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The Effect of System Restrictions on Acceptance of Self-Driving Cars

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Research Idea

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Abstract

Only some state of the art driving automation systems (DAS) of current self-driving cars include system restrictions that actively counteract misuse instead of only informing the drivers of the limitations of the system. Misuse can lead to accidents, which could reduce acceptance of self-driving cars at a population level. However, system restrictions could also affect acceptance as DAS with restrictions might be perceived less useful and provide less ease of use. In this paper, we describe an experiment that investigates this trade-off between safety and traditional technology acceptance constructs. We implement four different versions of a driving simulation application using a novel platform for mobile online experiments, MOE. We measure technology acceptance using an adapted UTAUT2 questionnaire before and after the driving simulation and compare it between the four different versions. This research has implications for new technologies that require a trade-off between safety and technology acceptance including self-driving cars.

Keywords: acceptance, driving simulation, self-driving cars, system restrictions, mobile online experiment

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Research Idea

Many surveys show that people are willing to accept self-driving cars without even having tested them (Kyriakidis et al. 2015). To many people it is not even clear what current self-driving cars are capable of. Names of driving automation systems (DAS) such as "Autopilot" suggest that cars equipped with such DAS are fully self-driving. This is not the case for current self-driving cars, which is a dangerous but widespread misconception leading to misuse (Fung 2015). Acceptance of self-driving cars could drop significantly as soon as the number of accidents rises due to misuse (Rajasekhar and Jaswal 2015). Recently, a Tesla car crashed with an active Autopilot causing a human casualty, which tragically showed the limitations of current self-driving cars (Vlasic and Boudette 2016).

Simply informing drivers of the shortcomings of state of the art DAS does not seem to be sufficient to prevent misuse as the reports of the misuse of Tesla's Autopilot suggest (Fung 2015). Other DAS, such as Intelligent Drive of Mercedes-Benz (Kurylko 2014), include system restrictions that actively counteract misuse besides informing the driver and, thus, might be safer. Previous research showed that trust (e.g., Ha and Stoel 2009) and risk perception (e.g., Martins et al. 2014) affects technology acceptance, which could be both affected by accidents. However, DAS with system restrictions might be perceived less useful and provide less ease of use, which are major determinants of technology acceptance (Davis 1989; Venkatesh et al. 2012). This leads to a potential trade-off between safety and traditional technology acceptance constructs, which needs to be considered to ensure acceptance of self-driving cars at a population level.

In order to analyze this potential trade-off, we conduct an online experiment using a mobile driving simulation application. The driving simulation shows a 2D top view of the car and its environment. It displays controls for enabling and disabling the DAS, changing the lane, accelerating, and decelerating. Thereby, it allows to simulate common obligations of drivers, for example, yielding the right-of-way at an intersection, stopping at a red light, or avoiding an obstacle on the road. The application also includes a visual detection response task (DRT) to evaluate the participant's attention (Bruyas and Dumont 2013).

We simulate four different versions of the DAS. A state of the art DAS, which requires the driver to take over control of the vehicle at any time, and a level 3 DAS, which allows the driver to cede full control to the car in certain situations and guarantees a comfortable transition time to manual driving as defined by the National Highway Traffic Safety Administration (NHTSA 2013). Furthermore, we simulate DAS with and without system restrictions. This results in a 2x2 factorial experiment design as summarized in Table 1. We use a between-subject design to avoid carryover effects (Charness et al. 2012).

	Without system restrictions DAS only informs the driver how to use the system correctly	**With system restrictions** DAS actively counteracts attempted misuse
State of the art $t_{TO} \in [0s, 7s]$	**Group 1**	**Group 2**
Level 3 DAS $t_{TO} = 7s$	**Group 3**	**Group 4**

Table 1. 2x2 full factorial experiment design

The time for takeover t_{TO} of the state of the art DAS varies between zero and seven seconds and is determined randomly as the driver needs to be able to take over control anytime. A t_{TO} of zero means that the system does not recognize a critical driving situation and, thus, is not able to notify the driver to take over control in advance. This might seem unconscionable but is a common shortcoming of current DAS. Additionally, we simulate a level 3 DAS that warns the driver seven seconds before a critical situation occurs, which requires human intervention. Previous research showed that drivers need seven seconds to get back into the loop from automated driving and react to critical situations appropriately (Gold et al.

