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Research Article

Acceptance of Driverless Vehicles: Results from a Large Cross-National Questionnaire Study

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Shuttles that operate without an onboard driver are currently being developed and tested in various projects worldwide. However, there is a paucity of knowledge on the determinants of acceptance of driverless shuttles in large cross-national samples. In the present study, we surveyed 10,000 respondents on the acceptance of driverless vehicles and sociodemographic characteristics, using a 94-item online questionnaire. After data filtering, data of 7,755 respondents from 116 countries were retained. Respondents reported that they would enjoy taking a ride in a driverless vehicle (mean = 4.90 on a scale from 1 = disagree strongly to 6 = agree strongly). We further found that the scores on the questionnaire items were most appropriately explained through a general acceptance component, which had loadings of about 0.7 for items pertaining to the usefulness of driverless vehicles and loadings between 0.5 and 0.6 for items concerning the intention to use, ease of use, pleasure, and trust in driverless vehicles, as well as knowledge of mobility-related developments. Additional components were identified as thrill seeking, wanting to be in control manually, supporting a car-free environment, and being comfortable with technology. Correlations between sociodemographic characteristics and general acceptance scores were small (<0.20), yet interpretable (e.g., people who reported difficulty with finding a parking space were more accepting towards driverless vehicles). Finally, we found that the GDP per capita of the respondents' country was predictive of countries' mean general acceptance score ($\rho = -0.48$ across 43 countries with 25 or more respondents). In conclusion, self-reported acceptance of driverless vehicles is more strongly determined by domain-specific attitudes than by sociodemographic characteristics. We recommend further research, using objective measures, into the hypothesis that national characteristics are a predictor of the acceptance of driverless vehicles.

1. Introduction

1.1. The Rise of Driverless Vehicles. Driverless vehicles are currently being developed in a number of commercial and research projects worldwide [1, 2]. Shuttles that function as shared transport systems are a promising business case [3]. Such shuttles may contribute to environmentally friendly mobility and tackle the inefficiencies of today's transport systems [4, 5]. However, driverless vehicles will only become a success if they are accepted by their users [6]. User acceptance of these vehicles needs to be studied at an early stage, preferably before the technology is publicly available.

1.2. Individual Predictors of Acceptance. Previous questionnaire studies on the acceptance of automated vehicles have identified several predictors of acceptance. It has been shown that men are more favorable towards automated vehicles than women. For example, it has been found that men were more likely to have a positive attitude towards automated vehicles [7], were more willing to pay more and were less concerned about automated vehicles [8], were more comfortable to allow a fully automated car to perform all functions [9], reported more pleasure and less anxiety with automated vehicles [10], and were more likely to express a positive intention to use and own automated vehicles than women [11].

The effect of age on acceptance is mixed. Becker and Axhausen [12] performed a review on questionnaire studies about automated vehicles and found that 6 out of 10 studies (i.e., [13–18]) that examined age effects reported that younger people were more accepting of automated vehicles than older people. In contrast, one online survey study in their review [19] found that people aged 36 to 65 had a more positive attitude and a stronger intention to use automated vehicles than people aged 18 to 35. In Nordhoff et al. [20], older people were more likely to intend to use driverless vehicles and were more positive towards the vehicle characteristics, but gave lower ratings to the effectiveness of the vehicle compared to their existing travel mode.

It has also been found that people with a higher income are willing to pay more for vehicles equipped with automated driving features [8, 13]. Furthermore, individuals with a higher driving mileage were more positive towards automated vehicles [8, 21], and had a higher willingness to pay for high automation levels [13].

Several researchers [22–24] have studied the role of personality-related attitudes as predictors of acceptance. For example, Bansal et al. [13] found that technology-savvy individuals were more positive towards automated vehicles, which is in agreement with Zmud and Sener [24] who found that individuals with a higher intent to use automated vehicles were the ones using smartphones, text messaging, Facebook, and transportation apps, and with Lavieri et al. [25] who found that tech-savvy individuals are likely to be early adopters of automated vehicles.

Some of the above-mentioned predictor variables are also used in technology acceptance models, which have been developed to explain and predict user behavior across a variety of domains. The Unified Theory of Acceptance and Use of Technology (UTAUT [26]) represents a synthesis of eight influential technology acceptance models, including the Theory of Reasoned Action (TRA) [27], the Technology Acceptance Model [28, 29], and the Theory of Planned Behavior (TPB) [30]. Using the UTAUT model as baseline, a conceptual model of the acceptance of driverless vehicles by Nordhoff et al. [6] postulates that acceptance is the result of the domain-specific attitudes performance expectancy and effort expectancy, as well as the symbolic-affective construct social influence and the pleasure-arousal-dominance framework [31]. The suitability of technology acceptance models to predict the acceptance of automated vehicles was shown by Madigan et al. [22, 32] and Zmud and Sener [24].

1.3. National Predictors of Acceptance of Driverless Vehicles. In addition to individual differences in the acceptance of automated vehicles, national differences have been studied as well. Participants from higher-income countries were found to be less comfortable with the transmission of their data [8], and less likely to express a positive comment about automated driving in an open-ended question [33]. Similarly, a cross-national survey by the World Economic Forum (WEF) and the Boston Consulting Group (BCG) [34] showed that the question "How likely would you be to let your children ride alone in a fully self-driving car?" was answered more positively by respondents from lower-income countries. In the same vein, the willingness to share a self-driving taxi was higher in low-income than in high-income countries [34], and respondents from China and India were more positive about automated vehicles than Japan, the US, UK, and Australia. However, both low- and high-income countries were equally concerned about safety issues related to fully automated cars [35].

1.4. Objectives of This Research. Although a large number of survey studies on automated driving exist (see [12], for a review), most of these studies have used relatively small and specific populations from Western countries (e.g., France, Switzerland, Germany, US, UK, and Australia). These studies examined the influence of respondents' demographics (e.g., age and gender) or attitudes (e.g., technology acceptance) on the acceptance of automated vehicles.

Based on findings from previous research (e.g., [8, 36]), it may be expected that correlations between sociodemographics and technology acceptance will be small at best (i.e., around $r = 0.10$). For example, a review of thirty years of acceptance research on wind energy suggests that demographic variables only explain a small amount of variance in attitudes towards wind energy [37]. Large sample sizes are thus needed to be able to detect significant correlations. For example, for a sample size of 400, the 99% confidence interval of a correlation of 0 is –0.13 to 0.13. Substantially larger sample sizes are needed to achieve statistical power for differentiating whether one correlation is stronger than another.

In summary, the above studies have contributed to knowledge of the acceptance of automated vehicles, but there is a paucity of knowledge regarding their acceptance in large cross-national samples. As the mobility sector faces a shift from motorized to sustainable and collaborative forms of mobility [38], this paper examines the role of individuals' wish for a car-free future, their knowledge of mobility-related developments, and their attitudes towards driverless vehicles (e.g., transport-related, symbolic-affective, usefulness, and ease of use) among 7,755 respondents from 116 countries. To examine cross-national effects, correlations between countries' GDP per capita and respondents' mean ratings were examined. The present study did not test hypotheses, but used an exploratory analysis to detect patterns in a large-sample dataset. More specifically, respondents completed a large number of diverse items, and we subjected the items to descriptive analyses to examine for which items the respondents showed low or high agreement. We subsequently performed a data reduction (principal component analysis) to examine the sources of variation in the data.

2. Methods

2.1. Instrument and Procedure. A 94-question survey was created on CrowdFlower (https://www.crowdflower.com). The survey instructions informed the respondents that their

Figure 1: Photos included at the top of the questionnaire [39, 40].

answer would be anonymous and that the completion of the survey would take around 20 minutes.

The instructions informed the respondents about a typical usage scenario with driverless vehicles as follows:

> *Automated vehicles are now being extensively tested on public roads by auto builders, suppliers and software companies. These vehicles still have steering wheel and pedals, and require a qualified driver to monitor the automation and to take back control when needed. This questionnaire is about the next level of automation being driverless vehicles. Driverless vehicles operate without a driver and do not have a steering wheel, gas or brake pedals. In the beginning, they will not operate on all roads and not in all traffic situations. With this survey, I would like to find out what do you think about these driverless vehicles and whether you would be ready and willing to accept and use them.*
>
> *Imagine that a driverless vehicle is waiting for you outside the train station or some other public transport stop (e.g. bus, tram, metro) to drive you to your final destination, providing last-mile transport. It can also drive you back to your original destination. The driverless vehicle is 100% electric. You may also book it on-demand via your smartphone-app. When you enter the vehicle, you may need to give in your destination via an interface – for example a keyboard – so that the vehicle knows where you would like to go. As the vehicle can accommodate 6–8 passengers, it may be the case that you share the vehicle with a few unknown travelers having the same destination like you. The pictures below show the interior and exterior of such a driverless vehicle.*

Next, two pictures of a driverless vehicle were shown from the French company Easymile [39, 40] (Figure 1) to ensure that respondents had an idea of the type of vehicle being the topic of our research.

No requirements regarding respondents' country were set. Each respondent was paid €0.20 for the participation in the survey.

2.2. Questionnaire Content

2.2.1. Survey Instructions and Sociodemographic Characteristics. The first two questions asked respondents whether they had read and understood the questionnaire instructions (Q1) and whether the instructions were clear (Q2). Questions Q3–Q27 and Q71 asked respondents about their sociodemographic characteristics and their travel behavior, including questions such as gender (Q3), year of birth (Q4), type of residential situation (Q7), and monthly net household income (Q12).

2.2.2. Domain-Specific Attitudes: Usefulness and Ease of Use. Questions Q49 and Q53 asked respondents to provide their agreement with whether they would use a driverless vehicle for their daily travel because it would be better and more convenient, or more useful, than their existing form of travel, respectively. Respondents were also asked to rate their agreement with whether using a driverless vehicle would be easier than existing travel (Q50), and whether learning to operate a driverless vehicle would be easy for them (Q52).

2.2.3. Transport-Related Attitudes: Satisfaction with Daily Travel and Enjoyment of Manual Driving. Respondents were asked whether they were satisfied with their daily travel in terms of the ability to organize their day flexibly with public transport (Q28) and whether they are satisfied with the possibilities available to cover their daily travel needs (Q31). In questions Q29, Q30, Q66, and Q69, respondents were asked whether they need a vehicle to be flexible (Q29), whether they consider driving especially fun (Q30), whether they often feel like a racing driver when driving manually (Q66), and whether they would like to learn to drive vehicles exceeding a speed of 300 km/h (Q69).

2.2.4. Symbolic-Affective Attitudes: Pleasure and Social Influence. Respondents were asked whether they would enjoy taking a ride in a driverless vehicle (Q37), and whether they would find it important that driverless vehicles are aesthetic in terms of styling and design (Q39). They were further asked questions relating to whether they would like to have their friends or family or other important people to them adopt the driverless vehicle before they do (Q60), and whether people who are important to them would like it when they would use a driverless vehicle (Q63).

