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Acceptance of truck platooning by professional drivers on German highways. A mixed methods approach

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ABSTRACT

Truck platoon driving is a current branch of automated driving, which has the potential to radically change the work routine of professional drivers. In a platoon system, one truck (semi-)automatically follows a lead truck with a reduced distance, which produces significant savings in fuel and enables better traffic flow. In a current application of truck platoon driving, the following vehicle operates at level-2 automation. Thus, the driver of the following truck merely has to supervise the semi-automated system, which takes over steering and speed control when engaged. Level-2 truck platoon driving had not been tested with professional drivers in real traffic before. We hypothesized that user acceptance would improve after the experience of platoon driving. Quantitative questionnaires and qualitative interviews were conducted with 10 drivers before and after an extensive Autobahn experience. The results show a clear increase of acceptance after the experience. Platoon driving was evaluated to be more useful, easier to use, and safer after the experience. Besides perceived driving safety, the prestige of truck platooning, the perceived usefulness of the system, and general technology affinity co-determined user acceptance.

1. Introduction

Platoon driving within the confines of a well-marked and intersection-free highway is a promising step on the road to fully automated driving. Platoon driving has become technically feasible and economically desirable. To date, user acceptance of level-2 automation in truck platooning has not been investigated in the field, but note that a study with level-1 automation has recently been conducted where longitudinal vehicle control was automated but steering was not (see Yang et al., 2018).

In level-2 automated platooning, the truck driver engages an automated system that lets the truck follow a lead truck. The system takes over lateral and longitudinal control, as well as communication with the lead truck. This automated coupling allows for reduced distances between the trucks, leading to fuel savings and improved traffic flow (Esser and Kurte, 2018; Roland Berger, 2016). Fuel savings of up to 20 % are expected for a two-truck platoon (Bonnet and Fritz, 2000; Browand et al., 2004; Dávila, 2013). Furthermore, platoon driving is seen as an answer to ever increasing traffic volumes, as it can save space on the highways by reducing the gap size between the vehicles. With increasing level of automation, platooning has the potential to ameliorate the professional driver staff shortage, which becomes increasingly severe (Costello and Suarez, 2015). Main reasons for the staff shortage are the increasing transportation volume and the demographic change. Furthermore, the profession is not very attractive, plagued by time pressure, stress, and the poor reputation of truck drivers in society, as assessed by over 500 professional drivers in 2012 (Lohre et al., 2012). If platoon driving could contribute to a more positive image of truck drivers and lead to less stressful work routines through semi-automated driving, this could revalue the profession of truck driving and attract young drivers. A more positive image could result from the additional qualification as platoon driver and in the future from advanced tasks, such as dispatching work, which could enrich the work routine.

Currently, platoon systems operate at level-1 or level-2-automation, that is the driver has to monitor the surrounding traffic as well as the platooning system in case a take-over to manual driving is requested.

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(Gasser and Westhoff, 2012; SAE, 2018). With increasing levels of automation, however, it will be possible for the drivers in the following vehicle to engage in secondary tasks or even sleep while driving.

In order to investigate the willingness of drivers to use alevel-2-automation platooning system, we hold that user acceptance can only be assessed when drivers already have experience driving semi-automated trucks in a platoon with small gaps. Without direct experience, skepticism against new technology, rumors, and assumptions predominate, as previous projects have shown (KONVOI, 2009; Neubauer et al., 2019; Putz, 2018; Shladover et al., 2015). The first European projects on platoon driving, PROMOTE CHAUFFEUR I and II, focused mainly on the technical feasibility of platoon driving. A project labeled KONVOI (2005–2009) analyzed the acceptance among professional truck drivers. However, the drivers never had the chance to experience the systems first-hand due to legal requirements. These acceptance data showed that most drivers expressed a negative attitude towards platoon driving, as gleaned from group discussions. In another written survey, drivers were neither approving nor disapproving of platoon driving, and had no clear negative or positive attitudes towards it (RWTH KONVOI, 2009). A more recent investigation with 25 professional drivers in Austria showed similarly ambiguous results. Half of the drivers evaluated platoon driving as useful, the other half did not. The majority had doubts or fears concerning the usage of the system but were also curious about it and showed interest in testing the technology (Putz, 2018).

To assess first-hand user acceptance, we conducted an investigation before and after extensive real-road platoon driving experience using qualitative and quantitative data. The driver of the semi-automated truck had to supervise the system (hands on steering wheel), which he could disengage instantaneously (automation level-2). The study took place within the scope of a platooning research project. Ten professional drivers were trained on the platoon system, which provided lateral as well as longitudinal vehicle control with a reduced gap size between the trucks of 15 m. Multiple long-distance drives were conducted in real traffic and the drivers evaluated the system before and after the experiment. The study sought to gain insights into the formation of behavioral intentions to use platoon technology and to quantify the development of acceptance throughout a test period of nine months. For this purpose, a questionnaire on the acceptance of platoon driving was developed, based on theories of the development of user acceptance.

2. Theory and questionnaire design

After the theory of planned reasoned action (Fishbein and Ajzen, 1975) and its extension, the theory of planned behavior (Ajzen, 1985) had been introduced, Davis (1986) adopted these models to investigate the acceptance of information technology systems. He developed the technology acceptance model (TAM), which aims to explain the formation of behavioral intention and actual behavior. According to TAM, there are two main factors that influence the attitude towards (and the intention to use) a technological system: *perceived usefulness* and *perceived ease of use*. *Perceived usefulness* is defined as “the prospective users’ subjective probability that using a specific application system will increase his or her job performance within an organizational context” (Davis et al., 1989, p. 985). *Perceived ease of use* is defined as “the degree to which the prospective user expects the target system to be free of effort” (Davis et al., 1989, p. 985). Both dimensions are presumed to be statistically distinct and can be determined by external variables. However, these variables are not further defined by the authors. Further developments of the technology acceptance model (TAM2, TAM3) do propose external variables like job relevance, public image, voluntariness, output quality, computer playfulness, and others (Venkatesh and Bala, 2008; Venkatesh and Davis, 2000).

For the present investigation a questionnaire on the acceptance of platoon driving was constructed based on TAM2. The original model was adapted based on the results of focus groups with professional truck drivers that were conducted in phase 1 of this study. The constructs *intention to use*, *perceived ease of use* and *perceived usefulness* were assessed by the original items (proposed by Venkatesh and Davis, 2000) and with additional custom items. *Perceived usefulness* was divided into perceived personal and perceived general usefulness, because participants of the focus group distinguished between their personal benefit of the technology and a general benefit for the environment or for their employer. As proposed by TAM2, the external variable *Image* was included in our questionnaire. It is defined as “the degree to which use of an innovation is perceived to enhance one’s image or status in one’s social system” (Moore and Benbasat, 1991, p. 195). It includes the perceived reputation of platoon driving among colleagues and in public and is called *occupational image* in the following. Other external variables proposed by TAM 2 were not included in our adaptation of the model, because they were not identified as important in the focus groups. However, one further construct was identified through the focus groups. It is called *driving safety* and includes different aspects of driving safety that were discussed intensively. Our adaption of the technology acceptance model for platoon driving is presented in Fig. 1. All assessed subscales and items are listed in Table 1.

