TRAVEL-TIME VALUATION FOR AUTOMATED DRIVING: A USE-CASE-DRIVEN STUDY

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ABSTRACT

An application-oriented evaluation of the implications of fully automated driving is of growing importance, particularly with regard to future user acceptance and usage. One of the most remarkable benefits of fully automated driving discussed is the potential of alternative travel-time use. Radical changes in time valuation and a rise in productivity are being discussed, which are highly relevant when evaluating transport-related measures, infrastructure investments and mode choice behavior. However, the lack of empirical examination and the inclusion of important aspects about the usage context, constraints and perceived benefits make predictions difficult.

This paper aims to bridge the gap by examining user acceptance and perceived advantages of automated vehicles on the basis of four specific use cases within the course of a quantitative online survey in Germany. The study includes detailed information on respondents' current use of, and attitudes towards, today's available transport modes, as well as their perception of the advantages of automated vehicles. Special focus is placed on current and future travel-time use.

Significant differences found in the adaption of specific use cases emphasize the importance of a differentiation of fully automated driving. Perceived benefits with respect to time use were mainly window gazing and relaxing, whereas the possibility of working seemed to be less valued. A probit model analysis examined influencing factors on the propensity of regarding working while traveling as an advantage - a strong significance of the current time use on public transport and long-distance train trips, gender and rational attitude towards public transport was revealed.

INTRODUCTION

The implementation of automated vehicles is envisioned in the not-too-distant future, although there are remaining uncertainties on various levels (technological, regulatory, etc.). Fully automated driving is often considered to have radical implications on future transport systems: it is supposed to reduce crashes or even eliminate them completely, it may have significant impact on traffic flow, reduce emissions, etc. (cf. 1, 2, 3). On the user side, the alternative use of time while driving is considered to be one of the most remarkable benefits. There are various directions that have been discussed in light of modified use of time while driving (cf. 4, 5, 6, 7). However, the assumed benefits are speculative to date and their perception and assessment by (potential) users lack systematic empirical examination. Current studies rarely go beyond the question of whether automated driving or automated vehicles are attractive for future users. In doing so, important aspects about the context of use, preconditions and constraints as well as perceived benefits and aims might not be addressed adequately. A recent study on automated driving was able to show that people do not have a uniform perception of automated driving and that their evaluation of the technology differs depending on the context (cf. 8). This demands the application of specific use cases into the research process to better explore these variances.

The aim of the paper is to contribute to the debate on the role of automated vehicles in connection to the transport system, its users and future mobility: in which way could fully automated driving change our transport behavior as well as the way we move? What are current perceptions and attitudes towards automated driving and how could they relate to future mode choice and anticipated travel-time use? The paper explores specific contexts of the use of fully automated driving in relation to individual user perspectives in Germany. A special focus is placed on the topic of alternative travel-time use. A quantitative online survey was conducted to examine the interrelationship of transport mode use, travel-time and specific uses cases of automated driving.

When we speak of ‘fully automated driving’ or ‘automated driving’ in the following, we refer to the Society of Automotive Engineers (SAE) taxonomy that contains six levels of increasing vehicle automation (8). This study focuses on the SAE level 4 and 5 specifications and also only introduces applicable use cases in the survey itself – assuming that, especially with regard to alternative travel-time use and valuation, fundamental changes would not be expected below level 4 automation where a human driver is, at least, required to “respond appropriately to a request to intervene” (9).

USE OF TRAVEL-TIME AND AUTOMATED DRIVING

In the discussion of the prospective benefits that automated vehicles may provide, the possibility of an altered time use – associated with an increase in productivity or comfort – is one of the most prominent examples (cf. 5, 7, 11, 12). Automated driving may lead to a more positive valuation of the time spent while on the road. Morning commute time especially is perceived as notably unpleasant and even less popular than work itself (13). Commuting is also associated with a range of health problems including stress and depression as well as a higher level of social stress (cf. 14). About 80% of U.S. workers are assumed to lose around fifty potentially productive minutes due to commuting every day – a vast economic source of unused potential (7). In Germany, about 8.5 million workers travel for more than an hour between their home and their workplace every day (14).

At the same time, travel-time savings are among the important factors when evaluating transport-related measures or infrastructure investments by means of a cost-benefit-analysis (cf. *15*). Also, time is highly relevant in determining mode choice in travel demand models. Usually, access and egress times are differentiated from in-vehicle-time; in the case of public transport, waiting and transfer times are often considered separately. No difference is made, though, with respect to time use while traveling. Traditionally, time spent traveling is regarded as “dead time”, taken away from the possibility of spending it more enjoyably (*16*, p. 190) and therefore as having a negative impact on the utility associated with mode choice. Travel-time savings are accordingly accounted for on the positive side of mode evaluation (e.g. *17*). On the other hand, various studies suggest a subjective value of time, depending for instance on the activities performed during the trip, influencing the perceived usefulness of the travel-time (e.g. *18*, *19*). Recently, a growing body of research is devoted to influencing factors for travel-time valuation that take into consideration the value of commuting in company (*13*), the importance of commuting time as a transitional phase between work and leisure (*20*), traveling in cars as places of retreat or “*cocoon*” (*21*, p. 105, *22*) or even as “*sanctuary escape from the world*” (*19*, p. 702), family quality time (*23*), etc. Furthermore, the digital information age allows for a more flexible and extensive use of time while traveling (*15*).

