Acceptance of Highly Automated Vehicles: A Factor Analysis Approach

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Abstract

Potential theoretical sub-dimensions of acceptance of highly automated vehicles remain unclear. A study investigated the sub-factors of a scale to measure acceptance of high levels of automation in vehicles. An online sample of participants completed an expanded, 50-item version of the Self-driving Car Acceptance Scale (SCAS; Nees, 2016). Exploratory factor analysis revealed eight sub-dimensions of acceptance: (1) general acceptance of high automation (including intention to use); (2) general concerns over high automation; (3) perceived benefits for people unable to drive; (4) ease of use concerns; (5) enjoyment of/preference for manual driving; (6) desire to be able to take back manual control; (7) social status and desirability; and (8) perceived technological-savvy. Correlations among factors suggested that general acceptance was positively related to perceived benefits for people unable to drive, perceived enhancement of social status, and perceived technology savvy. General acceptance was correlated with general concerns, ease of use concerns, enjoyment of/preference for manual driving, and the desire to be able to retake manual control. Practical and theoretical implications are discussed.

Keywords: vehicle automation; technology acceptance; factor analysis

Acceptance of Highly Automated Vehicles: Refinement of a Scale and Relationships with Desire for Control, Illusion of Control, and Driving Styles

Technology to automate driving tasks has advanced in recent years, but research consistently has shown public apprehension about high levels of vehicle automation (AAA, 2018; Kohl et al., 2017; Lee & Kolodge, 2018). Since a mandated transition to automation in vehicles seems unlikely, the success or failure of vehicle automation will hinge upon voluntary acceptance and use of vehicles with automated systems. *Acceptance* of highly automated vehicles has been defined as “a prerequisite for implementation success [that] determines whether [driverless vehicles] will be actually used” (Nordhoff et al., 2016). As such, acceptance is a broad psychological construct that precedes the *intention-to-use* highly automated vehicles, which in turn should (in the future) predict *observed use* of highly automated vehicles (Venkatesh et al., 2003). Potential underlying theoretical sub-dimensions of the acceptance construct remain unclear, however, and no standard measure of acceptance of highly automated vehicles has been adopted.

General acceptance of technology has been studied extensively, and multiple theoretical models of acceptance have been presented, including the Technology Acceptance Model (TAM) (Davis et al., 1989). The TAM proposed that *perceived usefulness*—the extent to which a person believes the technology will assist in the performance of a task—and *perceived ease-of-use*—the extent to which a person believes that using the technology will be undemanding—are the primary contributors to users’ attitude toward using technology, which in turn predicts intention-to-use and actual system use. In their Automation Acceptance Model (AAM), Ghazizadeh and colleagues (Ghazizadeh et al., 2012) added two additional factors to the TAM model. The extent to which automated technology matches a user’s values, experiences, and task needs was called

compatibility (of technology with automation). *Trust in automation* described the extent to which a person believes automation will reliably fulfill its intended function in a system.

Acceptance of automation in vehicles represents an even more specialized case of acceptance of automation. In particular, the prospect of automation in vehicles has presented acute safety concerns for end users (see Liu, Yang, & Xu, 2019) that may be unique—or at least more pronounced—for this application of automation as compared to automation in domains where automation failures do not pose a potential direct threat to life and limb. Conceptual, qualitative approaches to the dimensionality of acceptance of vehicle automation have emerged (Nees, 2016; Nordhoff et al., 2016). Although conceptual models can be useful in the early stages of research on a phenomenon, a pressing need is the development of theory supported by quantitative evidence of the factors contributing to acceptance of vehicle automation.

Factor analysis (FA) is process that can be used to empirically determine the structure of a set of variables (e.g., responses to items in a survey of acceptance) through quantitative analyses of the relationships between the variables. Correlated groups of measured variables (e.g. survey items) indicate higher order factors—latent variables that represent a common source of variance that explains the relationships among the individual items. (for overviews, see Comrey, 1988; Floyd & Widaman, 1995; Russell, 2002). For a broad construct like acceptance of highly automated vehicles, the underlying structure of acceptance (i.e., the sub-dimensions that contribute to acceptance) can be determined through the examination of extracted factors.