3. Materials and methods

3.1. Procedure and study design

To identify truck drivers’ assumptions and attitudes towards platooning and their acceptance of the technology, we used a mixed-methods design, containing qualitative interviews and quantitative questionnaires. Data acquisition took place between November 2017 and December 2018, near Munich, Germany. All questionnaires and interviews were conducted in German language. Following an explorative pretest-posttest design, the study consisted of four phases:

- Phase 1: focus groups and questionnaire development
- Phase 2: pretest interviews and questionnaires
- Phase 3: platoon driving experience
- Phase 4: posttest interviews and questionnaires

In Phase 1, five focus group interviews were conducted, each with four to seven professional truck drivers ($N = 23$) who participated voluntarily and had no prior experience with truck platoon driving. The focus groups took place between November 2017 and January 2018. The drivers signed an informed consent and filled out a questionnaire on demographics and technology affinity (TA) (Karrer et al., 2009). Afterwards they were informed about platoon technology by watching a video (available at: https://www.youtube.com/watch?v=OTbjFI4KE2c) and were asked about their thoughts about the technology and their attitude towards it. They were also asked what effect the technology might have in general and on their job in particular. All focus group interviews were recorded, fully transcribed, and analyzed by qualitative content analysis. A custom platoon driving acceptance questionnaire was developed based on the focus group results and following the basic premises of the technology acceptance model (Davis et al., 1989).

In Phase 2, ten test drivers were recruited (six of them had also participated in the prior focus groups). They gave informed consent and completed questionnaires and one-on-one qualitative interviews in February 2018. The questionnaires included questions on demographics, technology affinity (Karrer et al., 2009) and trust in automated systems (Jian et al., 2000) to better describe the sample. The test drivers also completed a custom questionnaire on acceptance of platoon driving. They were then interviewed individually for approximately 1 h, using a semi-standardized interview guideline similar to the one already used for the focus groups. A total of three drivers dropped out toward the end of Phase 1. They were replaced by additional drivers who were tested in April 2018.

In Phase 3, these test drivers ($N = 10$) experienced the platoon system in real traffic between June and December 2018. First, they

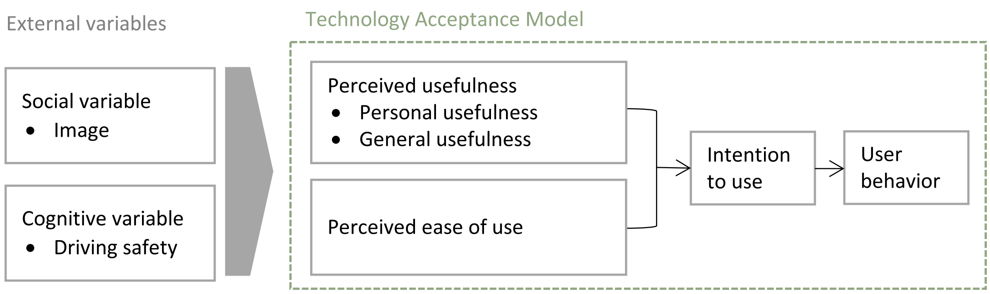

Fig. 1. Adaption of the technology acceptance model for the application of platoon driving.

Table 1
Subscales and items of the platoon driving acceptance questionnaire.

Construct	Items	Cronbach's Alpha	
		Pre	Post
Perceived personal usefulness	The application of this technology would make many things more comfortable. [a]	α = .77	α = .83
	Platoon driving is more pleasant than regular truck driving. [c]		
	This technology would help me complete my daily tasks more comfortably. [a]		
	I find the system to be useful in my job. [b]		
	I think with this technology driving on the highway will be more comfortable for me. [c]		
Perceived general usefulness	I think this technology will achieve fuel savings. [c]	α = .89	α = .90
	I think the technology could lead to less traffic jams on the highways in future. [c]		
	I think driving in platoons is environmentally friendly. [c]		
	I think platooning is useful for logistic companies. [c]		
	I think platoon driving would pay off for my employer. [c]		
	I think new technologies like platoon driving are necessary because the streets are getting more and more crowded. [c]		
Perceived ease of use	I find the system to be easy to use. [b]	α = .75	α = .89
	Learning to operate the system is easy for me.[d]		
Occupational image	People in my organization who use the system have more prestige than those who do not. [b]	α = .87	α = .91
	Having the system is a status symbol in my organization. [b]		
Driving safety	I think platoon driving is more safe than manual driving on the highway. [c]	α = .79	α = .82
	The short distance of 15 m between the platoon trucks scares me. [c]		
	I fear that such a system could be hacked. [c]		
	Platoon driving improves driving safety. [c]		
	I think the short gap between the two platoon trucks will cause problems because passenger cars will enter the gap. [c]		
	Platoon driving will help to avoid accidents. [c]		
	Platoon driving will cause problems with the surrounding traffic. [c]		
	I think the technology is not yet mature. [c]		
Intention to use	Assuming I have access to the system, I intend to use it. [b]		

[a] Translated original item by Kothgassner et al. (2012).
[b] Original item by Venkatesh and Davis (2000).
[c] Translation of custom item.
[d] Original item by Moore and Benbasat (1991).

completed an extensive training, which consisted of a general driving safety training (10 h), theoretical lessons on platoon technology and human-machine-interaction (10 h), practical driving lessons on a test site (10 h), and on the public highway (20 h). Note that there is no speed limit for passenger cars on German highways, which makes truck platooning particularly challenging. After the training, every driver completed up to 20 h of experimental driving on German highway A9, both as leading and following truck driver of a two-vehicle platoon. The drivers were accompanied by researchers to investigate the effects of platoon driving on driver state and driving behavior. The test drives took place between Munich and Nuremberg and started at 6 p.m. and 21 p.m. respectively. Traffic density was rather high around Munich (6–7 p.m. *Mdn* = 74.8 vehicles per minute, vpm) and then continuously decreased (7–8 p.m. *Mdn* = 27.9 vpm, 9–10 p.m. *Mdn* = 14.2 vpm, 10–11 p.m. *Mdn* = 17.8 vpm). Platoon driving was briefly interrupted by traffic events, technical problems, and legal requirements, therefore a test drive consisted on average of six platoon driving phases. Trust ratings as well as ratings of critical situations were assessed after every test drive. Subsequent to the experimental drives, commercial payload drives were conducted on the same route for up to three more weeks by the same drivers in the leading and following platoon vehicle.

