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A Questionnaire Study

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Research Article

Profiling the Enthusiastic, Neutral, and Sceptical Users of Conditionally Automated Cars in 17 Countries: A Questionnaire Study

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The L3Pilot project tested SAE Level 3 (L3) conditionally automated driving functions addressing driving and travel behavior, impacts on safety, efficiency, environment and socio-economics, and user acceptance. To investigate individual variance in acceptance of conditionally automated cars, an online survey was performed among 18,631 respondents from 17 countries evaluating differences in age, gender, knowledge about the functionality of conditionally automated cars, awareness, information consumption behavior, and expected benefits of conditionally automated cars. Respondents were divided into Enthusiasts, Neutrals, and Sceptics differing in a high, moderate, and low acceptance of conditionally automated cars, respectively. Enthusiasts, Neutrals, and Sceptics differed most with regard to the expected benefits in the productive use of travel time, comfort, and safety of conditionally automated cars. Enthusiasts were male, younger, more knowledgeable about conditionally automated cars, more aware of automated cars, and more likely to receive information about automated cars from different sources, expecting improvements in the productive use of travel time, comfort, and safety due to conditionally automated cars. All groups were most knowledgeable about the lane keeping behavior of conditionally automated cars and least knowledgeable about the operation of conditionally automated cars in dedicated operational design domains. The results indicate that the communication and marketing of automated cars should create a realistic image of the capabilities and limitations of conditionally automated cars where user education programs should be harmonized to calibrate expectations and educate the public.

1. Introduction

Over the years, comments from car manufactures and speculation from the media has given the public unrealistic and inaccurate expectations about the capabilities of automated cars and when they will be available [1–8]. As deadlines have passed and expectations not met, the hype around automated cars turned into disillusionment, which ultimately may affect public acceptance [1, 9–11].

Research in the field of automated vehicle acceptance has grown tremendously in the past few years. Online surveys and interview studies have shown a substantial variance in the intention to buy and use automated vehicles within and between populations. Studies have predicted automated vehicle acceptance as a function of direct and indirect factors adopting common technology acceptance models, applying bivariate correlation, regression, or structural equation analyses [12–15]. Others have used factor analysis to explore

or confirm the sources of variation in the dataset, i.e., latent structure underlying a set of variables [16]. Segmentation techniques clustered users on the basis of certain characteristics [17–21]. These included their enthusiasm/scepticism towards automated cars, attitudes towards the future use of automated cars on public roads, likelihood to purchase a personal and shared automated/driverless car, awareness/knowledge about automated cars, the perceived benefits and concerns about automated cars, age, and gender [17–21]. These clusters have been given different names such as attitudinal groups with a positive, negative, ambivalent, or indifferent attitude [19], Laggards and Pioneers [17], Likely Adopters and First Movers [21], or Sceptics, Indifferents, and Enthusiasts [20]. Sceptics were more concerned about automated cars and less enthusiastic than Indifferents and Enthusiasts. Indifferents were between Sceptics and Enthusiasts regarding their enthusiasm towards automated cars. Enthusiasts were most excited about automated cars and had the fewest concerns towards them [20]. In Liu [19], the people who were positive towards vehicle automation were more likely to be male, to have heard about automated cars, to perceive the benefits of automated cars, and were less likely to associate risks with automated cars.

Sceptics and Neutrals (i.e., equal to the Indifferents) constitute the largest share of the market in comparison to Enthusiasts [22]. Obtaining knowledge on Sceptics and Neutrals can offer insights into the overall impact on society, transport, and mobility, unleashing a huge market potential. The barriers to the acceptance of conditional automation can be identified, and user-group specific strategies and appeals developed (see [20, 23, 24]). In order to fulfil the potential of vehicle automation, it is important to gain an understanding of the attitudes of Enthusiasts, Neutrals, and Sceptics across countries, so that researchers and Original Equipment Manufacturers (OEMs) can address concerns and deliver the benefits of automated cars to their customers.

Various studies have shown cross-national differences in the awareness, user experience, attitudes towards automated cars, acceptance, perceived comfort riding automated cars, willingness to pay, and acceptance of the decisions of automated cars [12, 25–33]. In our previous study [34], the acceptance of conditionally automated cars by European car drivers was predicted by hedonic motivation, social influence, and performance expectancy, but we did not examine cross-national differences in acceptance. Moody et al. [35] revealed that country-level awareness of automated driving was positively related to GDP per capita, suggesting that respondents from economically developed countries were more aware of automated cars than others. A report of the European Commission [28] has shown that respondents from the Netherlands, Sweden, and Denmark were most aware of automated cars, while respondents from Poland, Romania, and Bulgaria were the least aware. Schrauth et al. [32] revealed that respondents from Spain, Sweden, and Slovenia regarded the introduction of conditionally automated cars most beneficial, while the assessment of the benefits of the introduction of conditionally automated cars was lowest among respondents from Germany, France, and the U.S.. Respondents from Germany, the U.S., and Australia were most concerned about the introduction of conditionally automated cars, while respondents from Slovenia, Spain, and Sweden were the least concerned. The authors have further shown that respondents from Spain and Slovenia had a higher level of acceptance of conditionally automated cars, while respondents from Australia and the U.S. did not differ significantly from France.

1.1. Research Gaps. These studies have advanced our understanding of how attitudes towards automated cars differ across groups of people and countries. However, they have the following limitations.

First, there is little understanding about how acceptance of conditional automation differs between Enthusiasts, Neutrals, and Sceptics across European and non-European countries. In fact, the examination of the attitudes towards and acceptance of *conditional automation* (L3) has been generally neglected by studies so far as they tended to focus on higher automation levels (see the study of Nordhoff et al. [5] in which it was mentioned that 3 out of 124 studies were devoted to conditional automation). In particular, in countries with a lower motorization and traffic density and higher road death rate and environmental pollution, automated cars have a huge potential to realize the benefits of automation and increase the quality of life [36].

Second, there is limited knowledge on how Enthusiasts, Neutrals, and Sceptics differ with regard to their perception of the benefits of conditionally automated cars. Obtaining knowledge on how Enthusiasts, Neutrals, and Sceptics differ with regard to the expected changes in the productive use of travel time, travel comfort, and the number of accidents is important given that productivity/efficiency, comfort, and safety were identified as one of the most important predictors of the attitudes towards and acceptance of (conditionally) automated cars [12, 15, 34, 37–40].

Third, there is limited knowledge about the differences between Enthusiasts, Neutrals, and Sceptics in terms of their knowledge about conditionally automated cars, their awareness of automated cars in general, and their information consumption behavior (i.e., frequency of use of sources to receive information about automated cars). Previous studies have acknowledged the importance of knowledge and information for the perceptions of automated cars [41–43]. Zhu et al. [15] found a positive influence of receiving information about automated cars from mass media on the perceived usefulness and perceived risks of automated cars. Receiving information from social media had no influence on the perceived usefulness but increased the perceived risks of automated cars. Lee et al. [12] revealed positive effects of traditional media on trust in automated cars, subjective norms (i.e., reliance on social networks to use automated cars), and self-efficacy (i.e., perceived capabilities to use automated cars). Social media, in turn, had negative effects on trust and positive effects on subjective norms and self-efficacy.

Understanding how Enthusiasts, Neutrals, and Sceptics across countries receive information about automated cars yields important practical recommendations for the OEMs, which can then more effectively design advertising and communication campaigns using the most common channels.

1.2. Research Objectives. The present study focused on SAE Level 3 conditionally automated passenger cars allowing users to take their eyes off the road and engage in other activities, thereby providing major benefits to their users. The study was performed among respondents from 17 countries in the context of the L3Pilot project. L3Pilot conducted large-scale piloting of conditionally automated passenger cars in order to address various technical and user challenges and evaluate their wider societal impacts [44].

We defined three groups that differed in their intention to use conditionally automated cars. Enthusiasts were defined as those who expressed their intention to use (i.e., accept) conditionally automated cars. Neutrals were defined as those who were neutral towards using conditionally automated cars, and Sceptics were defined as those who did not intend to use conditionally automated cars. It was examined how Enthusiasts, Neutrals, and Sceptics from 17 countries differed with regard to their age, gender, knowledge about conditionally automated cars, awareness of automated cars, frequency of receiving information about automated cars from different sources, and the expected changes on the productive use of travel time, travel comfort, and safety due to conditionally automated cars. Survey data were collected from people without experience with conditionally automated cars as such vehicles have not been commercialized yet.

2. Methodology

2.1. Procedure and Recruitment. An online questionnaire was administered to 18,631 respondents from seventeen countries (Brazil, China, Finland, France, Germany, Hungary, India, Indonesia, Italy, Japan, Russia, Spain, South Africa, Sweden, Turkey, U.K., and U.S.) that were selected on the basis of their current and future car market size and geographical representation. The questionnaire was conducted by the German market research institute INNOFACT AG (http://www.innofact.com) using the questionnaire tool EXAVO (https://www.exavo.de/surveytainment/). The Finnish data were collected by Taloustutkimus Oy (https://www.taloustutkimus.fi/in-english.html) among their nationally representative Internet panel using their proprietary questionnaire tool. The data collection from all European respondents except for the Spanish respondents as well as respondents from the U.S. and China took place between April and June 2019 among a sample that was representative of age, gender, and income of their country population, respectively, and that frequently used a private car, carsharing, and rental car as a driver. The data collection from the non-European and the Spanish respondents took place between March and April 2020. Respondents received the invitation to participate in the questionnaire study via e-mail. Their participation in the questionnaire was compensated: they either received financial compensation, vouchers, or had the opportunity to win prices by being a member in the panel.

2.2. Questionnaire Design. Prior to programming and launch, the questionnaire was pretested in several iteration rounds in order to warrant a logical ordering and clear meaning of the questionnaire items. A translation bureau translated the questionnaire to the national languages of the countries. A soft launch of the questionnaire was performed prior to official launch with approximately thirty respondents in order to resolve any implementation or wording errors. In order to ensure that responses were not influenced by the order in which questionnaire items were presented, those that did not follow a specific logic were presented in a random order across respondents.

2.3. Questionnaire Content. The questionnaire was divided into five main parts.

In the first part, respondents were asked to provide information about their age, gender, income, frequency of travel mode use, and travel mode use per trip purpose.

In the second part, respondents were provided with the following information about the functionality of conditionally automated cars in order to ensure they had sufficient understanding of conditionally automated cars:

> *"Have you ever heard of automated cars? There are different terms to define the capabilities of automated cars, such as self-driving, autonomous, automated, pilotless, driverless, and conditionally automated. With this questionnaire, we would like to get your opinion on conditionally automated cars. Conditionally automated cars can drive under limited conditions, such as driving on motorways, on congested motorways, in urban traffic, and in parking situations. They will not operate beyond these conditions. Conditionally automated cars do the steering, acceleration, and braking. They will stay in the lane and maintain a safe distance to the vehicle in front. They will also overtake slower moving vehicles or change lane. These cars still have gas and brake pedals and a steering wheel. You are not driving when the car is in conditionally automated mode—even if you are seated in the driver's seat. This will allow you to engage in other activities, such as e-mailing or watching videos. However, the car might ask you to resume vehicle control anytime, e.g., when approaching a construction site, which means you might have to stop what you are doing and resume control of the cars."*

Next, respondents were asked to indicate whether a conditionally automated car can stay in the lane, overtake on its own, operate in all conditions, ask the human driver to take over control, and whether drivers of conditionally automated cars can pursue other activities except for sleeping.