To date, studies using quantitative approaches to understand the dimensionality of acceptance of vehicle automation have produced inconsistent results. For example, Nordhoff, de Winter, Kyriakidis, et al., (2018) found evidence of a single general factor of acceptance of automated shuttles. This factor subsumed perceived usefulness and perceived ease-of-use—two

factors from the TAM model. Yet perceived usefulness did appear as a distinct dimension (as “performance expectancy”) in analyses by Madigan et al. (2015), who also examined acceptance of automated shuttles, and Kaur and Rampersad (2018), whose questionnaires targeted “driverless vehicles.” Tussyadiah et al. (2017) found evidence of trust/reliability as a distinct dimension of acceptance of self-driving taxis, whereas items to assess trust/reliability loaded on the general factor of acceptance in Nordhoff, de Winter, Kyriakidis, et al. (2018). Compatibility emerged as a distinct factor in the analyses of Deb et al. (2017), whose survey focused on pedestrians’ acceptance of high automation in vehicles. An array of additional potential factors affecting acceptance of vehicle automation also have been identified in these types of studies.

A potential methodological limitation of several of these studies is the use of principle components analysis (PCA), whose purpose is to extract mathematical component variables, rather than (FA), an approach whose purpose is to extract latent psychological variables. A complete treatment of the differences between PCA and FA is beyond the scope of this paper, but components derived from PCA include variance that is unique to specific variables (e.g., survey items) in the analysis. As such, PCA does not necessarily allow researchers to understand underlying latent variables (common factors), which by definition are characterized by common (not unique) variance among survey items. FA has been recommended over PCA for research on latent psychological variables (such as the acceptance construct of interest here) (Costello & Osborne, 2005; Russell, 2002; Widaman, 1993), although in some circumstances PCA and CFA may produce similar results.

The current study used EFA to examine acceptance of highly automated vehicles. The approach of this exploratory study was to: (1) collect data using a survey with items to represent a large number of potential latent sub-dimensions of acceptance of highly automated vehicles;

(2) conduct an EFA to empirically evaluate the dimensionality of acceptance; and (3) examine reliability of sub-dimensions and correlations among sub-dimensions.

Method

Participants

Participants ($N = 514$) were recruited online via Amazon Mechanical Turk (AMT). Mechanical Turk workers were required to be located in the United States, to have a task approval rating of greater than 95%, and to have at least 1000 previously approved tasks. The study description also indicated that the research was only open to licensed drivers. Participants were paid \$0.90 for their time. Fourteen participants dropped out of the study by closing the browser window before answering all survey questions; their data were not analyzed further. Fifty-one participants failed attention check questions (described below), so the final sample analyzed was $N = 449$ (172 females, 277 males). The mean age in the sample was 37.42 years ($SD = 11.72$, $mdn = 34$, range = 20-83). Self-reported racial/ethnic backgrounds represented in the sample were white ($n = 352$), Asian ($n = 43$), black or African American ($n = 35$), Hispanic or Latino ($n = 30$), American Indian or Alaska Native ($n = 6$), Native Hawaiian or Pacific Islander ($n = 1$), other ($n = 2$), and prefer not to answer ($n = 4$). Participants were allowed to select more than one category, so these numbers sum to a number greater than the sample size. Participants reported $M = 19.23$ years of driving experience ($SD = 12.08$, $mdn = 16.00$, minimum = 0.00, maximum = 62.00). Participants reported driving $M = 8.03$ hours per week ($SD = 7.24$, $mdn = 6.00$, minimum = 0.00, maximum = 65.00). Participants reported the scenario that best described where they drive most often as urban/city driving ($n = 249$), rural/small town driving ($n = 139$), distance/interstate/freeway driving ($n = 52$), and other ($n = 9$). On a scale from 1 (“not familiar at all”) to 7 (“extremely familiar”), participants rated their familiarity with the current

state of technology related to vehicle automation and self-driving cars as $M = 3.92$ ($SD = 1.53$, $mdn = 4.00$). Participants reported having read $M = 4.22$ articles about self-driving cars in print or online ($SD = 8.04$, $mdn = 2.00$, minimum = 0.00, maximum = 100.00)¹. One-hundred-eighty-two participants reported owning or using a vehicle that had automated features, including 150 instances of adaptive/automatic cruise control, 38 instances of automated braking, 20 instances of automatic steering/lane centering steering/lane keeping assist, 21 instances of Autopilot or Level 2 systems (see SAE International, 2016), 34 instances of forward collision warning, 28 instances of automatic parking/parking assist, and 34 instances of lane change warnings.

