"Should We Allow Him to Pass?" Increasing Cooperation Between Truck Drivers Using Anthropomorphism

Jana Fank(✉), Leon Santen, Christian Knies, and Frank Diermeyer

Institute of Automotive Technology, Technical University Munich,
Boltzmannstr. 15, 85748 Garching, Germany
{fank, knies, diermeyer}@ftm.mw.tum.de,
leon.santen@tum.de

Abstract. Studies from various disciplines have showed, that adding human characteristics to non-human object improves the interaction between human and this object. It can be assumed that human-like technologies have a positive influence on driver-vehicle interaction as well. This study investigates the potential to increase the willingness of truck drivers to cooperate during overtaking scenarios using anthropomorphized interfaces. Therefore, a driving simulator experiment was conducted with truck drivers. Two conversational agents have been developed, which differ in their degree of human characteristics. They supported the truck driver in the initiation and during the overtaking manoeuver by clarifying a willingness to cooperate and communicating the status of the overtaking process. The results indicated no significance in the drivers' willingness to cooperate in interaction with the two agents. However, the perceived human likeness increased through the addition of emotionality and identity. More than half of the drivers were in favor of the more human-like agent.

Keywords: Personal conversational agent · Anthropomorphism · Cooperation truck drivers · User study · Driving simulation

1 Introduction

Human-like technology has a major impact on human behavior and choices [1]. Various disciplines - such as human-robot interaction, human-computer interaction and marketing – are successfully improving their processes, system and/or communication in addressing humans by attributing human characteristics to their systems [2–4]. For example, adding a name or character description to an object, affects people's responses to the object [5, 6]. Such human-like technology is referred to as "anthropomorphism" [7]. Research investigates the role of anthropomorphized user interfaces, such as conversational-, virtual- and robotic agents in cars and concludes, that anthropomorphized interfaces are able to increase safety while driving [8–10], can increase trust in autonomous cars [11, 12] and acceptance of driver-car-interaction [13, 14]. So far, research has been focused on anthropomorphism in passenger vehicles. Nevertheless, truck drivers can benefit from the anthropomorphization of their vehicle

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as well. The user groups of truck and car drivers differ – which is why the transfer between the two user groups is limited. For example, truck drivers are typically older and more often male. In addition, the profession of truck driver cannot be easily compared with regular driving [15]. This study investigates, whether a human-like conversational agent has the potential to increase truck drivers' acceptance towards cooperative driver-assistance systems.

Cooperative manoeuver-planning has the potential to make traffic situations safer and more efficient overall [16]. Overtaking scenarios of trucks have a high potential for conflicts between car- and truck drivers, since car drivers might be forced to brake abruptly in the event of truck drivers suddenly cutting in [17]. Furthermore, such manoeuvers aggravate traffic inefficiencies. Car drivers are often hampered by long overtaking manoeuvers due to the low relative velocity between the two trucks [17]. Through a collective perception of road users and new technologies, communication, overtaking manoeuvers can be better coordinated. Relevant vehicle information in combination with data on the route ahead makes it possible to agree on the manoeuver parameters, e.g. location, time and speed. Other affected traffic may respond in a timely manner based on this information - by reducing speed [16]. Research has shown that cooperative driver-assistance systems increase the willingness to cooperate, but truck drivers do not accept this assistance [18]. This study investigates in a driving-simulator experiment, whether anthropomorphized interfaces could increase truck drivers' acceptance and willingness to cooperate during overtaking scenarios on highways.

2 Research Question

The aim of this contribution is the evaluation of anthropomorphized user interfaces for truck drivers - and furthermore, to investigate the effects of such interfaces on the acceptance of cooperative driver-assistance systems. In order to analyze the influence of anthropomorphized user interfaces, a driving simulator study was conducted. The first research question relates to the willingness to cooperate.

RQ1: Do truck drivers cooperate more often during overtaking scenarios with an anthropomorphized user interface?

To investigate the acceptance rate and the attitude of truck drivers faced with anthropomorphized user interfaces, following additional research question is pursued.

RQ2: Is it possible to increase trust, acceptance and the intention to use cooperative driving assistant systems through anthropomorphism?

3 Methods

3.1 Participants

A total of 30 participants (28 male, 2 female) with an average of M = 52.4 years (SD = 10.54) participated in the experiment. Due to technical problems, two datasets had to be excluded from further statistical analysis. 50% of the participants operated on long haul transport, 35.7% on regional transport and 7.1% on local transport. 7.1% of the participants operated in the transport sectors in context of construction or driving training[1]. On average, the participants had been operating trucks for 28.5 years (SD = 11.24).

The experience with conversational assistants varied within the sample. Only 14.3% of the participants frequently using conversational assistant embedded in smartphones, 14.2% of the participants in cars and 7.2% at home.