2.2.5. Personality-Related Attitudes: Trust, Liking of Being in Control, Enjoyment of Technology, Knowledge of Mobility, Future Orientation, Wish for Car-Free Future, and Skepticism. Further questions concerned the trust in driverless vehicles (Q44, Q56, Q58, Q64) and the preferred level of control and supervision in driverless vehicles (Q36, Q46, Q48, Q68, Q70). Respondents were also asked questions regarding their enjoyment of technology in general (Q72–Q74) and their knowledge of mobility-related developments (Q75–Q78, Q87). In Q83–Q86 and Q88–Q94, respondents were asked to indicate their level of agreement with items pertaining to their future orientation and their wish for a car-free future in cities. Questions Q42, Q57, Q59, and Q65 asked respondents to rate their level of skepticism with driverless vehicles. Specifically, respondents indicated whether they agreed with the statement that driverless vehicles would take away the driving pleasure or enjoyment (Q42), whether they would feel uncomfortable entrusting the safety of a family member to a driverless vehicle (Q57), whether they would refrain from using driverless vehicles because technology can sometimes fail (Q59), and whether they think that there will always be accidents, even with driverless vehicles on the road (Q65).

2.2.6. Intention to Use Driverless Vehicles. Respondents were presented with questions that addressed whether they would use a driverless vehicle that is 100% electric (Q38), whether they would share a driverless vehicle with around 6–8 fellow travelers having the same route like them (Q40), how often they intend to use a driverless vehicle when it is available on the market (Q41), and whether they would use a 100% electric driverless vehicle from the train station or some other public transport stop to their final destination or vice versa (Q43). Q54 asked respondents at which usage rate they would use a driverless vehicle. Respondents were further asked to indicate whether they would buy a driverless vehicle (Q80), and use it with other passengers as part of public transport (Q81), or in a carsharing scheme (Q82).

2.2.7. Miscellaneous Questions. As automated shuttles can accommodate 8 to 10 passengers in a small space at the same time, respondents were asked to indicate whether they prefer to keep a physical distance between themselves and strangers (Q61). They were also asked whether environmental protection is crucial for their choice of transportation in Q62. Q67 asked respondents to rate their agreement with whether driving without accidents is mainly a matter of luck.

2.2.8. Questions Not Included in the Analysis. Respondents were asked why they would use a driverless vehicle (e.g., to pick up kids from school or bring them to soccer practice) (Q32), which activities they would perform in a driverless vehicle (e.g., reading a book) (Q33), for which travel purposes they would use driverless vehicles (e.g., commuting to work) (Q34), which features they find attractive in driverless vehicles (e.g., button to stop the vehicle) (Q35), and how driverless vehicles should be operated (e.g., on a fixed schedule) (Q45). Q47 asked respondents about their preferred level of human supervision (e.g., remote supervision from external control room). In Q55, respondents were asked to indicate under which financial condition they would use a driverless vehicle. In Q79, respondents were asked to indicate the potential factors or concerns that would discourage them from using a driverless vehicle (e.g., loss of driving enjoyment). These questions were not included in the analysis because they had multiple options in a checkbox format and were not measured on an ordinal scale.

2.2.9. Measurement of Questionnaire Items. The above survey questions were based on literature about automated vehicles and technology acceptance [8, 17, 22, 23, 26, 41–44]. More specifically, the relevance of each response category was demonstrated by prior work on technology acceptance models, most notably the UTAUT model (Section 1.3). The role of transport-related attitudes (Section 2.2.3) was considered pivotal, as the success of driverless vehicles hinges on individuals' willingness to change their travel mode. Personality-related attitudes (Section 2.2.5) have been investigated before (e.g., [8]), but may need further investigation as their potential relevance for predicting preferences to use automated vehicles has been indicated before (e.g., [23, 24]). With developments such as the electrification of transport, the redesign of cities to promote sustainable modes of transport, and the restriction of private car use, people's attitudes towards a car-free future (Section 2.2.5) are important to be able to implement the necessary changes.

Questions Q28–Q31, Q36–Q40, Q42–Q44, Q48–Q53, Q56–Q70, Q72–Q78, Q80–Q83, Q87, Q92, and Q93 were measured on a six-point scale from 1 *(Disagree strongly)* to 6 *(Agree strongly)*. Questions Q84–Q86 were measured on a four-point scale from 1 *(Unlikely)* to 4 *(Probable)*. Questions Q88–Q91 were measured on a four-point scale from 1 *(I would not appreciate this development at all)* to 4 *(I would really appreciate this development)*. Q41 was on a scale from 1 *(Never or almost never)* to 5 *(Daily or almost daily)*. Q54 was on a scale from 1 *(Never)* to 6 *(When it is used by 95% to 100% of the people)*. Finally, Q94 was on a scale from 1 *(All parts of the city must be accessible by car. Therefore, more car parking space should be provided)*, to 2 *(The number of parking spaces should stay as it is)*, to 3 *(The number of parking spaces should be reduced to make more space available for other uses (e.g., pedestrians, bike parking, playgrounds or parks))*. All items had a response option "I prefer not to respond." The survey was administered in English.

2.3. Analyses of Responses. Descriptive statistics (i.e., means, standard deviations, and distribution of responses) were calculated per questionnaire item, and the mean ratings of items that were measured on a scale from *Disagree strongly* to *Agree strongly* were compared. Next, a principal component analysis (PCA) was conducted on all questions that were measured on an ordinal scale (except for the questions on the instructions Q1-Q2 and the sociodemographic questions Q3–Q27, Q71) to investigate the major sources of variation in the items. For the PCA, missing data due to respondents selecting "I prefer not to respond" were replaced with the value from the single "nearest neighbor" variable (1NN), using Euclidean distance. According to Beretta and Santaniello [45], 1NN imputation preserves the original variability of the data, which is why we selected this method instead of a multiple neighbors approach (kNN).

Spearman correlation coefficients were calculated between respondents' sociodemographics (Q3–Q27, Q71) and the component scores. These correlations were assessed in three ways: (1) across the whole sample of respondents, (2) across the respondents within each respondent's country, and then sample size weighting the correlations across the countries, and (3) across the whole sample while partialling out (i.e., controlling for) the time to complete the survey and whether participants found the instructions clear (Q2). Note that the second (i.e., "within-country") correlation coefficient is similar to the estimated fixed-effect coefficient when fitting a mixed-effects model to the data, with the respondents' country as grouping variable. The correlations between sociodemographics and component scores were deemed robust only if all three correlations were similar (i.e., all three correlations being 0.05 or higher, or −0.05 or lower). This threefold approach to assessing correlations with sociodemographics was intended to protect against the ecological fallacy (i.e., national differences may contribute to first correlation, but not to the second) and response style (i.e., the third correlation statistically controls for how quickly people answer the survey and whether they found the instructions clear).

Finally, it was investigated whether the acceptance of driverless vehicles is associated with the countries' developmental status. Spearman rank-order correlation coefficients (ρ) were calculated between countries' GDP per capita and the countries' mean component scores. Only countries with at least 25 respondents were selected for this cross-national analysis [8]. All analyses were conducted in MATLAB 2016a.

3. Results

3.1. Number of Respondents and Respondents' Satisfaction with the Questionnaire. In total, 10,000 questionnaires were completed. Responses were gathered between April 13 and April 19, 2015. CrowdFlower enables participants to rate their satisfaction with the questionnaire. Respondents were overall satisfied with the survey, with a score of 4.0 on a scale from 1 *(very dissatisfied)* to 5 *(very satisfied)*.

3.2. Data Filtering. We applied a strict data screening to enhance data quality. Participants were excluded if they indicated that they had not read the instructions (n = 107), if they reported a birth year yielding an age younger than 18 (n = 70) or older than 110 (n = 111), or if they did not indicate their age or gender (n = 156). This upper limit of age was selected as a reasonable maximum human lifespan [46]. Only strings that contained a four-digit birth year were retained for calculating the participants' age.

Respondents were also excluded if their country of origin was not identified by CrowdFlower (n = 1), and if they were affiliated with the same IP address (n = 172; the first response was kept, but subsequent items from the same IP address were removed), were faster than the fastest 5% (n = 497; see [47] for rationale), had missing data due to database/recording errors (n = 24), or responded "I prefer not to respond" or "I don't know" to 9 or more questions (i.e., 10% of the questions) (n = 731). Furthermore, we excluded respondents (n = 848) who selected the same answer *(Disagree strongly, Disagree moderately, Agree moderately, or Agree strongly)* to the questions "I would feel comfortable in a vehicle without a steering wheel, gas or brake pedals" (Q44) and "I would not use a driverless vehicle because technology can sometimes fail" (Q59) as these questions have opposite meaning. This exclusion was performed to filter out respondents with an acquiescent response style. In total, 2,245 respondents were excluded, leaving 7,755 respondents from 116 countries in the analysis.

3.3. Descriptive Statistics of the Questionnaire Items. The mean age of respondents was 32.49 years (SD = 10.53, Q4). 31.20% of the respondents were female, and 68.80% were male (Q3). 7,032 of 7,755 respondents answered the question about their net household income. Of those 7,032 respondents, 35% had a net monthly household income below $ 1,000, 23% between $ 1,000 and $ 1,599, 20% between $ 1,600 and $ 2,899, 11% between $ 2,900 and 3,999, 6% between $ 4,000 and $ 5,000, and 5% more than $ 5,000 (Q12).

Respondents lived on average 9.43 miles away from their workplace, training post, or school (SD = 15.56, median = 5, Q9), and on average had 1.34 vehicles in their household (SD = 0.86, Q15). Their most frequent mode of transport was "walking more than 500 meters per trip" (M = 3.96, Q22), and the "conventional vehicle, as a driver or passenger" (M = 3.90, Q25), followed by "public transport for distances below and over 100 km per one way" (M = 2.91, 2.15; Q26-Q27), "cycling" (M = 2.14, Q23), and a "moped or motorcycle as a driver" (M = 1.76, Q24).

3.3.1. Domain-Specific Attitudes: Usefulness and Ease of Use. Table 1 shows the means (M), standard deviations (SD), and distribution of the questionnaire items. For usefulness (Q49, Q53), the higher rating was obtained for using a driverless vehicle for daily travel because it would be better and more convenient than existing travel (M = 4.48, Q49), and the lower rating for thinking that driverless vehicles would be more useful than existing travel (M = 4.35, Q53). For ease of use (Q50, Q52), the higher rating was obtained for thinking that learning to operate a driverless vehicle would be easy (M = 4.76, Q52), while the lower rating was obtained for thinking that driverless vehicles would be easier to use than existing travel (M = 4.46, Q50).

3.3.2. Transport-Related Attitudes: Satisfaction with Daily Travel and Enjoyment of Manual Driving. For satisfaction with daily travel (Q28, Q31), the higher rating was obtained for being satisfied with the possibilities available to cover daily travel needs (M = 4.36, Q31), and the lower rating for being able to organize the day flexibly with public transport (M = 3.73, Q28). For enjoyment of manual driving (Q29, Q30, Q66, Q69), the highest rating was obtained for needing a vehicle to be flexible (M = 4.77, Q29), and the lowest rating for liking to learn to drive vehicles that can exceed the speed of 300 km/h (M = 3.27, Q69).