In Phase 4, acceptance of platoon driving after extensive on-road experience was measured by individual interviews and questionnaires in December 2018. All drivers ($N = 10$) completed the questionnaires on the acceptance of platoon driving again and answered further questions on future platoon driving scenarios. In subsequent qualitative interviews the drivers were asked to evaluate the platoon technology, their trust in the system, and its advantages and disadvantages. They were also asked about their expectations of how the technology will affect their job and the profession of truck drivers in general. Fig. 2 presents a visual overview of the research steps.

3.2. Participants

Before the test drives started, a total of $N = 23$ drivers with no experience in automated driving participated in focus group interviews. They voluntarily self-assigned to the focus groups, which were announced via a notice board in a medium-sized transport company. Their age ranged from 23 to 56 years ($M = 39$) and they had 0.5–36 years of work experience ($M = 15$). They scored medium high on technology affinity (M = 3.48, $CI = 3.28, 3.69$); the scale ranged from 1: low affinity to 5: high affinity.

$N = 10$ drivers volunteered as test drivers. They were informed about the possibility via a notice board in the same company as well as by their dispatchers. The selection was partly based on practical feasibility of the planned test drives in the shift operation. Interviews and questionnaires were conducted before platooning training and after all test drives. Their age ranged between 32 and 54 years ($M = 39$) and they had 9–25 years of work experience ($M = 14$). Their technology affinity scores ranged between 2.74 and 4.28 ($M = 3.55$, $CI = 3.10, 4.00$), which indicates medium levels of technology affinity (1: low affinity to 5: high affinity). Participants scored medium high on a scale measuring trust in

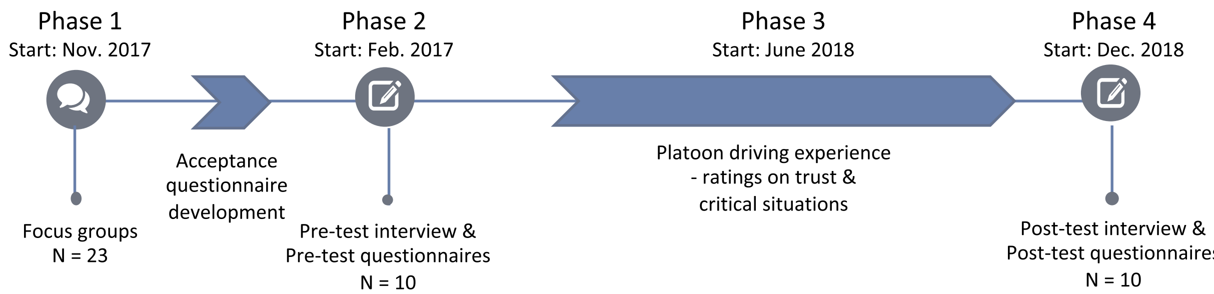

Fig. 2. Visual presentation of the research steps.

automated systems, which ranged from −3 = mistrust to 3 = trust (M = 0.24, CI = −0.72, 1.19).

3.3. Data analysis

All qualitative interviews were transcribed, and a qualitative content analysis (Mayring, 2010) was conducted. Qualitative results are presented with alias names and line numbers. Platoon driving acceptance was measured as agreement on a 5-point rating scale (−2: fully disagree, 1: somewhat disagree, 0: undecided, 1 somewhat agree, 2: fully agree). The questionnaire was conducted before and after the experience of platoon driving (phase 2 and phase 4). The items were combined to subscales per participant. We report mean values of the subscales and confidence intervals (CI) for within-subject designs (O'Brien and Cousineau, 2014). We calculated the CIs as follows: First we standardized the individual questionnaire scores as proposed by Cousineau (2005) and then added a correction factor of $\sqrt{2}$ to the scores as proposed by Morey (2008). Then we calculated 95% confidence intervals using a critical t-value of 2.69 and another correction factor of $\sqrt{2}/2$ following Baguley (2012). This approach of calculating confidence intervals enhances the interpretation of the data, as reporting CIs instead of p-values has been recommended recently (Cumming, 2014; Wasserstein et al., 2019). The same approach applies for the trust ratings in consecutive test drives. For all additional questionnaires or rating scale results that do not follow a pre-post design, we report mean values and regular 95% confidence intervals.

4. Results

4.1. Questionnaires and interviews

The test drivers (N = 10) completed the platoon driving acceptance questionnaire and were interviewed pre and post platoon driving experience. Overall questionnaire results are shown in Fig. 3. Quantitative and qualitative results are presented together for each subscale of the questionnaire in the following sections.

4.1.1. Perceived personal usefulness

Mean ratings of the subscale *personal usefulness* were higher after the experience of platoon driving (Pre: M = 0.10, *95 %-CI* = −0.17, 0.37; Post: M = 0.70, CI = 0.43, 0.97). Mean values of every item included in this subscale were higher in posttest than in pretest ratings. The item with the greatest mean value change was "Platoon driving is more pleasant than regular truck driving".

Qualitative data show that participants were unsure about the usefulness of the system before the test drives. Interview statements ranged from high levels of skepticism to weak optimism that the system will be

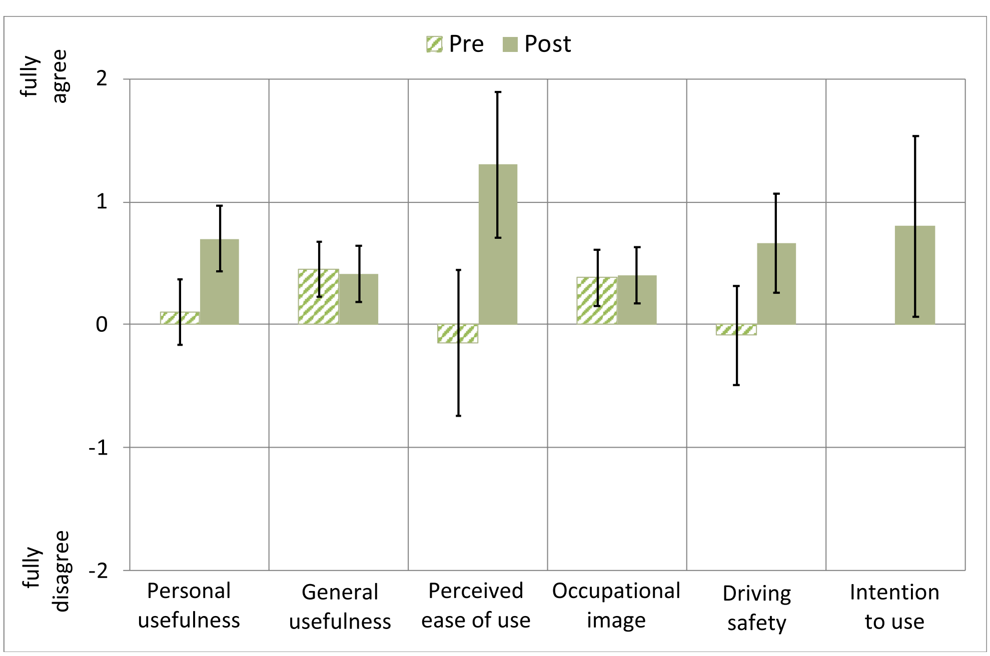

Fig. 3. Acceptance of platoon driving pre and post real traffic experience. Mean values with 95% Cousineau-Morey confidence intervals for within-subject designs with additional Baguley correction, N = 10, Δt = 9 months.

