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# What drives people to accept automated vehicles? Findings from a field experiment



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#### ABSTRACT

This field study aims at understanding the influence of direct experience of an automated vehicle (AV, Level 3) and explaining and predicting public acceptance of AVs through a psychological model. The model includes behavioral intention (BI) to use self-driving vehicles (SDVs, Level 5), willingness to re-ride (WTR) in our AV (Level 3), and their four potential determinants, namely perceived usefulness (PU), perceived ease of use (PEU), trust related to SDVs, and perceived safety (PS) while riding in our AV. The last two determinants are largely ignored, but we consider them critical in the context of AVs. Three-hundred students were invited as participants (passengers) to experience the AV. The trust, PU, PEU, and BI of the participants were recorded prior to their experiencing the AV; after this experience, all the constructs of the psychological model were recorded. The participants' experience with the AV was found to increase their trust, PU and PEU (but not BI), the consistency between PU/PEU and BI, and the explanatory power of BI. The model explained 55% of the variance in BI and 40% in WTR. PU, trust, and PS were found to be steady and direct predictors of both the acceptance measures; PEU predicted BI only after the participants' AV experience. Mediation analysis showed that trust also can indirectly affect AV acceptance through other determinants. Out-of-sample prediction confirmed the model's predictive capability for AV acceptance. The theoretical contributions and practical implications of the findings are discussed.

#### 1. Introduction

According to the World Health Organization (WHO, 2015), more than 1.2 million people die from road traffic crashes each year worldwide, leading to a huge impact on health and development. More than 70% of traffic crashes were associated with human error (Dhillon, 2007). The technology of automated vehicles (AVs) has the potential to dramatically reduce the traffic crashes caused by human error (NHTSA, 2016). AVs are capable of sensing the traffic environment, navigating through software algorithm, and controlling vehicle movement without driver's decisions and actions (Xu et al., 2017). This technology is regarded as a major technological breakthrough in ensuring roadway safety. AVs also have the potential to reduce traffic congestion, increase mobility, and reduce fuel consumption (Anderson et al., 2016; Bansal et al., 2016; Fagnant and Kockelman, 2015; Howard and Dai, 2014; Litman, 2015; Liu et al., in press). According to the Society of Automotive Engineers (SAE, 2014), AVs with conditional automation (Level 3), high automation (Level 4), and full automation (Level 5) can work in "self-driving" ("automated driving") mode.

The AV technology is gaining increasing attention of vehicle manufacturers, technology companies, policymakers, and also the

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public. Several researchers and organizations forecasted long-term adoption of AVs and made different predictions (Bansal and Kockelman, 2017; Nieuwenhuijsen et al., 2018). One of the most cited studies about AV's adoption is the one by Litman (2015), who forecasted that, by 2050s, automated driving will be included as a standard feature of most new vehicles and that AVs will constitute about 40–60% of vehicle fleets, 80–100% of vehicle sales, and 50–80% of vehicle travels. Litman also predicted that AVs' beneficial impacts on increasing road safety and reducing traffic congestion are likely to appear between the 2040s and 2060s. Bansal and Kockelman (2017) predicted that self-driving vehicles (SAE Level 5) are likely to be adopted by 24.8–87.2% of vehicle fleets by 2045. For an overview of market penetration forecasting, the readers may refer to Nieuwenhuijsen et al. (2018).

As argued by Shariff et al. (2017), the biggest roadblocks standing in the path of mass adoption of AVs may be psychological, not technological. If AVs are not widely accepted by the public, neither road safety can be improved, nor the predicted benefits to society and environment be achieved (Dong et al., in press; Noy et al., 2018). Current public opinion polls and surveys reveal that the public show some resistance or a neutral attitude toward AVs (Clark et al., 2016; Haboucha et al., 2017; König and Neumayr, 2017; Smith and Anderson, 2017). To better predict, explain, and increase public acceptance of emerging technologies such as AVs, one needs to thoroughly understand what makes the public accept or reject them (Davis et al., 1989; Nordhoff et al., 2016). Recognizing the need for research into the factors shaping AV acceptance, several researchers (e.g., Abraham et al., 2017; Choi and Ji, 2015; Deb et al., 2017; Madigan et al., 2017) conducted surveys to identify the determinants of the public's intention to use AVs.