3.3.3. Symbolic-Affective Attitudes: Pleasure and Social Influence. For pleasure (Q37, Q39), respondents gave the higher rating for thinking that they would enjoy taking a ride in a driverless vehicle (M = 4.90, Q37), and the lower rating for finding it important that driverless vehicles are aesthetic in terms of styling and design (M = 4.62, Q39). For social influence (Q60, Q63), respondents gave the higher rating for believing that people important to them would like it when they use driverless vehicles (M = 4.33, Q63), and the lower rating for liking to have their friends or family or other important people to them adopting the driverless vehicle before they do (M = 3.77, Q60).

3.3.4. Personality-Related Attitudes: Trust, Liking of Being in Control, Enjoyment of Technology, Knowledge of Mobility, Future Orientation, Wish for Car-Free Future, and Skepticism. Similar mean ratings were also obtained for trusting driverless vehicles (3.80–4.36; Q44, Q56, Q58, Q64), liking of being in control (3.92–5.18; Q36, Q48, Q68, Q70), enjoyment

Table 1: Means (M), standard deviations (SD), and distribution of questionnaire items on a scale from 1 (disagree strongly) to 6 (agree strongly), unless indicated otherwise*.

Semantic content	Item	M	SD	1	2	3	4	5	6
Liking of being in control	Q36. Would like to have button inside DV.	5.18	1.15	146	144	297	1299	1532	4296
Intention to use	Q38. Would use 100% electric DV.	5.09	1.20	200	168	301	1316	1804	3924
Enjoyment of technology	Q74. Fun to use electronic device.	4.99	1.10	79	179	402	1656	2143	3261
Pleasure	Q37. Think I would enjoy taking a ride in DV.	4.90	1.22	226	213	350	1610	2213	3114
Enjoy manual	Q29. Need vehicle to be flexible.	4.77	1.38	294	355	601	1539	1700	3230
Ease of use	Q52. Learning to operate DV would be easy for me.	4.76	1.18	162	218	536	2015	2228	2535
Intention to use	Q43. Would use 100% electric DV from train station to final destination.	4.72	1.25	256	227	506	1965	2217	2546
Enjoyment of technology	Q73. Rapidly and intuitively learn to handle unfamiliar electronic devices.	4.67	1.17	136	255	605	2201	2304	2210
Miscellaneous	Q62. Environmental protection crucial for transportation.	4.64	1.21	143	291	697	2267	1999	2312
Knowledge of mobility	Q75. Often think about how mobility in city could be improved.	4.63	1.22	163	320	681	2179	2110	2268
Pleasure	Q39. Would find it important that DVs are aesthetic in terms of styling and design.	4.62	1.21	201	263	601	2252	2286	2101
Intention to use	Q40. Would share DV with 6–8 fellow travelers.	4.48	1.29	296	343	752	2235	2192	1905
Usefulness	Q49. Would use DV for daily travel because would be better and more convenient.	4.48	1.28	289	329	754	2293	2168	1894
Ease of use	Q50. Think DV would be easier to use than existing travel.	4.46	1.28	273	328	849	2280	2118	1879
Enjoy manual	Q30. Driving is especially fun for me.	4.44	1.45	458	445	741	1899	1812	2263
Skeptical	Q65. There will always be accidents, even with DVs on the road.	4.38	1.27	227	434	908	2463	1976	1698
Trust	Q56. Trust that DV can drive without assistance from me.	4.36	1.25	280	370	872	2456	2280	1479

Table 1: Continued.

Semantic content	Item	M	SD	1	2	3	4	5	6
Satisfaction daily travel	Q31. Satisfied with possibilities available to cover daily travel needs.	4.36	1.28	272	442	886	2348	2189	1582
Usefulness	Q53. Think that DV would be more useful than existing travel.	4.35	1.30	308	391	948	2376	2033	1663
Liking of being in control	Q48. Would like to take over control from DV.	4.34	1.40	438	425	832	2314	1755	1940
Liking of being in control	Q70. Careful driver can prevent any accident on road.	4.33	1.40	322	600	1059	1865	1996	1886
Knowledge of mobility	Q87. Would like to use mobility flat-rate for mobility services in city.	4.33	1.12	191	296	731	3194	2036	1173
Social influence	Q63. People who are important to me would like it when I use DV.	4.33	1.18	221	328	896	2725	2193	1253
Intention to use	Q81. Would use SDVs together with passengers in public transport.	4.32	1.29	366	384	793	2505	2214	1453
Intention to use	Q80. Would like to buy SDV.	4.22	1.37	446	504	900	2452	1914	1504
Wish for car-free future	Q93. Roads be redesigned with bicycle lane that replaces car lane.	4.20	1.35	407	461	1077	2491	1741	1501
Trust	Q58. Trust DV to be safe and reliable in severe weather conditions.	4.15	1.34	384	532	1212	2346	1891	1354
Future orientation	Q83. SDVs will be legally accepted as independent drivers.	4.14	1.24	345	414	1122	2816	1935	1045
Intention to use	Q82. Would like to use SDVs in carsharing scheme.	4.09	1.27	402	492	1013	2807	1950	975
Miscellaneous	Q61. Prefer to keep physical distance between myself and strangers.	4.09	1.32	369	601	1193	2538	1797	1201
Trust	Q44. Would feel comfortable in vehicle without steering wheel, gas or brake pedals.	4.01	1.43	563	587	1388	2232	1581	1368
Knowledge of mobility	Q76. Friends and acquaintances often consult me on mobility options.	4.00	1.30	401	656	1208	2633	1883	929

Table 1: Continued.

Semantic content	Item	M	SD	1	2	3	4	5	6
Enjoyment of technology	Q72. Friends and acquaintances often ask for advice, when they have technical problem.	4.00	1.31	450	655	1066	2719	1886	921
Knowledge of mobility	Q78. Often provide others with information regarding mobility options.	4.00	1.30	396	662	1207	2670	1868	916
Knowledge of mobility	Q77. Often first to make people aware of new mobility.	4.00	1.33	428	656	1267	2542	1798	1014
Liking of being in control	Q68. When driver is involved in accident, (s)he did not drive properly.	3.92	1.41	471	877	1415	2100	1748	1099
Wish for car-free future	Q92. Would like to live in car-free neighbourhood.	3.88	1.48	703	730	1330	2236	1471	1238
Trust	Q64. Would trust driving skills of DV more than own driving skills.	3.80	1.47	732	803	1446	2060	1637	1019
Skeptical	Q42. DVs would take away the pleasure or enjoyment.	3.78	1.42	693	780	1340	2497	1477	920
Skeptical	Q57. Would feel uncomfortable entrusting safety of family to DV.	3.78	1.33	492	830	1621	2503	1461	806
Social influence	Q60. Would like to have friends or family adopt DV before I do.	3.77	1.30	520	740	1592	2676	1450	692
Intention to use	Q54. Indicate when you would use DV. Only most relevant option.*	3.74	1.15	221	768	2228	2555	1408	507
Satisfaction daily travel	Q28. Can organize my day flexibly with public transport.	3.73	1.49	884	821	1149	2308	1638	883
Intention to use	Q51. Even if more expensive than existing travel, would prefer DVs.	3.72	1.45	756	850	1537	2170	1504	904
Intention to use	Q41. Indicate when you would use DV. Only most relevant option.*	3.67	1.27	633	894	1399	2163	2573	
Skeptical	Q59. Would not use DV because technology can fail.	3.48	1.32	636	1128	1995	2429	946	594
Future orientation	Q86. SDVs will be normal part of everyday mobility.*	3.43	0.79	231	665	2102	4242		
Enjoy manual	Q66. Often feel like racing driver when driving manually.	3.40	1.55	1314	932	1388	2036	1250	687

Table 1: Continued.

Semantic content	Item	M	SD	1	2	3	4	5	6
Wish for car-free future	Q91. In cities, EVs will completely replace combustion engines within next 20–30 years.*	3.37	0.82	307	598	2284	3845		
Future orientation	Q84. SDVs will mostly be shared vehicles.*	3.36	0.85	338	671	2050	3796		
Enjoy manual	Q69. Like to learn to drive vehicles that exceed speed of 300 km/h.	3.27	1.72	1836	1011	1164	1604	1077	1014
Future orientation	Q85. SDVs will mostly be privately owned.*	3.22	0.93	426	1133	1870	3516		
Wish for car-free future	Q90. Roads in cities will be redesigned to privilege non-motorized travel.*	3.21	0.88	411	913	2590	3253		
Miscellaneous	Q67. Driving without accidents is mainly matter of luck.	3.16	1.53	1439	1445	1417	1849	989	575
Wish for car-free future	Q88. Many car-free neighborhoods with exceptional car use and no parking space.*	2.94	0.96	672	1258	2563	2226		
Wish for car-free future	Q89. City centers closed to car-traffic.*	2.89	0.99	789	1399	2439	2242		
Wish for car-free future	Q94. Think of your own neighbourhood. Which of following statements do you agree to most? Select only one option.*	1.83	0.82	3375	2302	2078			
Liking of being in control	Q46. Mind being transported by DV supervised by ECR?*	1.58	0.49	3136	4390				

Note. (E) DV = (electric) driverless vehicle, SDV = self-driving vehicle, and ECR = external control room.

of technology (4.00–4.99; Q73–Q75), knowledge of mobility (4.00–4.63; Q76–Q78, Q87), future orientation (3.22–4.14; Q83–Q86), wish for a car-free future (1.83–4.22; Q88–Q94), and skepticism (3.48–4.38; Q42, Q57, Q59, Q65).

For trusting driverless vehicles, respondents gave the highest rating for trusting that a driverless vehicle can drive without their assistance (M = 4.36, Q56), and the lowest rating was obtained for trusting the driving skills of a driverless vehicle more than one's own driving skills (M = 3.80, Q64).

The highest rating for liking of being in control and the highest overall mean rating were obtained for liking to have a stop button inside the driverless vehicle (M = 5.18, Q36), and the lowest rating for believing that when a driver is involved in an accident, (s)he did not drive properly (M = 3.92, Q68).

For skepticism, the highest rating was obtained for believing that there will always be accidents, even with driverless vehicles on the road (M = 4.38, Q65), and the lowest rating for not using a driverless vehicle because technology can sometimes fail (M = 3.48, Q59).

3.3.5. Intention to Use Driverless Vehicles. For intention to use (Q38, Q40, Q43, Q51, Q80–Q82), the highest rating was obtained for using a driverless vehicle that is 100% electric (M = 5.09, Q38), and the lowest rating for preferring driverless vehicles even if they are more expensive than existing travel (M = 3.72, Q51).

3.3.6. Miscellaneous Questions. For the miscellaneous items (Q62, Q67), the higher mean rating was obtained for environmental protection being crucial in the choice of transportation (M = 4.64, Q62), and the lower rating for believing that driving without accidents is mainly a matter of luck (M = 3.16, Q67).

In summary, the results indicate that driverless vehicles are regarded as fun, useful, and easy to use. Lower mean ratings, yet on the "agree" end of the scale (i.e., >3.5), were obtained for items relating to trusting those vehicles more than one's own driving skills.

