Public Opinion about Self-Driving Vehicles in the Netherlands

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ABSTRACT
The paper describes an investigation into the public opinion about self-driving vehicles among Dutch people. New in our approach is to design a questionnaire on the basis of different theories of acceptance of new technology in organisations and society in combinations with additional questions about specific factors such as the economic implications of self-driving vehicle services. As results, we present a predictive model of public opinion about self-driving cars that evaluates the relevant factors and which shows the feasibility of a theory-based approach to design survey tools.

KEYWORDS
User Assessment, technology acceptance, autonomous vehicles, self-driving vehicles, questionnaire design, public opinion.

ACM Reference format:

INTRODUCTION
Self-driving vehicles present a technologically advanced transportation method that presents some solutions to current transportation problems and presents a flexible approach to people's transportation wishes. The ability to drive is a symbol of mobility and independence that spans generations. In response to the quick technological developments in self-driving vehicles, at both the local and international levels, authorities have started to consider strategies to meet the challenges resulting from the introduction of such vehicles.

Self-driving vehicles, especially Google's self-driving car, have become popular in the media and became the focus of many reviews trying to gauge the perception of such upcoming vehicles (Rizzo, Jermeiland & Severson 2002). This study investigates public opinion about self-driving vehicles and attempts to identify the main factors affecting opinion about self-driving vehicles. For practical reasons, the study is limited to investigating public opinion in the Netherlands.

The Concept of Self-Driving Vehicles
A Self-driving vehicle is an innovative technological transportation method, and that is capable of identifying its environment and control without using human support (Coyle, Novack, Gibson & Novack, 2015). To qualify as a self-driving vehicle, it must be able to navigate without human intervention to a pre-determined place over roads that have not been specially adapted to this practice. Many such vehicles are being developed; however, as of May 2017 not a single self-driving vehicle that is permitted on public roads is completely autonomous (Millar, 2012).

They all required a human driver at the driving seat who is ready at a moment’s notice to take over control of the vehicle. Self-driving vehicles are using a variety of different techniques to detect their external environments, such as front cameras, sensors, laser light, GPS and computerized driving system.
Moreover, the internal environment in self-driving vehicles generally makes use of road side tracking to detect physical information from the road side to identify suitable roads to complete the trip, as well as exchanging information with the company’s vehicle control station (Gray & Graham, 2012). Most self-driving vehicles are manufactured and researched by the prominent vehicle manufacturing companies like: Audi, BMW, Ford, General Motors, Volkswagen and Volvo, but also Google (Coyle, Novack, Gibson & Novack, 2015).

Advantages and Disadvantages of Self-driving

Self-driving vehicles and connected technologies such as related vehicles, International Transmission System (ITS) and electrically powered vehicles have the power to change current transportation to become more maintainable, safer and appropriate linked to today’s systems (Zoldy & Torok, 2015). Self-driving vehicles may allow people to travel on demand to achieve benefits from markets of measure that initiate by existence part of a larger transportation system in the host country. Self-driving vehicles can address problems of safety, congestions, fuel efficiency and mobility (Gray & Graham, 2012). Developments in safety may be realized as soon as these is widespread of self-driving vehicles. Nowadays, vehicle’s automatic system can track traffic rules more concentrating and responsive than drivers can (Gray & Graham, 2012). In 2010, there were nearly 35,000 vehicle deaths in the U.S.; many of these fatalities were related to diverted driving, drunk driving and other human deficiencies (Janssens, 2014).

A study on linked vehicles claims that vehicle-to-vehicle communication may prevent 81% of all the vehicle crashes reported annually (Janssens, 2014). Implementation of self-driving vehicles at the city or regional level is likely to result in a decreased crowding of the transportation system when the market penetration of these automobiles has begun (Coyle, Novack, Gibson & Novack, 2015). These vehicles would then be able to evade blockade and avoid traffic congestion on public roads and move to parts before they start to slow down traffic (Zoldy & Torok, 2015). Moreover, replacing vehicles by vehicle ‘trains’ will possibly raise the capacity of motorway lanes by 36% at 45 mph, according to a particular computer model (Janssens, 2014). These volume developments would be achieved without the need to add traffic lanes, which is the current practices to increase road capacity (Millar, 2012).

Theories about Technology Acceptance

In order to study public opinion, one possibility is to design a questionnaire from scratch, creating ad-hoc questions that hopefully give some insight. As an alternative, in this study it was decided to determine to what extend, a questionnaire about public opinion could be created on the basis of general theories about the introduction and acceptance of new technologies. Each of these theories distinguishes a number of relevant factors for the acceptance of new technologies, and applied to the field of self-driving vehicles, these theories provide a systematic and theory-based approach to distinguish principal factors for the design of tools to study public opinion.

Theory of Reasoned Action (TRA). The Theory of Reasoned Action (TRA) was first proposed by Fishbein and Ajzen in 1975 and it is used extensively in marketing research. TRA is useful to study new behaviour e.g. beyond the reception of present information technology and comprises four universal concepts: behavioural attitudes, subjective norms, intention to use and actual use (Fishbein and Ajzen, 1980). Added explicitly in TRA is the idea that a person’s behaviour can be estimated from their purposes, which can be forecast from their attitudes and personal values.