Automated driving is supposed to lead to radical changes in the valuation of travel-time and also to new possibilities of engaging in activities while traveling. However, empirical examination has hardly yet taken place, leaving unclear how travelers would spend their time in fully automated vehicles and how this would contribute to specific perceptions and evaluations of different transport modes in the future. The following survey aims at bridging that gap and includes detailed information on respondents’ present travel-time use and valuation, their attitudes towards different modes of transport as well as perspectives on a future with automated vehicles.

A USE-CASE-DRIVEN STUDY ON AUTOMATED VEHICLES

Including automated vehicles in transport research requires specifying how the implementation of these systems may influence everyday mobility. This depends strongly on specific usage contexts – and on the advantages that they might offer in comparison to means of transport that are available today. Although there have been a rising number of studies that deal with attitudes towards, and acceptance of, automated driving, they rather focus on specific automated driving functions (e.g. automated parking) (e.g. *4*, *6*, *7*, *24*). Presenting practical applications, the explanatory validity of examinations could be enhanced with respect to benefits and consequences. The following study is part of a multi-disciplinary joint German and US-American project, funded by the Daimler and Benz foundation, where specific use cases were identified to “describe typical usage scenarios for autonomous driving” (*25*, p. 3). Although the selection is not exhaustive, the four use cases represent proxies of fully automated applications that cover the range from human driver + automated functions to no human driver allowed any more. The following section describes the use cases and gives an overview of expectations and assumptions as they are currently found in the literature, with particular focus on altered time use.

Use case 1: Highway pilot

The vehicle is able to take over the driving task “exclusively on interstates or interstate-like expressways”, managing “navigation, path tracking, and control” as well as the “safe handover” (*25*, p.17). It is capable of executing all driving tasks whenever in automated driving mode – and does therefore not require any situational awareness by the driver during that time. Two main benefits from an individual user perspective are 1) the relief of tasks that are often regarded as stressful (monotonous driving for long time periods, traffic jam or road work scenarios with exhausting braking and accelerating tasks) (cf. *4*) and 2) the possibility of spending time that was formerly tied to concentrating on the driving task in a different – potentially perceived as more worthwhile – way. Further benefits might be increases in safety (by minimizing the risk of accidents) and efficiency (by fluidizing traffic flow) – both could decrease travel-time.

Whereas today mostly public transport usage offers the possibility of spending time actively while traveling, a future with highway pilots could have significant impacts on the use of cars on long distances offering the same advantages as trains without having to share the space with other, unknown, passengers.

Use case 2: Valet parking

The vehicle is able to “re-park” itself after driver, passengers and cargo have got out and to return automatically “from the parking location to a desired destination” (*25*, p. 18). As the vehicle “can be privately owned, but might as well be owned by a carsharing provider or similar business model” (*25*, p. 19), this use case could show significant impacts on car ownership rates: decreased access effort would potentially increase comfort and the number of persons using shared vehicles, especially in inner-city regions (*1*, *7*).

In a recent survey, two-thirds of the respondents declared that they would want to use this automated function– the number was even higher if the respondents lived in dense urban spaces (cf. *24*). Benefits for users are therefore obvious: automated valet parking could help to ease time and parking pressures that often occur in areas where space for private parking is limited, cost-intensive and also frequently combined with long ways to and from the parking location. The function would facilitate the carrying of children and cargo, and make the use of cars easier for people with mobility constraints. Parking search traffic would be minimized substantially with positive effects on inner-city traffic and reduction of travel-time.

Use case 3: Fully automated vehicle

The driver can hand over the driving task to the vehicle whenever desired and “pursue other activities” (*25*, p. 17). There might be a decrease in inhibition thresholds for inexperienced, insecure or elderly drivers that would lead overall to rising car use and ownership rates as well as a decline in the use of public transport modes (cf. *1*, *3*). If a driver’s license is still required for these types of vehicles, though, predictions on possible impacts on car use and ownership rates become more difficult.

From the individual user’s perspective, increased safety as well as changing travel-time valuation might be important benefits. Benefits could especially apply for commuters that normally don’t drive ‘for fun’ (i.a. *1, 6)* – time onboard could be spent more productively or more meaningfully. This could have significant impacts on the transport system (see above) but also on future land use: if positive travel-time valuation increases, people could tend to accept longer commuting distances, live in the suburbs, or even in rural areas, while working in the city.

Use case 4: Vehicle-on-demand

The vehicle executes the driving task "in all scenarios with occupants, with cargo, but also completely without any payload" and could be made "available at any requested location" (25, p. 22). Passengers can only enter destination input or press a safe execute 'button' and, as a result, there won't be a driver cockpit anymore. This use case implies large-scale changes in the overall transport system. It allows for individual, flexible and comfortable mobility. The vehicles could bring car ownership rates down radically and lead to a car-sharing boom (*26*, *7*). This would have significant impacts on land use, as parking space could be freed for alternative use.