useful. Some expected high levels of stress in the following trucks because of the small distance and the automated system. *"You hang in the following truck and are about to explode, stressed out completely" (*driver12, 211). In this context, some drivers talked about the "white wall" the following truck driver will see, with a clear negative connotation. "*I can hardly imagine, having 10 m distance to a LKW in front, all the way from Munich to Nuremberg, this white wall* (driver11, 122). *"You're getting mad"* (driver13, 123). Some expected the system to relieve the following driver in the case of long highway distances, thus reducing stress. *"[…] if you drive at night, maybe four-and-a-half hours or more, it could be useful" (driver11, 281).* In the leading truck, some expected driving to be more exhausting because of increased responsibility. *"The front driver is jittering and smoking three packs of cigarettes because he knows: "I have my buddy Claus, Gustav, Miller, Meyer [in the back]. Shit, what the hell am I doing?" (driver13, 144).* Topics that were also closely connected to the usefulness of the system were driving autonomy, responsibility in case of malfunction and reliability of the system. Concerns surfaced about a loss of autonomy even for the lead driver because of the rather strict requirements with respect to speed, driving style, and route selection. The drivers were also skeptical about the reliability of the technology, which they took to be a prerequisite for the usefulness of the system. "*It will facilitate it [the work] if reliability is high*" (driver4, 60). Overall, most drivers expected no relevant relief for their daily tasks, because the driver in the following truck has to control the system while driving, and other jobs like loading and unloading the truck stay the same.

After the experience of platoon driving, statements about the usefulness had become more positive. The anticipated high stress level did not occur. *"Platoon driving was quite relaxed. You sit there, look in the mirror, observe the surrounding. And sit there and let it do the rest" (*driver12, 211). Drivers stated to have felt comfortable during the test drives. *"And if you follow nicely now, you are more relaxed, less stressed […]" (*driver2, 119). However, they also stated that platooning would be more useful if, in an advanced system, the driver of the following truck does not have to control the system permanently. Driving autonomy was also mentioned, the drivers experienced platooning in teams of two drivers during the test phase. While most drivers enjoyed working in teams, some considered the dependence on their colleague as a disadvantage. "*At the moment […] you have to wait for the other if you like it or not. […] That slows down the whole process*" (driver3, 89). All in all, comments about usefulness of platoon driving were more positive after the test phase. "*When I look at the whole thing now, then it is really useful on the highway*" (driver9, 89).

4.1.2. Perceived general usefulness

The mean rating of the subscale *general usefulness* was slightly positive and very similar before and after the driving experience (Pre: $M = 0.45$, $CI = 0.22, 0.68$; Post: $M = 0.42$, $CI = 0.19, 0.64$). Participants rather agreed with the statements that platoon driving will achieve fuel savings and is environmental friendly, but were unsure if it would prevent traffic jams.

The qualitative results that show general usefulness like fuel savings and better traffic flow did not play a great role in pretest interviews. Drivers were mostly skeptical about fuel savings and believed savings would only occur on test tracks. *"Well great fuel savings I don't believe in at all" (*driver3, 77). Some drivers questioned if the technology was developed to achieve positive effects for the environment or rather in order to reduce staff costs. "*Why do they develop something like this? Is it only because of the environment? Or to save fuel costs? Or just because later you can employ people who are not qualified as truck drivers*? (driver11, 344).

In posttest interviews, drivers were still not sure if great fuel savings occurred *"[…] the fuel saving potential that was hoped for, it has not been achieved yet in my opinion" (*driver10, 30). The analysis of fuel consumption within the research project showed fuel savings of three to four percent, which is in fact less than expected (MAN Truck and Bus, 2019). The participants were, however, optimistic that greater fuel savings could be achieved in the future. Some stated that saving space on the highway is an advantage but did not attach great importance to it.

4.1.3. Perceived ease of use

The subscale *ease of use* showed the greatest mean value change (Pre: $M = -0.15$, $CI = -0.75, 0.45$; Post: $M = 1.30$, $CI = 0.70, 1.90$). Platoon driving was perceived as easy to use after experiencing it in real traffic.

Prior to the platoon driving experience, participants were undecided whether the system would be easy to use or not. Drivers discussed if special skills were needed to be a platoon driver. In pretest interviews, some drivers assumed that the participation in extra training courses would be necessary to become a platoon driver and that drivers would need special IT skills. *"Because you need to be much more familiar with the technology. […] I think, then you need to take special workshops"* (driver4, 60). In contrast, others stated that future requirements for drivers could be lowered and that platoon trucks could be "driven by anybody". In this context, drivers were concerned of becoming dispensable.

After the experience, they stated the system was easy to use and easy to learn *"[…] the requirements are not that high. Because you don't really have to learn much" (*driver4, 125). The majority of drivers stated that the requirements for platoon driving are not very high.

4.1.4. Occupational image

The subscale *occupational image* was rated slightly positive without changes between pretest and posttest (Pre: $M = 0.38$, $CI = 0.15, 0.61$; Post: $M = 0.40$, $CI = 0.17, 0.63$).

In the view of the interviewees, platoon driving has different effects on perceived reputation and image. They expected a higher reputation if not status symbol quality among colleagues "*Between colleagues the reputation increases of course*" (driver9, 247), but no change in the public opinion about truck drivers *"I think a lot of car drivers will not even know what it* [platoon driving] *is*" (driver5, 204). They assume that car drivers would not notice any changes between platooning and normal trucks and generally do not have a high opinion of truck drivers. "[…] *People say: Truck drivers make the streets crowded. They cause traffic jams. […] I think that, despite Platooning, nothing will change*" (driver4, 223). Others even expected negative reactions of the surrounding traffic *"It might happen that we are probably perceived as more reckless than on normal tours*" (driver4, 111). Only few pretest and slightly more posttest statements were identified as concerning image improvements „*Less accidents, less traffic jams, more order on the street. The Image of the truck driver would improve" (*driver2, 312). Some drivers assume that people might think that anybody could drive a platoon truck. They also stated that car drivers will be irritated by the small gaps and long convoys. One driver was even scared of car driver reactions. The opinion on pay increases for platoon drivers was very inconsistent. Payment was also discussed in this context. Some drivers expected to earn more but were unsure if this was realistic, others were concerned that they would be paid less due to lower skill requirements.

