User Acceptance of Fully Autonomous Public Transport

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Keywords: Fully Autonomous Driving, Public Transport, Unattended Train Operation, User Acceptance.

Abstract: The development of fully automated vehicles is becoming more and more present in the social discussion. The image of fully automated cars is determined by automobile manufacturers and placed in the context of individual traffic. In contrast to fully autonomous private cars, fully automated public transport is already operating in some cities and is to be expanded in the future. Autonomous public transport offers great potential for the development and promotion of sustainable mobility concepts. However, the user acceptance is important for the enforcement and widespread use of these technical innovations. An online study on the acceptance of fully automated public transport based on quantitative data of a sample of N = 201 is presented. The results show a high level of familiarity with the topic and a very high level of overall intention to use fully automated public transport in the future.

1 INTRODUCTION

Autonomous driving is currently on everyone's lips – when it comes to the automotive sector. Until now, this development has mainly been linked to individual traffic. Driverless public transport plays a minor role in current research and development. In contrast to the fully autonomous car, fully autonomous buses and trains are already on public roads. In the Swiss town of Sitten autonomous buses have been in operation since 2016; people can also use autonomous buses in Lyon (France) and Michigan (USA). The buses have already traveled more than 50,000 kilometers and have transported 100,000 people. Driverless rail-bound trains and trams have been in operation for a considerably longer time, e.g. railway shuttles on airport grounds such as the Skyline at Frankfurt Airport (Germany, since 1994) or the subway in Paris (France, since 2012), Vancouver (Canada, since 1986) and Singapore (since 2003).

Public transport is an important part of urban mobility, as it relieves congestion in cities. But still, the private car is the most popular and most used means of transport, and its automation will probably increase its popularity, to the detriment of many forms of public transport. Automating the private car will cause many disadvantages that exist in the non-automated car to disappear: Users will not have to control the car themselves, or find a parking space and can spend their travel time with other activities such as sleeping, reading, etc. – aspects that, so far, are competitive advantages of public transport. These exclusive features of public transport will thus be eliminated by the automation of the car and therefore have initially contra-productive effects for public transport. Resultingly, existing public transport business models are increasingly under pressure and have to be questioned and rethought. And, in particular, while it is true that high-performance public transport systems (high-speed railways) will remain advantageous over autonomous vehicles in terms of performance, travel time and reliability, this does not apply to bus and rail transport outside the main axes or in medium-sized cities (VDV, 2015).

On the other hand, the automation of public transport also opens up new opportunities and could increase competitiveness. The advantages of fully-autonomous public transport include a lower error and accident rate, greater availability through reduced dwell times and shorter headways, and increased punctuality. Moreover, passenger transport costs could probably drop and passengers would not have to suffer from staff strikes. These advantages would make traveling on train and other forms of public transport more attractive and lead to an increase in passengers.

The fact that autonomous driving in public transport has not yet been able to spread further despite the advantages is primarily a result of the high investments in a fitout or conversion. Existing

Pakusch, C. and Bossauer, P.
User Acceptance of Fully Autonomous Public Transport.
DOI: 10.5220/0006472900520060
In *Proceedings of the 14th International Joint Conference on e-Business and Telecommunications (ICETE 2017) - Volume 2: ICE-B*, pages 52-60
ISBN: 978-989-758-257-8

systems, rails and stations would have to be reconstructed. This is why new projects and closed systems are particularly suitable for automation. First successful conversions of existing systems show that automation can be achieved more cost-effectively and more smoothly than previously expected (UITP, 2012).

In addition to the development of existing business models, new disruptive models are also being discussed. Fully autonomous vehicles, such as autonomous taxis or autonomous car sharing, can be used as public transport. These shared autonomous vehicles could strengthen public transport by overcoming the "last mile" and are also an alternative to owning a private car. Both the available and disruptive business models offer the opportunity to make traffic more sustainable and to reduce the number of private cars, which is currently rising and leading to increased congestion, especially in large cities. Mobility could be realized with fewer and more efficiently operating vehicles, whereby car traffic would decrease and public transport would increase (VDV, 2015).