Vehicles-on-demand could help to provide seamless use of transport means and therefore increase multimodal behavior. But it could also serve as a rival to public transport, increase VMT and the use of cars on the streets dramatically (see i.a. *1, 27*). Land use consequences could therefore be analogous to the fully automated vehicle. Overall, the numerous implications are hardly foreseeable to-date and developments could go in various directions.

STUDY DESIGN AND CORE ATTRIBUTES

The focus of recent empirical work on automated driving (cf. *4*, *6*, *7*, *24*) is usually on general attitudinal and acceptance issues, experiences with driver assistance systems, desired assistance or convenience functions. The studies rarely account for differentiation of the possible heterogeneous variants of automated driving and are not aimed at providing insights on behavioral changes or prospective application situations. We therefore conducted a survey which differentiates automated driving between the use cases described above and focuses on attitudes and anticipated uses of the respondents.

The online survey was collected in 2014 via an online market research panel where respondents were compensated financially for their participation. It was stratified by gender, age, income and education to receive a nearly representative sample for the German population. It consisted of 1,000 completed questionnaires. The first section of the questionnaire included information on the socio-demographics of the participants, as well as their level of knowledge and interest in the topic of automated driving and previous use of driver assistance systems. Subsequently, the current use of, and attitude towards, the available transport modes were collected. Additionally, the respondents were interviewed on their usual time use when traveling by car, long-distance train and public transport. In this paper, 'public-transport' (PT) is hereafter to be understood as urban rail and metro systems, buses and trams whereas 'train' is understood as long-distance services of 100 km distance and more.

In the second part of the survey, participants were asked detailed questions to one randomly selected use case (250 cases for each use case). Questions addressed anticipated use and deployment purposes, prospective substitute transport modes, perceived usefulness and expected changes in time use. Furthermore, attitudes towards the described vehicle, the respective need for intervention, and different aspects of design requirements were also asked for. TABLE 1 contains an overview of the socio-demographic characteristics of respondents and the sample structure.

TABLE 1: Key characteristics of the data set

Attribute	Level	Percent
Gender	female	56%
Age (years)	18-29	9%
	30 - 49	34%
	50 - 64	32%
	65+	26%
Children under 18 in the HH	no	76%
Highest educational level = High school degree	yes	30%
Highest professional qualification = University degree	yes	18%
Occupational status	full-time (>= 35 h/w)	32%
	part-time (18-<35 h/w)	13%
	other	55%
Household net income (Euro)	< 900	7%
	900-<1500	18%
	1500->2000	15%
	2000 - < 2600	14%
	2600 - < 3600	19%
	3600+	28%
Driving license	yes	90%
Rail card	Yes	9%
Number of cars in the household	0	13%
	1	52%
	2	29%
	3+	7%
Annual car mileage as driver (km)	< = 5.000 km (8.050 mi)	17%
	5.001 – 10.000 km (8.050 – 16.100 mi)	32%
	10.001 – 15.000 km (16.100 – 24.150 mi)	28%
	15.001 – 20.000 km (24.150 – 32.200 mi)	12%
	+20.000 km (32.200 mi)	12%
Usual car usage (driver)	(almost) daily	55%
	1-3 days a week	23%
	1-3 days a month	5%
	less than monthly	5%
	(almost) never	12%
Usual car usage (passenger)	(almost) daily	6%
	1-3 days a week	25%
	1-3 days a month	23%

	less than monthly	28%
	(almost) never	18%
Usual train usage (>=100 km)	(almost) daily	0%
	1-3 days a week	1%
	1-3 days a month	6%
	less than monthly	46%
	(almost) never	47%
Usual public transport (PT) usage	(almost) daily	14%
	1-3 days a week	10%
	1-3 days a month	18%
	less than monthly	30%
	(almost) never	29%

Descriptions of the use cases contained the core aspects of the scenarios but were deliberately kept short to allow the survey participants space for their own interpretations.

General results

A majority of the respondents (57%) declared general interest in automated driving. However, 44% said that they don’t have any knowledge of the topic at all and only 4% stated they are well or very well versed, or consider themselves as experts. Most often (78%), people come back to mass media when they want to get information on automated driving – almost two-thirds (64%) said they turn to experts (defined as dealer and service provider in the questionnaire), 56% talk to friends or colleagues and 40% seek exchange on social media platforms.

A vast majority (62%) would not want to hand over the complete vehicle operation and almost two-thirds would prefer to see themselves rather in the role of a supervisor (64%) than in the role of a passenger when driving in an automated vehicle. A question in the first section of the survey addressed the general willingness of respondents to replace their currently preferred mode of transport with an automated vehicle (which at this time was not further specified). In the further course of the survey, they were asked again whether they could imagine replacing their preferred mode of transport with an automated vehicle – this time after they had been introduced to any one of the four use cases. The answers towards the first question (automated vehicle in general) were quite undetermined: 59% declared they could “somewhat” or “somewhat not” imagine replacing their preferred means of transport by an automated vehicle, and only 27% rejected it. For the specific use cases (e.g. vehicle-on-demand), the respondents’ reactions were less indifferent and also more negative – 54% for example rejected a vehicle-on-demand (see Figure 1).