Materials

Expanded Self-driving Car Acceptance Scale. Participants completed an instrument created for this study, an expanded version of the Self-Driving Car Acceptance Scale (SCAS) (Nees, 2016). The expanded SCAS featured 50 statements (see Table 1) that were written to assess the extent to which participants were accepting of highly automated vehicles, as well as their intention-to-use highly automated vehicles. Responses were made on a 7-point Likert scale with the anchors “strongly disagree” and “strongly agree.” From a review of literature and theory, item selection was motivated by general theories of acceptance of technology (e.g., Venkatesh, Morris, Davis, & Davis, 2003), theory specific to the acceptance of automation (e.g., Ghazizadeh, Lee, & Boyle, 2012), and conceptual models of acceptance of vehicle automation (Nees, 2016; Nordhoff et al., 2016).

¹ One additional participant was excluded from this calculation for reporting having read 6254989 articles. Other responses from this participant did not appear to be unserious, so this response was assumed to be a data entry mistake. All other analyses included this participant's responses.

The instrument attempted to capture 13 potential latent dimensions of acceptance: (1) trust/reliability; (2) cost concerns; (3) compatibility/appropriateness of automation; (4) enjoyment of driving; (5) perceived usefulness of automation; (6) perceived ease-of-use of automation; (7) experience with automation/technology; (8) desire for human control; (9) accessibility of driving; (10) ride-sharing/environmental impact; (11) legal, liability, and insurance concerns; (12) hacking concerns; and (13) social desirability. The instrument also included four questions to assess a potential outcome criterion, which was intention-to-use vehicles with high automation. The instrument and the a priori hypothesized dimensionality of items are shown in the Appendix.

Procedure

Data were collected in October, 2017. The survey was hosted on Qualtrics. Participants were instructed to base their responses upon their acceptance of a highly automated vehicle (SAE International, 2016). The verbatim instructions were:

You will be asked to rate the extent to which you agree or disagree with about 50 questions about self-driving cars. For the purposes of this study, a "self-driving car" means a car that can do all of the things a human driver does without help or input from the human in the car. This means the car can automatically steer and turn, accelerate and brake, and monitor other vehicles and driving conditions without help from a human.

Participants then answered each question from the expanded SCAS inventory. Two additional attention check questions were presented within the SCAS inventory. The first check question stated "I am answering these questions honestly and to the best of my ability." The second check question stated "I am reading each question about self-driving cars carefully." Participants ($n = 51$) who entered responses < 6 ("agree") on the Likert scale for either question were excluded

from further analyses. SCAS questions, intention-to-use questions, and the two attention check questions were presented in a different random order for each participant.

Results

The Kaiser–Mayer–Olkin (KMO) measure suggested sampling was adequate for conducting FA, $KMO = .96$, and Bartlett’s test of sphericity showed the correlation matrix was significantly different from an identity matrix and thus showed relationships between measured variables, $\chi^2(1225) = 16178.06, p < .001$.

An EFA was conducted on 50 items related to acceptance of and intention-to-use highly automated vehicles. Principle axis factoring was used to extract factors with eigenvalues greater than 1, which left eight factors. Oblique (Promax) rotation was used, because existing theory has posited that sub-dimensions of acceptance may be correlated (e.g., the AAM, see Ghazizadeh et al., 2012).

Table 1 shows the rotated factor pattern matrix; only loadings $> .30$ were used to interpret the factors. Items with reverse scoring were not reversed before the EFA, so the signs (positive or negative) on loadings refer to items as written. Items with negative loadings were reversed before calculating Cronbach’s alpha for reliability. Higher scores indicate lower acceptance for Factors 2, 4, 5, and 6 (see Table 2), so those factors are designated as reversed in Table 1.