Technology Acceptance Model (TAM). Technology Acceptance Model (TAM), proposed by Fred Davis in 1989 was based on TRA as a primary research models to study in what way a person’s perceptions about the usefulness and ease of use, influence the attitude, intention and eventual use of a particular technology (Tsai, 2014).

Innovation Diffusion Theory (IDT). Innovation Diffusion Theory (IDT), first published by Everett M. Rogers in 1962, is the basis for the theory about how innovation diffusion into society, distinguishing innovators, early adopter, etc. (Baskerville & Pries-Heje, 2008). It has origins in economics, sociology and communication and a synthesis of adoption-diffusion literature. IDT identifies five factors that impact the application of innovation: relative advantage, compatibility, complexity, credibility, and observability. Relative advantage represents a person’s trust that e.g. self-driving vehicles is perceived as an improvement over traditional technologies, and it can be linked to different economic, social, ease of use and satisfaction aspects (Baskerville & Pries-Heje, 2008).

Theory of Planned Behaviour (TPB). Theory of Planned Behaviour is based on the idea that a person’s beliefs influence his or her behaviour which, in turn, influences attitudes and beliefs. TPB is an extension of the TRA model. TPB also applies to situations in which individuals don’t have explicit control over their behaviour (Ajzen, 1991).

Figure 2: Theory of Planned Behaviour (Ajzen, 1991)

Adaptive Structuration Theory (AST). Adaptive Structuration Theory (AST) is based on Anthony Giddens’ structuralism theory. DeSanctis and Poole adapted Giddens’ theory of education to the interaction of groups and organizations by technology and called it Adaptive Structuration Theory.
(Schwieger, Melcher, Ranganathan & Wen, 2006). Groups and organizations working with information technology make dynamically perceptions about the role and usefulness of the technology, and how it can be useful to their activities. These attitudes influence the way how technology is used and therefore facilitate its impact on group results.

**Principal Factors affecting Public Opinion**

Using the analysis of theories about technology acceptance, it is possible to distinguish some general or principal factors affecting public opinion about self-driving vehicles, as follows: Performance expectancy, Effort expectancy, Usefulness, Behavioural intention, and Ease of use. In addition to these factors based on theoretical considerations, it is necessary to add, beyond the general attitude towards self-driving vehicles as the main factor, two specific factors that directly influence attitude about self-driving vehicles: Road safety and Economic factor.

**Performance expectancy**. Performance expectancy shows the perceived usefulness of self-driving vehicle services. According to agreement theory, when customers' expectation are not satisfied, they will be discontented. Consumers in general are renowned for the consequences of perceived usefulness (related to performance expectancy) on user fulfilment (Tanaka, Takehara & Yamauchi, 2006).

**Effort expectancy**. Effort expectancy shows the perceived difficulty of using self-driving vehicles. The study by Tanaka also shows the effect of perceived ease of use (similar to effort expectancy) on user satisfaction (Tanaka, Takehara & Yamauchi, 2006).

**Usefulness**. When customers have the choice to wait for a full hour on a bus or take a self-driving vehicles directly from their apartment, the choice seems clear, other factors being equal. Usefulness in the context of self-driving vehicles for public transport relates to the availability of clean, well-maintained, timely and efficient services with good coverage and insurance.

**Attitude**. Attitude or Attitude towards Behaviour is the factor that mediates between a person's general beliefs and the specific behavioural intention of a particular technology. As such, it is not a genuine principal factor and it should not be confused with behavioural intention nor with the dependent factor of opinion about self-driving vehicles.

**Behavioural intention**. Behavioural intention is defined as an individual's perceived possibility or chance that he or she will be involved in an assumed activity. Behaviour intention indicates how hard an individual is prepared to try, and how inspired he or she is, to actually use a self-driving vehicle service. In theory, behavioural intention is the best immediate predictor of behaviour (Fishbein & Ajzen, 1980).

**Ease of use**. Usability or sometimes referred to as "easy to use" describes how easy it is, in a particular context, to use a service or product for its intended use. As such, it requires an understanding of customer requirements, an expression of usability objectives and the application of methods for usability assessments of self-driving vehicles (Branscomb & Thomas, 1984). The usability of self-driving vehicles is determined by the factors that determine usable products and services in general:

- Effectiveness, efficiency, engagement, mistake tolerance, and ease of learning.

**Method**

Each of the principal factors, derived from the theories on technology acceptance as well as the two specific factors road safety and economic factors and the overall attitude about self-driving vehicles was operationalised into sets of three or four different survey questions. For example, one of the questions to measure Behavioural Intention was "I predict that I will use self-driving vehicles on a regular basis in the future" and Attitude was operationalised with questions like: "Self-driving vehicle is a valuable instrument for future transport systems".

In addition to the Likert questions, a number of questions was used to acquire demographic data, such as gender, age, employment, drivers license, vehicle ownership, and familiarity with self-driving vehicles. Also, a number a questions asked for specific preferences regarding self-driving vehicles such as opinions, experiences, and general preference and expectations regarding self-driving vehicles.