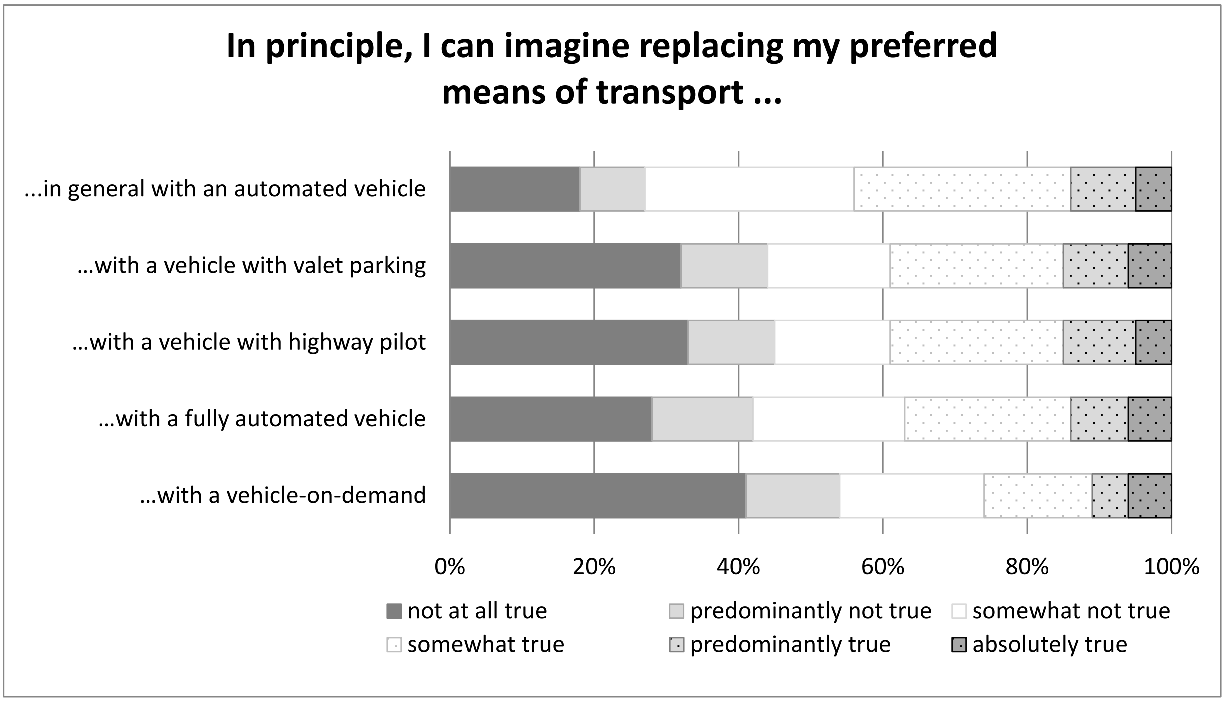

FIGURE 1: Stated willingness to replace the mode currently preferred with an automated vehicle

Results regarding present and future travel-time use

In order to obtain a first glance at possible implications of automated vehicles regarding the way people would spend ‘mobility time’, the questionnaire included questions on their current and anticipated future time use. The survey first asked which activities they were generally engaged in when traveling by public transport, long-distance train or car.
FIGURE **2** presents the results for the activities conducted while traveling by train and car. Time use in public transport resembles the one in trains and is only reported in written form.

By far the most mentioned activities pursued in public transport and trains were enjoying the landscape and the journey as well as conversing with companions or other passengers. 50% of the public transport users and two-thirds of the train users reported frequently or always enjoying the ride. Frequently or always using the time for conversations were 42%, 49% respectively. This is followed by listening to music, reading or relaxing as oft-mentioned activities. The answers thus appear to be in line with the findings reported by Lyons et al. (2007) for the activities conducted by British rail passengers (*28*): according to their study, window gazing was – especially on short trips – the most mentioned activity on train trips.

A notable 77% and 69% of respondents say they never work in short- or long-distance transport respectively, contrasted with almost 6% and 8% of respondents that work often or always when traveling by public transport or train. The answers differ – particularly on the train – statistically significantly by gender, income, education level, household size and the presence of children in the household (differences are listed subsequently as statistically significant when reaching a Pearson value of 0.05 or lower in a chi-square test). Thus 74% of women, but only 63% of men, reported never working in the train. Also, the probability of working often or always on the train is, at 10%, twice as high for people with a net household income of more than 2.600 Euros per month as in the group with a net household income below 2.600 Euros. Employment status proves to be statistically not significant. Our findings correspond well with the work of Gardner and Abraham, who reported on commuting activities that "[…] p*articipants tended to neglect the potential for journey time to be used productively* […]" (*16*, p. 190).