Interpretation of Factors

Factor 1: General Acceptance and Intention-to-use. Factor 1 ($n = 20$ items; 34% variance explained²; $\alpha = .96$) was interpreted to indicate general acceptance. Items loading

² For EFAs reported in this manuscript, the proportions of variance accounted for by factors are the rotation sums of squared loadings divided by the number of variables in the analysis. Because oblique rotation was used and factors are correlated, these values should be interpreted with

positively on this factor indicated higher trust, safety, reliability, perceived ease of use, willingness to pay, intention-to-use, and belief in a host of positive outcomes associated with highly automated vehicles. The wide range of items loading on this factor and the extremely high internal consistency of the factor suggested that respondents tended to have a general, holistic impression of highly-automated vehicles that drove responses. Theories of technology and automation acceptance have suggested that sub-constructs of acceptance (e.g., trust, perceived ease of use, intention to use) are distinct. Yet this general factor showed that items to assess these hypothetical sub-constructs loaded on a unitary latent variable

Factor 2: General Concerns (Reverse-scored). Factor 2 ($n = 9$ items, 22% variance explained; $\alpha = .91$) was interpreted to indicate general concerns, including liability, hacking, and cost. Like with Factor 1, the loading of all of these items onto the same factor suggests that these concerns are general and not well-differentiated. Of note, most of the items loading on this factor used similar wording about concerns. When this occurs in an EFA, it is possible that the factor indicates a methodological artifact of the wording of the questions. Despite this potential ambiguity, the items loading on this factor were not uniformly similar in wording, and they represented a fairly coherent set of general concerns.

Factor 3: Perceived Benefits for People Unable to Drive. Factor 3 ($n = 6$ items; 21% variance explained; $\alpha = .89$) was interpreted to indicate perceived benefits for people unable to drive for a wide variety of reasons, including age, disability, sickness, sleepiness, and intoxication. A question assessing highly automated vehicles as an alternative to public transportation also loaded on this factor.

caution. They are not fully unique to each factor, and they cannot be summed to obtain a total variance explained by the EFA.

Factor 4: Ease-of-use Concerns (Reverse-scored). Factor 4 ($n = 4$ items; 14% variance explained; $\alpha = .80$) was interpreted to indicate ease-of-use concerns, including concerns about learning how to use and update a highly automated vehicle. An item assessing concern about motion sickness also loaded on this factors.

Factor 5: Enjoyment of/Preference for Manual Driving (Reverse-scored). Factor 5 ($n = 3$ items; 14% variance explained; $\alpha = .85$) was interpreted to indicate enjoyment of and a preference for manual driving.

Factor 6: Desire to be Able to Take Back Manual Control (Reverse-scored). Factor 6 ($n = 4$ items; 7% variance explained; $\alpha = .67$) was interpreted to indicate a desire to have the option to take back manual control from the automation.

Factor 7: Social Status and Desirability. Factor 7 ($n = 3$ items; 7% variance explained; $\alpha = .71$) was interpreted to reflect beliefs that a highly automated vehicle would confer higher social status on the user.

Factor 8: Technological Savvy. Factor 8 ($n = 3$ items; 7% variance explained; $\alpha = .71$) was reflected to interpret technological savvy and general enjoyment of the use of technology.