3.4. Principal Component Analysis of the Questionnaire Items: General Acceptance Component. A PCA was performed of the responses on the 58 items that were measured on an ordinal scale (i.e., Q28–Q31, Q36–Q44, Q46, Q48–Q54, Q56–Q70, Q72–Q78, Q80–Q94). The Kaiser-Meyer-Olkin (KMO) index of sampling adequacy was 0.941, indicating that the data are suitable for factor-analytic purposes [48].

Based on the scree plot (Figure 2), and based on the interpretability of the loadings, we decided to retain one general component. This component was interpreted as "general acceptance." The Cronbach alpha for the 58 variables was 0.899 and 0.928 if selecting the 32 from 58 variables that loaded higher than 0.4, a common cut-off value [49]. The participants' scores on the component were standardized, so that the mean was equal to 0 and the standard deviation was equal to 1 (min = −4.71, max = 2.36, and N = 7,755).

Table 2 provides an overview of the 58 items and their corresponding loadings on the general acceptance component.

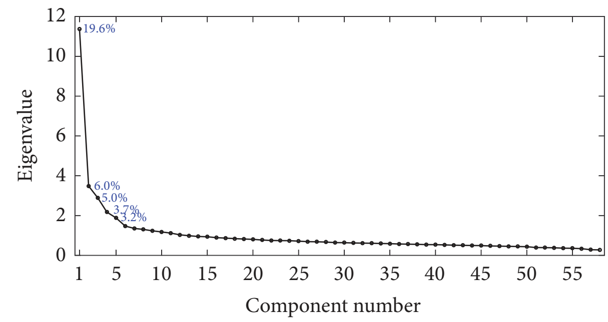

Figure 2: Eigenvalues of the correlation matrix sorted in descending order ("scree plot"). Also shown are the percentages of variance explained (being proportional to the eigenvalue) for the first five components. It can be seen that one dominant component emerged, explaining 19.6% of the variance.

Loadings are referred to as negative if smaller than 0, small if between 0 and 0.40, medium if between 0.40 and 0.60, and high if larger than 0.60.

(i) Negative and small mean loadings were obtained for skepticism towards driverless vehicles (−0.35 to −0.08; Q42, Q57, Q59, Q65; mean loading = −0.16).

(ii) Small mean loadings were obtained for items capturing the satisfaction with daily travel (0.11–0.22; Q28, Q31; mean loading = 0.16), enjoyment of manual driving (0.16–0.19; Q29–Q30, Q66, Q69; mean loading = 0.17), and the liking of being in control (0.08–0.31; Q36, Q46, Q48, Q68, Q70; mean loading = 0.20).

(iii) Small to medium mean loadings were obtained for the wish for a car-free future (0.14–0.47; Q88–Q94; mean loading = 0.37), future orientation (0.24–0.56; Q83–Q86; mean loading = 0.39), and enjoyment of technology (0.33–0.46; Q72–Q74; mean loading = 0.39).

(iv) Medium mean loadings were obtained for items measuring social influence (0.29–0.66; Q60, Q63; mean loading = 0.47), intention to use (0.11–0.65; Q38, Q40-Q41, Q43, Q51, Q54, Q80-Q81; mean loading = 0.52), knowledge of mobility-related developments (0.49–0.58; Q75–78, Q87; mean loading = 0.53), pleasure of driverless vehicles (0.46–0.67; Q39, Q37; mean loading = 0.57), trust in driverless vehicles (0.49–0.65; Q44, Q56, Q58, Q64; mean loading = 0.57), and ease of use of driverless vehicles compared to respondents' existing form of travel (0.49–0.71; Q50, Q52; mean loading = 0.60).

(v) High mean loadings were obtained for items pertaining to the perceived usefulness of driverless vehicles (0.72–0.73; Q49, Q53; mean loading = 0.73).

We have also done a supplementary analysis in which we retained five components instead of one component, because the scree plot suggests that although a single dominant component exists, a five-component solution may also be appropriate. After oblique rotation of the loadings (Promax,

Table 2: Component loadings.

Semantic content	Item	GAC	Component 1	Component 2	Component 3	Component 4	Component 5
Usefulness	Q49. Would use DV for daily travel because would be better and more convenient.	**0.73**	**0.80**	0.08	0.03	−0.03	−0.05
Usefulness	Q53. Think that DV would be more useful than existing travel.	**0.72**	**0.75**	0.15	−0.03	−0.01	−0.01
Ease of use	Q50. Think DV would be easier to use than existing travel.	**0.71**	**0.77**	0.14	−0.01	−0.02	−0.04
Ease of use	Q52. Think that learning to operate DV would be easy for me.	**0.49**	**0.43**	−0.12	0.30	−0.08	0.11
Pleasure	Q37. Think I would enjoy taking a ride in DV.	**0.67**	**0.79**	−0.11	0.18	−0.06	−0.11
Pleasure	Q39. Would find it important that DVs are aesthetic.	**0.46**	**0.43**	0.12	0.36	−0.05	−0.03
Social influence	Q63. People who are important to me would like it when I use DV.	**0.66**	**0.57**	0.20	0.02	0.03	0.09
Social influence	Q60. Would like to have friends or family adopt DV before I do.	0.29	0.28	**0.49**	0.21	−0.02	−0.13
Trust	Q56. Trust that DV can drive without assistance from me.	**0.65**	**0.75**	−0.03	−0.03	−0.07	−0.02
Trust	Q58. Trust DV to be safe and reliable in severe weather conditions.	**0.58**	**0.64**	0.18	−0.11	−0.07	0.02
Trust	Q44. Would feel comfortable in vehicle without steering wheel, gas or brake pedals.	**0.56**	**0.65**	0.10	−0.18	−0.02	−0.03
Trust	Q64. Would trust driving skills of DV more than own driving skills.	**0.49**	**0.52**	0.34	−0.22	0.08	−0.08
Intention to use	Q80. Would like to buy SDV.	**0.65**	**0.62**	0.10	−0.03	−0.02	0.09
Intention to use	Q38. Would use 100% electric DV.	**0.61**	**0.69**	−0.19	0.30	0.01	−0.15
Intention to use	Q43. Would use 100% EDV from train station to final destination.	**0.59**	**0.67**	−0.16	0.20	−0.02	−0.10
Intention to use	Q81. Would use SDVs together with passengers in public transport.	**0.59**	**0.53**	0.05	−0.06	0.07	0.06

Table 2: Continued.

Semantic content	Item	GAC	Component 1	Component 2	Component 3	Component 4	Component 5
Intention to use	Q82. Would like to use SDVs in carsharing scheme.	**0.57**	**0.47**	0.18	−0.08	0.06	0.13
Intention to use	Q51. Even if more expensive than existing travel, would prefer DVs.	**0.55**	**0.51**	**0.42**	−0.12	−0.03	0.08
Intention to use	Q41. Indicate when you would use DV. Only most relevant option.	**0.53**	**0.60**	−0.17	−0.09	−0.04	0.04
Intention to use	Q40. Would share DV with 6–8 fellow travelers with same route like.	**0.52**	**0.51**	0.00	0.11	0.03	−0.03
Intention to use	Q54. Indicate when you would use DV. Only most relevant option.	0.11	0.17	0.26	0.14	0.00	−0.20
Knowledge of mobility	Q87. Would like to use mobility flat-rate for mobility services in city.	**0.58**	0.38	−0.05	0.12	0.17	0.13
Knowledge of mobility	Q75. Often think about how mobility in city could be improved.	0.56	0.19	−0.07	0.12	0.13	**0.42**
Knowledge of mobility	Q78. Often provide others with information regarding mobility options.	**0.52**	−0.02	0.27	−0.10	0.03	**0.78**
Knowledge of mobility	Q77. Often first to make people aware of new mobility options.	**0.51**	−0.05	0.28	−0.12	0.02	**0.80**
Knowledge of mobility	Q76. Friends and acquaintances often consult me on mobility options.	**0.49**	−0.06	0.26	−0.08	0.02	**0.78**
Future orientation	Q83. SDVs will be legally accepted as independent drivers.	**0.56**	**0.52**	0.14	−0.10	0.03	0.08
Future orientation	Q86. SDVs will be normal part of everyday mobility.	**0.45**	0.31	0.04	0.02	0.23	0.00
Future orientation	Q84. SDVs will mostly be shared vehicles.	0.31	0.16	0.04	0.10	0.23	−0.03
Future orientation	Q85. SDVs will mostly be privately owned.	0.24	0.12	0.27	0.08	0.12	−0.02
Wish for car-free future	Q93. Roads be redesigned with bicycle lane that replaces car lane.	**0.47**	0.05	−0.01	0.04	**0.58**	0.08

Table 2: Continued.

Semantic content	Item	GAC	Component 1	Component 2	Component 3	Component 4	Component 5
Wish for car-free future	Q91. In cities, EVs will completely replace combustion engines within next 20–30 years.	0.43	0.08	−0.19	0.04	**0.60**	−0.02
Wish for car-free future	Q90. Roads and streets in cities will be redesigned to privilege non-motorized travel.	0.41	−0.06	−0.07	−0.04	**0.76**	0.01
Wish for car-free future	Q92. Would like to live in car-free neighbourhood.	**0.41**	0.01	−0.04	−0.04	**0.67**	0.00
Wish for car-free future	Q88. Many car-free neighborhoods with exceptional car use and no parking space.	0.39	−0.07	0.10	−0.10	**0.72**	0.04
Wish for car-free future	Q89. City centers closed to car-traffic.	0.32	−0.15	0.02	−0.10	**0.78**	−0.01
Wish for car-free future	Q94. Think of your own neighbourhood. Which of following statements do you agree to most? Select only one option.	0.14	−0.08	−0.27	−0.13	**0.46**	0.00
Enjoyment of technology	Q74. Fun to use electronic device.	**0.46**	0.19	−0.34	0.31	0.00	0.37
Enjoyment of technology	Q73. Rapidly and intuitively learn to handle unfamiliar electronic devices.	0.39	0.04	−0.27	0.22	−0.02	**0.53**
Enjoyment of technology	Q72. Friends and acquaintances often ask for advice, when they have technical problem.	0.33	−0.12	0.00	0.03	−0.03	**0.69**
Liking of being in control	Q70. Careful driver can prevent any accident on road.	0.31	0.08	0.19	0.20	0.09	0.15
Liking of being in control	Q36. Would like to have button inside DV.	0.27	0.28	−0.26	**0.58**	−0.01	−0.16
Liking of being in control	Q68. When driver is involved in accident, (s)he did not drive properly.	0.22	0.01	0.32	0.09	0.10	0.12
Liking of being in control	Q46. Mind being transported by DV supervised by ECR?	0.12	0.01	0.20	−0.04	0.06	0.08
Liking of being in control	Q48. Would like to take over control from DV when want this.	0.08	−0.02	0.17	**0.53**	−0.06	−0.03
Enjoy manual	Q30. Driving is especially fun for me.	0.19	0.01	0.19	**0.48**	−0.16	0.19
Enjoy manual	Q66. Often feel like racing driver when driving manually.	0.18	−0.05	**0.60**	0.10	−0.07	0.24

Table 2: Continued.