The question therefore arises as to whether a combination of automated driving and public transport is a flexible and efficient transport solution that can also make public transport attractive to former non-customers. An important factor for the successful implementation of such a concept is the acceptance of new technologies. Therefore, the present study examines whether the use of autonomous vehicles in public transport is accepted by existing and potential customers. A survey was conducted on the attitude towards autonomous public transport. The survey results are presented and discussed below.

2 FULLY AUTONOMOUS DRIVING

In general, fully autonomous driving (FAD) is understood as the autonomous, targeted driving of a vehicle in real traffic without the driver's intervention (SAE International, 2016). Public transport includes both local public transport services with buses and smaller vehicles that are not rail-bound and local rail-bound services. For both areas, international standards of full automation have been defined. According to the J3016 standard (SAE International, 2016), six levels of automation can be distinguished for road traffic: no automation (0), driver assistance (1), partial automation (2), conditional automation (3), high automation (4) and the last stage of full automation (5).

Similarly, the International Association of Public Transport (UITP) defines five grades of automation (UITP, 2012). Level 0 describes conventional on-sight train operation, as is known from ordinary roadways. Grade 1 is a combination of manual travel and train control. The driver controls the journey, starts and stops the vehicle and operates the doors. The train operation is not automated, but some parameters of the trip can be controlled via a train control. Grade 2 is semi-automatic train operation (STO). The driver triggers the start and controls the doors. Otherwise, the journey will be carried out fully automatically from the start to the stop. If necessary, the driver can immediately take over the driving control. There are already many Grade 2 automatic train operation systems. Grade 3 is the driverless train operation (DTO). There is no longer a driver, but only a train attendant instead of a constant control by a driver. The train attendant controls the doors and, in the event of an emergency, takes over control. Grade 4 is unattended train operation (UTO, or manless train operation MTO) with no staff on the train and all operations being automated. The control center can intervene in the train operation.

In the following, we refer to the fully automated systems, i.e. to level 5 of the J3016 standard in non-railbound traffic and to grade 4 of the UITP.

User acceptance is decisive for the success of technological innovations. According to Davis` Technology Acceptance Model (TAM), the actual acceptance of technology is crucial to whether a person intends to use this technology (Davis, 1989). The person's intention is, in turn, determined by perceived usefulness and perceived ease of use of that technology. Currently, fully-automated vehicles are a technological innovation that is not yet market-ready and therefore has not yet or seldom been tested by users. Exceptions are the already operating examples of fully automated trams and autonomous buses, which are in test phases. For those buses, user acceptance can only be determined a priori. An a priori acceptance analysis determines the user evaluation of a technology before the users could test the technology (Payre et al., 2014). Naturally, in assessing the new technology, the individual imaginative power of the persons interviewed plays an important role. However, it seems reasonable to expect that the intention to use a technology such as the fully autonomous public transport could be predicted to some extent by its a priori acceptability.

2.1 Private Autonomous Vehicles

In the last years, the research on fully autonomous vehicles for private individual transportation has witnessed a boost in work covering topics such as advanced driver assistance systems, connected cars or autonomous, self-driving, or driverless vehicles. Several studies have focused on particular technological issues. In addition to technical feasibility, ethical and legal aspects (Riek & Howard, 2014) as well as user acceptance play an important role. User acceptance can only be assessed by means of a priori evaluation, since the potential users can not yet gain experience with the fully automatic vehicles.

Some studies analyzed the users` a priori acceptance of autonomous cars. With regard to autonomous cars in general, a recent study by Payre et al. (2014) reveals that a large majority of the population have a positive attitude and can imagine buying and/or using autonomous cars. The literature further shows that acceptance depends on several other parameters. Studies such as the one by EY (2013) show that some respondents are afraid that the enjoyment of driving will decrease as a result of full automation and they welcome the option of taking over control whenever they want. Other factors are age and gender, individual personality, pre-experience with partly autonomous cars, characteristics of the innovation, the driving environment, and the manufacturer's reputation (Nordhoff, 2014; Rödel et al., 2014). At the same time, other studies report that people are concerned about self-driving vehicles (Howard and Dai 2014). These concerns seem to be cultural, country and gender dependent: females seem to be more concerned than males (Schoettle and Sivak, 2014).