Table 1. SCAS Items and Pattern Matrix

Item	F1	F2(R)	F3	F4(R)	F5(R)	F6(R)	F7	F8
I would trust a self-driving car to get me to my destination.	.96							
I would ride a self-driving car.	.92							
I would borrow or rent a self-driving car.	.90							
Self-driving car will be safe.	.87							
A self-driving car would allow me to be more safe while in the car.	.86							
I would like to own a self-driving car.	.84							
Self-driving cars will be reliable.	.79							
I do not think that computers should be driving cars.	-.76							
I would be interested in sharing a self-driving car with others instead of owning my own personal vehicle.	.75							
I would be willing to pay more for a self-driving car compared to what I would pay for traditional car.	.72							
Self-driving cars will reduce the stress of driving.	.70							
Self-driving cars will reduce traffic problems.	.66							
The benefits of a self-driving car would outweigh the amount of money it would cost.	.64							
I would feel comfortable riding in a car that had no steering wheel.	.57					-.33		
A self-driving car would allow me to be more productive.	.54							
Self-driving cars would allow me to live a more environmentally-friendly lifestyle.	.53							
Self-driving cars will be easy to use.	.51							
I would be more likely to use self-driving cars after my friends or family have tried them.	.38						.30	
I would be concerned that self-driving cars could be hacked.		.81						
I would be concerned about legal problems that could arise from owning a self-driving car.		.80						
I would be concerned about how insurance works with self-driving cars.		.78						
I would be concerned about who is held liable for accidents in a self-driving car.		.77						
If I owned a self-driving car, I would worry that an unauthorized person could access the cars' software.		.76						
I would be concerned about the security of the computers in self-driving cars.		.72						
I would be concerned that I would have to pay for traffic violations committed by my self-driving cars.		.70						
I would be concerned about the cost of a self-driving car compared to a traditional car.		.57						
There are some driving scenarios that will be too difficult for a self-driving car to handle.	-.33	.36						
Self-driving cars would help older adults who no longer drive.			.85					
A self-driving car would be useful for times when I am too sleepy to drive.			.84					
Self-driving cars would help people who cannot drive because of a disability.			.80					
A self-driving car would be useful for times when I am too sick to drive.			.73					
A self-driving car would be useful for times when I am too intoxicated to drive.			.68					
Self-driving cars would give me an alternative to using public transportation.			.42					
It would take me a long time to figure out how to use a self-driving car.				.77				
It would be a lot of work to figure out how to use a self-driving car.				.71				
I would be concerned about getting motion sickness while riding in a self-driving car.				.60				
It would be a hassle to update the software in self-driving cars.				.39				
There are tasks in my life that have been made easier by computers doing the work for me.								
I enjoy driving a car.					.93			
I would miss normal manual driving if my car drove itself.					.76			
I prefer to be the driver rather than the passenger in a car.					.69			
Even if I had a self-driving car, I would still want to drive myself most of the time.					.56			
It would be important to me to have the option to turn off the computer and drive myself in a self-driving car.						.80		
It is important for a human to be able to take back control from a self-driving car.						.71		
It would be important for a self-driving car to give me information about what it is doing while it is driving a car.						.41		
Other people would be impressed if I owned a self-driving car.							.64	
Owning a self-driving car would be a symbol of my status to others.							.60	
I am a technology-savvy person.								.57
I prefer using new technology instead of doing things "the old-fashioned way."	.39							.41
I like to use technology to make tasks easier for me.								.39

Factor correlations are shown in Table 2. General acceptance was strongly positively related to perceived benefits for people unable to drive and moderately positively related to perceived enhancement of social status and perceived technology savvy. General acceptance was strongly negatively correlated with general concerns, ease of use concerns, and enjoyment of/preference for manual driving and weakly negatively correlated with desire to be able to retake manual control.

Table 2. *Factor Correlations (N = 449)*

Factor	1	2	3	4	5	6	7
1. General Acceptance							
2. General Concerns	-.592						
3. Perceived Benefits for People Unable to Drive	.654	-.215					
4. Ease of Use Concerns	-.472	.472	-.376				
5. Enjoyment/Preference for Manual Driving	-.480	.449	-.225	.293			
6. Desire to Retake Manual Control	-.110	.381	.248	-.165	.291		
7. Social Status and Desirability	.342	-.117	.204	-.097	-.132	.030	
8. Technological Savvy	.344	-.109	.401	-.108	-.087	.085	-.012

Discussion

Limitations and Caveats

Participants were acquired via online sampling, which may not be representative of the general population of drivers. Participants had not actually interacted with the highly automated vehicles examined here, because those vehicles are not available to consumers. A general positive or negative attitude about *the potential for* self-driving technology likely was the primary factor driving responses to the scale questions. This attitude may be unstable and malleable. Acceptance will be affected by actual experiences with automation (Beggiato et al., 2015). Acceptance also may be different for different levels of automation (e.g., Hewitt et al., 2019); we only examined attitudes toward high automation.

Practical Applications

Our EFA produced a General Acceptance factor of 20 items with high internal consistency reliability. This factor could potentially be useful as a short, survey-based measure of acceptance of highly automated vehicles, as it seemed to capture a wide range of potential beliefs related to acceptance. More research is needed to establish the validity of the scale.