3.2 Conversational Agent

In this study, two conversational agents were implemented to support drivers' cooperation during an overtaking manoeuver. The conversational agent asked the driver to accept or reject the overtaking request of an approaching truck. It communicated the status of the overtaking process and reminded the driver to make a decision. These two conversational agents differed in the human characteristics which were added. Compared to the 'speech assistant' (SA), the conversational agent 'ICo' (Intelligent Co-driver) had an identity. Its speech announcements always worded in the first person, for example, 'I'll adjust our speed…' ICo was also emotionalized. Emotionality has a great effect on perceived anthropomorphism and human-likeness [1]. Positive as wells as negative reactions were implemented through characteristic speech gestures, such as 'Wohooo' or 'too bad' (Table 1). In addition, the emotional synthesis of CereVoice Engine Text-to-Speech SDK © from CereProc was used.

Table 1. Example of speech announcement of the speech assistant (SA) and the intelligent Co-driver (ICo)

State	Speech announcement SA	Speech announcement ICo
Introduction	Speech assistant activated, please activate the ACC	Hey, my name is ICo. I am your personal assistant and I will support you today. Please activate the ACC
Request	Incoming overtaking request. Do you want to cooperate?	There is a request from the person behind. Should we allow him to pass?
Acceptance	Overtaking request accepted. Speed will be set to 78 km/h	Woohoo! All right! I'll adjust our speed to 78 km/h
Rejection	Overtaking request declined	Too bad, maybe next time
Prompt	Please make a choice	Hey, make up your mind please!
Success	The operation was successfully completed	Awesome! Cooperation succeeded!

There were three different speech announcements for accepting and rejecting the overtaking manoeuver, for a successful overtaking manoeuver, and for the prompt to turn on the automated autonomous cruise control system (ACC).

[1] local: up to 50 km, regional: 50–150 km and long haul transport: more than 150 km per day.

3.3 Apparatus

Studies with driving simulators allow the realization of different traffic scenarios, which can be precisely reproduced for several participants. Furthermore, the interaction with other road users can be modelled, specifically evoking situations which occur with a low frequency in reality [19].

For the present study, the driving simulator located at the Institute of Automotive Technology of the Technical University of Munich was used (Fig. 1). The simulator is embedded in a MAN TGS truck cabin. The visualization of the scenery is effected by a projection system featuring a 210° view and three flat screens, in order to display the rear mirror views. The simulated route was programmed using the driving-simulation software SILAB © 4 of the Würzburg Institute for Traffic Sciences GmbH.

All dashboard symbols, including those showing current speed, torque, and distance to vehicles ahead and behind as well as information from the cooperative driving-assistance system were displayed on a TFT-display in the instrument cluster. The participants had a multifunctional steering wheel to interact with the system as well as with the conversational agent. For example, a yes- and no-button to accept or reject the cooperation request.

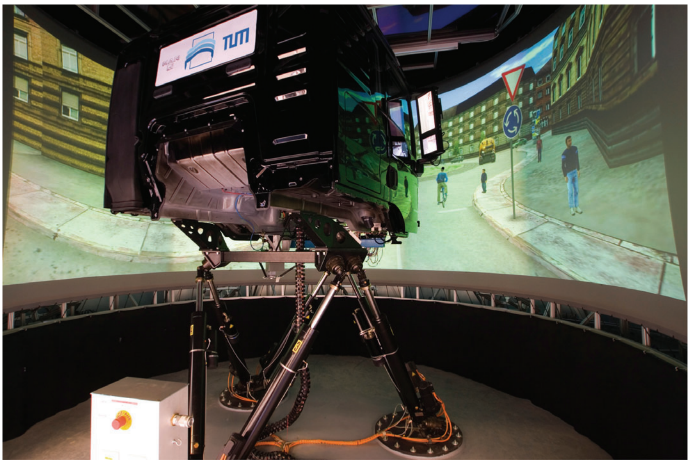

Fig. 1. Driving simulator at the Institute of Automotive Technology of the Technical University Munich

3.4 Scenario and Roadway Design

Each road contained a three-lane highway. In every ride, three trucks requested to overtake the ego-truck. At the beginning of every journey, the conversational agent asked the participant to set the autonomous control system (ACC) to 80 km/h. The approaching truck would send a request to overtake the ego-truck. The participant could accept or reject the request. The conversational agent asked the participant for feedback again 8 s after the initial request. In case of a refusal, the requesting truck remained driving behind the ego-truck. If the request was accepted, the conversational agent informed the participant that the ego-truck had begun to automatically reduce its speed to 78 km/h. After a successful overtaking manoeuver, the conversational agent communicated the completion of the process to the participant.