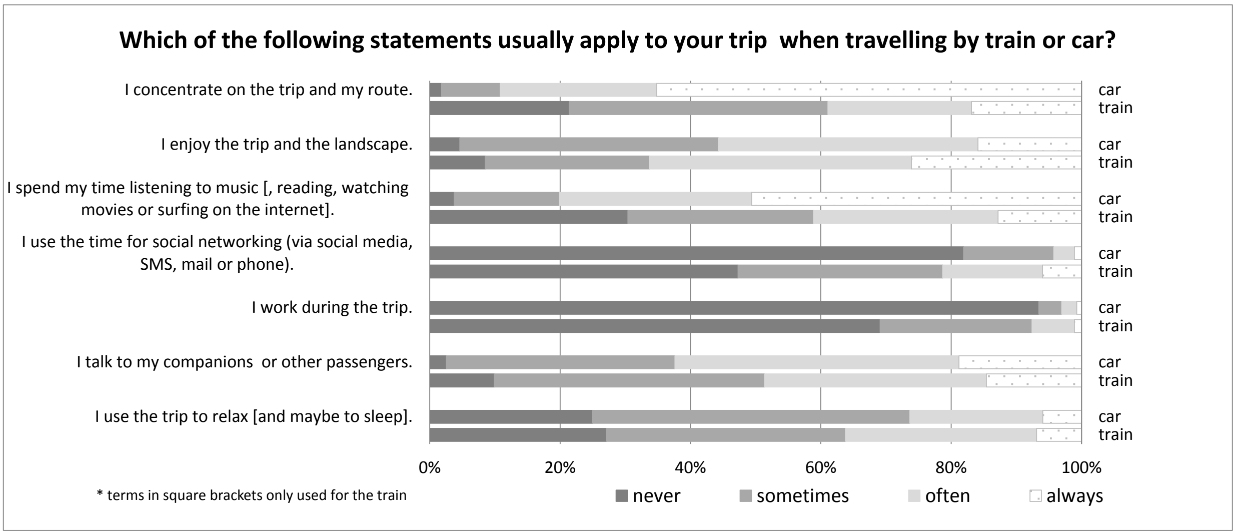

FIGURE 2: Usual time use when traveling by car (N=824) and train (N=1.000)

Focusing on the ride and the route is naturally the main activity in the car. Around 80% of the car drivers are meanwhile often or always listening to music, about two-thirds chat with their passengers. More than half of the respondents stated that they often or always enjoy the ride and the scenery while driving. Lastly, 7% of the car drivers reported to at least sometimes work in the car.

Subsequently, respondents were asked about perceived advantages of the different automated vehicles in the scenarios. FIGURE 3 shows the results for the highway pilot as well as the fully automated vehicle and the vehicle on demand. Except for the opportunity to talk with fellow passengers, answers show strong statistically significant differences between the highway pilot and use cases 3 and 4 (fully automated vehicle, vehicle-on-demand), thus indeed indicating a perceived distinction of the scenarios by the interviewees. The particular advantages most respondents could agree with were the enhanced possibility of enjoying the trip and the landscape as well as the chance of talking to fellow travelers. In both cases, about a third stated they considered this predominantly or strongly an advantage of the fully automated vehicle.

The small proportion of those who see an advantage in the ability to work on the move is striking: only 13% of the respondents agree predominantly or strongly with the related statement. In the case of the highway pilot, this share drops below 10%. The little attraction the possibility of working in the car seems to hold is surprising when looking at the results of a German survey conducted by Autoscout24 (*24*). Here, almost a third of the respondents wished for the opportunity to use their car as a mobile office.