In the third part, respondents were asked to indicate whether they had heard of automated cars before taking part in the questionnaire. If they ticked "yes," they were asked to report how often they receive information on automated cars from online communities, websites about IT, cars, or

motoring; social media; radio and TV; friends, family, and colleagues; car dealers, manufacturers, and suppliers; and newspapers and magazines. Respondents were also asked to rate their level of technology readiness.

In the fourth part, respondents were asked to indicate their willingness to allow conditionally automated cars collect personal data, and their general attitudes towards and acceptance of conditionally automated cars using the constructs from UTAUT2 (Unified Theory of Acceptance and Use of Technology).

The fifth part asked respondents to indicate their intention to use conditional automation in different operational design domains, such as urban roads, congested motorways, motorways, and in parking situations.

The sixth part asked respondents to report for which trip purposes they would use conditionally automated cars. Respondents were also asked to indicate to what extent they expect conditionally automated cars impacting their personal mobility, including their productive use of travel time, travel comfort, and number of accidents. With the final questions of the survey, respondents were asked to provide further information about their mobility behavior, previous experience with road vehicle automation, and socio-demographic profile.

The present study will report the results to the questions addressing respondents' degree of knowledge of conditionally automated cars, awareness of and frequency of receiving information about automated cars from various sources, and expected benefits of conditionally automated cars. Other questions were addressed in Lehtonen et al. [45] and Nordhoff et al. [34]. The whole questionnaire is provided in the L3Pilot Deliverable D7.1 [34–45].

2.4. Data Filtering. Data were filtered for inconsistencies and absence of important responses. In order to target car drivers, individuals were excluded if they indicated to "almost never" use the private car, carsharing, and rental car as driver or did not provide a response to these questions in the first stage. Individuals were further excluded if they indicated that they made daily use of all transport modes and indicated to daily use the airplane because this mobility pattern was considered very unlikely. Individuals were also excluded if they provided inconsistent socio-demographic responses (i.e., being at the age of 20 years old while being retired) and/or responded "I don't know" to all questions measuring the knowledge of the functionality of conditionally automated cars. "I prefer not to respond" responses were defined as missing values and excluded from the analysis.

2.5. Data Analysis. The data were analysed in two steps. A confirmatory factor analysis was performed and reported in Nordhoff et al. [34]. This showed that the factor loadings (λ = lambda) of the two questions "I intend to use a conditionally automated car in the future" ($\lambda = 0.88$) and "I plan to buy a conditionally automated car once it is available" ($\lambda = 0.80$) exceeded the recommended threshold of 0.70, well summarising the variance in behavioral intention (i.e., measure for acceptance). The questions "Assuming that I had access to a conditionally automated car," "I predict that I would use it," "I plan to use a conditionally automated car in adverse weather conditions such as during heavy rain or fog and in darkness," and "I would use a conditionally automated car during my everyday trips," were omitted from behavioral intention due to factor loadings lower than 0.70 and high inter-construct correlations [34]. In the current paper, we combined the two questions measuring behavioral intention—"I intend to use a conditionally automated car in the future" and "I plan to buy a conditionally automated car once it is available"—to create a composite score for behavioral intention (see [46]). The scores of these two questions were averaged using data from 18,054 respondents. Based on the five-point Likert scale, a score between 1 and 5 was assigned to each respondent. Those who scored between 1 and 2 were defined as Sceptics, i.e., individuals who were sceptical towards the use of conditionally automated cars ($n = 2{,}906$). Those who scored between 2.5 and 3.5 were defined as Neutrals, i.e., individuals who were neutral towards using conditionally automated cars ($n = 7{,}522$). Those who scored between 4 and 5 were defined as Enthusiasts, i.e., individuals who were enthusiastic towards using conditionally automated cars ($n = 7{,}626$).

Second, in order to examine differences between Enthusiasts, Neutrals, and Sceptics in their age, gender, knowledge about conditionally automated cars, awareness of automated cars and information consumption behavior, and the expected benefits of conditionally automated cars, Spearman rank-order correlations were computed.

3. Results

3.1. Respondents. An overview of respondents' age and gender is given in Table 1.

3.2. Acceptance of Conditionally Automated Cars among Enthusiasts, Neutrals, and Sceptics. As shown in Figure 1, 42% of the respondents in the sample were Enthusiasts, 42% were Neutrals, and 16% were Sceptics. Respondents from non-European, lower-GDP countries were less enthusiastic about using conditionally automated cars than respondents from European, higher-GDP countries. India (84%), Turkey (76%), and Indonesia (74%) had the highest proportion of Enthusiasts, while Sweden (23%), Germany (18%), and Finland (13%) had the lowest. Russia (55%), Japan (53%), and Hungary and Spain (51%) had the highest proportion of Neutrals, while Brazil and Indonesia (25%), Turkey (20%), and India (13%) had the lowest. The highest proportion of Sceptics could be found in Finland (40%), Germany (30%), and Sweden (29%), the lowest proportion of that was found in China, Brazil, and Indonesia (1%).

3.3. Socio-Demographics

3.3.1. Age and Gender. As shown in Figure 2(a), 55% of Enthusiasts were male. The gender differences were

Table 1: Respondents' age and gender (i.e., M = mean, SD = standard deviation, and n = number of respondents, relative frequencies).

Question	Age (in years)							Gender	
	M	SD	n	18–22 (%)	23–35 (%)	36–55 (%)	56–69 (%)	Male (%)	Female (%)
All countries	40.72	13.63	18,631	10	29	43	18	50	50
Brazil (BR)	37.48	12.42	1057	13	34	42	11	50	50
China (CN)	37.20	11.88	1004	13	33	46	9	50	50
Finland (FI)	50.22	12.04	1021	2	12	48	38	59	41
France (FR)	42.72	13.86	1164	9	26	44	21	48	52
Germany (DE)	43.87	14.87	1133	11	20	41	27	50	50
Hungary (HU)	41.90	14.11	1146	9	29	41	21	49	51
India (IN)	35.33	11.85	1054	18	37	37	9	51	49
Indonesia (ID)	35.25	10.87	1059	14	38	42	6	51	49
Italy (IT)	42.67	13.23	1186	8	26	47	20	50	50
Japan (JP)	45.04	13.46	1074	6	24	43	27	51	49
Russia (RU)	37.70	11.82	1079	12	35	42	11	46	54
Spain (ES)	42.15	12.35	1074	6	28	47	18	51	49
South Africa (ZA)	35.53	12.74	1070	20	33	38	9	48	52
Sweden (SE)	42.46	14.93	1177	9	30	40	21	52	48
Turkey (TR)	37.11	11.78	1060	13	35	42	11	50	50
United Kingdom (UK)	41.21	13.64	1217	9	29	43	18	49	51
United States (US)	43.54	14.49	1056	7	27	40	26	48	52

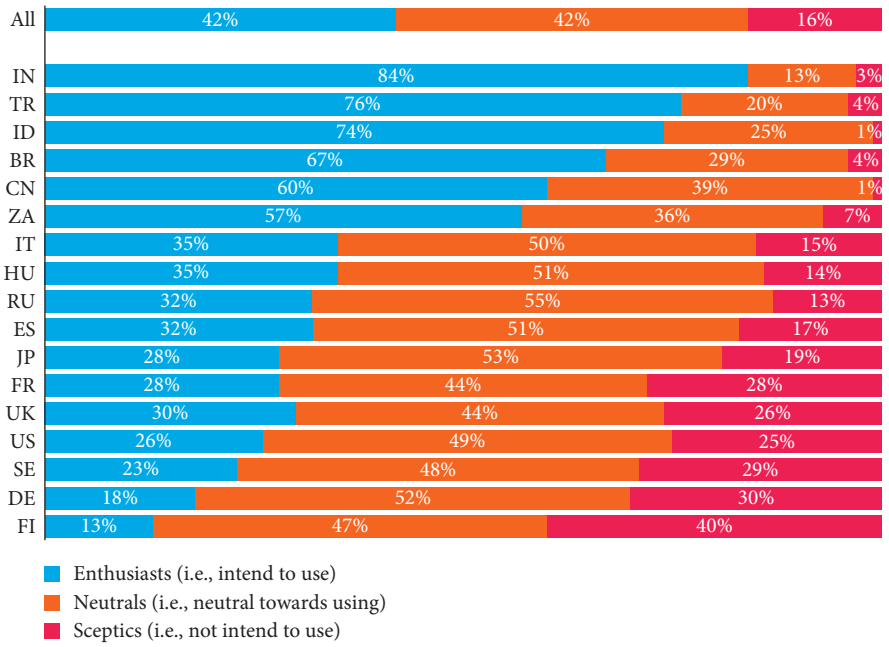

Figure 1: Percentage values of Enthusiasts, Neutrals, and Sceptics towards conditionally automated cars ($M = 3.38$, SD = 1.09, and $n = 18{,}054$).

positive and small in all countries ($r = < 0.20$) (gender was dummy coded; male = 1) and significant in most countries (not significant in Indonesia and Russia). This suggests that Enthusiasts were more often male than female. However, in Brazil, China, India, and Turkey, the correlation was negative, suggesting that Females were more likely than Males to be Enthusiasts (not significant in Brazil).

As shown in Figure 2(b), Sceptics (67%) were more likely than Neutrals (59%) and Enthusiasts (57%) to be between 36 and 69 years. Negative correlations between age and intention to use conditionally automated cars were found in almost all countries ($r = < -0.35$). The correlation was not significant in Hungary, Indonesia, and Japan. A positive correlation was found in China, India, and Turkey. Note that the correlation was not significant in India and Turkey.

3.4. Knowledge about Conditionally Automated Cars

3.4.1. System Functionality. Enthusiasts (89%) were more likely than Neutrals (83%) and Sceptics (82%) to know that conditionally automated cars can stay in the lane (Figure 3(a)). The correlation between knowledge about lane