4.1.5. Driving safety

Mean ratings concerning *driving safety* were higher post, compared to pre platoon driving (Pre: $M = -0.09$, $CI = -0.49, 0.32$; Post: $M = 0.66$, $CI = 0.26, 1.06$). The greatest mean value change was found for the item evaluating the platoon distance. Before the driving experience, participants anticipated being somewhat scared of the short distance, but after the test drives this tendency was reversed (Pre: $M = 0.70$, $CI = 0.19, 1.21$; Post: $M = -1.40$, $CI = -1.91, -0.89$).

Results of the qualitative interviews showed that driving safety was of high importance for the drivers, and concerns with respect to driving safety predominated in pre-test interviews. Before the test drives, the majority was concerned about the small distance between the platoon vehicles. "*With this distance that you drive [in a platoon] you don't have many possibilities to react, to decide for yourself*" (driver9, 128). They also feared hacker attacks or viruses and system failure. "*The only thing I'm really scared of is that a system fails. […] You can never prevent all errors*" (driver9, 71). Drivers also anticipated passenger cars to enter the gap between the trucks, underestimating the hazardousness of such behavior.

In posttest interviews, driving safety was stressed to be one of the main advantages of the system. "*If I save fuel then this is a positive side-effect. This is not as important to me. […] For me safety of the driver is important. Everything else comes afterwards. […] I only like the system because of its safety" (*driver9, 46). The small gaps were not described as aversive anymore; instead drivers described a very quick adaptation to the small gaps. *"In the beginning I thought it was awkward, because of the distance. But if you are inside and drive with it, it is totally normal, I think." (*driver8, 17). Passenger cars that cut in between the platoon vehicles were still an important topic, but the drivers experienced these situations as predictable and therefore not as critical. "[…] *if someone tries to enter the gap, you notice it, because it is in your field of view. And then you still have the possibility to brake, to split up the platoon. You can still react yourself. That means it is not that dramatic*" (driver9, 45). They described that the greater the gap between the platoon vehicles, the more likely were passenger cars to enter it, particularly near highway on-ramps and exit ramps. Broken-down vehicles on the hard shoulder were mentioned as another potential danger. In pre and in posttest interviews, some drivers stated that they would rather not activate the platoon system if weather conditions were bad, which included ice and snow. All in all, driving safety was evaluated as high after the platoon experience, it was expected to prevent accidents "*All the rear-end collisions that you always see in television, these collisions I think will be drastically reduced with it* [platoon driving]" *(driver1, 120).*

4.1.6. *Trust & reliance*

After every test drive, participants rated their trust in the platoon partner and the platoon system on a 5-point scale (-2 = mistrust to 2 = trust). Aggregated per participant, overall ratings show high levels of trust towards the platoon system ($M = 1.43$, $CI = 0.93, 1.92$) as well as their platoon partner ($M = 1.65$, $CI = 1.16, 2.14$). Fig. 4 shows the development of trust in the following vehicle throughout the test drives. It becomes apparent that high levels of trust had already been established during the training.

One major finding revealed by the interviews with the test drivers was a change of trust in the platoon technology and the co-driver. Before the test drives, participants were unsure if they would be able trust the system *"But you don't want to rely on the technology completely. Not right at the beginning" (driver5, 127);* "*Well I am a bit ambiguous about it. Because giving 50 tons into the hands of a computer just like that - very strange feeling*" (driver5, 49).

After the test drives, they stated to have experienced the system as reliable, and that they had learned to trust it *"Yes, the system, which means the brake system and so on, I trust completely […] You can trust it because you know that it works" (driver2, 253); "All the concerns that you might have in the beginning […] you set aside, when you just trust the system"* (driver9, 5). *"I trust the technology. Also, if it was only 5 m [gap distance]" (driver4, 70).* The drivers also mentioned that the trust was already established during the training on the test track, the experience of the system in a full braking maneuver was impressive for them and important to build trust in the system. "[the trust was built] *through the experience, that we just drove. We were on the test track. And we experienced different scenarios" (driver2, 46)*. They also mentioned that it was easy to trust the co-driver because they all knew each other. They were unsure if it would be as easy to trust an unfamiliar or novice driver.

4.1.7. *Critical situations*

During the test drives, participants reported a total of 15 critical situations. Most of these situations were due to cut-in vehicles. Participants rated the criticality of the situations after each drive on a rating scale (1–3: harmless, 4–6: unpleasant, 7–9: dangerous, 10: uncontrollable). On average, drivers rated cut-in vehicles as unpleasant but not dangerous ($M = 4.5$, $CI = 2.6, 6.5$). When asked in the interviews about cut-in vehicles, drivers reported that passenger cars tended to cut in near highway exits "*without thinking that they also risk their life*" *(driver10, 37)*. The platoon system was designed to detect cut-in vehicles and automatically enlarge the gap between the trucks. The drivers stated that the system reacted accordingly and in time so that the situations were manageable *"[…] the system handles it [cut-in vehicles]. Of course, if I see that it'll be tight with the cut-in vehicle, then I have to react to it. But normally not" (dirver2, 38).*

Fig. 4. Trust ratings by the following vehicle drivers throughout the test drives. Mean values with 95% Cousineau-Morey confidence intervals for within-subject designs with additional Baguley correction.

4.1.8. Intention to use

The intention to use platoon driving was assessed with a single item: "Assuming I have access to the system, I intend to use it". In total, the intention to use the system was high after the platoon driving experience. Seven drivers intended to use the system, two drivers were undecided and one disapproved. The driver who disapproved commented on driving in the following vehicle as follows: *"Well fine, I rather drive alone, right? I mean I enjoy driving. That's why I became a truck driver. And I don't like to be guided, because I am the driver [...]. And I don't want to be guided by a computer." (driver3, 85)*. When asked about the negative aspects of driving in the lead vehicle he stated: *"Negative is that I have to always worry about the follower. Is he still there? [...] you have to wait for the other if you like it or not" (driver3, 98)*.

4.1.9. Future of platoon driving

After the driving experience, participants completed a questionnaire on the future of platoon driving, individual interviews also focused on this topic. The results are presented in the following. Three future scenarios were explained to the drivers, the first was *multi-brand-platooning* where trucks of different manufacturers can build platoons on the highway. The system was stated to be similar to the one the drivers tested, such that they would still have to supervise the automated system. Participants were asked how much they would like to drive in one of the following roles in this scenario: as platoon leader/as platoon follower/alternating as leader and follower/without platooning (−3: very reluctantly; +3: very preferably). The results show that they did not have a clear preference for one driving mode (leader: $M = 1.10$, $CI = 0.01, 2.19$; follower: $M = 0.80$, $CI = -0.24, 1.84$; alternatingly: $M = 1.10$, $CI = 0.08, 2.12$; without platooning: $M = 1.10$, $CI = 0.01, 2.19$).