Most studies focus on autonomous cars in general but neglect ownership as a relevant category. In particular, the surveys do not differentiate between ownership and usership models but focus on private cars only – whether explicitly or implicitly. Only a few investigations look at self-driving mobility services, e.g., self-driving taxis, in detail (e.g., Burns et al., 2013; Hars, 2015). However, such usership-oriented business models are becoming increasingly important, especially for the new generation Y that tends to use things instead of owning them. A development away from ownership towards usership in the field of mobility could lead to completely new, disruptive business models (Pakusch et al., 2016).

2.2 Shared Autonomous Vehicles

Some studies have examined shared autonomous vehicles (SAV) as a form of public private transport in more detail. These include in particular simulations of SAV fleets, which could be used in medium to large cities (Burghout et al., 2015; Spieser et al., 2014). Burns et al. (2013) find that the average SAV cost per mile is 31 percent less than the average cost of a privately owned vehicle. They calculate that all trips could be executed with a fleet of only 15% of the number of privately owned vehicles. Similar results are presented by Fagnant and Kockelman (2014) and Fagnant et al. (2015) who respectively replace only 3.5% and 1.3% of private cars through SAV. They conclude that each SAV can replace around eleven, respectively nine conventional vehicles with a reasonable wait time (one minute or less). Owczarzak and Żak (2015) develop eight different concepts of passengers' public transportation solutions based on autonomous driving and compare them with traditional forms of passenger transportation. Their results show that either the variant Autonomous Vehicle Only or the variant Combination of Buses and Autonomous Vehicle serve best as urban transportation solutions.

These simulations show that new mobility concepts in public transport can be sustainable solutions and efficient extensions to existing concepts. Acceptance studies for SAV are rare. Krueger et al. (2016) recently published a study on the preferences of potential users. They identified multimodal travel patterns to be typical characteristics of potential shared autonomous vehicle users. In addition current carsharing users are more likely to use shared autonomous vehicles with dynamic ride sharing. Results of their stated choice analysis showed that service attributes, including the given travel time, waiting time and travel cost, are significant determinants of shared autonomous vehicle use and dynamic ride sharing acceptance. As expected, respondents were willing to pay more for a shared autonomous vehicle without dynamic ride sharing than for a shared autonomous vehicle use with dynamic ride sharing.

2.3 Public Transportation

The implementation of unattended train operation (UTO) systems allows operators to increase the average speed of vehicles, to optimize the running time of trains, to shorten headways, and to reduce dwell time in stations (UITP, 2012). Although automation in public transport has progressed, the automobile industry is placing far more effort into developing autonomous cars. One reason for this is that politics is preferably promoting the automotive sector. In addition, effort and expense are involved in reconstructing existing public transport routes – not only for technical but also for financial reasons (UITP, 2012).

In contrast to private transport, some fully autonomous vehicles have been used in public for many years, especially in rail-bound public transport. However, few available studies have examined the acceptance of autonomous public transport. Since fully-automatic vehicles are already in use in public transport, some studies have, at least, deduced the user's acceptance, looking at user numbers for these systems. For example, the Copenhagen Metro is operating fully autonomously and records an increasing number of passengers. According to the Danish Transport Research Institute, a lot of users from other transportation modes have moved to the Metro since it was first established in 2002. The Metro received up to 47% of the bus passengers and up to 20% of the local train passengers during its first two years of operation. Up to 13% of the car drivers and 9% of the bicycle riders also chose to switch to the Metro in some areas during the same first two years, 2003 and 2004. The operator, The Metro Company, regularly surveys users' satisfaction. The latest satisfaction inspections showed that 98% of the users were either “happy” or “very happy” with the Metro. The satisfaction with the Metro can also be seen in the increasing number of passengers with 3.3 million passengers in 2002 to 40 million trips in 2007 (Ansaldo STS, 2016).

As another example, the fully automated Line 1 in Paris (France) carries 725,000 passengers daily. Line 14 of the Paris Metro, the first wide-gauge automatic metro in the world, serves 500,000 passengers daily. The number of passengers grew from 3.5 million in 1998 to 80 million in 2009 (UITP, 2012).