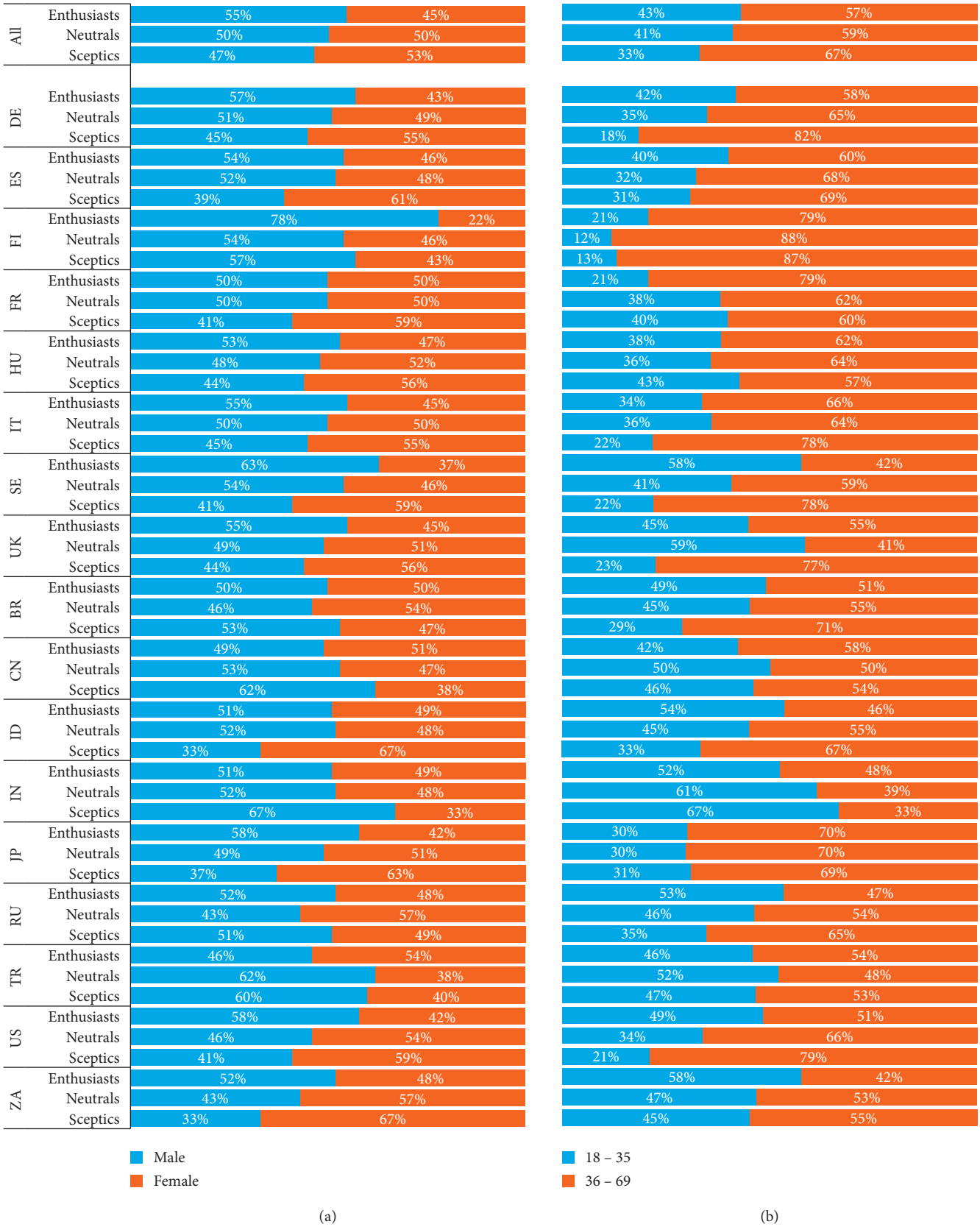

Figure 2: (a) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in gender. (b) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in age. Note that the age categories 1 (18–22) and 2 (23–35) were merged into one age category, and 3 (36–55) and 4 (56–69) were merged into a separate age category, respectively.

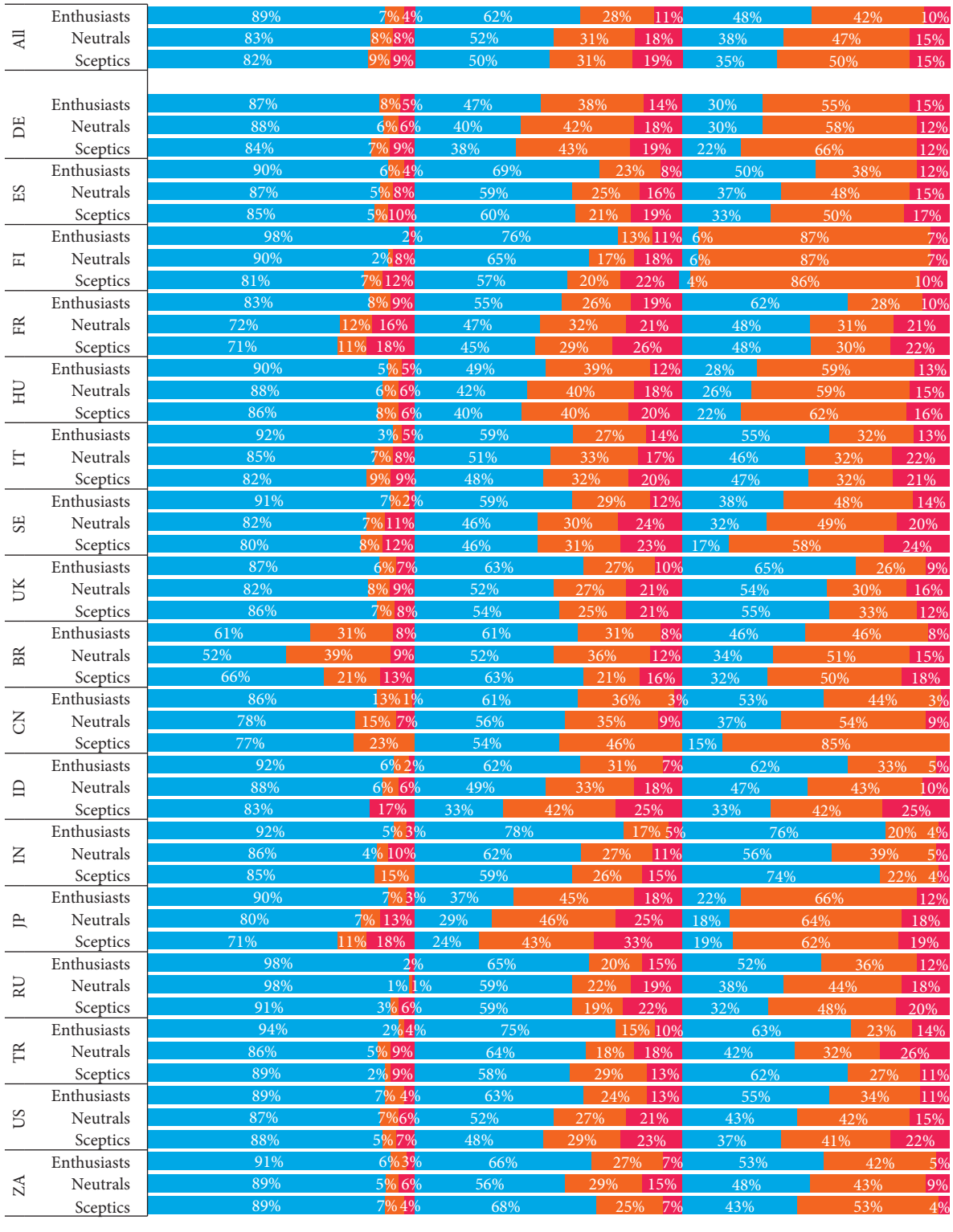

Figure 3: Continued.

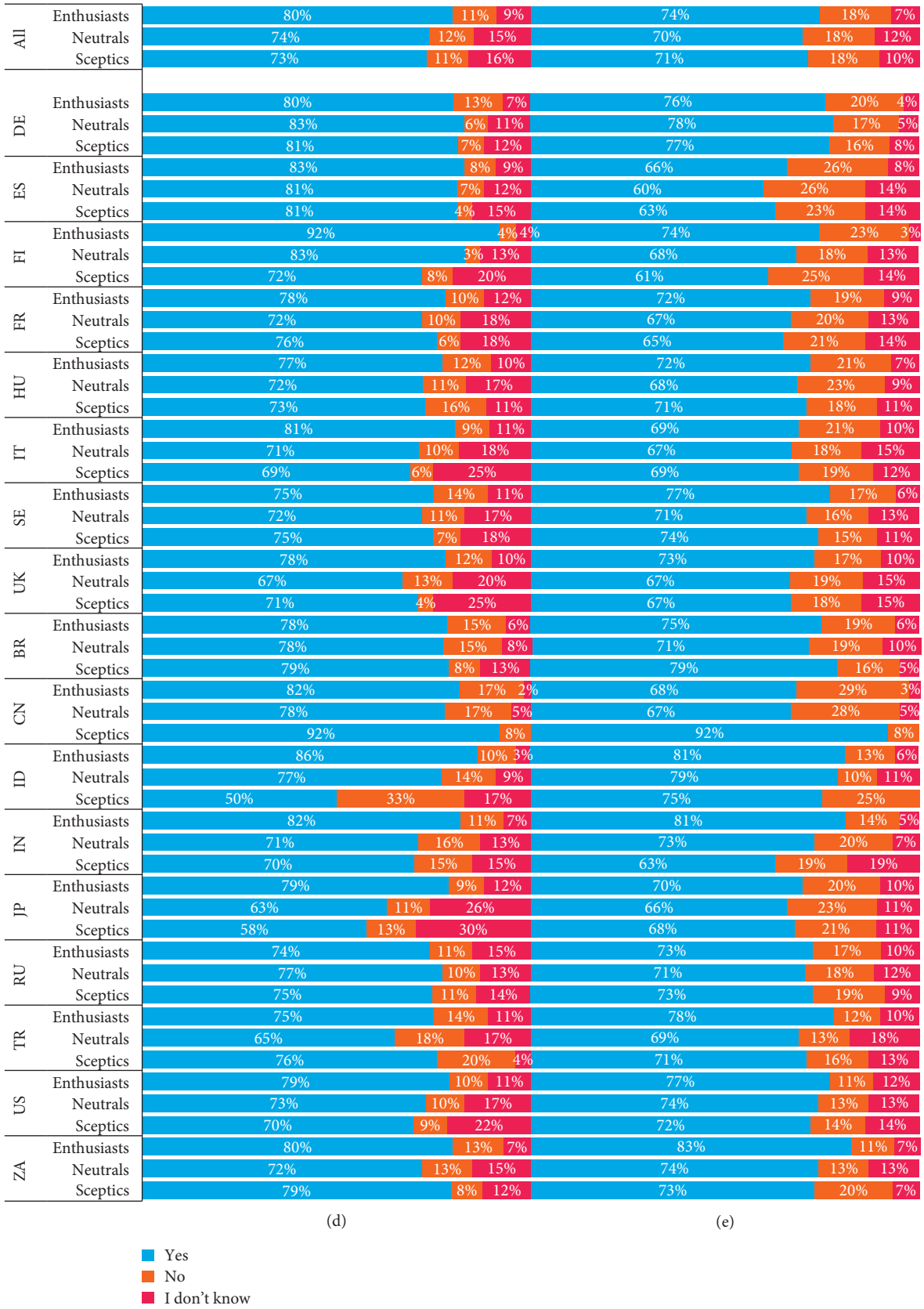

Figure 3: (a) Percentage values of Enthusiasts, Neutrals, and Sceptics according to their response to whether conditionally automated cars can stay in the lane (Q6); the correct response is Yes. (b) Percentage values of Enthusiasts, Neutrals, and Sceptics according to their response to whether conditionally automated cars can initiate automatic lane change maneuvers (Q7); the correct response is Yes. (c) Percentage values of Enthusiasts, Neutrals, and Sceptics according to their response to whether conditionally automated cars can operate in every condition (Q8); the correct response is No. (d) Percentage values of Enthusiasts, Neutrals, and Sceptics according to their response to whether they have to take over control from a conditionally automated car as driver anytime (Q9); the correct response is Yes. (e) Percentage values of Enthusiasts, Neutrals, and Sceptics according to their response to whether they are able to engage in secondary activities except for sleeping (Q10); the correct response is Yes.

keeping behavior and the intention to use conditionally automated cars was positive and small ($r = < 0.25$), yet not significant in Germany, Hungary, India, South Africa, Spain, the U.K., and U.S.

Enthusiasts (62%) were more likely than Neutrals (52%) and Sceptics (50%) to know that conditionally automated cars can initiate automatic lane change maneuvers (Figure 3(b)). Conversely, in Brazil and South Africa, Sceptics were more likely than Neutrals and Enthusiasts to know the correct response. The correlation between knowledge about automatic lane change maneuverers and the intention to use conditionally automated cars was positive and small in all countries ($r = < 0.20$).

