not completely in line with the hypothesis. We assumed that information transparency (providing information about the upcoming actions of the vehicle) would lead to increased trust. But the current results provide no evidence that this is the case, as the effects of the symbolic information condition on trust were not significantly different from the no information condition. Instead, six participants gave the condition with symbolic information negative evaluations on trust compared to the condition without information. The qualitative data indicated that this was because the vehicle did not provide useful information in hazardous situations, so that participants thought they were working with an error-prone system and reduced their trust accordingly (J. D. Lee & Moray, 1992; Muir & Moray, 1996). Uncertainty is a main factor in determining whether humans trust another agent (King-Casas et al., 2005). The lack of required information about hazardous situations apparently created uncertainty, reducing trust in the vehicle.

On the other hand, the results for the symbolic + anthropomorphic information are in line with the hypothesis, indicating that adding an anthropomorphic layer to the symbolic information condition significantly increased participants' trust relative to the no information condition and the symbolic information condition. Participants in the symbolic + anthropomorphic information condition had a favorable view of the anthropomorphic representation and accepted the idea of eyes passing information as part of the vehicle. Especially, with respect to the hazardous situations, the participants in Group 2 (symbolic + anthropomorphic information) also noticed the hazardous situations, but only one of them gave a negative evaluation. Obviously, the effect of the hazardous situations on loss of trust was different between the two groups. These results are consistent with the finding that anthropomorphic agents result in greater trust resilience and a higher resistance to breakdowns in trust (de Visser et al., 2016). Trust is a dynamic process, even on a short time scale of interaction (Ekman et al., 2016). Humans have a different attitude toward automated agents than to human agents in errors (Madhavan & Wiegmann, 2007). A failure from an automated agent may be perceived as pointing toward more possibilities for future failure than a failure from a human, since automated agents are thought to be inflexible and objective and humans are intelligent and subjective (Dijkstra, Liebrand, & Timminga, 1998). Anthropomorphism creates familiarity with the system based on established human skills and human–human interaction (J.-G. Choi & Kim, 2009). Thus, increasing anthropomorphism may create a protective resistance against future errors (de Visser et al., 2016). Specifically, as autonomous vehicles are a new technology, anthropomorphism appears to be a useful design feature to increase trust in autonomous vehicles.

At the same time, participants also commented about the function and the design of the eyes. They emphasized the function of eyes to observe the road condition over the human-like appearance of eyes to express kindness. The results indicate that the anthropomorphism led to different expectations according to its appearance and behavior compared to the symbolic information condition. Participants expected that the eyes would adopt human drivers' norms to observe the road condition and surroundings of the vehicle. This confirms the finding that the appearance of the system provides cues to people for making assumptions about the system's capabilities (Goetz et al., 2003). However, just as the findings in the field of robotic systems, in the first place robots should perform their jobs accurately and in the second place provide enjoyable looks (Lohse, 2011). "Anthropomorphism should not be seen as the 'solution' to all human–machine interaction problems but rather it needs to be researched more to provide the 'language' of interaction between man and machine" (Duffy, 2003, p. 181). In addition, anthropomorphism is not suitable for every scenario. For example, in emergency or crisis situations, a simple and striking symbol is more direct and helpful to passengers. In sum, the appearance and behavior of intelligent agents should match the main tasks of autonomous vehicles.

Several limitations of this study should be addressed in future research. Although we wanted to minimize the effects of variation in initial trust through the experimental design, asking for judgments relative to a reference condition in the questionnaire, participants still showed wide variation in trust in the autonomous vehicle, especially as they did not have prior interactions with autonomous vehicles and experienced hazardous situations in the driving trip. Therefore, it is an interesting research problem how initial trust of humans may affect the acceptance of autonomous vehicles and how the trust resulting from the actual experience of driving in an autonomous vehicle may be influenced through design for people with different levels of initial trust. Another limitation of this study is that it was conducted in a driving simulator, where there was no risk for harm whatsoever. It might be that the effects of condition (symbolic vs. symbolic + anthropomorphic) in real-life situations are different. Finally, participants looked at the road and the interface, while in fully autonomous vehicles they may be expected to engage in other activities, not looking at the road and the interface. In such conditions, it needs to be investigated whether the current proposals are still effective.

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