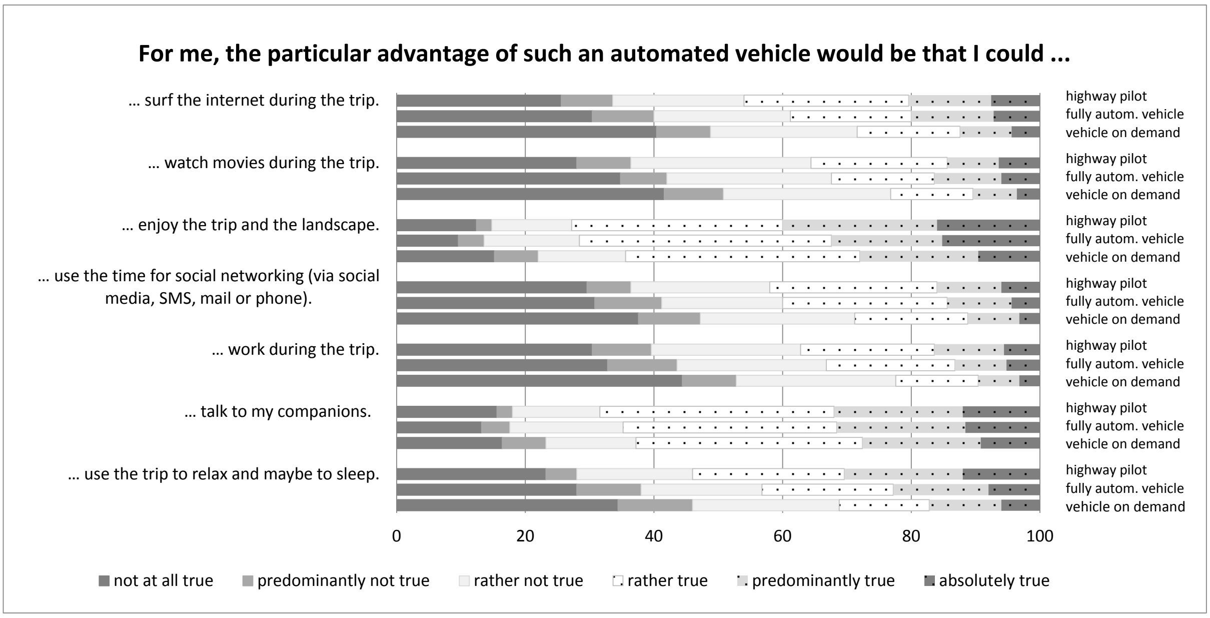

FIGURE 3: Perceived advantages of the different automated vehicles presented in the uses cases by the respondents (N=250 each)

Overall, advantages of automated vehicles were predominately identified for those activities already favored in today's conventional cars. Not having to concentrate on the driving procedure is welcomed as a possibility for having more time or less distraction, especially for window gazing and talking.

Influencing factors on the propensity of working in an automated car

In order to identify the factors influencing the decision to work in an automated car, an ordered probit model (*29*) was used. The dependent variable is the 6-step ordinal variable indicating the users' answers as to whether they considered the possibility of working a special advantage of an automated vehicle (see FIGURE 3). The independent variables are binary dummies or continuous variables (partially stemming from originally ordinal scales) of socio-demographic attributes and usual travel behavior as well as statements of mode perception and attitudes. Additionally, their current time use when traveling by public transport, train or car was used as explanatory variables.

In order to harness all observations for the analysis, we formulated a single model with use-case-specific constants for the case of the fully automated vehicle as well as the vehicle-on-demand. All independent variables (see TABLE 1and TABLE 2) are standardized to ease identifying and comparing their importance. Only the final selection of important predictors is presented here, but robustness checks with diverging predictor sets of up to all variables did not produce substantial differences in identifying important predictors. Analysis was limited to respondents using cars on a regular basis (90% of the sample). The model produces a solid result with an R-squared of .13 and five significant cut-off points that are statistically different from each other. Detailed results are presented in TABLE 3. Significant p-values are marked with one up to three stars indicating a significance niveau of $p<0.1$, $p<0.05$ and $p<0.01$, respectively.

TABLE 2: Independent variables used additionally to those presented in table 1 for probit model analysis

Variable	Scale type
Subject area: travel behavior	
Usual usage of: car sharing	ordinal 1-5 (c)
Usual usage of: ride sharing	ordinal 1-5 (c)
Subject area: mode perception	
Driving means above all relaxation for me.	ordinal, 1-6 (a)
I admire people who set up their everyday lives so that they do not own a car anymore.	ordinal, 1-6 (a)
Through the use of the car I can save a lot of time.	ordinal, 1-6 (a)
I can organize my everyday life without a car very well.	ordinal, 1-6 (a)
On driving a car I like that it is comfortable.	ordinal, 1-6 (a)
The car is the cheapest means of travel for me.	ordinal, 1-6 (a)
For ecological reasons, I feel obliged to do without the car in everyday life as often as possible.	ordinal, 1-6 (a)
I just need the private space of your own vehicle.	ordinal, 1-6 (a)
For me, driving on public transport is relaxing.	ordinal, 1-6 (a)
Local public transport is the cheapest means of travel for me.	ordinal, 1-6 (a)
I appreciate the public transportation because there is usually something interesting to watch.	ordinal, 1-6 (a)
For environmental reasons, I find it useful to use public transport.	ordinal, 1-6 (a)
For me, the public transportation is not very attractive, because I do not know if I can find a free seat.	ordinal, 1-6 (a)
Public transport is a safe means of transport for me.	ordinal, 1-6 (a)
How important is social reputation when choosing your means of transport?	ordinal, 1-6 (d)
How important are costs when choosing your means of transport?	ordinal, 1-6 (d)
How important is time when choosing your means of transport?	ordinal, 1-6 (d)
How important is comfort when choosing your means of transport?	ordinal, 1-6 (d)
How important is independence when choosing your means of transport?	ordinal, 1-6 (d)
How important is stress avoidance when choosing your means of transport?	ordinal, 1-6 (d)
Subject area: current time use	
I use the trip to relax and maybe to sleep.	ordinal, 1-4 (e)
I talk to my companions or other passengers.	ordinal, 1-4 (e)
I work during the trip.	ordinal, 1-4 (e)
I use the time for social networking (via social media, SMS, mail or phone).	ordinal, 1-4 (e)
I spent my time listening to music, reading, watching movies or surfing on the internet.	ordinal, 1-4 (e)
I enjoy the trip and the landscape.	ordinal, 1-4 (e)
I concentrate on the trip and my route.	ordinal, 1-4 (e)
Subject area: automated driving	
In principle, I can imagine replacing my previous preferred means of transport by	ordinal, 1-6 (a)