Sceptics (50%) were more likely than Neutrals (47%) and Enthusiasts (42%) to know that conditionally automated cars cannot operate in all conditions (Figure 3(c)). The correlation between the knowledge about the operation of conditionally automated cars and the intention to use conditionally automated cars was negative and small ($r = \leq -0.15$), yet not significant in Finland, France, Hungary, Italy, Japan, and South Africa.

3.4.2. Role of Human Drivers in Conditionally Automated Cars. Enthusiasts (80%) were more likely than Neutrals (74%) and Sceptics (73%) to know that they have to take over control from conditionally automated cars when requested (Figure 3(d)). The correlation between the knowledge about having to take over control from conditionally automated cars was positive and small ($r = < 0.25$), yet not significant in Brazil, China, France, Germany, Hungary, Russia, South Africa, Spain, Sweden, and the U.K.

Enthusiasts (74%) were more likely than Sceptics (70%) and Neutrals (71%) to know that they can pursue activities in conditionally automated cars except for sleeping (Figure 3(e)). The correlation between the knowledge about the possibility to engage in secondary activities except for sleeping and the intention to use conditionally automated cars was positive and small ($r = < 0.15$), yet only significant in Finland, Italy, India, South Africa, and Turkey.

3.5. Awareness of Automated Cars. Enthusiasts (78%) were more likely than Neutrals (73%) and Sceptics (74%) to had heard about automated cars before participation in the questionnaire (Figure 4). The correlation between the awareness of automated cars and the intention to use conditionally automated cars was small and positive ($r = \leq 0.15$) and only significant in China, Finland, France, Hungary, Indonesia, Italy, Japan, and Turkey.

3.6. Frequency of Receiving Information about Automated Cars

3.6.1. Social Media, Online Communities, and Websites about IT, Cars, or Motoring. Enthusiasts (46%) were more likely than Neutrals (25%) and Sceptics (21%) to receive information about automated cars from social media, online communities, and websites about IT, cars, or motoring daily (Figure 5(a)). The correlation between the frequency of receiving information about automated cars from online communities and websites about IT, cars, or motoring was positive and significant in all countries ($r = < 0.45$). The correlation between the frequency of using social media was positive and significant in all countries ($r = < 0.50$).

3.6.2. Radio, TV, Newspapers, and Magazines. Enthusiasts (36%) were more likely to receive information about automated cars from radio, TV, newspapers, and magazines daily than Neutrals (21%) and Sceptics (20%) (Figure 5(b)). In China, India, Indonesia, Turkey, and the U.S., Sceptics and Neutrals were more likely than Enthusiasts to make daily use of these sources to receive information about automated cars. The correlation between the frequency of receiving information about automated cars from the radio, TV, newspapers, and magazines and the intention to use conditionally automated cars was positive and significant in all countries ($r = < 0.40$).

3.6.3. Family Members, Friends, and Colleagues. Enthusiasts (38%) were more likely to receive information about automated cars from friends, family members, and colleagues daily than Neutrals (20%) and Sceptics (18%) (Figure 5(c)). In China and Turkey, Sceptics were more likely than Enthusiasts to talk with family members, friends, and colleagues daily about automated cars. The correlation between talking with friends, family members, and colleagues about automated cars and the intention to use conditionally automated cars was positive and significant in all countries ($r = < 0.45$).

3.6.4. Car Dealers, Manufacturers, and Suppliers. Enthusiasts (27%) were more likely to receive information about conditionally automated cars from car dealers, suppliers, and manufacturers daily than Neutrals (13%) and Sceptics (12%) (Figure 5(d)). In China and Turkey, Sceptics were more likely than Enthusiasts, respectively, to receive information from car dealers, manufacturers, and suppliers daily. The correlation between receiving information about automated cars from car dealers, manufacturers, and suppliers and the intention to use conditionally automated cars was positive and significant in all countries ($r = < 0.45$).

3.7. Expected Benefits: Productive Use of Travel Time, Travel Comfort, and Safety. Enthusiasts (58%) were more likely to expect an increase in the productive use of travel time than Neutrals (48%) and Sceptics (36%) (Figure 6(a)). The correlation between the expected changes in the productive use of travel time and the intention to use conditionally automated cars was positive ($r = \leq 0.40$), yet not significant in France, Hungary, and Russia.

Enthusiasts (67%) were more likely to expect an increase in travel comfort than Neutrals (58%) and Sceptics (38%) (Figure 6(b)). The correlation between the expected change in travel comfort and the intention to use conditionally automated cars was positive and significant in all countries ($r = < 0.55$).

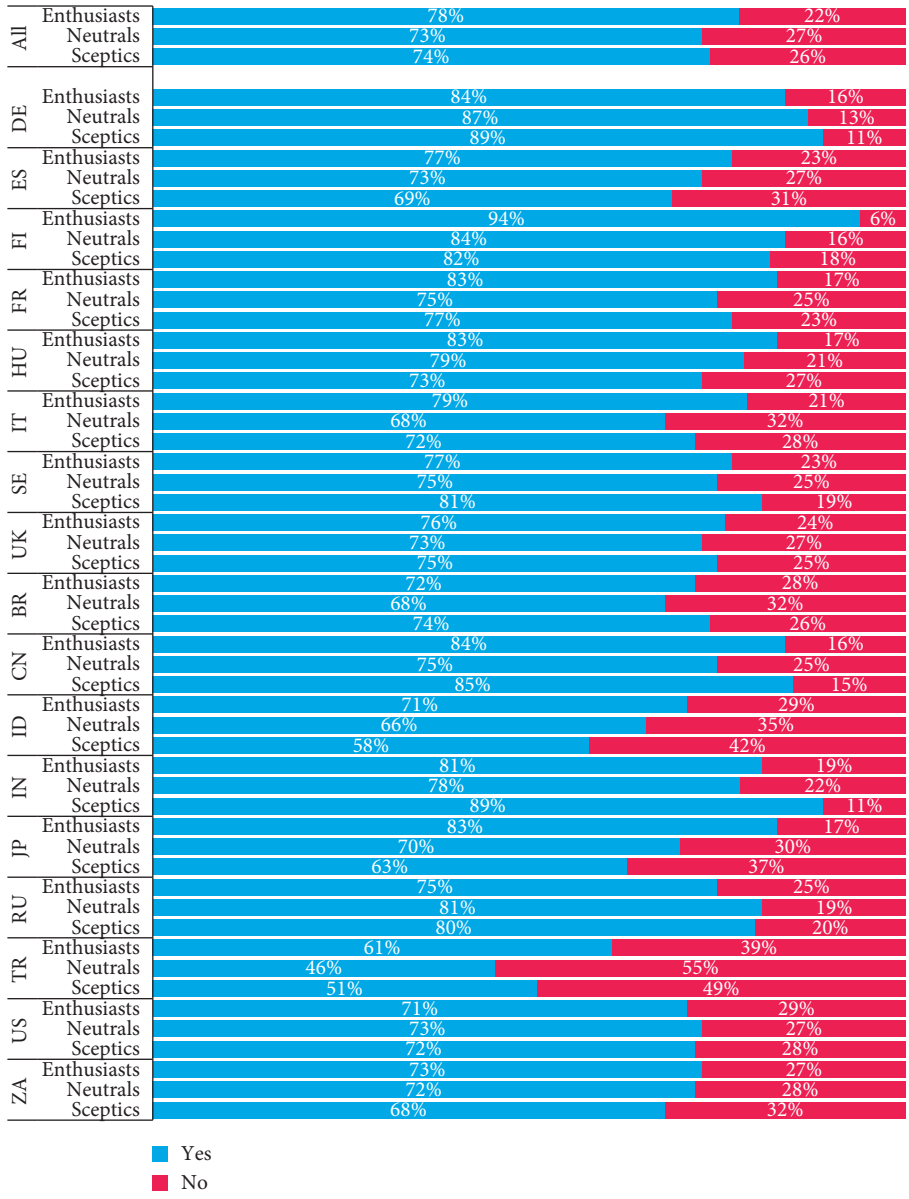

Figure 4: Percentage values of Enthusiasts, Neutrals, and Sceptics differing in their awareness of automated cars before taking part in the questionnaire (Q11).

Enthusiasts (57%) were more likely to expect a decrease in the number of accidents than Neutrals (41%) and Sceptics (19%) (Figure 6(c)). The correlation between the expected change in the number of accidents and the intention to use conditionally automated cars was negative ($r = < -0.50$), yet not significant in China and India.

Table 2 provides an overview of the Spearman rank-order correlation coefficients.

4. Discussion

The present study investigated differences between respondents from 17 countries in terms of their acceptance of conditionally automated cars, age and gender, knowledge about conditionally automated cars, awareness of automated cars and information consumption, and the expected benefits associated with conditionally automated cars.

4.1. Acceptance of Conditionally Automated Cars. 42% of the sample were identified to be Enthusiasts (i.e., people who expressed an intention to use conditionally automated cars), 42% were identified as Neutrals (i.e., people who indicated to be neutral towards using conditionally automated cars), and 16% were identified as Sceptics (i.e., people who did not express an intention to use conditionally automated cars). With only 42% of respondents expressing an intention to use conditionally automated cars, the acceptance of these cars can be regarded as rather low. The reservation of our study respondents corresponds with the scepticism of the public towards automated cars [28, 32, 33, 47–49]. Our finding may

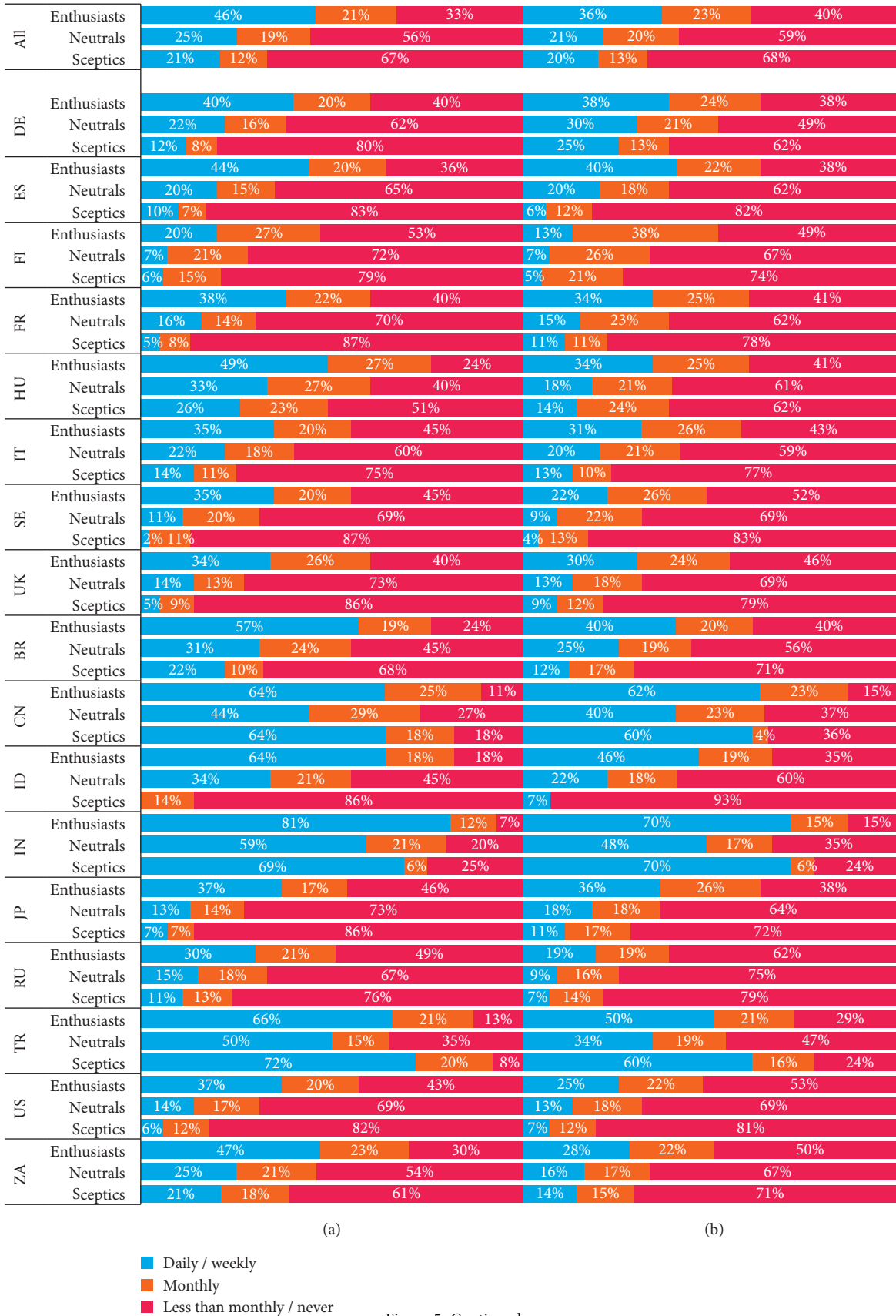

Figure 5: Continued.