Theoretical Implications

Dimensionality of Acceptance of Highly Automated Vehicles. Researchers (Hewitt et al., 2019; Nees, 2016; Nordhoff et al., 2016) typically have described acceptance of high automation in vehicles as a multidimensional construct, but empirical analyses of scales and questionnaires have not uncovered a consistent set of sub-dimensions. The EFA in our study offered some evidence of multidimensionality, as the ratings from a 50-item scale factored into 8 interpretable dimensions of acceptance. Some of these dimensions appeared to represent hypothesized constructs from existing conceptual models (e.g., perceived ease-of-use, lack thereof, was capture in our Factor 4). Still, the EFA in our study generally did not support the dimensionality of acceptance as described in existing theory.

Our first General Acceptance factor included items related trust, safety, reliability, perceived ease of use, willingness to pay, and intention-to-use highly automated vehicles—the theorized outcome of acceptance. This suggested that these hypothetical sub-dimensions were actual part of the same latent variable. In other words, rather than operating as independent (but possibly correlated) contributors to acceptance, responses to all of these types of items functioned in largely the same way in our study. A similar general factor was reported by Nordhoff, de Winter, Kyriakidis, et al. (2018), and their study used a large sample size and a large battery of survey questions, which made it well-suited for detecting multidimensionality.

Although further validation is required, this finding suggested that many important aspects of acceptance are not well-differentiated at the current time. Instead, our study suggested that people seem to have a general impression that holistically influences their acceptance of—and intention-to-use—highly automated vehicles.

Still, more research is needed to confirm and expand upon this finding. There has been considerable variability in the number and meaning of the factors extracted in quantitative analyses of acceptance of high automation in vehicles. Methodological differences that could contribute to these different findings include the use of different (and different numbers of) questions/scales, the use of different analysis techniques (e.g., PCA versus EFA), and differences in sampling and sample sizes. It is also possible that there are real differences in the factors affecting acceptance as a function of the target vehicle type (e.g., shuttles versus personal vehicles), or that cultural differences (e.g., across countries) affect the dimensionality of acceptance. Acceptance (and potentially the sub-factors composing it) may change after experiencing automation (see Molnar et al., 2018). For example Xu et al. (2018) reported that perceived ease-of-use predicted intention-to-use automated vehicles after participants had experienced a ride in an automated vehicle, but not before.

Construct Validity of Intention-to-use. Existing theories of technology acceptance indicate that intention-to-use and acceptance are distinct constructs. In these theories, intention-to-use follows acceptance (or its sub-dimensions, such as perceived ease-of-use) and precedes observed behavioral use of a technology (e.g., Ghazizadeh et al., 2012; Venkatesh et al., 2003). We wrote four items to assess intention-to-use highly automated vehicles. Those items were: (1) “I would ride in a self-driving car”; (2) “I would like to own a self-driving car”; (3) “I would borrow or rent a self-driving car”; and (4) “Even if I had a self-driving car, I would still want to

drive myself most of the time” (reverse scored). The first three items loaded on the first general acceptance factor of the EFA, and the loadings were quite high (see Table 1). To examine this relationship more closely, we correlated (1) the average of the raw ratings for the 17 items from Factor 1 that were unrelated to intention-to-use (as written), with (2) the average of the four intention-to-use items. The correlation was $r(447) = .899, p < .001$. Thus, our evidence suggested acceptance and intention-to-use could be the same construct—or at least that our particular measures could have assessed the same construct.

Our survey items to assess intention-to-use were very similar to items written to assess intention-to-use in other research (Montoro et al., 2019; Payre et al., 2014; Sener et al., 2019), so it seems unlikely that this result stems from the design of our questions. Our finding is potentially problematic for theory on acceptance of highly automated vehicles—existing theory suggests that intention-to-use should be an outcome or criterion of acceptance. The high correlations are consistent with our interpretation above—namely that our participants’ responses to questions about self-driving vehicles seemed to be driven by a holistic, general impression of vehicle automation rather than a nuanced set of attitudes. Thus, it is perhaps not surprising that our survey-based measures of acceptance and intention-to-use produced highly-related scores. Still, our results suggest that researchers should use caution when treating intention-to-use as an outcome or criterion in survey-based studies of acceptance; specifically, care should be taken to establish that the two constructs are distinct before treating intention-to-use as an indicator of criterion validity. The ideal outcome criterion for studies of acceptance would be actual, observed use of highly automated vehicles. That criterion is not attainable until such vehicles reach consumers. In the absence of an ideal criterion, more research is needed to determine the

extent to which survey-based measures (e.g., of intention-to-use) can serve as effective surrogates for validating scales to measure acceptance of highly automated vehicles.

