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On sceptics and enthusiasts: What are the expectations towards self-driving cars?

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ABSTRACT

Automation in transport is increasing rapidly. While it is assumed that automated driving will have a significant impact on travel demand, the nature of this impact is not clear yet. Based on an online survey ($N = 3040$), this study explores the expected consequences of automated driving in the Danish population. Participants were divided into three homogeneous segments based on attitudes towards automated and conventional car driving: Sceptics (38%); Indifferent stressed drivers (37%) and Enthusiasts (25%). The attitudinal segments differ in their socio-demographic profiles, current travel behaviour, interest in use-cases for self-driving cars, and anticipated changes of behaviour in a future with self-driving cars. People who are enthusiastic about self-driving cars are typically male, young, highly educated, and live in large urban areas, while Sceptics are older, car reliant and more often live in less densely populated areas. The indifferent group consists of more car reluctant people. The expected advantages of self-driving cars generally resemble the aspects highlighted in other studies, such as relief from driving tasks and the possibility of doing other things while travelling, with some variation between the three segments. Preferred future scenarios include car ownership rather than sharing solutions as well as residential relocation, which is considered by 22% of all participants as a consequence of the possibility of working in the car (13% of Sceptics; 28% of Enthusiasts). All in all, increased travel demand can be expected from an uptake of increasingly automated cars, which will be realised in the different segments with different speeds, depending on policies, business models, and proven functionality and safety.

1. Introduction

Transport planning and research is increasingly focussing on automated driving and its potential effects on transport behaviour and infrastructure. While still difficult to grasp and assess, many researchers expect significant changes within the planning horizons associated with infrastructure decisions that are taken today. Thus, for transport planning there is an urge to develop scenarios for transport automation. Academic publications and publications from a public policy perspective have developed scenarios for the adoption of automated driving based on historical adoption rates of new technologies or general societal change assumptions (Levinson et al., 2016; Milakis et al., 2017). Other studies have focused on the likely effects of automated driving on traffic flow and infrastructure performance in terms of delay and capacity (Aria et al., 2016; Department for Transport, 2016). However, the methodologies for assessing the behavioural responses to automated transport are weakly established and the forecasting of future options that very few have experienced calls for a widening of the methodologies applied. This includes considering the public's expectations towards automated or self-driving cars as an indication of how the transformation towards automation could develop. Knowledge about the public's expectations can also help to refine estimations of adoption rates and speeds as among the most important variables when it comes to foreseeing the effects on the transport system.

Researchers have been working on explanatory frameworks and have adopted models to assess automation uptake and its acceptance, including the Technology Acceptance Model (Davis, 1989), and frameworks presenting a wider set of possible associations (Ghazizadek et al., 2012; Nordhoff et al., 2016). As Nordhoff et al. (2016) suggest, multiple psychological, situational and socio-economic factors influence acceptance. These include: expected performance, expectations about one's own efforts, social influences, pleasure related to driving, perceived control, the level of automation, the vehicle type and quality, tech-savviness/interest, driving impairments, productivity of driving

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time, past and current driving experiences, sensation-seeking behaviour, the level of trust, the traffic situations/use-case for automated driving, and socio-economic levels. Only a few of these factors have been included in acceptance studies until now. Following Becker and Axhausen (2017), results point towards effects of gender, age, income, awareness of automation trends, and level of autonomy in the current vehicle as correlates of acceptance towards automated driving. Men and younger individuals are more likely to accept autonomous driving, whereas higher incomes imply a higher willingness to pay. Awareness of and experience with automation in vehicles are also positively related to acceptance. Additional factors that are suggested to affect acceptance include level of urbanisation and the monotony of the current driving tasks.

According to Payre et al. (2014) and Bjørner (2017), the preferred use-cases for automated driving are highway driving in congested conditions as well as parking the car. In addition, it is generally assumed that disability or physical conditions prohibiting driving are key factors for interest in or acceptance of automated driving (e.g., Saripalli, 2017). However, according to Fraedrich et al. (2016) empirical results, people with mobility impairment do not have a special interest in self-driving cars – their willingness to use them is even lower than that of people without mobility impairment.