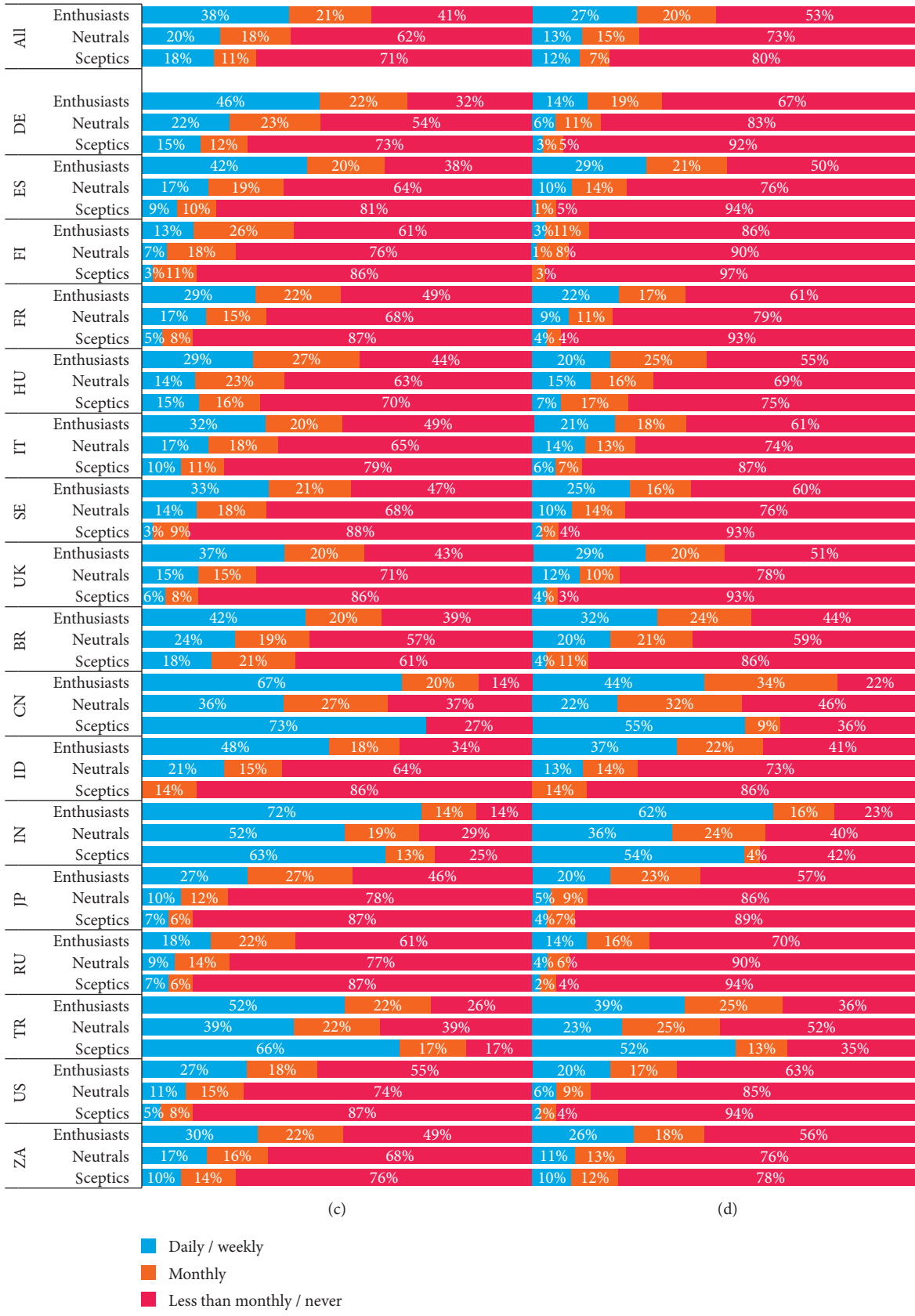

Figure 5: Percentage values of Enthusiasts, Neutrals, and Sceptics differing in the frequency of receiving information about automated cars from online communities (e.g., blogs and forums), websites about IT, cars or motoring (Q12.1), and social media (e.g., Facebook, Instagram, Twitter, and YouTube) (Q12.2). (b) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in the frequency of receiving information about automated cars from radio, TV (Q12.3), newspapers, and magazines (not online) (Q12.6). (c) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in the frequency of receiving information about automated cars from friends, family members, and colleagues (Q12.4). (d) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in the frequency of receiving information about automated cars from car dealers, manufacturers, and suppliers (Q12.5).

FIGURE 6: (a) Percentage values of Enthusiasts, Neutrals, and Peptics differing in their expectation about the changes in the productive use of travel time due to conditionally automated cars (Q21.1). (b) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in their expectation about the changes in travel comfort due to conditionally automated cars (Q21.2). (c) Percentage values of Enthusiasts, Neutrals, and Sceptics differing in their expectation about the changes in the number of traffic accidents due to conditionally automated cars (Q21.3).

Table 2: Spearman rank-order correlation matrix (note that the correlations were multiplied by 100).

Question	Intention to use conditionally automated cars																
	DE	ES	FI	FR	HU	IT	SE	UK	BR	CN	ID	IN	JP	RU	TR	US	ZA
Q2. Age (in years)	−24***	−13***	−7*	−27***	−5, n.s.	−14***	−33***	−27***	−10***	12***	−3, n.s.	0, n.s.	−2, n.s.	−11***	3, n.s.	−27***	−17***
Q3. Gender (1 = male)	8**	8**	9**	8**	7*	9***	15***	8**	−0, n.s.	−8*	0, n.s.	−6*	14***	4, n.s.	−16***	14***	12***
Q6. Staying in the lane (1 = yes)	5, n.s.	6, n.s.	22***	13***	3, n.s.	11**	9***	1, n.s.	7*	12***	9**	5, n.s.	18***	8**	14***	1, n.s.	2, n.s.
M	1.21	1.19	1.24	1.40	1.18	1.21	1.26	1.24	1.49	1.21	1.12	1.13	1.30	1.05	1.13	1.19	1.14
SD	0.55	0.54	0.61	0.73	0.52	0.56	0.62	0.58	0.64	0.48	0.42	0.43	0.65	0.31	0.47	0.53	0.46
Q7. Overtaking on its own (1 = yes)	7*	9**	15***	8**	7*	10***	10***	8**	6*	10***	18***	16***	10***	6*	14***	8**	9**
M	1.78	1.52	1.57	1.72	1.73	1.64	1.73	1.62	1.51	1.46	1.52	1.31	1.94	1.57	1.39	1.65	1.47
SD	0.73	0.73	0.80	0.79	0.73	0.75	0.79	0.77	0.66	0.60	0.68	0.58	0.74	0.78	0.68	0.78	0.67
Q8. Operating in all conditions (2 = no)	−10***	−10***	2, n.s.	−1, n.s.	−4, n.s.	−0, n.s.	−10***	−5**	−8*	−11***	−15***	−15***	3, n.s.	−10***	−12***	−6*	−5, n.s.
M	1.85	1.74	2.05	1.66	1.88	1.70	1.91	1.55	1.68	1.58	1.49	1.31	1.97	1.74	1.57	1.72	1.56
SD	0.62	0.69	0.37	0.76	0.63	0.77	0.69	0.71	0.65	0.59	0.62	0.55	0.60	0.72	0.76	0.73	0.62
Q9. Asking driver to take over control anytime (1 = yes)	2, n.s.	3, n.s.	22***	4, n.s.	5, n.s.	12***	−2, n.s.	5, n.s.	3, n.s.	5, n.s.	13***	11***	16***	−0, n.s.	7*	6*	5, n.s.
M	1.29	1.30	1.37	1.42	1.40	1.43	1.44	1.47	1.29	1.23	1.21	1.27	1.56	1.39	1.39	1.44	1.33
SD	0.64	0.67	0.75	0.76	0.72	0.76	0.76	0.79	0.59	0.49	0.52	0.59	0.84	0.72	0.69	0.77	0.66
Q10. Pursuing other activities except sleeping (1 = yes)	1, n.s.	4, n.s.	13***	8*	−1, n.s.	0, n.s.	−1, n.s.	5, n.s.	4, n.s.	0, n.s.	2, n.s.	12***	3, n.s.	2, n.s.	10**	2, n.s.	8**
M	1.29	1.50	1.46	1.45	1.40	1.46	1.39	1.46	1.34	1.36	1.27	1.27	1.44	1.39	1.36	1.40	1.30
SD	0.57	0.70	0.72	0.71	0.65	0.72	0.68	0.72	0.61	0.55	0.58	0.57	0.68	0.67	0.69	0.71	0.63
Q11. Having heard of automated cars before survey (1 = yes)	−4, n.s.	5, n.s.	9**	6*	6*	9**	−3, n.s.	1, n.s.	1, n.s.	14***	8**	5, n.s.	15***	−4, n.s.	13***	−1, n.s.	3, n.s.
M	1.13	1.27	1.15	1.22	1.21	1.28	1.23	1.26	1.29	1.19	1.30	1.19	1.28	1.21	1.42	1.28	1.28
SD	0.34	0.44	0.36	0.42	0.41	0.45	0.42	0.44	0.45	0.40	0.46	0.39	0.45	0.41	0.49	0.45	0.45
Q12. 1. Receiving information about automated cars from online communities and websites about IT, cars, or motoring (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	31***	40***	27***	40***	23***	27***	44***	42***	36***	22***	37***	26***	40***	26***	26***	33***	33***
M	2.28	2.48	2.29	2.21	3.13	2.53	2.22	2.32	3.21	3.59	3.43	4.04	2.14	2.45	3.63	2.19	2.88
SD	1.25	1.26	0.95	1.22	1.16	1.28	1.21	1.25	127	1.06	1.23	1.05	1.20	1.12	1.14	1.22	1.24
Q12.2. Receiving information about automated cars from social media (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	35***	34***	22***	46***	19***	25***	42***	43***	36***	24***	37***	23***	34***	27***	22***	34***	33***
M	2.44	2.27	1.84	2.39	3.01	2.55	2.30	2.42	3.42	3.62	3.73	4.19	2.20	2.35	3.99	2.31	3.14
SD	1.42	1.20	0.91	1.39	1.16	1.34	1.25	1.34	1.32	1.12	1.21	1.03	1.31	1.16	1.11	1.23	1.32

Table 2: Continued.