Semantic content	Item	GAC	Component 1	Component 2	Component 3	Component 4	Component 5
Enjoy manual	Q29. Need vehicle to be flexible.	0.17	0.19	−0.01	**0.43**	−0.22	0.04
Enjoy manual	Q69. Like to learn to drive vehicles that exceed speed of 300 km/h.	0.16	−0.05	**0.45**	0.05	−0.13	0.32
Satisfaction daily travel	Q28. Can organize my day flexibly with public transport.	0.22	0.12	0.11	0.10	0.22	−0.11
Satisfaction daily travel	Q31. Satisfied with possibilities available to cover daily travel.	0.11	0.05	0.13	**0.47**	0.01	−0.13
Skeptical	Q42. DVs would take away the pleasure or enjoyment.	−0.08	−0.26	0.30	**0.42**	−0.03	0.06
Skeptical	Q65. There will always be accidents, even with DVs on the road.	−0.09	−0.17	−0.10	**0.41**	0.07	−0.10
Skeptical	Q57. Would feel uncomfortable entrusting safety of family to DV.	−0.13	−0.34	0.29	0.39	0.10	−0.01
Skeptical	Q59. Would not use DV because technology can fail.	−0.35	**−0.58**	0.30	0.34	0.13	−0.02
Miscellaneous	Q61. Prefer to keep physical distance between myself and strangers.	−0.03	−0.09	0.19	0.37	0.05	−0.15
Miscellaneous	Q62. Environmental protection crucial for transportation.	**0.50**	0.26	0.06	0.18	0.21	0.10
Miscellaneous	Q67. Driving without accidents is mainly matter of luck.	0.05	−0.03	**0.54**	0.00	0.00	0.00

Note. DV = driverless vehicle; SDV = self-driving vehicle. The general acceptance component is the first principal component. Components 1–5 are the first five components, after Promax rotation. Component loadings of magnitude > 0.40 are listed in boldface.

with kappa = 4), the five components were interpreted as (1) general acceptance, (2) thrill seeking, (3) wanting to be in control manually, (4) supporting a car-free environment, and (5) being comfortable with technology. The loadings of the five-component solution are shown in Table 2. Cronbach's alpha for these five components (after selecting the items that loaded higher than 0.4) were 0.916, 0.587, 0.580, 0.763, and 0.800, indicating that the first component is most consistent.

3.5. Correlations between Sociodemographic Characteristics and the General Acceptance Score. Table 3 shows the correlations between sociodemographic characteristics and the general acceptance score. It can be seen that the survey time and whether the respondents found the survey instructions clear (Q2) correlated relatively strongly with the general acceptance score ($\rho = 0.20$ and 0.22, resp.). Hence, these two variables were partialled out. These partial correlations were similar to the zero-order correlations (Table 3).

Furthermore, it can be seen that whole-sample and within-country correlations were similar, but not for all items. For example, across the whole sample a near-zero correlation was found between respondents' income (Q12) and general acceptance ($\rho = -0.01$), while within countries this correlation was slightly positive ($\rho = 0.06$). Here, it is possible that the large national differences in income masked the positive correlation between income and general acceptance within nations.

Overall, the correlations between sociodemographic characteristics and general acceptance component scores were small (<0.20). The strongest correlation with the general acceptance score was found with the difficulty of finding a parking place ($\rho = 0.17$, Q16), and the frequency of use of public transport (<100 km) ($\rho = 0.14$, Q26). Having a monthly pass or annual travel card for public transport ($\rho = 0.11$, Q19), living in a city environment ($\rho = 0.12$, Q7), frequency of walking more than 500 m per trip ($\rho = 0.08$, Q22), frequency of cycling ($\rho = 0.06$, Q23), and distance of living from workplace, training post, or school ($\rho = 0.07$, Q9) also correlated with general acceptance. No robust correlations (i.e., stronger than 0.05 for all three correlation types) were found between age (Q4) and gender (Q3) and the general acceptance score. Males had a higher general acceptance score than females across the whole sample, but this effect was not statistically significant within countries.

3.6. National Differences in the General Acceptance Score. This section presents results from 7,188 respondents from 43 countries with 25 or more respondents. The three countries with the highest GDP per capita were the USA ($ 52,980), Canada ($ 52,305), and the Netherlands ($ 50,793), whereas the three countries with the lowest GDP per capita were India ($ 1,455), Pakistan ($ 1,282), and Bangladesh ($ 954).

We found that the developmental status of the respondents' country (GDP per capita) was predictive of the countries' mean general acceptance score ($\rho = -0.48$, $n = 43$; Figure 3(a)). For example, respondents from higher-income countries gave more negative ratings to intention to use (e.g., Q51 "Even if it were more expensive than my existing form of travel, I would prefer driverless vehicles to my existing form of travel", $\rho = -0.64$), the perceived effectiveness (e.g., Q50, "I think driverless vehicles would be easier to use than my existing form of travel", $\rho = -0.57$), and pleasure of driverless vehicles (e.g., Q39, "I would find it important that driverless vehicles are aesthetic in terms of styling and design", $\rho = -0.57$).

As a validity check of the self-reports, we observed that the mean self-reported income (Q12) correlated strongly with GDP per capita ($\rho = 0.71$, $n = 43$; Figure 4(a)), whereas the median self-reported annual mileage (Q17) correlated strongly with GDP per capita on a national level ($\rho = 0.71$, $n = 43$; Figure 4(b)).

Table 4 shows cross-national correlations for a number of additional variables (selected from [50]). It can be seen that the general acceptance score correlates substantially not only with GDP per capita but also with other developmental indexes, including national performance in educational tests ([51]; $\rho = -0.60$), average life expectancy in 2013 ([52]; $\rho = -0.43$), motor vehicle density ([52]; $\rho = -0.59$), median age in 2014 ([53]; $\rho = -0.52$), and road traffic death rate per 100,000 population ([54]; $\rho = 0.56$). The second component (i.e., thrill seeking) correlates negatively ($\rho = -0.72$; see Figure 3(b)) with GDP per capita, meaning that people in lower-income countries are more thrill seeking. Also, respondents in higher-income countries reported to be less supportive of a car-free environment ($\rho = -0.44$), and to be less comfortable with technology ($\rho = -0.44$).

4. Discussion

4.1. Main Results at the Individual Level. A variety of studies have previously examined the acceptance of automated vehicles. However, there is limited knowledge on the acceptance of automated vehicles without steering wheel and brake and gas pedals across countries. The present study surveyed 7,755 respondents from 116 countries on their acceptance of driverless vehicles, attitudes towards technology, knowledge of mobility-related developments, and sociodemographic characteristics, using a 94-item online questionnaire.

We found that respondents considered driverless vehicles easy to use and convenient (Q49, Q50, Q52). Furthermore, respondents could imagine using 100% electric driverless vehicles in connection with public transport (Q43). The perceived enjoyment of taking a ride in driverless vehicles was also rated positively by respondents (M = 4.90/6, Q37). This corresponds with Nordhoff et al. [20], who found that respondents strongly agreed with the statement that the driverless vehicle was fun and enjoyable after having taken a ride in the vehicle (M = 5.40/6). Our respondents gave the highest rating (M = 5.18/6, Q36) to being able to take over control from a driverless vehicle by a button inside the vehicle to stop it, which indicates that participants want to be able to retain some degree of control over the driverless vehicle. This finding is in line with Schoettle and Sivak [18] who found that 96.2% of respondents preferred the availability of vehicle controls.

By means of a PCA, we reduced the scores on all questionnaire items into one general component of acceptance. A general acceptance component for driverless vehicles is a

Table 3: Means (M) and Spearman rank-order correlations (ρ) between sociodemographic characteristics and the general acceptance score (GAC) for the whole sample, for respondents within countries, and for the whole sample after partialling out the time to complete survey and whether respondents found instructions clear (N = 7,755).

Item	M	ρ with GAC (whole sample)	ρ with GAC (within country)	ρ with GAC (survey time & instructions clear partialled out)
Survey time ranking 0-1	0.54	0.20	0.14	—
Survey start time	—	0.05	0.02	0.05
Survey end time	—	0.05	0.02	0.05
Q2. The definitions given in the instructions are clear to me	5.36	0.22	0.26	—
Q3. What is your gender? 1 (female), 2 (male)	1.69	0.07	0.01	0.09
Q4. Year of birth (converted to age) (open question)	32.49	0.02	0.08	−0.02
Q7. Which of the following possibilities describe your current residential situation the most? 1 (Outside city in house in countryside) to 4 (In apartment in immediate city centre)	2.95	0.12	0.08	0.10
Q8. Number of people in household between 14 and 17 years (open question)	0.27	0.05	0.03	0.06
Q8. Number of people in household between 6 and 13 years (open question)	0.36	0.04	0.02	0.04
Q8. Number of people in household younger than 6 years (open question)	0.35	0.04	0.02	0.04
Q8. Number of people older than 18 years old (open question)	2.67	0.09	0.01	0.08
Q9. Distance between home and workplace, training post or school (in miles) (open question)	9.43	0.07	0.06	0.08
Q12. Net monthly household income 1 (<$ 1,000) to 6 (>$ 5,000)	2.45	−0.01	0.06	−0.01
Q13. Having valid driver license 1 (No), 2 (Yes)	1.80	0.03	0.05	0.02
Q15. Number of vehicles in household 1 (0), 2 (1), 3 (2), 4 (3), 5 (>3)	1.34	0.00	0.01	−0.01
Q16. Difficulty of finding parking space 1 (Not at all difficult) to 4 (Very difficult)	2.52	0.17	0.12	0.16

Table 3: Continued.

Item	M	ρ with GAC (whole sample)	ρ with GAC (within country)	ρ with GAC (survey time & instructions clear partialled out)
Q17. Annual driving mileage as driver or passenger (in miles) (open question)	8,190	−0.00	0.07	−0.04
Q18. Involvement in accidents in last three years 1 (0), 2 (1), 3 (2), 4 (3), 5 (4), 6 (5), 7 (>5)	0.43	0.02	−0.01	0.04
Q19. Having monthly pass or annual travel card for public transport 1 (No), 2 (Yes)	1.34	0.11	0.07	0.13
Q20. Distance between home and nearest public transport stop (in min.) 1 (<5 min.), 2 (5–10 min.), 3 (10–20 min.), 4 (20–30 min.), 5 (>30 min.)	1.93	0.03	0.01	0.05
Q21. Number of carsharing memberships 1 (0), 2 (1), 3 (2), 4 (>2)	0.22	0.03	0.01	0.08
Q22. Frequency of walking more than 500 meters per trip 1 (Never or almost never) to 5 (Daily or almost daily)	3.96	0.08	0.08	0.07
Q23. Frequency of cycling 1 (Never or almost never) to 5 (Daily or almost daily)	2.14	0.06	0.06	0.09
Q24. Frequency of using moped or motorcycle as driver 1 (Never or almost never) to 5 (Daily or almost daily)	1.76	0.08	0.01	0.11
Q25. Frequency of using conventional vehicle as driver or passenger 1 (Never or almost never) to 5 (Daily or almost daily)	3.90	0.08	0.07	0.05
Q26. Frequency of using light transit (<100 km per one way) 1 (Never or almost never) to 5 (Daily or almost daily)	2.91	0.14	0.09	0.15
Q27. Frequency of using public transport (>100 km per one way) 1 (Never or almost never) to 5 (Daily or almost daily)	2.15	0.10	0.03	0.14
Q71. Severity of motion sickness 1 (I do not experience motion sickness), 2 (Moderate), 3 (Severe)	1.70	−0.09	−0.08	−0.05

Note. For a sample size of 7,755, correlations of 0.03 and higher, or −0.03 and lower, are statistically significantly different from zero, $p < 0.01$.