The same question was asked for *highly automated platoon driving*, where the driver of the following truck would not have to supervise the system anymore and could engage in other tasks. Again, there was no clear preference for one of the roles. However, for highly automated platoon driving, mean values were higher than for semi-automated platoon driving. Highest mean values were found for driving alternatingly ($M = 1.5$, $CI = 0.35, 2.65$). Drivers were also asked what they would prefer to do while driving in the following truck in case of full automation. Six drivers were undecided, two preferred leisure time, two preferred to perform extra tasks like working as dispatcher. If they had to fulfill extra tasks during highly automated driving, they stated to expect at least 25 % salary increase. One driver stated, however, that he would be unwilling to work while driving.

Scenario three was described as driving in the leading truck with a *platoon vehicle following fully automatedly* (without a driver). Participants were asked how much additional stress such a vehicle would cause compared to a regular trailer (1: no additional stress to 10: much more additional stress). The results show that on average, a fully automated platoon vehicle would cause slightly more stress ($M = 3.20$, $CI = 0.74, 5.66$).

In the interviews one of the drivers stated to see increasing automation as a threat to his job. "*The only thing that comes to my mind concerning automated driving is: I lose my job*" (driver3, 406). The majority, however, shared a more optimistic outlook. *"I'm looking forward to full automation, to the topic of electric mobility. Platoon is quite nice, quite exciting. But I think there is still room for more" (driver4, 167)*. A degree of automation, in which the following car needs no driver, is not imaginable for them, because the interviewed drivers see their presence as essential for the client contact and unloading, especially in small or old logistic hubs and in the inner cities. "*Full automation is not happening yet. [...] I can't imagine that it will happen. Because you always need humans*" (driver5, 572). "*The long-haul drives will be fully automated. The short-haul drives, the last mile to the customer will stay in the hands of humans*" (driver9, 154). It became clear that the drivers evaluated the current state of platoon driving to be a transition period to higher stages of automation. "*In my opinion the whole platooning test is just a preliminary stage to fully automated driving*" (driver10, 54).

4.2. Correlations among subscales

The subscales of the posttest acceptance questionnaire were checked for internal consistency and correlations among the subscales. The consistency of all scales of the questionnaire were acceptable, $\alpha > 0.75$. The correlations are presented in Table 2. The table also exploratively includes the variables *technology affinity* and *trust in automated systems.* They were initially conducted to better describe the sample, but during the experiment it became clear that trust and the general attitude towards technology might be of high importance.

Concerning the subscales of the technology affinity questionnaire, *general usefulness* had the highest correlation with *intention to use*. It was correlated with *personal usefulness*, *image*, and *driving safety*. *Ease of use* was more or less uncorrelated to all other variables. It should also be noticed that *technology affinity* was highly correlated with *intention to use*, but not with any other variable. This is striking, as this relation was not expected beforehand. *Trust in automated systems* was also strongly correlated with the intention to use the platoon system.

5. Discussion

The interviews and questionnaire results show that most drivers were intrigued by the new platooning technology. Most importantly, we found a clear increase of acceptance after experience with the system in real traffic. Before the on-road experience, concerns predominated among drivers. They expected high levels of stress due to the small gap size and they were skeptical about the reliability of the system. A recent questionnaire and interview study reported similar results with regard to drivers' acceptance of platooning technology (level-1 automation) before the experience: The majority of drivers ($N = 15$) stated that they would not enjoy platoon driving and expressed concerns regarding loss on control and responsibility (Neubauer et al., 2019). In studies on highly autonomous trucks, drivers were found to have safety concerns (Richardson et al., 2017) or to be rather neutral about the technology (Fröhlich et al., 2018). However, we found that the drivers' concerns did not materialize after the on-road experience of truck platoon driving. After the test phase, drivers instead stated that platooning would make driving more comfortable. They also expressed that the current state of platoon driving, where the system has to be supervised at all times, is an intermediate stage, which needs to be further improved to achieve more advantages for the driver. Notwithstanding, personal usefulness was rated higher after the drives, and the majority of drivers would already use the platoon system if it were available in their company. The only other study on platoon acceptance that included an on-road experience had been conducted in the US with a total of 9 drivers and a level-1 platooning system. Pre-exposure acceptance was not collected in this

Table 2
Correlations among acceptance subscales

	1	2	3	4	5	6	7
1 Intention to use	1						
2 Personal usefulness	.43	1					
3 General usefulness	.73	.76	1				
4 Ease of use	.01	-.12	.21	1			
5 Image	.32	.59	.69	.32	1		
6 Driving safety	.47	.54	.82	.36	.91	1	
7 Technology affinity	.77	-.13	.28	.04	.05	.21	1
8 Trust in automated systems	.62	.35	.58	-.26	-.01	.22	.47

Fields are marked with darker color the higher the correlation (white: <0.3, light grey 0.3–0.5, grey: 0.5–0.7, dark grey > 0.7) study. However, after the experience the drivers' overall satisfaction with the system was positive as well (Yang et al., 2018).

The evaluation of general usefulness did not change through experience. Positive effects like fuel savings and better traffic flow were mentioned but not seen as important. In fact, increased safety was found to be most important to drivers, when it comes to truck automation (Richardson et al., 2017).

The public occupational image also did not change through experience; the drivers did not believe that the prestige of truck drivers changes due to platoon driving. However, a better image among colleagues was stated. These results are in contrast to the prior assumption that platoon driving improves the public image of drivers. Yet, they are in line with prior findings by Yang and collegues (2018), who reported that drivers did not think platoon driving would make the truck driver job more attractive.

Driving safety was evaluated more positively after the test drives. In contrast to concerns about the small gap size and the reactions of the surrounding traffic that predominated in the beginning, platoon driving was perceived as safer than manual driving after the test phase. The system was perceived as reliable, and the drivers stated high levels of trust in the system as well as in their platoon partner. These high levels of trust were already established after the platoon training and remained high during the test drives. Yang and collogues (2018) reported medium to high trust ratings after the first experience with the system. The drivers rather trusted the system's reaction to cut-in attempts of other vehicles, but were unsure about system reliability when they drove on downsloping roads. Trust in the other driver of the platoon was found to be very high. We conclude that trust establishes quickly and forms a prerequisite for the positive evaluation of platooning systems. Its influence should be addressed systematically in further studies.