But still, several gaps exist in this field of research. First, the efforts to understand public acceptance of AVs are still very limited and its psychological determinants remain largely unknown (Abraham et al., 2017; Madigan et al., 2017; Nordhoff et al., 2016). Second, most of the studies relied on online surveys and focused on knowing the general views of those participants who have little or no real experience of AVs (Nordhoff et al., 2017). Such an approach as this may prevent arriving at realistic findings. The participants' perceptions and responses are guided by the description of AVs provided in the questionnaire (or provided by surveyors) or other information sources (e.g., the social media) (Rahman et al., 2017). This is called 'information-exposure approach' or 'messagelearning approach' in attitude research. Therefore, those participants may not be able to truly visualize the operation and functionality of the AV and the way they are likely to interact with it. As such, what they develop may only be an inaccurate mental model of AVs (Körber et al., 2018). To avoid this sort of situation, the survey must be focused on people who have the experience of riding in AVs and rely on their perspectives to understand and explain public acceptance of AVs. Recently, several field studies were carried out on automated shuttles (ASs) to elicit the opinion of the first-users of ASs (Madigan et al., 2017; Moták et al., 2017; Nordhoff et al., 2017) and understand their perceptions while riding in the AS (Salonen, 2018). In so far as the authors' knowledge goes, no such field study has been carried out so far on private AVs.

For enhancing the existing field knowledge and understanding the psychological drivers behind AV acceptance, a field experiment was conducted. For this, a number of students (N = 300) were invited to participate as passengers and gain first-hand experience of riding in the AV (SAE Level 3), developed by the authors. Utilizing the feedback given by those participants, we investigated the influence of the direct experience on AV acceptance and also on its psychological determinants, and built and tested a psychological model to explain and predict the participants' willingness to re-ride in the AV and intention to use self-driving vehicles (SDVs, SAE Level 5) in future.

#### 2. Theoretical framework and hypotheses

#### 2.1. Acceptance and psychological models to explain acceptance

Acceptance is "the precondition that will permit new automotive technologies to achieve their forecasted benefit levels" (Najm et al., 2006, p. 5-1). This definition implies that acceptance is essential for implementing new technologies in the transportation system. Adell et al. (2014) also defined driver acceptance of in-vehicle systems as "the degree to which an individual incorporates the system in his/her driving, or, if the system is not available, intends to use it" (p. 18). Although acceptance is defined in different ways, the general understanding is that it is a multi-faceted concept, involving different aspects (e.g., willingness to pay, intention to use) (Adell et al., 2014). Usually, researchers focus on the single aspect of acceptance.

Several models of human behavior and theories of technology acceptance are suggested to explain user acceptance, including the Technology Acceptance Model (TAM) (Davis, 1989; Davis et al., 1989), Theory of Planned Behavior (TPB) (Ajzen, 1991), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and UTAUT2 (Venkatesh et al., 2012). Among them, TPB was proposed to explain human behavior in general, whereas other three models were initially developed to explain technology acceptance in Information Systems research. Three types of constructs are involved in these models, including people's belief and perception of a technology, behavioral intention (BI) to use this technology, and actual usage behavior. The basic tenet of these models is that people's perceptions and beliefs (representing the information base) will determine their intentions, which, in turn, translate into actual behavior. Understanding the major perception factors that shape intention and actual behavior is critical. In TAM, perceived usefulness (PU) and perceived ease of use (PEU) are recognized as the two direct predictors of BI (which will be introduced later). TPB includes three components of BI—attitude, subjective norm, and perceived behavioral control (similar to PEU). It suggests that positive attitude, favorable normative, and volition control beliefs will positively affect BI in using a technology. In UTAUT, performance expectancy (i.e., PU), effort expectancy (i.e., PEU), and social influence are assumed to positively affect BI, which, together with facilitating conditions, positively influence actual behavior. In UTAUT2, three more constructs (hedonic motivation, price value, and habit) are added.

The above-cited models have already been used to explain driver's acceptance of new in-vehicle technologies (Park and Kim, 2014; Rahman et al., 2017). These models have also been adopted for recent survey-based studies on AVs and ASs (Choi and Ji, 2015;

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