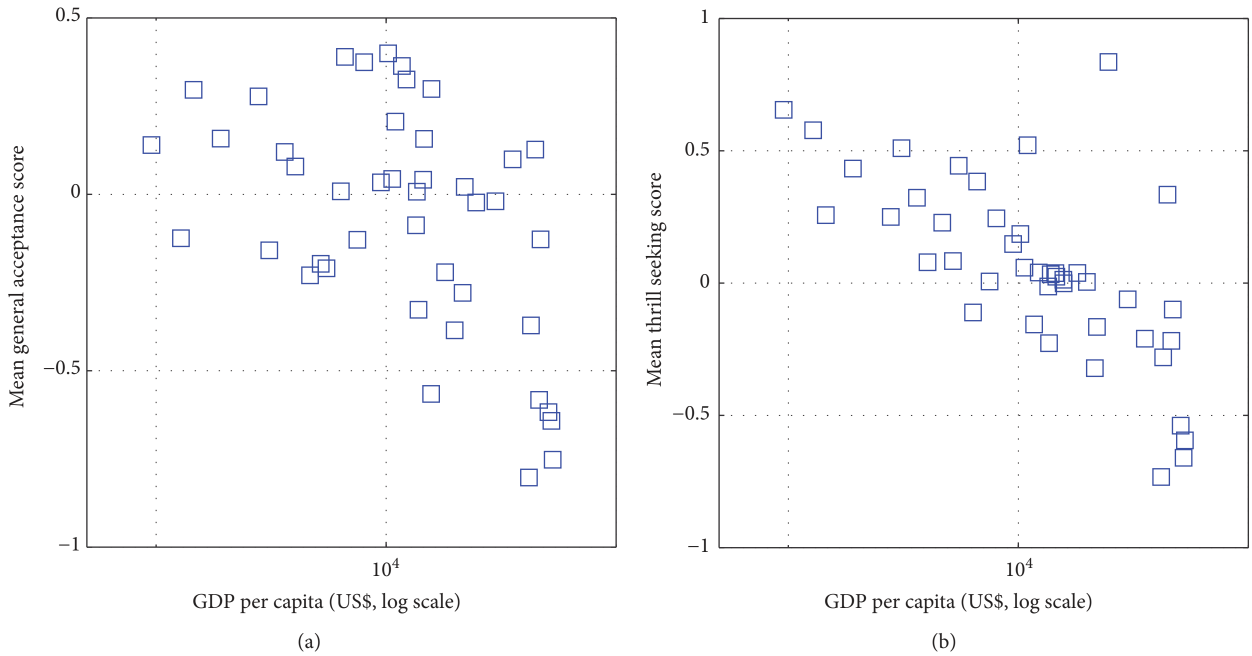

Figure 3: Correlation between countries' gross domestic product (GDP) per capita and participants' mean general acceptance score (a) and participants' mean thrill seeking score (b). Each marker represents a country with 25 or more respondents ($n = 43$).

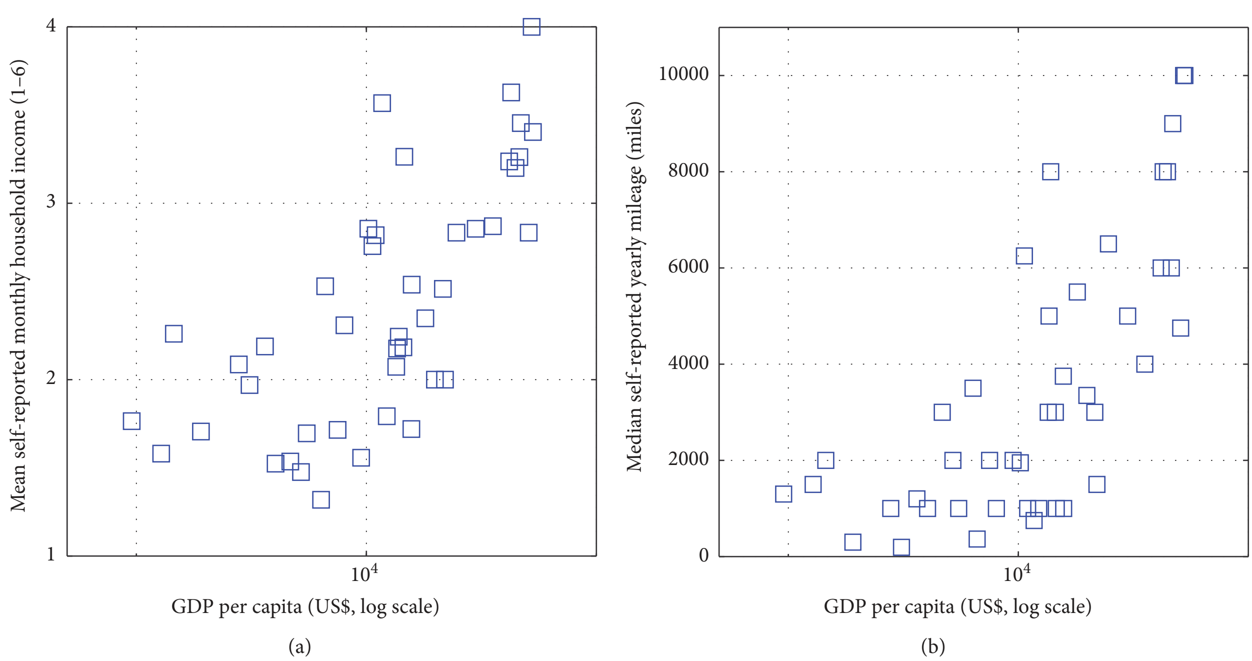

Figure 4: Correlation between countries' gross domestic product (GDP) per capita and participants' mean self-reported net household income (a) and participants' median self-reported yearly mileage (b). Each marker represents a country with 25 or more respondents ($n = 43$).

novel idea, which could move research on the acceptance of driverless vehicles in a new direction. The decision to retain one component may come at a price of oversimplification. However, we argue that the general acceptance component is a parsimonious reflection of the diverse items that concern acceptance of driverless vehicles. Also, the single component is in accordance with the percentage of variance explained by the components (scree plot) and was clearly interpretable. The notion of a single factor or component has also been proposed in various psychological domains with the general intelligence factor and the general personality factor being notable examples [55, 56]. Future studies should explore the hierarchical structure of the acceptance component. Thus, while we argue that a single acceptance component exists

Table 4: Spearman correlation matrix at the national level (n = 43).

	1	2	3	4	5	6	7	8	9	10	11
(1) General acceptance score											
(2) Component 1 score (general acceptance)	0.98										
(3) Component 2 score (thrill seeking)	0.50	0.41									
(4) Component 3 score (wanting to be in control manually)	0.04	0.05	−0.32								
(5) Component 4 score (supporting a car-free environment)	0.82	0.78	0.38	0.10							
(6) Component 5 score (being comfortable with technology)	0.92	0.88	0.55	−0.04	0.72						
(7) Road traffic death rate per 100,000 population	0.56	0.52	0.67	−0.22	0.26	0.58					
(8) Gross domestic product (GDP) per capita	−0.48	−0.42	−0.72	0.21	−0.44	−0.44	−0.58				
(9) National performance in educational tests	−0.60	−0.56	−0.78	0.35	−0.39	−0.67	−0.71	0.66			
(10) Average life expectancy	−0.43	−0.37	−0.70	0.16	−0.25	−0.45	−0.67	0.82	0.67		
(11) Motor vehicle density	−0.59	−0.53	−0.86	0.27	−0.45	−0.60	−0.71	0.88	0.81	0.81	
(12) Median age	−0.52	−0.45	−0.79	0.11	−0.25	−0.55	−0.73	0.60	0.73	0.66	0.80

Note. The general acceptance score is the first principal component score. The component 1–5 scores are the scores for the first five components, after Promax rotation.

at the top of the hierarchy, the existence of lower-level constructs is also likely. While the current general acceptance component is mainly an assembly of attitudinal constructs (e.g., knowledge of mobility, wish for car-free future) and behavioral beliefs (e.g., pleasure, social influence), the role of further entities such as values or norms (e.g., ecological or proenvironmental attitudes [57]) could be investigated.

High mean loadings (>0.60) on the general acceptance component were obtained for perceived usefulness. This aligns with the UTAUT model [26], which found that usefulness ("performance expectancy") is a main determinant of the acceptance of driverless vehicles. Medium mean loadings (~0.5) occurred for social influence, trust, and intention to use. These findings support the role of social influence, intention to use [22], and trust [58] as determinants of the acceptance of driverless vehicles.

The correlations between sociodemographic characteristics and general acceptance scores were small (<0.20), which is in agreement with studies examining the influence of sociodemographics on proenvironmental behavior [36], or with acceptance research on wind energy [37]. However, the small correlations were interpretable: The strongest correlation was found for the difficulty of finding a parking place, which is consistent with the literature on acceptance of transport-related measures (e.g., [59, 60]). The difficulty of finding a parking place may be indicative of the severity of transport-related problems and could therefore be a factor that influences people's willingness to accept driverless vehicles as a solution to this problem. The present study further found that living in the city and frequency of public transport use were positively correlated with the general acceptance score. These positive correlations may be explained because the driverless shuttle as depicted in the survey (Figure 1) is a form of public transport, and some people are more accustomed to using public transport and sharing space with strangers than others. In summary, our findings indicate that sociodemographic characteristics are less influential than domain-specific attitudes (e.g., performance expectancy) in predicting self-reported acceptance of driverless vehicles.

4.2. Main Results at the National Level. The countries' mean general acceptance score was negatively correlated with national GDP per capita and other developmental indexes (e.g., average life expectancy, motor vehicle density). In an additional analysis, we retained five instead of one component (Table 2), and we observed substantial negative correlations between countries' GDP per capita and the mean thrill seeking score, and between GDP per capita and the mean score for supporting a car-free environment (Table 4). These national differences may reflect national differences in thrill seeking personality, or effects of differences in road infrastructure (see also [50]). For example, low-income countries suffer more from transport-related problems [54, 61], which may make technological solutions and a car-free infrastructure in cities appealing for people living in these countries. It is recommended for future research to examine the mechanisms that explain the national differences in the acceptance of driverless vehicles. The relationships between the general acceptance component and the four additional components, as well as with other variables identified in this study, could be more closely examined in confirmatory studies using multiple well-defined scales (e.g., sensation seeking scale by Zuckerman et al. [62], in addition to our thrill-related items) and multivariate analyses (e.g., structural equation modeling).

Our study revealed differences between within-country and across-countries correlations. For example, the correlation between gender and the general acceptance scores was stronger for males across countries than within countries. This can be explained by a confounding effect, in the sense that the lower-income countries contained a relatively high proportion of males ($\rho = -0.49$, $n = 43$, Q2, see supplementary material), and respondents in lower-income countries were more accepting of driverless cars. We recommend that future research makes a distinction between within-country and between-country effects.