After the experience of platoon driving, the system was evaluated as significantly easier to use and easier to learn than first expected. However, high ratings on this scale did not substantially correlate with any other scale and therefore do not seem to have great impact on overall acceptance.

With respect to the future of truck platoon driving, especially in the focus groups in phase 1 of this study, negative comments about job loss occurred. Likewise, other studies reported that drivers fear to lose their jobs (Neubauer et al., 2019) or to become redundant (Richardson et al., 2017). However, the test drivers of this study looked optimistically into the future and were not scared to lose their jobs. The majority thought that they were indispensable because they did not expect an automated system to be able to unload or navigate in inner cities or on logistic hubs any time soon.

Concerning the driving role (leader/follower) no clear preferences emerged, and the drivers stated that they would like to be able to switch between roles. Even when asked about a highly automated platoon system that would allow the driver to engage in secondary tasks, no clear preference for one role occurred. In fact, both roles, as well as switching between roles, and driving altogether without a platoon system were rated as equally convenient. Likewise, Neubauer et al. (2019) reported that switching between roles in a platoon (leader/follower) would be beneficial. Alternating driving roles might be a strategy to prevent monotony and fulfil the drivers' desire for independence. Autonomy and independence were also found to be one of the main reasons for job starters to become a truck driver (Lohre et al., 2012). Therefore, the possibility to choose between driving as leader, as follower, or without a platoon is an important factor that should not be underestimated.

The analysis of questionnaire data showed that the subscales *general usefulness* and *personal usefulness* were highly correlated. *General usefulness* was again highly correlated with the *intention to use. Ease of use* on the other hand was not correlated significantly to any other questionnaire scale. The results show that if the system was judged as easy to use, this by itself had no great effect on the actual intention to use it. Instead, the *perceived usefulness* of the system was strongly connected to *intention to use*. Note, however, that the variable *technology affinity,* which was measured exploratively, had the highest correlation with the intention to use in this study. It might be most important that platoon drivers bring along a positive attitude towards technology in general to be willing to use platoon driving. This should be further investigated with additional drivers, as the number of drivers had to be limited to ten drivers in our study.

5.1. Limitations

The first and most important limitation is the small sample size in this study. Due to the extensive exposure and high safety standards of the on-road tests, only ten drivers participated in this study. This may be the lower limit of what can carry statistical weight. Therefore, the results are not necessarily generalizable and await replication. Yet they provide a good idea of a first on-road experience by professional drivers. It is important to mention that six of the test drivers had also participated in the prior focus groups. However, the additional exposure of a focus group should not constitute a major bias, as the drivers had heard about platoon driving before and probably already discussed the topic with colleagues.

Another concern might be that the test drivers received much attention through the extensive training and press coverage. This might have influenced their attitudes towards the platoon system. Given the novelty of automation, only time will tell if acceptance changes when less attention is given to the drivers. Furthermore, the safety prerequisites were very high in this study. The platoon system did function very reliably, but it was deactivated in the case of bad weather conditions, near highway junctions and on down/upgrades. Thus, the drivers experienced the system as dependable, and only few critical situations occurred. Experiencing system limits or failure in bad weather would certainly impact the attitudes towards the system and its acceptance.

5.2. Practical implications

The hands-on experience of platoon driving seems critical for the development of positive attitudes toward platoon driving. The reliability and safety of platoon systems is more important to the drivers than are general benefits like fuel savings, environmental friendliness, or improved traffic flow. If a system is experienced to be reliable, drivers start to trust the system and lose their initial fear towards it. To increase acceptance, the availability of platoon demonstrations and first-hand experience could be beneficial. Furthermore, it might be important to provide the possibility to switch between driving as leader or follower of the platoon, as it is important for the drivers to maintain the skill levels required in take-over situations. Also, the drivers described that they appreciated driving in teams and knowing their platoon partner. Thus, it would be important to provide certain information about the other drivers in a platoon in further system configurations.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix I. Questionnaire results per participant

	Trust score[a]	TA-EG score[b]	Personal usefulness pre[c]	Personal usefulness post[c]	General usefulness pre[c]	General usefulness post[c]	Ease of use pre[c]	Ease of use post[c]	Image pre[c]	Image post[c]	Driving safety pre[c]	Driving safety post[c]	Intention to use post[c]	Trust in platoon system[d]	Trust in platoon partner[d]
Driver 1	-,13	4,28	0,80	0,60	1,17	0,67	0,00	1,00	0,60	0,80	0,88	1,25	2,00	1,00	1,00
Driver 2	1,25	2,94	0,60	1,60	1,33	0,83	0,50	0,50	1,20	0,60	0,75	0,75	0,00	1,00	2,00
Driver 3	−2,13	2,74	−1,00	0,00	−0,50	−0,67	1,00	2,00	0,80	0,40	−1,25	0,50	−2,00	0,50	1,00
Driver 4	,63	3,91	0,60	0,80	0,67	−0,17	0,50	0,50	−0,80	−1,00	0,13	−0,25	1,00	1,00	0,50
Driver 5	1,13	4,14	0,40	1,00	0,33	1,00	−0,50	2,00	0,40	1,40	−0,50	1,38	2,00	2,00	2,00
Driver 6	-,50	2,91	0,00	1,60	0,00	0,50	0,00	1,00	0,20	1,00	−0,75	0,50	1,00	1,75	2,00
Driver 7	,50	3,64	0,20	1,60	1,67	1,83	−1,50	2,00	1,80	2,00	−0,25	2,00	2,00	2,00	2,00
Driver 8	,50	3,68	−0,20	0,20	0,00	0,33	−2,00	2,00	−0,40	−1,00	0,00	−0,13	1,00	2,00	2,00
Driver 9	1,75	3,73	0,20	0,20	1,00	0,50	0,50	1,00	0,20	0,00	0,63	0,75	1,00	2,00	2,00
Driver 10	-,63	3,54	−0,60	−0,60	−1,17	−0,67	0,00	1,00	−0,20	−0,20	−0,50	−0,13	0,00	1,00	2,00

[a] encoding: -3 = mistrust, 3 = trust.
[b] encoding: 1 = low affinity, 5 = high affinity.
[c] encoding: -2 = fully disagree, 2 = fully agree.
[d] encoding: -2 = mistrust, 2 = trust.

References

Ajzen, I., 1985. From intentions to actions: a theory of planned behavior. In: Kuhl, J., Beckmann, J. (Eds.), Action Control. Springer, Berlin, Heidelberg, pp. 11–39.

Baguley, T., 2012. Calculating and graphing within-subject confidence intervals for ANOVA. Behav. Res. Methods 44 (1), 158–175.

Bonnet, C., Fritz, H., 2000. Fuel Consumption Reduction in a Platoon: Experimental Results with Two Electronically Coupled Trucks at Close Spacing (No. 2000-01-3056). SAE International, Warrendale, PA.