2013). It is very difficult to anticipate such situations even seven seconds in advance, especially when the behavior of human drivers needs to be anticipated. Therefore, we set t_{TO} of the level 3 DAS to a realistic value of 7s.

We put special emphasis on the authenticity of the DAS and, thus, implemented them similar to existing ones. The system without restrictions resembles the Tesla Autopilot, which only informs the drivers of the shortcomings of the DAS. The system with restrictions resembles the Mercedes E-Class Intelligent Drive DAS, which actively counteracts attempted misuse. It requires the participant to perform an interaction with the system every 30 seconds. If no interaction occurs, a visual warning will be displayed followed by an acoustic warning. Another acoustic warning follows 10, 15, 16, 17, 18, and 19 seconds later. With the last acoustic warning 20 seconds later, the DAS will be automatically disabled and the car starts to decelerate. If the DAS is activated, the participants increase their mileage even if the driving simulation is minimized on their mobile device. The DAS without system restrictions will not complain while the DAS with restrictions warns the users if they minimize the application and actively counteracts this misuse as described above. In addition, a DRT will be used to detect a lack of attention while the application is displayed, which is also considered misuse depending on the reaction time. We test the following hypotheses:

H1a: Technology acceptance before using the DAS is higher with the DAS without restrictions.

H1b: Technology acceptance after using the DAS is higher with the DAS with restrictions.

H2: Technology acceptance after using the DAS correlates with the distance traveled.

H3: Occurrence of misuse correlates with the number of accidents.

H4: Occurrence of misuse differs between the experiment groups so that it is lower for the DAS with system restrictions and level 3 DAS.

DAS without restrictions seem desirable from a technology acceptance perspective since they might be perceived more useful and are easier to use (H1a). However, DAS without restrictions might cause more accidents resulting in a decline in technology acceptance after using the DAS (H1b). Participants who use the DAS more extensively and traveled a higher distance have higher behavioral intentions to use the DAS (H2). During the experiments, the participants are likely to attempt to misuse the DAS. Misuse may increase the probability to cause an accident as first experiences with self-driving cars suggest (H3). Occurrence of misuse is lower for systems with restrictions and level 3 DAS (H4).

Technology acceptance before and after using the DAS will be measured using an adapted UTAUT2 questionnaire (Venkatesh et al. 2012). We simulate the four different DAS in an online experiment using a mobile driving simulation application implemented on a novel platform for mobile online experiments, MOE. MOE offers applications for Android and iOS using Apache Cordova for cross-platform development. The experiment will be conducted as follows. First, all participants will be randomly assigned to one of the four experiment groups. Second, they will be provided with a description of their DAS. Third, they fill out a first questionnaire that assesses technology acceptance before the driving simulation starts. Fourth, they start the driving simulation in which they can choose to enable the DAS or drive manually. In the driving simulation, the participants will encounter different situations that require human intervention. If they do not react in time, which is determined by the treatment (Table 1), they cause an accident. After an accident, the participants lose part of their monetary compensation, which increases with the distance traveled. Fifth, the participants fill out a second questionnaire after the driving simulation that assesses technology acceptance using the same questions as in step three. The questionnaire also allows to state comments and thoughts about the DAS. In the last step, the participants receive their compensation and are debriefed.

This research addresses both theoretical and practical issues. For practice, this research aims to clarify, which approach for DAS to prefer based on safety considerations and technology acceptance. We provide a novel approach to analyze technology acceptance by using a novel platform for mobile online experiments, MOE. The results of this research could be applicable to other new technologies that require a trade-off between safety and technology acceptance.

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