an automated vehicle.	
How would you rate your personal knowledge on the subject of "Automated Driving"?	ordinal, 1-6 (b)
I am interested in the subjec of "Automated Driving".	ordinal, 1-6 (a)

a: 1) not at all true 2) predominantly not true 3) rather not true 4) rather true 5) predominantly true 6) absolutely true
b: 1) no knowledge 2) heard of already 3) read some articles 4) well acquainted with the topic 5) very knowledgeable 6) expert
c: 1) (almost) never 2) less than monthly 3) 1-3 days a month 4) 1-3 days a week 5) (almost) daily
d: 1) highly unimportant 2) very unimportant 3) rather unimportant 4) rather important 5) very important 6) highly important
e: 1) never 2) sometimes 3) often 4) always

TABLE 3 : Results of an ordered probit model for considering the possibility to work as an advantage of automated vehicles

Variable	Coef.	Std. Err.	Significance
Socio-demography			
Female	-0.233	0.047	***
ln (Age)	-0.084	0.054	
Children in HH	0.089	0.047	*
Rail card	-0.113	0.047	**
3+ cars in HH	0.140	0.048	***
Annual car mileage (km) 10k+	-0.089	0.049	*
Usual travel behavior, attributes of modes and mode perception			
Regular mode: car (driver)	0.133	0.051	***
Regular mode: car (pass.)	-0.091	0.048	*
Regular mode: train	0.106	0.051	**
Importance: Image	0.103	0.046	**
Importance: Time	0.133	0.048	***
PT trips are relaxing	-0.157	0.061	***
PT is cheapest for me	0.093	0.056	*
PT makes sense for ecol.	0.164	0.056	***
PT is a safe & secure mode	0.122	0.061	**
Actual time use			
PT time use: work	0.249	0.055	***
PT time use: landscape	0.208	0.056	***
Train time use: work	0.144	0.056	***
Train time use: digital comm.	0.129	0.054	**
Train time use: landscape	-0.108	0.057	*
Car time use: landscape	-0.101	0.051	**
Use case differentiation			

Use case fully automated vehicle	0.156	0.048		***
Use case vehicle-on-demand	0.269	0.048		***
Cut-off Points	**Value**	**Std. Err.**		
cut1	-0.359	0.058		
cut2	-0.091	0.057		
cut3	0.718	0.062		
cut4	1.569	0.080		
cut5	2.331	0.115		
Ordered probit regression	Number of obs	=	624	
	LR chi2(23)	=	247.98	
Log likelihood = -853.49691	Prob > chi2	=	0.0000	
	Pseudo R2	=	0.1268	

Usual socio-demographic attributes show little relevance for the answering scheme. Whereas women are substantially less likely to view the option of working positively, neither employment status nor educational level and household income have a significant influence. The (logged) age of the respondent shows a slightly diminishing effect on the dependent variable but is not highly significant (p=.116). The presence of children in the household has a slightly positive effect on the likeliness of working in automated cars. Whereas the number of cars in the household did not show significant continuous impact on this dependent variable, being a member of a household with a high car ownership rate (3+ cars) does have a strongly positive impact. Ownership of a rail card, as well as an elevated annual car mileage, both being proxies for a generally high level of traffic participation, exhibited a statistically significant negative impact.

We then looked to see if respondents habitual travel behavior helped to predict if they would welcome the option of working in an automated vehicle. Those who used cars or trains frequently proved to be more likely to do so. Often being a car passenger, though, reveals a negative impact on this dependent variable. No significant impact was found in relation to using public transport, bikes, car pooling and car sharing.

Next, we analyzed variables related to the perception of cars and public transport. None of the car-related perception items (pleasure of driving, exhibiting driving expertise, car as a place of relaxation/comfort) were found to have a statistically significant impact. Variables indicating a rational, ecologically-oriented attitude towards public transport, though, affected the dependent variable positively. In contrast, considering public transport trips relaxing had a negative impact.

In the survey, we examined the importance of fulfilling specific needs, such as independence, balancing stress-freedom, cost, safety, comfort or eco-friendliness when choosing a transport mode. All dimensions mentioned, as well as driving experience, proved insignificant; exclusively a focus on time and image aspects show a positive impact on seeing the possibility to work as an advantage of automated vehicles.

The stated current time use exhibited strong explanatory power. While time use when traveling by car did not prove relevant, with the exception of enjoying the trip and the landscape, active time use in train and public transportation is highly correlates with the outcome of the dependent variable. The more frequently respondents spend time working - especially in public transportation but also in long-distance trains - the more likely they are to consider working possibilities as an advantage of automated vehicles. The frequency of time use on trains for social networking showed further positive impact. The latter was of no significance on shorter rides with public transport, though. The frequency of using time on either mode for relaxing and sleeping, reading, listening to music or even talking to companions appears irrelevant. Also, the frequency of using time for concentrating on the trip and the route showed no significance. How often people spent time enjoying the trip and the landscape had a significant impact in all three modes – with the impact being highly significant and positive in the case of public transport and with a negative effect for train and car use.

