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Acceptance of Self-driving Cars: An Examination of Idealized versus Realistic Portrayals with a Self-driving Car Acceptance Scale

Michael A. Nees
Lafayette College, Easton, PA, neesm@lafayette.edu

Despite enthusiastic speculation about the potential benefits of self-driving cars, to date little is known about the factors that will affect drivers' acceptance or rejection of this emerging technology. Gaining acceptance from end users will be critical to the widespread deployment of self-driving vehicles. Long-term acceptance may be harmed if initial acceptance is built upon unrealistic expectations developed before people interact with these systems. A brief (24-item) measurement scale was created to assess acceptance of self-driving cars. Before completing the scale, participants were randomly assigned to read short vignettes that featured either a realistic or an idealistic description of a friend's experiences during the first six months of owning a self-driving car. A small but significant effect showed that reading an idealized portrayal in the vignette resulted in higher acceptance of self-driving cars. Potential factors affecting user acceptance of self-driving cars are discussed. Establishing realistic expectations about the performance of automation before users interact with self-driving cars may be important for long-term acceptance.

INTRODUCTION

As prototypes of highly automated vehicles have emerged, public and media interest in the possible implications of ubiquitous self-driving cars has grown. Speculative benefits of the advent of self-driving cars have included increased safety, fewer traffic problems, and a windfall of work or leisure time in the vehicle (for a review, see Litman, 2014). Recent indications have suggested that some design teams believe they can engineer the role of the human operator out of the system altogether (see Markoff, 2014), and advertisements for prototype self-driving cars have shown passengers engaged in business or leisure activities in rear-facing seats ("The Mercedes-Benz F 015 Luxury in Motion.," n.d.). Initial reports have suggested the public has begun to embrace the portrayal of self-driving cars in which the human has no supervisory control. For example, one study (Payre, Cestac, & Delhomme, 2014) reported that driving while impaired from alcohol, drugs, or medications was a major dimension of acceptance of self-driving vehicles, and other studies have suggested that people expect to be able to engage in a wide variety of secondary tasks in self-driving cars (Kyriakidis, Happee, & De Winter, 2014; Pettersson & Karlsson, 2015).

These emerging expectations may reflect overconfidence in our ability to automate the driving task. The implementation of autonomous vehicles faces considerable unresolved challenges. The technology to support self-driving cars remains limited and inadequate, and a host of other difficulties stands in the way of widespread deployment of autonomous vehicles (Hodson, 2015). Only recently have the human factors dilemmas for autonomous vehicles begun to receive their due consideration (Merat & Lee, 2012).

If previous human factors examples of complex automated systems (e.g., in aviation, for a review see Cummings & Ryan, 2014) can offer insight, the goal of removing the human from driving altogether may be difficult to achieve and may not even be a desirable outcome. Unless automation of driving can be implemented with perfect or near-perfect reliability—an outcome that seems implausible, especially during anticipated transitional phases of deployment during which self-driving cars will share roads with traditional vehicles (Sivak & Schoettle, 2015)—the human likely will retain a supervisory role during automated driving. One well-known consequence of automation is that it tends to shift workload from manual tasks to monitoring tasks, sometimes without reducing overall workload (Endsley & Kiris, 1995). Human operators of autonomous vehicles seem to be in danger of being allocated an especially mundane function: to continuously maintain awareness of the driving scenario in anticipation of very infrequent occasions when human intervention will be necessary. These types of vigilance tasks are especially effortful and stressful (Warm, Parasuraman, & Matthews, 2008) and seem to be performed poorly (Molloy & Parasuraman, 1996) even (and perhaps more so) when the target event is infrequent (Bailey & Scerbo, 2007).

Even if appropriate interfaces can be designed to keep drivers in the loop, it remains unclear whether consumers would accept an automated vehicle that could perform all driving tasks, did perform most driving tasks, yet demanded a high amount of monitoring workload. Such workload could result from a deliberate design decision to allocate monitoring functions to the driver. Monitoring workload also could emerge from drivers' lack of trust in the system, as people may feel compelled to attend to the automation even if human oversight is not required. Either scenario could prevent or dissuade the driver from engaging in secondary tasks. Monitoring workload may negatively impact acceptance, as engagement with secondary tasks seems to be viewed as a primary end-user benefit of vehicle automation (see Pettersson & Karlsson, 2015).