Beside Nordhoff et al. (2016), the studies of Zmud et al. (2016), Lavieri et al. (2017) and Lee et al. (2017) point towards the importance of attitudinal and lifestyle factors, including social support and affinity for technology, for the expectations towards the adoption of automated driving. In addition to individual factors, cultural factors also seem to play a relevant role, as studies indicate strong differences between countries with respect to concerns with the technology (Kyriakidis et al., 2015) as well as in the interest in using automated driving (Schoettle and Sivak, 2014; Lang et al., 2016). People in high-income countries, for instance, show more concern with vehicle data transmission (Kyriakidis et al., 2015). With regard to general acceptance, 85% of Indian and around 75% of Chinese consumers indicate that they would take a ride in a fully self-driving car, while only 36% of Japanese and around 40% of German and Dutch consumers indicate the same. In France, the UK and the US, acceptance is around 50% (Lang et al., 2016). The different levels of acceptance may be related to the anticipated advantages as compared to conventional car driving, evaluated on the background of the existing transport system and related problems such as congestion, accident risk, and pollution (Lang et al., 2016).

As it is still unknown what the key 'drivers' or determinants of automated driving are, there is a need for more research on user acceptance or interest in automated driving – including results from different countries.

This paper contributes to the state of knowledge by studying the acceptance of automated driving and related expectations in the Danish population. Besides considering the population as a whole, we divide it into homogeneous segments based on attitudes towards automated and conventional car driving. The attitudinal segments are characterised by their socio-demographic profiles, travel behaviour, interest in use-cases for self-driving cars, and the respondents' anticipated change of behaviour in a future with self-driving cars. Showing the relationship of attitudinal sub-groups to other variables makes the results transferable to other countries and provides more insights into possible future scenarios than results based on the Danish population as a whole.

2. Method

2.1. Sample and procedure

Data for this study were collected in November and December 2016 via an online survey carried out for the Danish Road Directorate by Wilke (Vejdirektoratet and Wilke, 2017). The target population were adults 18 years or older. A sample of 3040 people was drawn from 35,000 members of Wilke's online survey panel. The panel is continuously recruited through several channels including social media, telephone and face-to-face contact to allow representation of the diversity of the Danish population. The sampling was further stratified to reflect the composition of the Danish population with respect to age, gender and region of residence. The sample consisted of 1526 women and 1514 men, aged 18–89 years.

2.2. Measures

In the following section, we describe the parts of the questionnaire that were analysed in the present study.

Car access and travel patterns: Respondents were asked how many cars they had in the household and if they had a driving licence. They were further asked how often they used different modes of transport (1 = "daily"; 6 = "never") and those with a car in the household were asked for which of the following purposes they typically used the car: commuting to work; leisure activities, sport and shopping; holiday; driving for the fun of it (cruising).

Interest and attitudes towards self-driving cars: To define self-driving cars, a fully self-driving vehicle scenario was presented to the participants, which was an adapted version of the scenario used by Lang et al. (2016) for their study of expectations towards self-driving cars across different countries. The description included pictures of different variants of self-driving cars and stated, inter alia, that these cars would be able to drive even without a driver/passenger. On the basis of this scenario, people were asked to assess how much they agreed with different aspects of self-driving cars and conventional cars on a five-point Likert scale (1 = "totally disagree"; 5 = "totally agree"). Items included both positive and negative expectations about self-driving cars and items measuring car excitement and car stress (see Table 1 for a list of items). Participants were further asked which of eleven potential advantages of self-driving cars they expected (see Table 5). On a five-point Likert scale participants were asked to assess their interest in different forms of self-driving vehicles, such as self-driving taxis with or without a back-up driver (1 = "not interested at all"; 5 = "very interested"), and how likely it was that they would use/buy a self-driving car when available (1 = "very unlikely"; 5 = "very likely"; see Table 6).

Expectations towards fully automated vehicles: Respondents were asked how they expected their car use to change when having a self-driving car (1 = "drive much less"; 5 = "drive much more"), whether they expected to use the car more for specific purposes and whether they expected to move farther away from the city because of the possibility of working in the car. The questions were partly based on the behavioural adaptations reported from the semi-structured interviews by Zmud et al. (2016). Finally, expectations of the year when self-driving cars would become available on the Danish car market were requested.

Background information included age, gender, education, income, household size and place of residence. In addition, general technology acceptance was assessed with one item. This item was adopted from Rogers (2003) innovation scale as a measure to generally assess the respondents' interest in using new technologies.

2.3. Analysis

In transport research and practice, the segmentation of transport users into sub-groups based on attitudinal variables is often used to describe varying user needs and expectations (e.g., Siren and Haustein, 2013) and as a basis for more targeted interventions (see Haustein and Hunecke, 2013 for an overview). Based on their attitudes towards self-driving cars and conventional cars, we divided the population into segments by means of cluster analysis (see Section 3.1). In a preliminary step, the number of attitudes was reduced to their underlying dimensions based on a principal component analysis (PCA). Based on the results of the PCA, mean scales were calculated, which then served as the input variables for the cluster analysis. We conducted cluster analyses using the k-means algorithm for two to five cluster solutions. We compared the