These figures show that the acceptance of rail-bound, fully automated trains is very high. Since autonomous buses have only been in test phases, there are considerably fewer user experiences in this area that can provide information on the acceptance. In Sitten (Switzerland) the SmartShuttles “Tourbillon” and “Valère” are on the road. They have traveled more than 1,000 kilometers through more than 800 laps through the old town of Sitten so far, transporting around 7000 passengers. Passengers are regularly interviewed. Some are somewhat skeptical before the trip, but after the ride most of them are very positive. The rating does not depend on the age: many travelers over 55 years are enthusiastic. The under-20s use the fully automated shuttle quite naturally as if it were a conventional bus (PostAuto, 2016). But since studies on the acceptance of autonomous vehicles have not clearly shown significant dependencies between age and intention to use such vehicles (Rödel et al., 2014; Krueger et al., 2016), we would like to examine the relationship of age and acceptance of autonomous public transport.

On the basis of the above findings, we formulate the following hypotheses, which we want to analyze:

H1: Acceptance of fully-automated public transport depends on age.

H2: Previous experience with autonomous vehicles increases acceptance of fully autonomous public transport.

H3: The acceptance of fully-automated rail-bound vehicles is greater than the acceptance of fully automated non-rail-bound vehicles.

3 METHODOLOGY

To investigate the acceptance of fully autonomous public transport, we conducted an online survey, which consisted of three parts. In the first part, the participants were briefly informed about the topic of autonomous public transport in an introductory text. They were made aware of operating examples such as driverless airport shuttles and driverless trams (Nuremberg, Germany), in order to remind them that there are already autonomous public transport services and to remind them of possible experiences. The second part began with questions related to the use of current means of transport, experiences and attitudes of the participants towards autonomous public transport and an assessment of first, the intention to use automated public transport in general and second, the willingness to use different autonomous means of transport. Answers could be given on a five-point Likert scale. We used open questions to get insights about the participants` previous experiences with and the attitudes to autonomous means of transport. Demographic data were collected at the end of the questionnaire. The questionnaire was tested in pretests for comprehensibility and revised. Subsequently, the survey was advertised in Germany in various social networks and online platforms and released from 21.11.-19.12.2016. The survey was completed by 201 participants, 49.3% of whom were female. The average age of the participants is low at only 26.2 years, and ranges from 18 to 81 years. The sample shows a disproportionate percentage of students, whose choice of transport is strongly determined by external conditions (financial budget, well-developed urban transport in cities, and presence of a student ticket at reasonable costs). This can be seen in the figures for the most frequently used mean of transport: 17.4% mainly use private cars, 49.3% use subways and trams, 21.9% mainly trains, and a further 8.5% use buses. The sample therefore uses the public transport system disproportionately highly in comparison to the general public.

4 RESULTS

4.1 Experience with Autonomous Driving

With 91%, the majority of the participants in the survey had already heard of autonomous driving. 37.1% of respondents had already tested at least one autonomous vehicle. 22.9% of the participants had experienced an autonomous train, 20.9% an autonomous tram or metro, and one respondent (0.5%) stated having been driven in an autonomous vehicle, both a bus and a car (multiple mentioning was possible here). The participants stated in a free text field that they were transported by autonomous airport shuttles at the airports in Frankfurt and Dusseldorf, the autonomous subway in Paris and the autonomous mobile Dockland Light Railway in London. Respondents who have already had experience with an autonomous vehicle (n = 76) felt safe (8.5 out of 10 points). The few participants, who did not feel safe said that they do not fully trust the electronics and programming of the vehicle and feel insecure as they cannot estimate what would happen in the event of operational disturbances or accidents. Also, a user had bad experiences when he saw people or luggage being pinched in the automatic closing doors. The most common reason for a secure feeling during the autonomous voyage was that the systems used are controlled, closed and rail-bound traffic systems where there is neither oncoming traffic nor other road users (13 entries).

"Because the train cannot deviate from the rail and the system is well secured."

"They were simple routes without any other traffic and the routes were very short. I see no reason to feel unsafe."

Some other participants consider the technique to be more reliable than a human driver (13 entries).

"The autonomous train feels just as secure as a traditional train. The system has passed many tests and has worked so far without any problems."

"Because a well-programmed computer is more reliable than any human being."

Other reasons were that participants had hardly noticed that they used an autonomous vehicle, that the journey was smooth and that they trusted the advanced technology.