Neither interest in or acquaintance with automated driving, nor being open minded towards replacing the current transport mode, showed a statistically significant impact on seeing the advantages of altered time use. Despite the discussed similarity between the three use cases and their associated predictors (which remain mostly the same, as our robustness checks confirmed), the two use-case-specific constants show substantial differences in the absolute level of the dependent variable. The probability of welcoming the option of working is, compared to the base case (the highway pilot), substantially higher in the case of the fully automated vehicle, and especially the vehicle-on-demand – the two use cases explicitly involving urban context.

CONCLUSION AND OUTLOOK

A use-case-driven evaluation of the possible implications of fully automated driving is gaining importance, especially with regard to future user perspectives. The online survey that was carried out emphasized the significance of differentiation: When respondents were asked whether they could imagine replacing their preferred means of transport with an automated vehicle, approval ratings varied strongly depending on a non-specific question or the introduction of specific use cases.

The notion of wasted, unproductive time being turned into economically valuable time is one dominant argument in the debate on automated driving. The way people will spend their time while traveling in future might not only affect the valuation of different transport modes but also the distances travelers are willing to overcome. This may possibly have radical impacts on the transport system as well as on land use. Therefore, the study focused on current and potential future time use.

Currently, listening to music, talking to passengers and enjoying both the trip and the landscape are activities people are engaged in most often while driving. The latter is also the most prominent activity on train and public transport rides. Working while traveling, in current time use, plays only a minor role – which is not only due to the fact that people might not want to spend their time working while traveling but also to the fact that there are various jobs where work-related activities cannot be executed while en route. Focusing on prospective time use, the survey was therefore able to verify that the underlying assumption of people wanting to spend their time ‘productively’ while traveling, if only they could, has to be regarded with caution. When asked what they considered to be the advantages of fully automated vehicles, only a minor share explicitly declared working while traveling to be a benefit. Instead, respondents favored activities for automated driving that they already prefer today in conventional cars – e.g. window gazing, conversing or listening to music.

The factors influencing the propensity to regard potential ‘freed’ time to work in an automated vehicle as an advantage of the future technology were examined by means of a probit model. Current time use in particular was identified as an important predictor of the perception and evaluation of potentially being able to work while traveling in an automated vehicle – simply put, respondents that report work as frequent activity during their trips to date are more likely to wish to work in an automated vehicle in the future. On the other hand, the more people spend their time enjoying the landscape on longer trips today, the less likely they are to imagine spending their time working in the future. Frequent travel by car or public transport has a positive effect on this perception – regardless if people enjoy driving a car or not. Furthermore, factors that could be attributed to a ‘tight time regime’ gained almost no significance: while male respondents showed a slightly higher likeliness of wanting to work, no correlation could be stated for income and full-time occupational status – only if time was considered to be an important factor concerning mode choice, positive effects were identified.

The similarities between current and future time use patterns could support the assumption that people considered time spent at current activities adequately invested, thus perceiving that “[t]*ime in the car […] is not necessarily time that is lost*” (*21*, p. 104) but possibly associated with a positive utility in itself (*32*, *19*). Time available in a fully automated vehicle, therefore, may not be so much regarded as a future “[…] *gift, that I can use just for myself*” (*30*, own translation). In contrary, people might already now perceive their time as spent in a subjectively meaningful way and experience travel as “*a gift rather than a burden*.” (*31*, p. 81) This notion is also supported by others: Mokhtarian and Salomon found out that about a third of their respondents stated they used their commute time productively, while almost half disagreed with the statement that their travel-time was generally wasted time (*19*). Similarly, Lyons showed in his study that only 13% of respondents considered their time as wasted whereas 30% stated they made very worthwhile use of their travel-time (*32*). In an earlier paper, Lyons et al. were able to indicate that commuters are more likely to consider their travel-time as wasted than people traveling for leisure or business reasons (*28*), indicating that repetitive traveling might rather be a source of considering time as wasted.

Another possible way of interpretation might be though, that many current car users or users of the transport system in general, still only have a vague idea about specific benefits that automated driving could bring. Peters and Dütschke, in their study on the acceptance of electric mobility, suggested that attitudes towards new, little-known systems are in general difficult to assess and therefore rather based on previous mobility patterns (*33*). This not only demands for an even more-specific identification and specification of use cases of automated driving when analyzing potential impacts. The results also emphasize the necessity of both empirical as well as analytical work allowing for a more detailed examination of the perception and valuation of travel-time. This also gains importance in relation to transport modelling as “[i]*mproving our forecasts of travel behavior may require viewing travel literally as a ‘good’ as well as a ‘bad’(disutility)*” (*19*, p. 695, *15*). In this context “*simply knowing what people are doing is not enough*” (*32*, p. 2) as the perception of having time spent worthwhile is depending on the type of journey, and particularly on the individual und her/his specific needs.

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