4.3. Study Limitations. Although it is important to study the acceptance before the technology is commercially available, the respondents did not physically get to see driverless vehicles, which may bias results. For example, it is possible that the respondents had overly positive attitudes that may have been nurtured by the portrayal of automated vehicles in the media.

Second, the survey instructions did not include a reference to the capabilities of the driverless vehicle, nor its speed. Current prototypes of driverless vehicles drive at a speed of 8 to 20 km/h [20]. It can be assumed that these speeds are too slow for integrating these vehicles into traffic without jeopardizing traffic flow efficiency or the acceptance by potential users.

Third, the crowdsourcing participants are not necessarily representative of the general population as they are younger and more highly educated compared to the general population [63]. Future research should more closely examine the effects in representative cross-national populations, using gender- and age-stratified samples.

Fourth, the survey was conducted in April 2015, meaning that the possibility exists that our data are not representative of today's public opinion, for example, due to changes in media coverage about automated vehicles. Abraham et al. [64] found that respondents were less comfortable with self-driving vehicles than a sample from one year ago. On the other hand, self-driving vehicles have not been commercialized yet, but are only used as part of various experiments and demonstration projects worldwide. Therefore, there has been little opportunity for respondents to actually experience self-driving vehicles and to adjust their opinion accordingly.

Finally, the use of self-reported measures in technology acceptance studies has been criticized, as the data that are collected are not independent of the method that is used to collect the data [65]. Our study indeed found evidence for common method effects, as the general acceptance score correlated relatively strongly with the time to complete the survey, and with whether participants found the survey instructions clear ($\rho \sim 0.20$ at the individual level, $n = 7{,}755$). At the national level ($n = 43$), it is possible that the negative correlation between the countries' mean general acceptance scores and GDP per capita ($\rho = -0.48$) reflects a common method bias due to social desirability or response style. For example, it is possible that respondents in higher-income countries gave lower acceptance ratings because of their better command of the English language. Better English language skills may be a reason why respondents in higher-income countries took less time to complete the survey ($\rho = -0.65$), and found the instructions clearer ($\rho = 0.43$, Q2; see supplementary material). Indeed, it cannot be ruled out that language barriers jeopardized the validity of our results, in the sense that it is possible that respondents in non-English speaking countries had difficulty with understanding the meaning of certain questions, as well as the notion of driverless shuttles. Then again, we did find strong correlations between GDP per capita and mean self-reported income (Q12), and median mileage (Q17) ($\rho = 0.71$ and 0.71, resp.), suggesting that self-reports are largely valid. Furthermore, GDP per capita correlated *positively* with some items (e.g., $\rho = 0.39$ for "Q36. I would like to have a button inside the driverless vehicle which I can press to stop it"), but *negatively* with others (e.g., $\rho = -0.64$ for "Q51. Even if it were more expensive than my existing form of travel, I would prefer driverless vehicles to my existing form of travel"), which suggests that respondents in different countries meaningfully responded to item content and showed no strong acquiescence bias by "agreeing" with all survey items. More fundamentally, our research points to interesting issues when it comes to measuring "acceptance", as acceptance is inherently a subjective construct that is substantively related to bias and preconceptions. Similar discussions have been held regarding the interpretation of the general factor of personality (GFP). Musek ([66, page 120]) pointed out that "considering the fact that some variance of the social desirability itself represents a substantive trait, the obvious conclusion is that GFP can only partly be explained by social desirability as a mere response style." Future research should use self-reports together with objective usage data of driverless vehicles.

4.4. Conclusions. In conclusion, our survey showed that respondents believe that driverless shuttles are easy to use and convenient. Our study also revealed cross-national differences and found that lower-income countries were more accepting of driverless vehicles than higher-income countries. Finally, we extracted a general acceptance component, which is an innovative measure that comprises pivotal items concerning the acceptance, and hence future success, of driverless vehicles.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Supplementary Materials

S1: results_overview19.xlsx: overview of questionnaire results. S2: zip-file of further supplementary materials. *(Supplementary Materials)*

References

[1] G. Eden, B. Nanchen, R. Ramseyer, and F. Evéquoz, "On the road with an autonomous passenger shuttle: integration in public spaces," in *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 1569–1576, ACM, Denver, Colo, USA, 2017.

[2] S. Shladover, "The Truth about Self-Driving Cars: They are coming, but not the way you may have been led to think," *Scientific American*, vol. 314, no. 6, pp. 52–57, 2016.

[3] Attias D., "The autonomous car, a disruptive business model?" in *The Automobile Revolution*, Attias D., Ed., Springer International Publishing, Switzerland, 2017.

[4] A. Scheltes and G. Correira, "Exploring the use of automated vehicles as last mile connection of chain trips through an agent-based simulation model: An application to Delft," in *Proceedings*

of the International Journal of Transportation Science and Technology, vol. 6, pp. 28–41, Netherlands, 2017.

[5] B. Van Arem, N. Van Oort, M. Yap, B. Wiegmans, and G. H. Correira, *Opportunities and Challenges for Automated Vehicles in the Zuidvleugel*, 2015, http://nielsvanoort.weblog.tudelft.nl/files/2015/03/TUD2103-essay-final.pdf.

[6] S. Nordhoff, B. Van Arem, and R. Happee, "Conceptual model to explain, predict, & improve user acceptance of driverless podlike vehicles," *Transportation Research Record*, vol. 2602, pp. 60–67, 2016.

[7] L. M. Hulse, H. Xie, and E. R. Galea, "Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age," *Safety Science*, vol. 102, pp. 1–13, 2018.

[8] M. Kyriakidis, R. Happee, and J. C. F. De Winter, "Public opinion on automated driving: Results of an international questionnaire among 5000 respondents," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 32, article no. 813, pp. 127–140, 2015.

[9] M. Regan, M. Cunningham, V. Dixit et al., *Preliminary Findings from The First Australian National Survey of Public Opinion about Automated And Driverless Vehicles*, 2017, http://advi.org.au/wp-content/uploads/2017/07/ADVI-Public-Opinion-Survey-7June2016.pdf.

[10] C. Hohenberger, M. Spörrle, and I. M. Welpe, "How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups," *Transportation Research Part A: Policy and Practice*, vol. 94, pp. 374–385, 2016.

[11] J. Piao, M. McDonald, N. Hounsell, M. Graindorge, T. Graindorge, and N. Malhene, "Public views towards implementation of automated vehicles in urban areas," *Transportation Research Procedia*, vol. 14, pp. 2168–2177.

[12] F. Becker and K. W. Axhausen, "Literature review on surveys investigating the acceptance of automated vehicles," *Transportation*, vol. 44, no. 6, pp. 1293–1306, 2017.

[13] P. Bansal, K. M. Kockelman, and A. Singh, "Assessing public opinions of and interest in new vehicle technologies: An Austin perspective," *Transportation Research Part C: Emerging Technologies*, vol. 67, pp. 1–14, 2016.

[14] J. Missel, *Ipsos MORI Loyalty Automotive Survey*, 2014, http://www.ipsos-mori.com/researchpublications/researcharchive/3427/Only-18-per-cent-of-Britons-believe-driverless-cars-to-be-an-important-development-for-the-car-industry-to-focus-on.aspx?utm_campaign=cmp_325684&utm_source=Getanewsletter.

[15] Seapine Software, "Study Finds 88 Percent of Adults Would Be Worried about Riding in a Driverless Car," http://www.seapine.com/about-us/press-release-full?press=217, 2014.

[16] Power JD, *Automotive Emerging Technologies Study Results*, 2012, http://autos.jdpower.com/content/press-release/gGOwCnW/2012-u-s-15automotive-emerging-technologies-study.htm.

[17] B. Schoettle and M. Sivak, *A Survey of Public Opinion about Autonomous and Self-Driving Vehicles in the U.S., the U.K., and Australia*, 2014, https://deepblue.lib.umich.edu/bitstream/handle/2027.42//103024.pdf.

[18] B. Schoettle and M. Sivak, *Motorists' Preferences for Different Levels of Vehicle Automation*, 2015, https://deepblue.lib.umich.edu/bitstream/handle/2027.42//103217.pdf.

[19] C. Rödel, S. Stadler, A. Meschtscherjakov, and M. Tscheligi, "Towards autonomous cars: The effect of autonomy levels on Acceptance and User Experience," in *Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2014*, USA, September 2014.

[20] S. Nordhoff, J. De Winter, R. Madigan, N. Merat, B. Van Arem, and R. Happee, "User acceptance of automated shuttles in Berlin-Schöneberg: A questionnaire study," *Manuscript Submitted for Publication*, 2017.

[21] R. Shabanpour, S. N. D. Mousavi, N. Golshani, J. Auld, and A. Mohammadian, "Consumer preferences of electric and automated vehicles," in *Proceedings of the 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems, MT-ITS 2017*, pp. 716–720, IEEE, Naples, Italy, June 2017.

[22] R. Madigan, T. Louw, M. Dziennus et al., "Acceptance of Automated Road Transport Systems (ARTS): An adaptation of the UTAUT model," in *Proceedings of the 6th Transport Research Arena*, pp. 2217–2226, Elsevier, Warsaw, Poland, 2016.

[23] M. D. Yap, G. Correia, and B. Van Arem, "Valuation of travel attributes for using automated vehicles as egress transport of multimodal train trips," *Transportation Research Procedia*, vol. 10, pp. 462–471, 2015.

[24] J. P. Zmud and I. N. Sener, "Towards an understanding of the travel behavior impact of autonomous vehicles," *Transportation Research Procedia*, vol. 25, pp. 2500–2519, 2017.

[25] P. S. Lavieri, V. M. Garikapati, C. R. Bhat, R. M. Pendyala, S. Astroza, and F. F. Dias, "Modeling individual preferences for ownership and sharing of autonomous vehicle technologies," *Transportation Research Record: Journal of the Transportation Research Board*, pp. 1–10, 2017.

[26] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: toward a unified view," *MIS Quarterly: Management Information Systems*, vol. 27, no. 3, pp. 425–478, 2003.

[27] M. Fishbein and I. Ajzen, *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*, Addison-Wesley, Boston, Mass, USA, 1975.

[28] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quarterly*, vol. 13, no. 3, pp. 319–339, 1989.

[29] F. D. Davis, R. P. Bagozzi, and P. R. Warshaw, "User acceptance of computer technology: a comparison of two theoretical models," *Management Science*, vol. 35, no. 8, pp. 982–1003, 1989.

[30] I. Ajzen, "From intentions to actions: A theory of planned behavior. In," in *Action-Control: from Cognition to Behavior*, J. Kuhl and Beckmann, Eds., pp. 11–39, Springer, Heidelberg, Germany, 1985.

[31] A. Mehrabian, "Pleasure-arousal-dominance: a general framework for describing and measuring individual differences in temperament," *Current Psychology*, vol. 14, no. 4, pp. 261–292, 1996.

[32] R. Madigan, T. Louw, M. Wilbrink, A. Schieben, and N. Merat, "What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of automated road transport systems," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 50, pp. 55–64, 2017.