4.2 Intention to Use Fully Autonomous Transport

Approximately three-quarters of the respondents (77.6%) can generally imagine using autonomous public transport regularly in the future. The characteristics gender, age and current main means of transport have no significant influence on the basic setting for or against the future use of the autonomous public transport (Pearson`s chi-square test p> 0.05). The results also do not indicate a relationship between age and the assessment of the various automated means of transport (table 1). Hypothesis 1 therefore cannot be confirmed.

The collected data show that the previous experience with autonomous transport has an influence on the willingness to use autonomous transport in the future. 88% of the interviewees, who had already experienced autonomous transport, can imagine using it in the future, while the figure for participants without previous experience is only 72%. There is a significant difference in the scores for experienced (M=0.880, SD=0.327) and non-experienced (M=0.720, SD= 0.451) participants (Contingency Coefficient: 0.184; p=0.008). There is therefore evidence that hypothesis 2 is true. The previous experience with autonomous driving also influences the evaluation of different transport modes. Participants who have already gained experience with autonomous driving have a higher willingness to use different and new transport modes than those who have no experiences with autonomous transport. An exception is in their evaluation of the autonomous car (table 1).

The interviewees see advantages, especially in the innovative and advanced technology, the expected improved flexibility, and in the higher availability of the systems, and they expect a reduction in traffic accidents. On the other hand, the interviewees see uncertainties because of their lack of experience and the high degree of reliance on technology. When the participants were asked which of the autonomous modes of transport they would most likely use on a

Table 1: Group Statistics and t-test for Equality of Means.

	Age	N	Mean	SD	Mean Diff.
Evaluation FA_Car	>= 30.0	29	3.00	1.581	.024
	< 30.0	170	2.98	1.479	
Evaluation FA_Bus	>= 30.0	29	2.83	1.490	-.178
	< 30.0	169	3.01	1.302	
Evaluation FA_Train	>= 30.0	30	3.60	1.221	-.271
	< 30.0	171	3.87	1.109	
Evaluation FA_Metro	>= 30.0	29	3.69	1.285	-.228
	< 30.0	171	3.92	1.140	
Evaluation FA_Tram	>= 30.0	29	3.69	1.228	-.088
	< 30.0	171	3.78	1.152	
Evaluation FA_Taxi/ Carsharing	>= 30.0	28	2.57	1.476	-.084
	< 30.0	171	2.65	1.339	

	Sex 0=m; 1=f	N	Mean	SD	Mean Diff.
Evaluation FA_Car	.0	101	3.38	1.475	.805 ***
	1.0	98	2.57	1.400	
Evaluation FA_Bus	.0	101	3.52	1.331	1.112 ***
	1.0	97	2.41	1.068	
Evaluation FA_Train	.0	102	4.2	1.099	.742 ***
	1.0	99	3.45	1.033	
Evaluation FA_Metro	.0	102	4.26	1.033	.775 ***
	1.0	98	3.49	1.160	
Evaluation FA_Tram	.0	102	4.15	1.066	.780 ***
	1.0	98	3.37	1.125	
Evaluation FA_Taxi/ Carsharing	.0	101	3.08	1.426	.885 ***
	1.0	98	2.19	1.118	

	Main Mean of Transport 0=PT; 1=Car	N	Mean	SD	Mean Diff.
Evaluation FA_Car	.0	159	3.05	1.500	.491 †
	1.0	34	2.56	1.375	
Evaluation FA_Bus	.0	157	3.00	1.340	.257
	1.0	35	2.74	1.221	
Evaluation FA_Train	.0	160	3.80	1.132	-.143
	1.0	35	3.94	1.056	
Evaluation FA_Metro	.0	159	3.86	1.163	-.116
	1.0	35	3.97	1.098	
Evaluation FA_Tram	.0	159	3.77	1.148	.024
	1.0	35	3.74	1.197	
Evaluation FA_Taxi/ Carsharing	.0	159	2.74	1.374	.514 *
	1.0	35	2.23	1.190	