Question	Intention to use conditionally automated cars																
	DE	ES	FI	FR	HU	IT	SE	UK	BR	CN	ID	IN	JP	RU	TR	US	ZA
Q12.3. Receiving information about automated cars from radio and TV (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	18***	38***	13***	28***	16***	23***	28***	32***	23***	26***	31***	25***	26***	14***	20***	22***	22***
M	2.90	2.69	2.28	2.69	2.83	2.64	2.30	2.44	2.91	3.65	3.10	3.68	2.77	2.34	3.39	2.35	2.65
SD	1.34	1.23	0.79	1.18	1.12	1.22	1.05	1.19	1.29	1.16	1.29	1.32	1.19	0.99	1.30	1.15	1.24
Q12.4. Receiving information about automated cars from friends, family members, and colleagues (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	32***	38***	23***	38***	25***	29***	41***	40***	29***	34***	35***	25***	37***	26***	19***	32***	23***
M	2.56	2.54	1.96	2.24	2.51	2.41	2.17	2.30	2.93	3.55	3.11	3.90	2.13	2.13	3.43	2.11	2.55
SD	1.22	1.23	0.83	1.16	1.08	1.21	1.14	1.21	1.30	1.18	1.28	1.17	1.17	1.01	1.23	1.14	1.24
Q12.5. Receiving information about automated cars from car dealers, manufacturers, and suppliers (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	29***	44***	23***	38***	21***	24***	37***	41***	29***	31***	38***	26***	36***	34***	18***	33***	30***
M	1.81	2.13	1.57	1.91	2.25	2.07	1.89	2.04	2.69	3.08	2.79	3.53	1.90	1.74	3.01	1.78	2.32
SD	0.95	1.12	0.69	1.12	1.10	1.17	1.11	1.20	1.23	1.08	1.22	1.31	1.02	0.94	1.26	1.04	1.24
Q12.6. Receiving information about automated cars from newspapers and magazines (not online) (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	21***	38***	19***	33***	22***	29***	29***	29***	23***	32***	32***	24***	32***	24***	24***	19***	22***
M	2.62	2.44	2.24	2.30	2.49	2.52	2.29	2.39	2.85	3.30	3.05	3.98	2.26	1.97	3.30	2.08	2.48
SD	1.33	1.23	0.84	1.17	1.12	1.21	1.11	1.20	1.27	1.16	1.27	1.11	1.19	1	1.24	1.12	1.18
Q21.1. Change in productive use of travel time due to conditionally automated cars (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	18***	14***	40***	5, n.s.	−4, n.s.	10***	11***	16***	21***	16***	21***	20***	24***	2, n.s.	8*	24***	8*

Table 2: Continued.

Question	Intention to use conditionally automated cars																
	DE	ES	FI	FR	HU	IT	SE	UK	BR	CN	ID	IN	JP	RU	TR	US	ZA
M	3.59	3.53	3.47	3.31	3.27	3.43	3.33	3.35	3.57	3.63	3.60	3.73	3.41	3.57	3.59	3.50	3.62
SD	0.97	1.02	0.84	0.91	1.03	0.99	0.97	0.92	1.20	1.17	1.05	1.30	0.77	1.17	1.43	0.99	1.27
Q21.2. Change in travel comfort due to conditionally automated cars (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	33***	22***	53***	18***	11***	23***	18***	20***	29***	15***	25***	23***	29***	15***	16***	24***	26***
M	3.59	3.66	3.52	3.46	3.76	3.63	3.33	3.36	3.80	3.81	3.88	3.95	3.49	3.86	3.89	3.45	3.88
SD	1.02	1.06	0.96	0.98	1.07	1.02	0.97	0.93	1.17	1.18	1.04	1.22	0.82	1.12	1.39	1.06	1.20
Q21.3. Change in number of accidents due to conditionally automated cars (1 = never, 2 = less than monthly, 3 = monthly, 4 = weekly, and 5 = daily)	−33***	−26***	−47***	−32***	−32***	−23***	−33***	−23***	−29***	−5, n.s.	−10***	−4, n.s	−27***	−30***	−34***	−29***	−20***
M	2.70	2.61	2.78	2.75	2.50	2.59	2.87	3.03	2.34	2.62	2.56	2.99	2.66	2.51	2.08	2.93	2.48
SD	1.04	1.02	1	0.98	1.07	1.03	1.01	0.97	1.15	1.16	1.18	1.44	0.89	1.07	1.25	1.04	1.25

Note. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; n.s. = not significant. The scales of the questions Q12.1–Q12.6 and Q21.1–Q21.3 were reverse-coded. The questions Q6–Q11 were dummy coded.

reflect the specific nature of conditional automation, which limits the expected efficiency and safety benefits in contrast to driverless fully automated vehicles, which are expected to maximize the benefits of road vehicle automation (e.g., increases in safety, comfort, and efficiency) due to their capability to drive without any driver inputs. It is also plausible that respondents could not accurately envision their interaction with conditionally automated cars given their lack of physical exposure to these cars.

4.1.1. Differences between Countries. Respondents from non-European, lower-GDP countries were more accepting of conditionally automated cars than respondents from European, higher-GDP countries. This corresponds with studies that have shown a higher acceptance of automated cars among lower-GDP than higher-GDP countries [47, 50, 51]. In the study of Schoettle and Sivak [30], respondents from China were among the respondents with the most positive attitudes towards automated cars. In Ansys's [25] Global Autonomous Vehicle Report, respondents from India were most comfortable with riding in an automated car today, while respondents from China, U.K., and Japan were the least comfortable. In Deloitte's [50] Global Automotive Consumer Study, respondents from China, India, and the U. S. were the least likely to believe that self-driving vehicles will not be safe and respondents from Japan and South Korea the most likely. In the Eurobarometer survey [28], respondents from higher-GDP European countries such as France and Germany were more likely to feel not comfortable with travelling in a fully automated vehicle without human supervision than respondents from lower-GDP European countries such as Romania, Poland, and Portugal. Furthermore, in our study, Russia, Japan, Hungary, and Spain had the highest proportion of Neutrals, while Brazil, Indonesia, and India had the lowest. This reflects the study of Schoettle and Sivak [30], where more than half of the respondents from Japan were neutral towards automated cars. The higher acceptance of conditionally automated cars among respondents from lower-GDP countries may reflect the dissatisfaction with transport and the severity of transport problems in these countries and the expectation that automated cars will lead to a substantial improvement in personal mobility [51, 52]. This explanation corresponds with the study of Wang et al. [53] who found that the expected safety improvement due to automated cars was highest in India and lowest in the United Kingdom. Furthermore, respondents from lower-GDP countries may require lower safety standards of automated vehicles than respondents from higher-GDP countries [35], being more likely to engage in risky driving than respondents from higher-GDP countries [1, 54]. Furthermore, higher-GDP countries already have high-quality infrastructure for the deployment of automated vehicles in place [1]. Third, respondents from lower-GDP countries may be more comfortable with and enthusiastic about new technologies [51], probably because they are less concerned or simply less aware of so-called "higher-order needs" [55] (e.g., cybersecurity, liability, and privacy), which some see threatened by the introduction of automated cars (see [56]). Fourth, these respondents may also be more aware of governmental support and policies to enable a large-scale deployment of automated cars (see [57]). Fifth, the scepticism of higher-GDP countries representing the "classical automobile nations" such as Germany, Italy, France, and Sweden may be rooted in the expected loss of driving enjoyment due to more automation and connectivity in passenger cars.

4.2. Age and Gender. The study revealed inconsistent gender differences. Males tended to be more enthusiastic towards using conditionally automate cars than Females in the majority of countries. These gender differences do correspond with the literature on automated vehicle acceptance, which has generally shown that Males were more positive towards automated cars than Females [28, 31, 32, 49, 58]. In China, India, and Turkey, Females were more likely than Males to be positive towards the use of conditionally automated cars. In Brazil, Germany, Indonesia, and Russia, the gender differences were not significant. We recommend future research to address the mechanisms behind the gender differences in the acceptance of conditionally automated cars. In the study of [57], Females with higher environmental concerns were more likely than Males to intend to use automated cars. Females who considered automated cars less useful were less likely to intend to use automated cars.

Respondents aged between 36 and 69 years tended to be more sceptical towards using conditionally automated cars than respondents aged between 18 and 35 years. This finding is in line with literature, which has reported ambivalent (i.e., either weak, significant, or non-significant positive or negative) effects of age on the intention to use automated cars [28, 32, 49, 59].

4.3. Knowledge about Conditionally Automated Cars. All three groups were generally knowledgeable about the capability of conditionally automated cars to stay in the lane and allow them to engage in secondary activities except for sleeping and about the possibility to ask them to take over control anytime. They were less knowledgeable about the capability of conditionally automated cars to initiate automatic lane change maneuvres, and that their operation is limited to operational design domains. It is noteworthy that the response behavior of the Enthusiasts, Neutrals, and Sceptics is relatively homogenous and accurate across the knowledge questions. This may indicate that respondents had a profound knowledge and understanding of the capabilities of conditionally automated cars or that they had a better understanding of the instructions about conditionally automated cars they received prior to participation in the questionnaire.

The more profound knowledge about the lane keeping capability of conditionally automated cars may reflect the familiarity with lane departure warning and lane keeping assist, which were introduced in 2005 and 2014, respectively [60], representing the third-most common feature [28]. In contrast, the feature allowing automatic lane change maneuvres was introduced in 2018 [60], which may explain

respondents' uncertainty about the capability of conditionally automated cars to overtake on their own as they are simply less familiar with this feature. Respondents' limited knowledge about conditionally automated cars may reflect the global confusion and incorrect expectations about automated cars. Conditionally automated cars have received less media coverage than partly- and fully automated cars (e.g., Tesla's Autopilot system and Google's/Waymo's self-driving car project). The media and representatives of the car industry have oversold the capabilities and expected market release of automated cars. This, however, misleads and confuses the public and creates the false expectation that fully automated cars do either already exist now or will enter the market soon [1–3, 6, 8, 61].

Enthusiasts were more likely than Neutrals and Sceptics to give more correct responses to four out of five knowledge questions. They knew that conditionally automated cars can stay in the lane, overtake on their own, ask human drivers to take over control, and allow drivers to engage in secondary, eyes-off road activities except for sleeping. Sceptics were more likely than Neutrals and Enthusiasts to understand that the operation of conditionally automated cars is constrained to operational design domains. This may suggest that their scepticism can be explained by their awareness of the limited operation of conditionally automated cars, which diminishes the expected safety and efficiency benefits. It is also plausible that the information presented in the instructions did not change the prior attitudes of respondents. In order words, Sceptics remain sceptic and Enthusiasts enthusiastic even though the instructions contain information that are in contrast to their negative or positive beliefs, respectively.