**Participants**

According to initial plan, about a 100 participants were sought in each of two places: Ede-Wageningen where the experiments were taking place with prototype self-driving vehicles and people were supposedly somewhat familiar with self-driving vehicles, and Rotterdam, where the public was not. Within the time-frame, the plan was not feasible and instead, a total number of 100 participants was approached in Ede-Wageningen and Rotterdam. Preliminary analysis did not show any significant differences between the two cities.

**Results and Data Analysis**

**Demographic data, expectations and opinions**. This section describes the most relevant and notable outcomes of the questionnaire results. With respect to demographic data, 42% of the respondents were male and 58% were female. Age groups were distributed as follows: 18-30: 14%, 31-40: 11%, 41-50: 15% , and above 50: 33% of the respondents. 72% of respondents had a valid driving license, while 28% of respondents did not. Regarding familiarity, 56% of respondents are familiar with driverless vehicles like Wepod or related technology, while 44% of respondents are not familiar. 16% of respondents are experienced in driving or being driven in a driverless vehicle, while 84% of respondents are not experienced.

Regarding opinions about driverless driving, 31% of the respondents are excited about driverless vehicle compared to a manual vehicle, 38% interesting, 13% concerned, while 31% of respondents are not interested at all. 27% of respondents prefer self-driving vehicles over the current manual vehicles, 31% don’t prefer, while 27% have no preference either way. Regarding expectations, 4% of respondents expect comfort, 17% expect comfort and safety, 43% expect quality, comfort and safety, 17% of respondents expect only safety, 9% expect quality and safety,
3% expect reliability, while 7% of respondents expect prestige from a driverless vehicle.

**Likert, rating scale data**. Data from the Likert scales were collected for each question. For example, performance-expectancy-1 is the question: “I expect that using self-driving vehicle would increase the convenience of future transport”. Here, 37% of respondents agreed that using self-driving vehicle would increase the convenience of future transport, while 39% of respondents gave moderate answers and 24% of respondents disagreed with the above statement. Overall, ratings are moderate but positive towards driverless vehicles.

Subsequent analysis of the Pearson correlations between each of the factors and public opinion about self-driving vehicles is fairly high: except for economics factor: 0.697 and performance expectancy: 0.742, all other correlation coefficients range from 0.845 and 0.9; all statistically significant at 0.000 (2-tailed).

**Multiple Regression Analysis**. All the data from each factor such as performance-expectancy were collected and checked for reliability using Cronbach’s alpha, and checked for deviations from the normal distribution. The data were subsequently analysed with a multiple regression analysis with the following model summary:

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>R Square Change</th>
<th>F Change</th>
<th>df1</th>
<th>df2</th>
<th>Sig. F</th>
</tr>
</thead>
<tbody>
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<td>0.933</td>
<td>0.082</td>
<td>0.94</td>
<td>711.256</td>
<td>8</td>
<td>91</td>
<td>0.000</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Economic Factor, Attitude, Effort Expectancy, Ease of Use, Road Safety, Performance Expectancy, Usefulness, Behavioural Intention

The associated multiple regression equation for the eight variables and Public Opinion about Self-driving Vehicles is as follows:

Public Opinion about Self-driving Vehicles = 0.012 + 0.020(Performance Expected) + 0.010(Effort Expected) + 0.405(Usefulness) + 0.436(Behavioural Intention) + 0.069(Ease-of-Use) + 0.002(Antitude) + 0.024(Road Safety) + 0.017(Economic Factor)

The Adjusted R Squared indicates that 98.4% of variance of public opinion about self-driving vehicles in Netherlands is explained by the eight variables.

**Chi-Square Analysis**. A Chi-Square test was used to test each of the eight hypotheses of the study. For each variable, the hypothesis that there is no relationship between the variable (Performance Expectancy, etc.) and Public Opinion about Self-driving Vehicles in the Netherlands, had to be rejected (p < .001).

**DISCUSSION AND CONCLUSION**

This study investigated the influence of a number of theory-based as well as several specific factors that influence public opinion about self-driving vehicle service in the Netherlands. We obtained strong evidence for positive relations between public opinion and, respectively: performance expectation, effort expectancy, usefulness, behavioural intention, ease of use, attitude, road safety, and economic factor. Note however, that not all factors are equally strong: factors like Usefulness and Behavioural intention seem much more important then e.g. Ease of Use or Effort expectancy. Given that the Usefulness and Intention are already in place, this means that, on the basis of this investigation, policy makers and self-driving vehicles service providers should initially focus on Ease of Use and Effort expectations among customers, in order to provide optimal access to self-driving vehicle services.

Another significant result of the study is that a theory-based approach for designing tools to study public opinion is feasible. Apart from 2 factors, specific for public opinion about self-driving vehicles (Road safety and a general Economic factor), the results show that all the factors that were derived from theories about how new technologies are accepted by specific groups and by society, do indeed have a significant influence on public opinion.

Apart from the advantages of building a consistent theoretical framework, our results show that this approach is actually useful and effective in designing a particular questionnaire as a tool to determine public opinion in the field of self-driving vehicles.

**REFERENCES**