3.5 Experimental Design

A within-subjects design was used to compare the two conversational agents. In every test procedure, the participants firstly drove one route to familiarize themselves with the simulator. Then, they drove two identical routes, in which they were tasked with overtaking trucks with the aid of a cooperative driving assistant. The degree to which the two conversational agent was apparent during these two rides was permuted to guarantee maximum comparability of the learning and adaptation process between the participants.

Subjective and objective data on the matter were collected. For every ride, acceptance or rejection of the overtaking requests were recorded. Parallel to this, trust was measured via a questionnaire pursuant according to Jian et al. [20]. Acceptance was evaluated using the Van der Laan questionnaire [21]. The intention to use was measured by the three items from Moon and Kim [22]. A self-designed four item-scale functioned as a measurement of the subjects' willingness to cooperate with the conversational agent (ranging from 'strongly disagree' to 'strongly agree'). The items are defined as follows:

Item 1: The conversational agent motivates me to cooperate.
Item 2: Through the conversational agent, I can better assess the intentions of the other drivers in cooperation situations.
Item 3: Through the conversational agent, I can recognize cooperation partners, which I would have overlooked without it.
Item 4: Through the conversational agent, I entered into cooperation that I would not have entered without it, because I wouldn't have understood the background to the manoeuver.

Furthermore, the participants were asked to rate the human-likeness of the conversational agent on the Likert-scale (ranging from 'strongly-disagree' to 'strongly agree'). After the participants had experiences the conversational agent, they were asked for reason for accepting or rejecting the cooperation request.

4 Results

The collected data was analyzed with paired sign tests and Wilcoxon tests. Spearman's r was used for analyzing correlation. In summary, the participants experienced 84 cooperation scenarios per conversational agent. In the interaction with the SA, the participants more often agreed to cooperate ($n = 69$), as in the interaction with ICo ($n = 67$). The paired sign test did not indicate a significant effect ($z = 0.316$, $p = .752$, $n = 28$). The most frequently cited reason for acceptance or rejection was the participants' curiosity ($n = 28$) as to what would happen, if they were to accept or reject the request. In addition, the participants ($n = 8$) felt that there was no reason for them to refuse the request with regard to the traffic situation (e.g. high traffic density or time pressure).

Before analyzing the subjective data of the questionnaire, the reliability was measured using Cronbach's alpha showing that reliability of the questionnaire was acceptable [23] (Table 2).

Table 2. Cronbach's alpha questionnaire

	Alpha SA	Alpha ICo
Acceptance	.947	.948
Trust	.876	.837
Cooperation	.763	.741
Intention to use	.914	.955

Acceptance was measured with the scale from Van der Laan [21] (ranging from –2 to +2). It divides acceptance into two subscales: usefulness and satisfaction. Participants rated the SA highest with a mean of 1.15 (SD = 0.748) within the subscale usefulness (ICo: 1.09, SD = 0.782). Within the subscale satisfaction, ICo was rated highest 0.97 (SD = 0.748; SA: 0.867, SD = 1.090). Wilcoxon test did not indicate a significant difference between the two conversational agents (satisfaction: z = –0.300, p = .764, n = 28; usefulness: z = 0.975, p = .330, n = 28).

The subjective measurement of trust [20] (ranging from 0 to 6) showed that the participants tended to have a higher trust in ICo with a mean score of 4.37 and SD = 0.723 (SA: 4.23, SD = 0.860). Wilcoxon test indicates no significant effects (z = –0.831, p = .406, n = 28).

The participants rated the willingness to cooperate with ICo (ranging from 0 to 6) higher with a mean of 4.02 (SD = 1.251; SA: 3.78, SD = 1.204). No significant effect was detected with the Wilcoxon test (z = –0.862, p = .389, n = 28).

The intention to use was measured by the scale by Moon and Kim [22]. The descriptive statistics indicate, that the participants would use ICo than SA with a mean of 4.393 and SD = 1.560 (SA: 4.140, SD = 1.591). The Wilcoxon test showed no significant effects (z = –0.794, p = .427, n = 28).

At the end of the experiment, participants were asked which of the speech assistant they would prefer for interaction: 64.3% of the participants preferred ICo.

The participants were asked how human-like they perceived the respective conversational agent (7-point-Likert Scale ranging from 0 to 6). The participants rated ICo more human-like than the SA with a median of 5.00 (SD = 0.960; SA: 4.00, SD = 1.474). The paired sign test indicate a significant effect (z = –2.405, p = .016, n = 28). The item 'human-like' was used to calculate possible correlation between the constructs 'acceptance', 'trust', 'cooperation' and 'intention to use' (Table 3). For calculation of the correlation, Spearman's r was used. The results indicate, that for ICo 'usefulness', 'satisfaction', 'trust' and 'intention to use' correlate with a high effect size and 'cooperation' with a medium effect size [24]. For SA no significant correlation could be calculated.