Browand, F., McArthur, J., Radovich, C., 2004. Fuel Saving Achieved in the Field Test of Two Tandem Trucks (UCB-ITS-PRR-2004-20). California PATH Program, Los Angeles, CA.

Costello, B., Suarez, R., 2015. Truck Driver Shortage Analysis 2015. The American Trucking Associations, Arlington, VA.

Cumming, G., 2014. The new statistics: why and how. Psychol. Sci. 25 (1), 7–29.

Dávila, A., 2013. SARTRE Report on Fuel Consumption (Technical Report for European Commission under the Seventh Framework Programme Project 233683 Deliverable 4.3). Brussles.

Davis, F.D., 1986. A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results. Doctoral dissertation. Massachusetts Institute of Technology. Retrieved from. https://dspace.mit.edu/handle/1721.1/15192.

Davis, F.D., Bagozzi, R.P., Warshaw, P.R., 1989. User acceptance of computer technology: a comparison of two theoretical models. Manag. Sci. 35 (8), 982–1003.

Esser, K., Kurte, J., 2018. *Autonomes Fahren- Aktueller Stand, Potentiale und Auswirkungsanalyse, Studie im Auftrag des Deutschen Industrie- und Handelskammertag (DIHK) e. V.* Köln: KEConsult.

Fishbein, M., Ajzen, I., 1975. Belief, Attitude, Intention and Behavior: an Introdution to Theory and Research. Addison-Wesley, Reading, Mass.

Fröhlich, P., Sackl, A., Tröesterer, S., Meschtscherjakov, A., Diamond, L., Tscheligi, M., 2018. Acceptance factors for future Workplaces in highly automated trucks. In: Proceedings - 10th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, Automotive UI 2018. ACM Press, New York, New York, USA, pp. 129–136.

Gasser, T.M., Westhoff, D., 2012. BASt-study: definitions of automation and legal issues in Germany. In: Proceedings of the 2012 Road Vehicle Automation Workshop (July). Irvine, CA: Paper presented at the Workshop on the Future of Road Vehicle Automation.

Jian, J.-Y., Bisantz, A.M., Drury, C.G., 2000. Foundations for an empirically determined scale of trust in automated systems. Int. J. Cogn. Ergon. 4 (1), 53–71.

Karrer, K., Glaser, C., Clemens, C., Bruder, C., 2009. Technikaffinität erfassen – der Fragebogen TA-EG. Der Mensch Im Mittelpunkt Technischer Systeme 8, 196–201.

KONVOI, V., 2009. Entwicklung und Untersuchung des Einsatzes von elektronisch gekoppelten Lkw-KONVOIs (Abschlussbericht). Technische Informationsbibliothek u. Universitätsbibliothek, Aachen.

Kothgassner, O.D., Felnhofer, A., Hauk, N., Kastenhofer, E., Gomm, J., Kryspin-Exner, I., 2012. TUI: Technology Usage Inventory Manual. FFG, Vienna.

Lohre, D., Bernecker, T., Stock, W., Düsseldorf, K., 2012. ZF-Zukunftsstudie Fernfahrer – Der Mensch im Transport- und Logistikmarkt. Euro Transport Media Verlag, Friedrichshafen.

MAN, Truck, Bus, 2019, May 10. Platooning in the logistics industry: researchers see great potential in real operations after tests | MAN Truck Germany. https://www.truck.man.eu/de/en/man-world/man-in-germany/press-and-media/Platooning-in-the-logistics-industry_-Researchers-see-great-potential-in-real-operations-after-tests-372998.html.

Mayring, P., 2010. Qualitative inhaltsanalyse. In: Handbuch Qualitative Forschung in der Psychologie. VS Verlag für Sozialwissenschaften, Wiesbaden, pp. 601–613.

Moore, G.C., Benbasat, I., 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. Inf. Syst. Res. 2 (3), 192–222.

Morey, R.D., 2008. Confidence intervals from normalized data: a correction to Cousineau (2005). Tutorials Quantit. Methods Psychol. 4 (2), 61–64.

Neubauer, M., Schauer, O., Schildorfer, W., 2019. A scenario-based investigation of truck platooning acceptance. In: Stanton, N. (Ed.), Advances in Human Factors of Transportation. AHFE 2019. Advances in Intelligent Systems and Computing, vol. 964. http://link.springer.com/10.1007/978-3-030-20503-4_41.

Neubauer, M., Schauer, O., Schildorfer, W., 2019. A Scenario-Based Investigation of Truck Platooning Acceptance. Advances in Human Factors of Transportation. AHFE 2019. Advances in Intelligent Systems and Computing, 964. Springer, Cham, pp. 453–461.

O'Brien, F., Cousineau, D., 2014. Representing Error bars in within-subject designs in typical software packages. Quant. Methods Psychol. 10 (1), 56–67. http://www.tqmp.org/RegularArticles/vol11-2/p126.

Putz, J., 2018. Akzeptanz von Lkw-Platooning-Eine Untersuchung der Akzeptanz von Platooning bei Lkw-Fahrern österreichischer Transportunternehmen. Master's thesis. University of Applied Sciences Upper Austria.

Richardson, N., Doubek, F., Kuhn, K., Stumpf, A., 2017. Assessing truck drivers' and fleet managers' opinions towards highly automated driving. Adv. Intell. Syst. Comput. 484, 473–484.

Roland Berger, 2016. Automated Trucks - the Next Big Disrupter in the Automotive Industry? Roland Berger GmbH, Munich.

SAE, 2018. Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems. SAE Int. 1–12. J3016_2018.

Shladover, S.E., Campbell, R., Kailas, A., Boyd, S., Torrey, F., 2015. Industry Needs and Opportunities for Truck Platooning. UC Berkeley: California Partners for Advanced Transportation Technology. https://escholarship.org/uc/item/6723k932.

Venkatesh, V., Bala, H., 2008. Technology acceptance model 3 and a research agenda on interventions. Decis. Sci. J. 39 (2), 273–315.

Venkatesh, V., Davis, F.D., 2000. A theoretical extension of the technology acceptance Model : four longitudinal field studies. Manag. Sci. 46 (2), 186–204. https://www.jstor.org/stable/2634758.

Wasserstein, R.L., Schirm, A.L., Lazar, N.A., 2019. Moving to a world beyond "$p < 0.05$". American Statistician 73 (Suppl. 1), 1–19.

Yang, S., Shladover, S.E., Lu, X.-Y., Spring, J., Nelson, D., Ramezani, H., 2018. A First Investigation of Truck Drivers' On-The-Road Experience Using Cooperative Adaptive Cruise Control. California Partners for Advanced Transportation Technology, UC Berkeley. https://escholarship.org/uc/item/92359572.