	Experience FAD 0=no; 1=yes	N	Mean	SD	Mean Diff.
Evaluation FA_Car	.0	123	2.90	1.484	-.203
	1.0	76	3.11	1.502	
Evaluation FA_Bus	.0	122	2.70	1.290	-.716 ***
	1.0	76	3.42	1.278	
Evaluation FA_Train	.0	125	3.66	1.121	-.441 **
	1.0	76	4.11	1.090	
Evaluation FA_Metro	.0	124	3.67	1.167	-.567 ***
	1.0	76	4.24	1.069	
Evaluation FA_Tram	.0	124	3.56	1.150	-.549 ***
	1.0	76	4.11	1.102	
Evaluation FA_Taxi/ Carsharing	.0	123	2.50	1.283	-.364 †
	1.0	76	2.87	1.445	

FA = Fully Autonomous; PT = Public Transport; FAD = Fully Autonomous Driving
a) Significance: †: p ≤ .1; *:p ≤ .05; **: p ≤ .01; ***p ≤ .001;

scale from 1 (low) to 5 (high), they preferred the subway (3.89), the train (3.83), and the tram (3.77) (overall mean rail-bound vehicles: 3.83) over the autonomous bus (2.98), the autonomous private car (2.98), and the autonomous taxi or carsharing (2.64) (overall mean non rail-bound vehicles: 2.87). The use of a one-sample t-test shows that the mean value for rail-bound vehicles differs significantly from the mean value for non rail-bound vehicles (p=0.000). The results of this sample support hypothesis 3 that autonomous rail-bound means of transport are preferred to autonomous non-rail-bound means of transport.

We have additionally checked whether the assessments of the individual autonomous modes differ in the different characteristics of the participants (see table 1). In comparison to age gender plays an important role. The male respondents rate the autonomous traffic modes systematically higher (M = 3.77, SD = 1.03) than the female participants (M = 2.92, SD = 0.85, p = 0.000). Regardless of the nature of the means of transport, the willingness of men to use autonomous transport is significantly higher than that of women.

Since the use of transport means is usually marked by routines (Aarts et al., 1997), it can be assumed that existing preferences in the transport mode choice will also influence future transport mode choices. Taking account of the particular composition of the sample, which, in contrast to the total population, generally uses public transport as the main means of transport, a more differentiated discussion of the result of the preferential autonomous modes of transport is required. The review of this results shows that the preferences of users that currently use the private car as the main means of transport are partly different from the preferences of the participants traveling by public transport. Respondents currently using the private car are less likely to use an autonomous car (M = 2.56, SD = 1.38) than public transport users (M=3.05, SD=1.50; p=0.08). The car drivers also gave lower rates for autonomous taxis or carsharing (M = 2.23, SD = 1.19) than the public transport users (M = 2.74, SD = 1.37; p=0.04). With regard to the other autonomous modes of transport, car drivers do not differ significantly from public transport users.

5 DISCUSSION

The present study confirms that autonomous driving has reached a high degree of familiarity among the population. While some studies found acceptance rates for fully autonomous cars around 68% (Payre et al., 2014; Schoettle and Sivak, 2014), the willingness to use autonomous public transport in the future is slightly higher in our study with 77.6%. In particular, prior experience with autonomous transport systems positively affects user acceptance. Only a few users have had bad experiences with autonomous public transport. Our results are consistent with previous studies that have shown that prior experience with technology increases the acceptance of that technology (Burton-Jones and Hubona, 2006; Taylor and Todd, 1995). This result was evident not only in the general willingness to use autonomous public transport regularly, but also in the comparison of the various fully automated means of transport.

While there is no difference in the overall intention to use automated public transport between males and females, the results show distinct differences in the willingness to use different automated transportation means. Males are more willing to use every single one of the automated transportation means than females. These results confirm findings of prior acceptance research that has shown females have higher levels of concerns with self-driving vehicles than have males (Schoettle and Sivak, 2014). Thus females are less open-minded to the use of automated transportation means than men, regardless of the type of transport.