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Expanded Self-driving Car Acceptance Scale (with a priori hypothesized dimensions)

All items are rated on a scale from 1 (Strongly disagree) to 7 (Strongly agree)

Perceived reliability of automation (Trust)

1. Self-driving cars will be safe.
2. I would trust a self-driving car to get me to my destination.
3. Self-driving cars will be reliable.

Cost of automation

4. I would be willing to pay more for a self-driving car compared to what I would pay for a traditional car.
5. The benefits of a self-driving car would outweigh the amount of money it would cost.
6. I would be concerned about the cost of a self-driving car compared to a traditional car.

Compatibility (appropriateness of automation)

7. I do not think that computers should be driving cars.
8. It is important for a human to be able to take back control from a self-driving car.
9. There are some driving scenarios that will be too difficult for a self-driving car to handle.

Enjoyment of to-be-automated task

10. I enjoy driving a car.
11. I prefer to be the driver rather than the passenger in a car.
12. I would miss normal manual driving if my car drove itself.

Perceived usefulness of automation

13. A self-driving car would allow me to be more productive.
14. A self-driving car would allow me to be more safe while in the car.
15. Self-driving cars will reduce traffic problems.
16. Self-driving cars will reduce the stress of driving.

Perceived ease of use of automation

17. Self-driving cars will be easy to use.
18. It would be a lot of work to figure out how to use a self-driving car.
19. It would take me a long time to figure out how to use a self-driving car.
20. It would be a hassle to update the software in self-driving cars.

Experience with automation/technology

21. I like to use technology to make tasks easier for me.
22. I prefer using new technology instead of doing things “the old-fashioned way.”
23. There are tasks in my life that have been made easier by computers doing the work for me.
24. I am a technology-savvy person.

Intention-to-Use Highly Automated Vehicles

25. I would like to own a self-driving car.
26. Even if I had a self-driving car, I would still want to drive myself most of the time.
27. I would ride in a self-driving car.
28. I would borrow or rent a self-driving car.

Desire for Manual Control

29. It would be important to me to have the option to turn off the computer and drive myself in a self-driving car.
30. It would be important for a self-driving car to give me information about what it is doing while it is driving.
31. I would feel comfortable riding in a car that had no steering wheel.

Disability/mobility/intoxication/sickness

- 32. Self-driving cars would help people who cannot drive because of a disability.
- 33. A self-driving car would be useful for times when I am too sleepy to drive.
- 34. A self-driving car would be useful for times when I am too intoxicated to drive.
- 35. Self-driving cars would help older adults who no longer drive.
- 36. A self-driving car would be useful for times when I am too sick to drive.
- 37. I would be concerned about getting motion sickness while riding in a self-driving car.

Sharing/Lifestyle/Green

- 38. Self-driving cars would allow me to live a more environmentally-friendly lifestyle.
- 39. Self-driving cars would give me an alternative to using public transportation.
- 40. I would be interested in sharing a self-driving car with others instead of owning my own personal vehicle.

Legal/liability/insurance

- 41. I would be concerned about who is held liable for accidents in a self-driving car.
- 42. I would be concerned about legal problems that could arise from owning a self-driving car.
- 43. I would be concerned about how insurance works with self-driving cars.
- 44. I would be concerned that I would have to pay for traffic violations committed by my self-driving car.

Hacking

- 45. I would be concerned that self-driving cars could be hacked.
- 46. I would be concerned about the security of the computers in self-driving cars.
- 47. If I owned a self-driving car, I would worry that an unauthorized person could access the car's software.

Social influence/status

- 48. Owning a self-driving car would be a symbol of my status to others.
- 49. I would be more likely to use self-driving cars after my friends or family have tried them.
- 50. Other people would be impressed if I owned a self-driving car.

Source: Expanded from a smaller set of questions in Nees, M. A. (2016). Acceptance of Self-driving Cars: An Examination of Idealized versus Realistic Portrayals with a Self-driving Car Acceptance Scale. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 60(1), 1449–1453.