4.4. Awareness and Information Consumption. Our study has shown that respondents were generally aware of automated cars before participating in the survey, with Enthusiasts being more aware of automated cars than Sceptics and Neutrals. All groups received most information about automated cars from traditional mass media channels (i.e., radio, TV, newspapers, and magazines) and least information from friends, family, and colleagues and car dealers, manufacturers, and suppliers. This corresponds with the study of McDonald et al. [62], which has shown that the proportion of respondents recalling someone at the dealership offering training related to the systems Adaptive Cruise Control, Automated Emergency Braking, Forward Collision Warning, Lane Departure Warning, and Lane Keeping Assist ranged between 42% and 56%. In the study of Lin et al. [63], 35% of respondents ($n = 20$) indicated that the information given by the salesperson about Tesla's Autopilot system confused them.

Enthusiasts were more likely to receive information about automated cars frequently than Neutrals and Sceptics from all information sources. Large differences between Enthusiasts and Sceptics in terms of their frequency to receive information about automated cars from online communities and social media existed in Brazil, France, Indonesia, Japan, Spain, and Sweden. These may relate to an unequal access to information about automated cars or a general lack of interest in technological trends and developments, such as automated cars, among Sceptics in these countries. Increasing the information exposure among Sceptics may support acceptance of conditionally automated cars. The differences could also be explained by structural differences between Enthusiasts, Neutrals, and Sceptics, e.g., differences in socio-demographics (except for age and gender) and personality that cannot be overcome by increasing the exposure to automated cars and warranting equal access to information. Furthermore, it was found that the differences between Enthusiasts and Sceptics in terms of using mass media (i.e., newspapers, magazines, radio, and TV) to receive information about automated cars were smaller than the differences in their use of social media. This may suggest that the mass media channels have already diffused to a larger part of the general population. Sceptics in China and Indonesia received information about automated cars from friends, family members, and colleagues more often than Enthusiasts. This points to a strong reliance on friends, family members, and colleagues in especially collectivistic, family-oriented cultures and the relevance of using this communication channel to promote automated cars effectively.

4.5. Expected Benefits of Conditionally Automated Cars. The largest differences between Enthusiasts, Neutrals, and Sceptics were found in their perception of the expected benefits (efficiency, comfort, and safety) of conditionally automated cars. This indicates that the expected benefits are key factors driving the acceptance of conditionally automated cars as in other surveys [12, 27, 42, 53, 64, 65]. Enthusiasts were more likely to expect an increase in the productive use of travel time and travel comfort than Neutrals and Sceptics. This could be explained with regard to the particular nature of conditional automation, which pertains to the dual role of the human driver whose attention is distributed over the driving task and secondary activities. It is plausible that Sceptics may be less willing to engage in secondary eyes-off road activities because of their (incorrect) belief that they have to monitor the performance of the automated car, they like to drive and manually control their car, or because the routes and length of their trips do not permit the engagement in secondary activities. The study further revealed that Sceptics were less likely than Neutrals and Enthusiasts to expect a decrease in the number of accidents. The reservation of Sceptics corresponds with Xiao et al. [40] who have shown that the reduction of fatal crashes is small (at lower market penetration rates yet increases with higher market penetration rates). This may suggest that they lack trust in the safe and reliable operation of conditionally automated cars, considering it too risky to divert their attention away from the driving task. Future research and development should aim to demonstrate safety of conditional automation [66] and inform users to achieve justified levels of trust in automation.

4.6. Implications for Policy and Practice. In order to educate the public about conditionally automated cars and calibrate expectations [29], it is important to create more opportunities to come in touch with conditionally automated cars and

higher levels of automation when the technology is ready for such activities, e.g., through living labs. Car dealers could be better trained about system capabilities and limitations, offering consumers the possibility to test conditionally automated driving functions in the context of test rides or on a longer-term basis (e.g., monthly subscription). In this context, the public can be exposed to conditionally automated cars and their safe and reliable operation but also encounter their limitations. This could help to gain the trust of Neutrals and Sceptics. It could also be considered to digitalize the purchase of a (conditionally automated) car in order to reach a large audience more conveniently, which is especially relevant against the background of the current pandemic situation.

The communication and marketing of automated cars should create a realistic image of the capabilities and limitations of conditionally automated cars. User education programs should be harmonized, and the SAEJ3016 taxonomy [67] should be translated into a simpler taxonomy with easy-to-read and understandable guidelines for users. Positive and knowledgeable opinion leaders could be "installed" in collectivistic and family-oriented cultures given the strong reliance on friends, family, and colleagues in these countries. An alternative strategy could be to more effectively market the benefits of conditionally automated cars via the communication channels that Sceptics use.

In order to encourage effective use of the travel time, the design of conditionally automated cars has to warrant the safe and comfortable engagement in eyes-off road activities even though the driver has to be able to respond to requests from the car to resume control. Potential discomfort (e.g., urge to take over control from the automated car) should be overcome by "comfortable" automated driving styles creating high trust levels and resolving motion sickness associated with eyes-off road driving [68].

Finally, the public could be "warmed up" for conditionally automated cars promoting currently available partially automated cars. Automated cars could be subsidised, motivated by proven safety benefits (e.g., tax exemption, reimbursement, and discount on registration) (see [40]), particularly in lower-GDP countries.

4.7. Limitations and Recommendations for Future Research. As conditionally automated cars are not yet widely available, the respondents in the present study did not physically experience conditionally automated cars but were asked to imagine the use of these cars. Thus, respondents' mental image and expectations of conditionally automated cars may be skewed and biased, not reflecting the actual capabilities of conditionally automated cars (see [27]). We recommend future research to examine attitudes towards and acceptance before and after respondents experience conditionally automated cars using driving simulators (see [12]) and controlled pilots.

Second, the questions measuring respondents' knowledge about conditionally automated cars may not necessarily address the factual knowledge of respondents but the capability of respondents to read, understand, and memorize the information contained in the instructions prior to answering the knowledge questions.

Third, the questions capturing respondents' awareness and frequency of receiving information about automated cars were targeted at automated cars in general rather than conditionally automated cars in particular. It is plausible that asking respondents to rate their awareness and frequency of receiving information about automated cars might have confused respondents because they anticipated questions being tailored to conditionally automated cars. However, this was done in order to avoid biased responses due to a potential confusion among respondents being confronted with the term "conditionally automated" they most likely have no association with given that conditionally automated cars have not been available yet and received only scant attention in the media. We recommend future research to investigate the respondents' awareness of conditionally automated cars and the type of information Enthusiasts, Neutrals, and Sceptics receive about automated cars from different channels (see [12, 15]).

Fourth, the present study was limited to the analysis of the differences in age, gender, knowledge about conditionally automated cars, awareness of and frequency of receiving information about automated cars, and the expected benefits of conditionally automated cars between Enthusiasts, Neutrals, and Sceptics. Future research should investigate other potentially relevant predictors of the acceptance of conditionally automated cars such as the innovation diffusion theory constructs (e.g., compatibility and observability) and other psychological variables (e.g., trust) [69].

Fifth, the samples drawn from the European and non-European countries are neither representative of the general European nor non-European populations but of the populations of the individual countries from which they were selected. We recommend future research to recruit samples that are representative of the general population of car drivers in terms of age, gender, education, and income.

5. Conclusions

The present online survey showed that 42% of the sample were Enthusiasts (i.e., people who expressed an intention to use conditionally automated cars), 42% were Neutrals (i.e., people who indicated to be neutral towards using conditionally automated cars), and 16% were Sceptics (i.e., people who did not express an intention to use conditionally automated cars). Respondents from the European countries were generally less accepting of conditionally automated cars than respondents from the non-European countries. It was investigated how Enthusiasts, Neutrals, and Sceptics differed with regard to their age, gender, knowledge about functionality of conditionally automated cars, information consumption, and expected benefits of conditionally automated cars. Large differences between the three groups were found in terms of their expectation of the benefits of conditionally automated cars. Effects of age and gender were small and inconsistent across countries. Enthusiasts were generally more likely to be male, younger, more knowledgeable about conditionally automated cars, more informative about automated cars, and more likely to expect

increases in the productive use of travel time, comfort, and safety.

Data Availability

The data used to support the findings of this study will be made publicly available on Zenodo repository. Zenodo was created in 2013 by the EU-funded OpenAIRE project and CERN to be an all-purpose open research repository.

Disclosure

Responsibility for the information and views set out in this publication lies entirely with the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] P. Bazilinskyy, M. Kyriakidis, D. Dodou, and J. De Winter, "When will most cars be able to drive fully automatically? Projections of 18,970 survey respondents," *Transportation Research Part F: Traffic Psychology and Behavior*, vol. 64, pp. 184–195, 2019.

[2] C. Chan, "Advancements, prospects, and impacts of automated driving systems," *International Journal of Transportation Science and Technology*, vol. 6, no. 3, pp. 208–216, 2017.

[3] L. Dixon, "Autonowashing: the greenwashing of vehicle automation," *Transportation Research Interdisciplinary Perspectives*, vol. 5, Article ID 100113, 2020.

[4] K. Funkhouser, E. Tanner, and F. Drews, "Know it by name: Human factors of ADAS design," in *Proceedings of the 2017 Autonomous Vehicles Symposium*, San Francisco, CA, USA, 2017.

[5] S. Nordhoff, M. Kyriakidis, B. Van Arem, and R. Happee, "A multi-level model on automated vehicle acceptance (MAVA): A review-based study," *Theoretical Issues in Ergonomics Science*, vol. 20, pp. 682–710, 2019.

[6] S. E. Shladover, "The truth about "Self-Driving" cars," *Scientific American*, vol. 314, pp. 52–57, 2016.

[7] J. Stewart, "Drivers wildly overestimate what "semiautonomous" cars can do," 2018, https://www.wired.com/story/semi-autonomous-systems-safety-research-euro-ncap-thatcham/.

[8] K. Werner, "A paradigm shift in autonomous cars (and more) at vehicle displays," *Information Displays*, vol. 35, 2019.

[9] G. Currie, "Lies, damned lies, AVs, shared mobility, and urban transit futures," *Journal of Public Transportation*, vol. 21, no. 1, pp. 19–30, 2018.

[10] T. H. Davenport, "Can we solve AI's 'trust problem'? MIT Sloan Management Review," 2018, https://sloanreview.mit.edu/article/can-we-solve-ais-trust-problem/.

[11] A. Feldhütter, C. Gold, A. Hüger, and K. Bengler, "Trust in automation as a matter of media influence and experience of automated vehicles," in *Proceedings of the Human Factors and Ergonomics Society 2016 Annual Meeting*, pp. 2024–2028, Washington, DC, USA, 2016.

[12] J. Lee, F. Baig, and X. Li, "Media influence, trust, and the public adoption of automated vehicles," *IEEE Intelligent Transportation Systems Magazine*, 2021.

[13] Z. Xu, K. Zhang, H. Min, Z. Wang, X. Zhao, and P. Liu, "What drives people to accept automated vehicles? Findings from a field experiment," *Transportation Research Part C: Emerging Technologies*, vol. 95, pp. 320–334, 2018.

[14] T. Zhang, D. Tao, X. Qu, X. Zhang, R. Lin, and W. Zhang, "The roles of initial trust and perceived risk in public's acceptance of automated vehicles," *Transportation Research Part C: Emerging Technologies*, vol. 98, pp. 207–220, 2019.

[15] G. Zhu, Y. Chen, and J. Zheng, "Modelling the acceptance of fully autonomous vehicles: a media-based perception and adoption model," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 73, pp. 80–91, 2020.

[16] J. F. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, *Multivariate Data Analysis*, Pearson Education Limited, Essex, England, 2014.

[17] S. Hardman, R. Berliner, and G. Tal, "Who will be the early adopters of automated vehicles? Insights from a survey of electric vehicle owners in the United States," *Transportation Research Part D: Transport and Environment*, vol. 71, pp. 248–264, 2019.