[33] P. Bazilinskyy, M. Kyriakidis, and J. de Winter, "An international crowdsourcing study into people's statements on fully automated driving," *Procedia Manufacturing*, vol. 3, pp. 2534–2542, 2015.

[34] World Economic Forum (WEF) and Boston Consulting Group (BCG), "Self-driving vehicles in an urban context," http://www3.weforum.org/docs/WEF_Press%20release.pdf, 2015.

[35] B. Schoettle and M. Sivak, *Public Opinion about self-driving vehicles in China, India, Japan, the U.S., the U.K., and Australia*, 2014, http://deepblue.lib.umich.edu/bitstream/handle/2027.42/109433/103139.pdf?sequence=1&isAllowed=y.

[36] P. C. Stern, "New environmental theories: Toward a coherent theory of environmentally significant behavior," *Journal of Social Issues*, vol. 56, no. 3, pp. 407–424, 2000.

[37] J. Rand and B. Hoen, "Thirty years of North American wind energy acceptance research: What have we learned?" *Energy Research and Social Science*, vol. 29, pp. 135–148, 2017.

[38] S. Barr and G. Shaw, *Knowledge Co-Production And Behavioural Change: Collaborative Approaches for Promoting Sustainable Mobility*, D. Hopkins and J. Higham, Eds., Goodfellow Publishers, Oxford, UK, 2016.

[39] Easymile, *Video of EZ10 at EPFL: Demonstration of the EZ10 driverless vehicle at the École Polytech-nique Fédérale de Lausanne (EPFL)*, Springer, Lausanne, Switzerland, 2015, http://easymile.com/easymile-on-youtube/.

[40] H. Schuhmacher, "WEPODS: Autonome Minibusse," http://androidmag.de/report/wepods-autonome-minibusse/, 2015.

[41] A. Parasuraman, "Technology readiness index (TRI): a multiple-item scale to measure readiness to embrace new technologies," *Journal of Service Research*, vol. 2, no. 4, pp. 307–320, 2000.

[42] S. Vlassenroot, K. Brookhuis, J. De Mol, and F. Witlox, "Acceptability of ISA: results from a large-scale survey in Belgium and the Netherlands," in *Proceedings of the 8th ITS European Congress and Exhibition on Intelligent Transport Systems and Services*, Lyon, France, 2011.

[43] D. Yagil, "Reasoned action and irrational motives: A prediction of drivers' intention to violate traffic laws," *Journal of Applied Social Psychology*, vol. 31, no. 4, pp. 720–740, 2001.

[44] R. Krueger, T. H. Rashidi, and J. M. Rose, "Preferences for shared autonomous vehicles," *Transportation Research Part C: Emerging Technologies*, vol. 69, pp. 343–355, 2016.

[45] L. Beretta and A. Santaniello, "Nearest neighbor imputation algorithms: A critical evaluation," *BMC Medical Informatics and Decision Making*, vol. 16, article no. 74, pp. 197–208, 2016.

[46] X. Dong, B. Milholland, and J. Vijg, "Evidence for a limit to human lifespan," *Nature*, vol. 538, no. 7624, pp. 257–259, 2016.

[47] J. C. F. De Winter and P. A. Hancock, "Reflections on the 1951 Fitts list: Do humans believe now that machines surpass them?" in *Proceedings of the 6th International Conference on Applied Human Factors and Ergonomics (AHFE)*, pp. 5334–5341, Las Vegas, Nev, USA, 2015.

[48] H. F. Kaiser, "A second generation little jiffy," *Psychometrika*, vol. 35, no. 4, pp. 401–415, 1970.

[49] R. A. Peterson, "A meta-analysis of variance accounted for and factor loadings in exploratory factor analysis," *Marketing Letters*, vol. 11, no. 3, pp. 261–275, 2000.

[50] J. C. F. de Winter and D. Dodou, "National correlates of self-reported traffic violations across 41 countries," *Personality and Individual Differences*, vol. 98, pp. 145–152, 2016.

[51] H. Rindermann, "The g-factor of international cognitive ability comparisons: The homogeneity of results in PISA, TIMSS, PIRLS and IQ-tests across nations," *European Journal of Personality*, vol. 21, no. 5, pp. 667–706, 2007.

[52] World Bank, http://data.worldbank.org/indicator, 2015.

[53] Central Intelligence Agency, "The World Factbook," Retrieved from https://www.cia.gov/library/publications/the-world-factbook/fields/2177.html, 2015.

[54] World Health Organization, *Global Status Report on Road Safety 2015*, World Health Organization, Geneva, Switzerland, http://www.who.int/violence_injury_prevention/road_safety_status/2015/GSRRS2015_Summary_EN_final2.pdf?ua=1, 2015.

[55] A. R. Jensen, *The g Factor: The Science of Mental Ability*, Praeger, Westport, Connecticut, USA, 1998.

[56] J. Musek, "A general factor of personality: evidence for the Big One in the five-factor model," *Journal of Research in Personality*, vol. 41, no. 6, pp. 1213–1233, 2007.

[57] L. Steg and C. Vlek, "Encouraging pro-environmental behaviour: An integrative review and research agenda," *Journal of Environmental Psychology*, vol. 29, no. 3, pp. 309–317, 2009.

[58] J. K. Choi and Y. G. Ji, "Investigating the Importance of Trust on Adopting an Autonomous Vehicle," *International Journal of Human-Computer Interaction*, vol. 31, no. 10, pp. 692–702, 2015.

[59] L. Steg and C. Vlek, "The role of problem awareness in willingness-to-change car-use and in evaluating relevant policy measures," in *Traffic and Transport Psychology*, J. A. Rothengatter and E. Carbonell Vaya, Eds., pp. 465–475, Pergamon, Oxford, UK, 1997.

[60] S. A. Rienstra, P. Rietveld, and E. T. Verhoef, "The social support for policy measures in passenger transport. A statistical analysis for the Netherlands," *Transportation Research Part D: Transport and Environment*, vol. 4, no. 3, pp. 181–200, 1999.

[61] S. N. Forjuoh, "Traffic-related injury prevention interventions for low-income countries.," *The International Journal of Injury Control and Safety Promotion*, vol. 10, no. 1-2, pp. 109–118, 2003.

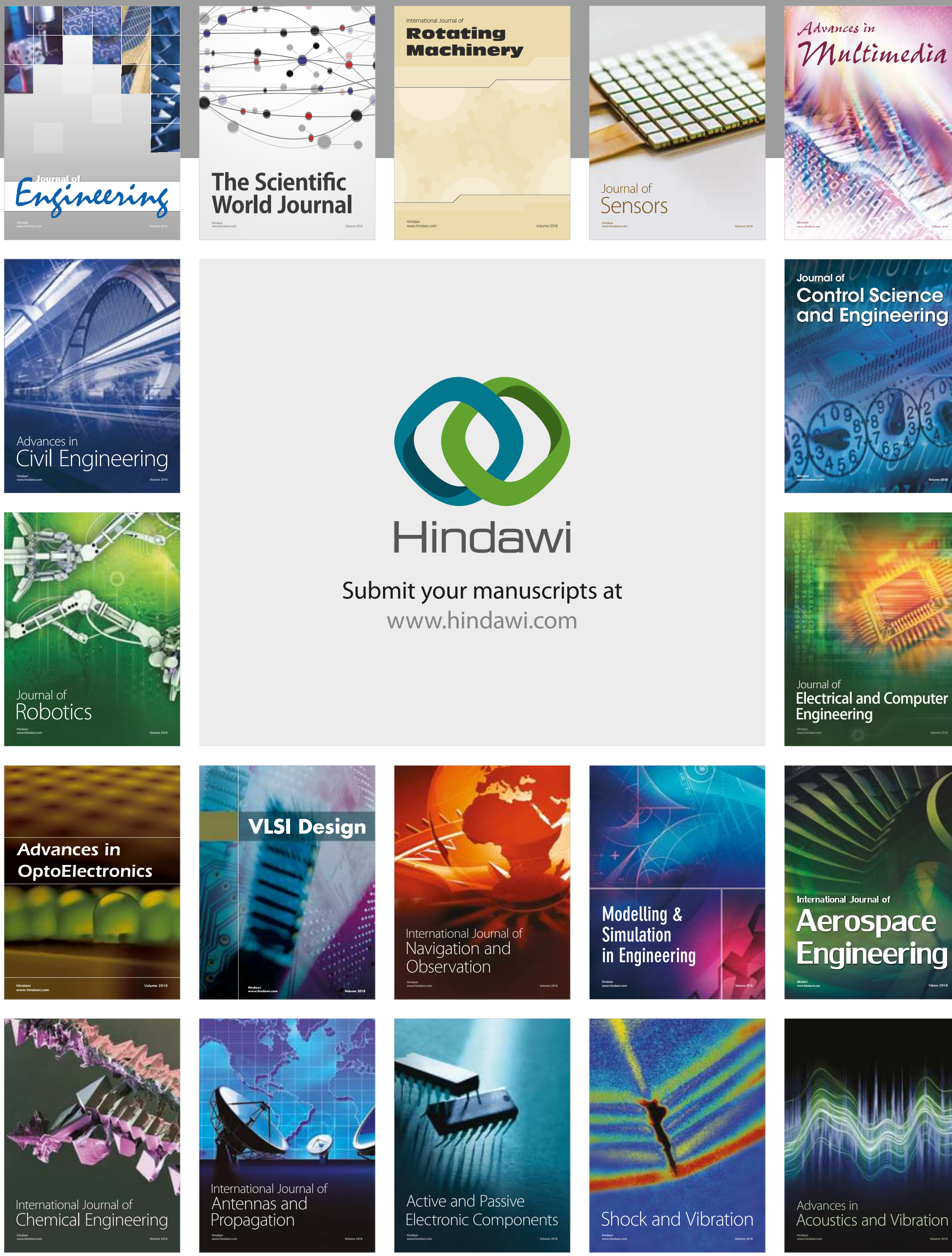
[62] M. Zuckerman, S. Eysenck, and H. J. Eysenck, "Sensation seeking in England and America: cross-cultural, age, and sex comparisons," *Journal of Consulting and Clinical Psychology*, vol. 46, no. 1, pp. 139–149, 1978.

[63] J. C. F. De Winter, M. Kyriakidis, D. Dodou, and R. Happee, "Using crowd flower to study the relationship between self-reported violations and traffic accidents," in *Proceedings of the 6th International Conference on Applied Human Factors and Ergonomics (AHFE)*, pp. 2518–2525, Las Vegas, Nevada, USA, 2015.

[64] H. Abraham, B. Reimer, B. Seppelt, C. Fitzgerald, B. Mehler, and J. F. Coughlin, "Consumer interest in automation: Change over one year," in *Proceedings of the Transportation Research Board 97th Annual Meeting*, Washington Convention Center, Washington DC, USA, 2018.

[65] D. W. Straub Jr. and A. Burton-Jones, "Veni, vidi, vici: Breaking the TAM logjam," *Journal of the Association for Information Systems*, vol. 8, no. 4, pp. 223–229, 2007.

[66] J. Musek, *The General Factor of Personality*, Academic Press, Cambridge, Mass, USA, 2017.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