The fact that the participants seem to prefer rail-bound means of transport and even buses against autonomous cars and autonomous carsharing is not surprising. Since the choice of transportation modes is usually marked by routines (Aarts et al., 1997), it can be assumed that existing preferences in the choice of transportation modes also affect the choice of future means of transport. The cause of this result could lie in the car motives locus of control and sensation seeking. Studies on the adoption of Advanced Driver Assistance Systems show that locus of control and sensation seeking are character traits that influence driving behaviour when using Advanced Driver Assistance Systems (Rudin-Brown and Ian Noy, 2002; Stanton and Marsden, 1996). Locus of control is defined as the extent to which a person can control the occurrence of an event (Rotter, 1966). Sensation seeking is defined as a character trait that is looking for new experiences and stress stimuli (Zuckerman, 2014). Both properties are extremely important in the evaluation of fully automated vehicles, since users give up control over the vehicle and cannot evoke driving excitement by themselves. Driving with an autonomous vehicle can, however, be also an exciting experience for some people. Todays' users have no control over non-autonomous public transport and thus presumably no locus of control even at current levels. Sensation seeking is not a motive why users choose public transport. For the user, there is no big change when public transport will be automated. Users are passengers before and after the automation of the public transport, in both cases the user have no contact to the driver. This is different in the case of cars, which users previously controlled themselves, an activity now done by the car itself. Through the automation of cars, the user's role changes from a driver to a passenger. In this respect, drivers appreciate the possibility to have the locus of control and sensation seeking. Both aspects are lost in fully autonomous vehicles. From the point of view of users, the automation of cars leads to a substantially greater change than the automation of public transport. This could be a reason for the poor rating of autonomous cars and autonomous carsharing. For an accurate assessment, it would be important to investigate the motifs locus of control and sensation seeking within the context of a further study. As the participants were asked which means of transport they were most likely to use, and not to which they would convert completely, the evaluation of the participants might also be understood to mean that drivers would retain their previous car and would only use the autonomous public transport as a supplement.

In contrast, public transport users rate the autonomous public transport not significantly higher. This result could indicate that public transport users are also latent car drivers and appreciate locus of control and sensation seeking on passenger cars and cannot imagine doing so without a car.

Considering all results, it is important to note that the study is not representative in terms of age and the current use of transport; therefore the results are not directly transferable to the whole population. In addition, it should be noted that the survey was carried out in Germany and that the German public transport system certainly differs from the public transport of other countries in various aspects. Such differences may also affect the participants` assessment of future concepts. Nevertheless, the study provides interesting and important insights into the groups of young and well-educated individuals, who will be an important target group in some years, following the progressive automation of public transport. In addition, the group of young people who are still in training is a group whose traffic behavior has not yet been consolidated and can therefore be influenced. The study thus makes an important contribution to the exploration of the user acceptance of autonomous public transport systems.

5 CONCLUSION AND IMPLICATIONS

Modern societies are mobile societies characterized by highly individualized lifestyles. This mobility is facilitated by transport systems, with cars being the main means of transport. In this context, autonomous driving is currently one of the major research and development activities. A major challenge to the development of these transport systems is their implementation as they involve a great investment for public transport operators. For new transportation lines, automation costs have a relatively low comparative weight within the overall budget (UITP, 2012). It is true that investments in the expansion of the public transport system are very high. Existing examples such as Paris` Line 1 demonstrate that it is possible to convert high capacity lines without service interruption. To minimize impact, conversion projects should be at the end of the life cycle of the existing equipment. In addition to technical feasibility, ethical and legal aspects (Riek and Howard, 2014) as well as user acceptance play important roles. Recently, the a priori user acceptance of autonomous cars and autonomous taxis has been investigated in various studies (EY, 2013; Krueger et al., 2016; Payre et al., 2014). There are hardly any studies on the acceptance of autonomous public transport. This paper should close this gap.

Autonomous public transport offers great potential for the development and promotion of sustainable mobility concepts. Our study has shown that autonomous driving is well known among users and that some users have already experienced autonomous traffic systems in the past. It also shows that the willingness to use the autonomous public transport in the future is high among the participants. Approximately three-quarters of the respondents (77.6%) can imagine driving regularly in the future with autonomously moving public transport. Previous experience with autonomous transport has a positive influence on the acceptance of autonomous public transport. Policies and research should allow users access to autonomous public transport even in test phases so that users can have positive experiences. Particularly at a young age and in phases of the so-called windows of opportunity, which can lead to a change in the mobility behavior, users can thus develop routines and develop long-term sustainable mobility behavior.

ACKNOWLEDGEMENTS

The authors thank Claudia Wirth, Lorena Thiel and Rebecca Nyßen for helping to develop and distribute the online survey. The research project 'CAR-Bits' (FKZ 01MD16004D) is funded by the German Federal Ministry for Economic Affairs and Energy.

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