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

[19] P. Liu, "Positive, negative, ambivalent, or indifferent? Exploring the structure of public attitudes toward self-driving vehicles on public roads," *Transportation Research Part A: Policy & Practice*, vol. 142, pp. 27–38, 2020.

[20] T. A. S. Nielsen and S. Haustein, "On sceptics and enthusiasts: What are the expectations towards self-driving cars?" *Transport Policy*, vol. 66, pp. 49–55, 2018.

[21] S. Pettigrew, L. Mitiku Dana, and R. Norman, "Clusters of potential autonomous vehicle users according to propensity to use individual versus shared vehicles," *Transport Policy*, vol. 76, pp. 13–20, 2019.

[22] E. M. Rogers, *Diffusion of Innovations*, The Free Press, New York, NY, USA, 4th edition, 1995.

[23] M. Laroche, J. Bergeron, and G. Barbaro-Forleo, "Targeting consumers who are willing to pay more for environmentally friendly products," *Journal of Consumer Marketing*, vol. 18, no. 6, pp. 503–520, 2001.

[24] S. Pettigrew, C. Worrall, Z. Talati, L. Fritschi, and R. Norman, "Dimensions of attitudes to autonomous vehicles," *Urban, Planning and Transport Research*, vol. 7, pp. 19–33, 2019.

[25] Ansys, "Global autonomous vehicles report: analyzing public perceptions of future unmanned transportation," 2019, https://www.ansys.com/-/media/ansys/corporate/resourcelibrary/other/ansys-autonomous-survey-report.pdf.

[26] M. Bellone, A. Ismailogullari, T. Kantala, S. Mäkinen, R. M. Soe, and M. A. Kyyrö, "A cross-country comparison of user experience of public autonomous transport," *European Transport Research Review*, vol. 13, 2021.

[27] A. Edelmann, S. Stümper, and T. Petzoldt, "Cross-cultural differences in the acceptance of decisions of automated vehicles," *Applied Ergonomics*, vol. 92, Article ID 103346, 2021.

[28] European Commission, "Special Eurobarometer 496: Report: Expectations and concerns of connected and automated

driving," 2020, https://ec.europa.eu/commfrontoffice/publicopinion/index.cfm/Survey/getSurveyDetail/instruments/SPECIAL/surveyKy/2231.

[29] S. A. Kaye, I. Lewis, S. Forward, and P. Delhomme, "A priori acceptance of highly automated cars in Australia, France, and Sweden: A theoretically-informed investigation guided by the TPB and UTAUT," *Accident Analysis & Prevention*, vol. 137, Article ID 105441, 2020.

[30] 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/2027.42/108384/103024.pdf?sequence=1&isAllowed=y.

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

[32] B. Schrauth, S. Maier, C. Kraetsch, and W. Funk, *Report on the Findings of the Brave Population Survey. Deliverable 2.3 From The Eu-H2020-Project BRAVE: BRidging the gaps for the adoption of Automated VEhicles*, Materialien aus dem Institut für empirische Soziologie an der Friedrich-lexander-niversit, Nuremberg, Germany, 2020, https://www.researchgate.net/profile/Walter_Funk/publication/342078557_Report_on_the_findings_of_the_BRAVE_population_survey_Deliverable_23_from_the_EU-H2020-project_BRAVE_-BRidging_the_gaps_for_the_adoption_of_Automated_VEhicles/links/5ee0f2a945851516e66.

[33] TNS Opinion & Social, "Special Eurobarometer 427: Autonomous systems: Report," 2015, https://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_427_en.pdf.

[34] S. Nordhoff, T. Louw, S. Innamaa et al., "Using the UTAUT2 model to explain public acceptance of conditionally automated (L3) cars: A representative questionnaire study among 9,118 car drivers from eight European countries," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 74, pp. 280–297, 2020.

[35] J. Moody, N. Bailey, and J. Zhao, "Public perceptions of autonomous vehicle safety: An international comparison," *Safety Science*, vol. 121, pp. 634–650, 2020.

[36] A. Thomas and J. Trost, "A study on implementing autonomous intra city public transport system in developing countries–India," in *Proceedings of the 7th International Conference on Advances in Computing & Communications, ICACC-2017*, Cochin, India, August 2017.

[37] O. Carsten and M. H. Martens, "How can humans understand their automated cars? HMI principles, problems and solutions," *Cognition, Technology & Work*, vol. 21, pp. 3–20, 2019.

[38] ERTRAC, "Connected automated driving roadmap," 2019, https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf.

[39] National Highway Traffic Safety Administration NHTSA, "Ensuring American leadership in automated vehicle technologies: Automated Vehicles 4.0," 2020, https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/360956/ensuringamericanleadershipav4.pdf.

[40] G. Xiao, J. Lee, Q. Jiang, H. Huang, M. Abdel-Aty, and L. Wang, "Safety improvements by intelligent connected vehicle technologies: a meta-analysis considering market penetration rates," *Accident Analysis & Prevention*, vol. 159, Article ID 106234, 2021.

[41] E. C. Anania, S. Rice, N. W. Walters, M. Pierce, S. R. Winter, and M. N. Milner, "The effects of positive and negative information on consumers' willingness to ride in a driverless vehicle," *Transport Policy*, vol. 72, pp. 218–224, 2018.

[42] E. Fraedrich and B. Lenz, *Taking a Drive, Hitching a Ride: Autonomous Driving and Car Usage. Autonomous Driving*, J. Maurer, J. Gerdes, B. Lenz, and H. Winner, Eds., Springer, Berlin, Germany, 2016.

[43] D. A. Sanbonmatsu, D. L. Strayer, Y. Zhenghui, F. Biondi, and J. M. Cooper, "Cognitive underpinnings of beliefs and confidence in beliefs about fully automated vehicles," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 55, pp. 114–122, 2018.

[44] L3Pilot, "About L3Pilot," 2020, https://l3pilot.eu/.

[45] S. Nordhoff, A. Beuster, T. Kessel et al., "Deliverable D7.1. Annual quantitative survey about user acceptance towards ADAS and vehicle automation," 2021.

[46] Health Quality Council of Alberta (HQCA), "Understanding patient and provider experiences with relationship, information, and management continuity," 2016, https://hqca-hqca-ca-wp.azurewebsites.net/wp-content/uploads/2018/05/Relationship_Information_Management_Continuity_Aug2016.pdf.

[47] S. Etzioni, J. Hamadneh, A. B. Esztergár-Kiss et al., "Modeling cross-national differences in automated vehicle acceptance," *Sustainability*, vol. 12, pp. 1–22, 2020.

[48] C. J. Haboucha, R. I. Ishaq, and Y. Shiftan, "User preferences regarding autonomous vehicles," *Transportation Research Part C: Emerging Technologies*, vol. 78, pp. 37–49, 2017.

[49] C. Tennant, S. Stares, and S. Howard, "Public discomfort at the prospect of autonomous vehicles: Building on previous surveys to measure attitudes in 11 countries," *Transportation Research Part F: Traffic Psychology & Behavior*, vol. 64, pp. 98–118, 2019.

[50] Deloitte, "What's ahead for fully autonomous driving: consumer opinions on advanced vehicle technology. Perspectives from Deloitte's global automotive consumer study," 2017, https://www2.deloitte.com/cn/en/pages/consumer-industrial-products/articles/fully-autonomous-driving.html.

[51] S. Nordhoff, J. De Winter, M. Kyriakidis, B. Van Arem, and R. Happee, "Acceptance of driverless vehicles: Results from a large cross-national questionnaire study," *Journal of Advanced Transportation*, vol. 2018, Article ID 5382192, 22 pages, 2018.

[52] KPMG, "Autonomous vehicles readiness index: assessing countries openness and preparedness for autonomous vehicles," 2019, https://assets.kpmg/content/dam/kpmg/xx/pdf/2019/02/2019-autonomous-vehicles-readiness-index.pdf.

[53] L. Wang, H. Zhong, W. Ma, M. Abdel-Aty, and J. Park, "How many crashes can connected vehicle and automated vehicle technologies prevent: a meta-analysis," *Accident Analysis & Prevention*, vol. 136, Article ID 105299, 2020.

[54] P. Liu, Y. Du, L. Wang, and D. Y Ju, "Ready to bully automated vehicles on public roads?" *Accident Analysis & Prevention*, vol. 137, Article ID 105457, 2020.

[55] A. H. Maslow, *Motivation and personality*, Harper, Manhattan, NY, USA, 1954.

[56] 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, pp. 127–140, 2015.

[57] J. Lee, F. Baig, M. A. H. Talpur, and S. Shaikh, "Public intentions to purchase electric vehicles in Pakistan," *Sustainability*, vol. 13, no. 10, 5523 pages, 2021.

[58] F. Nazari, M. Noruzoliaee, and A. K. Mohammadian, "Shared versus private mobility: Modeling public interest in

autonomous vehicles accounting for latent attitudes," *Transportation Research Part C: Emerging Technologies*, vol. 97, pp. 456–477, 2018.

[59] S. Haghzare, J. L. Campos, K. Bak, and A. Mihailidis, "Older adults' acceptance of fully automated vehicles: effects of exposure, driving style, age, and driving conditions, driving style, age, and driving conditions," *Accident Analysis & Prevention*, vol. 150, Article ID 105919, 2021.

[60] X. Mosquet, M. Andersen, and A. Arora, "A roadmap to safer driving through advanced driver assistance systems," 2015, https://image-src.bcg.com/Images/MEMA-BCG-A-Roadmap-to-Safer-Driving-Sep-2015_tcm9-63787.pdf%20.

[61] W. Payre, S. Birrel, and A. M. Parkes, "Although autonomous cars are not yet manufactured, their acceptance already is," *Theoretical Issues in Ergonomics Science*, vol. 22, 2020.

[62] A. McDonald, C. Carney, and D. V. Mc Gehee, "Vehicle owners' experiences with and reactions to advanced driver assistance systems," 2018, http://aaafoundation.org/wp-content/uploads/2018/09/VehicleOwnersExperiencesWithADAS_TechnicalReport.pdf.

[63] R. Lin, L. Ma, and W. Zhang, "An interview study exploring Tesla drivers' behavioral adaptation," *Applied Ergonomics*, vol. 72, pp. 37–47, 2018.

[64] Q. Chen, H. Huang, Y. Li et al., "Modeling accident risks in different lane-changing behavioral patterns," *Analytic Methods in Accident Research*, vol. 30, Article ID 100159, 2021.

[65] Q. Jiang, H. Huang, W. Zhao, F. Baig, J. Lee, and P Li, "Intention of risk-taking behavior at unsignalized intersections under the connected vehicle environment," *IEEE Access*, vol. 9, pp. 50624–50638, 2021.

[66] A. Bjorvatn, Y. Page, H. Weber et al., "Impact evaluation results," *L3Pilot Deliverable*, vol. D74 pages, 2021.

[67] SAE International, "Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles: J3016_202104," 2021, https://www.sae.org/standards/content/j3016_202104/.

[68] T. Irmak, D. M. Pool, and R. Happee, "Objective and subjective responses to motion sickness: The group and the individual," *Experimental Brain Research*, vol. 239, no. 2, pp. 515–531, 2020.

[69] K. F. Yuen, Y. D. Wong, F. Ma, and X Wang, "The determinants of public acceptance of autonomous vehicles: an innovation diffusion perspective," *Journal of Cleaner Production*, vol. 270, Article ID 121904, 2020.