Table 3. Calculated correlation (Spearman) between the construct 'acceptance', 'trust', 'willingness to cooperate' and 'intention to use', with the item 'human-like' for SA and ICo

Construct		SA	ICo
Usefulness	r_s	.344	.632
	p	.073	<.001*
Satisfaction	r_s	.274	.578
	p	.158	<.01*
Trust	r_s	.258	.659
	p	.185	<.001*
Cooperation	r_s	.238	.464
	p	.222	.013*
Intention to use	r_s	.286	.566
	p	.140	.002*

*significant ($p < .05$).

5 Discussion

It was indicated that anthropomorphized user interfaces increase the willingness to cooperate of truck drivers during overtaking scenarios. Furthermore, it was predicted, that truck drivers' acceptance of cooperative driving-assistance systems can be increased by anthropomorphized conversational agents as well. Objective and subjective data showed no difference between the conversational agent SA and the more human-like conversational agent ICo. Descriptive statistic indicated a tendency towards ICo according to the scales for satisfaction, trust, cooperation and intention to use, although statistical analysis indicates no significant effects. With the aim of creating a more human-like conversational agent, ICo was emotionalized through emotional synthesis and characteristic speech gestures. The participants noticed ICo as being more similar to humans than SA, showing that emotionality is an important factor influencing the perceived human-likeness of conversational agents. The perceived human-likeness correlated with the construct 'acceptance', 'trust', 'cooperation' and 'intention to use' for ICo, but not for SA.

One possible reason for these results could be that the difference between the two conversational agents were minor. Forster et al. [12] had measured trust between a generic interface without speech interaction and a human-like conversational agent. He concluded that drivers had more trust in the human-like agent. Other studies have shown that drivers already anthropomorphize when they speak with their ordinary navigation system [25]. Perhaps speech itself, as a means of communication with the interface, is sufficient to generate anthropomorphism. Since there is no comparison between a generic interface and a language assistant, this test result cannot state whether anthropomorphism increases the willingness to cooperate, rather that more human-likeness based on emotionality does not increase the willingness to cooperate. On the other hand, other added human characteristics (e.g. body language, personality) or forms of humanization (e.g. embodiment, physical presence) may have an impact on the willingness to cooperate. In future studies, these questions will be further investigated. However, it is not sure that the item 'human-likeness' indicates the construct of "anthropomorphism". For example, Złotowski [1] designed a six item questionnaire to measure anthropomorphism. In future studies it could be useful to evaluate anthropomorphized user interfaces according to a similar metric.

In addition, the results show that the interaction time with the two conversational agents was too short. The participants accepted or rejected cooperation request based on their curiosity. In future studies, care should be taken to ensure that the subjects interact with the agents for a longer period of time so that the curiosity and desire to test flattens out over time. In addition, the participants had difficulties distinguishing between the cooperative assistance system and the conversational agents. This could be another reason for the lack of difference between the agents. In the next study it should be considered whether the agent accompanies the truck drivers in further use cases (e.g. navigation or planning of driving and rest times), so that it is guaranteed that the conversational agent is considered detached from the assistance system.

Furthermore, the acceptance to cooperative driving assistance system was higher than in previous studies [18]. One reason could be that compared to the previous study the driving situation was not challenging enough. The participants stated that it was no problem to cooperate in the scenario, because of the empty roads and lack of time pressure. Maybe a more challenging driving situation or some time pressure would alter the results.

More than half of all participants would want to use the more human-like ICo rather than the speech assistant. The question arises as to what exactly the reason for this is, since the acceptance rate and the intention to use do not differ between the two agents. Perhaps anthropomorphism contributes less to perceived pragmatic qualities, such as usefulness, than to hedonic qualities, such as emotion and identification [26]. People tend to form long-lasting emotional bonds with products, if there are anthropomorphized [27]. In an online survey, truck drivers were most likely to want to use a conversational agent if it gave them joy and social bonding [28]. From this background, it seems reasonable not to ignore the user experience in further investigations of the effects of anthropomorphism in the driver-vehicle interaction.

6 Conclusion

Research yields that anthropomorphism in an automotive context could have positive effects on the interaction between driver and car. This study investigates the effect of anthropomorphism on the driver-truck interaction. In a driving-simulator study involving truck driver, it was examined whether the willingness of truck drivers to cooperate is increased by an anthropomorphized conversational agent. For this purpose, two conversational agents were developed, which differ in their degree of human-likeness. The results showed no significance between the two agents. However, the participants preferred interaction with the conversational agent, which was perceived as being more human-like. This study was the first in a series of studies investigating the effects of anthropomorphism or human-likeliness of interfaces on driver vehicle interaction. The results suggest further improvements that need to be made in the next studies and where special attention needs to be paid.

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