Further, research (Beggiato & Krems, 2013) has suggested that initial idealistic expectations about automation are especially harmful to later trust and acceptance when those expectations do not align with the functionality people experience when using the system. Although the ultimate capabilities of self-driving cars are yet to be seen, unrealistic expectations could be a barrier to acceptance. Highly idealized portrayals have begun to foster expectations that self-driving cars will require little or no human intervention and will create a windfall of work, leisure, or social time during transit. A scenario that seems equally or perhaps even more plausible, especially in early rounds of deployment, is one in which the human driver closely monitors automated vehicles and must be prepared to resume manual control on short notice during most or all of her time in a self-driving car.

Initial deployment of self-driving cars could be slowed or harmed if the technology is received with disappointment. Trust in automation is influenced by expectations and attitudes that develop before a person uses a system (Hoff & Bashir, 2015), thus it will be important to understand acceptance before the arrival of self-driving cars on markets (see Payre et al., 2014). To the extent that idealized portrayals of vehicle automation already have begun to influence acceptance, they may also be encouraging unrealistic expectations about automation performance that could be counterproductive to acceptance in the long run.

In this experiment, an online sample of participants read either a realistic or an idealized description of a close friend or family member's experiences during the first six months of ownership of a self-driving car. The realistic vignette emphasized that the driver felt the need to monitor the vehicle during automated operations and occasionally needed to resume manual control to prevent accidents. The idealistic scenario described a vehicle with perfect reliability that did not require human monitoring or intervention and had won the driver's trust. A novel, 24-item scale assessed acceptance of self-driving cars in both vignette conditions and a control condition. The idealized portrayal was hypothesized to increase overall acceptance of self-driving cars.

METHOD

Participants

Participants ($N = 303$) 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 $0.50 for their time. Fifteen participants failed attention check questions (described below), so the final sample analyzed was $N = 288$ (106 females, 182 males). The mean age in the sample was 35.5 years ($SD = 12.46$, $mdn = 31.5$, range = 19 – 83). Self-reported racial/ethnic backgrounds represented in the sample were white ($n = 234$), Asian ($n = 28$), black or African American ($n = 23$), Hispanic or Latino ($n = 11$), American Indian or Alaska Native ($n = 3$), Native Hawaiian or Pacific Islander ($n = 2$), and other ($n = 1$). Participants were allowed to select more than one category, so these numbers sum to a number greater than the sample size.

Materials

Vignettes. Two vignettes described hypothetical scenarios involving a close friend or family member's experiences during the first six months of ownership of a self-driving car. The realistic vignette described a balance of positive and negative experiences with the vehicle, but it was written to emphasize a scenario in which the driver felt obligated to monitor the car carefully during periods of vehicle automation. The realistic vignette also mentioned instances where human intervention was needed to successfully avoid accidents. The idealistic vignette was written to emphasize a scenario in which the driver has little or no role to play during periods of vehicle automation. The vignette mentioned instances where the vehicle automation successfully avoided accidents without human intervention. Both vignettes pointed out that the car was as safe as or safer than a human driver. The full text of both vignettes is presented in the Appendix. Parallel versions of both vignettes that indicated a male friend or family member were also created. Across all vignette conditions, participants were randomly assigned to read a vignette that described either a male or female car owner. This variable was not of interest and was not examined further.

Self-driving Car Acceptance Scale. Participants completed an instrument created for this experiment, the Self-driving Car Acceptance Scale (SCAS). The SCAS featured 24 statements that were written to assess the extent to which participants were accepting of self-driving cars. Responses were made on a 7-point Likert scale with the anchors "strongly disagree" and "strongly agree." Item selection was motivated by general theories of acceptance of technology (e.g., Venkatesh, Morris, Davis, & Davis, 2003) as well as theory specific to the acceptance of automation (e.g., Ghazizadeh, Lee, & Boyle, 2012). Questions were written to reflect eight potential sub-dimensions of acceptance of self-driving cars. Some questions were adapted from or inspired by items in the published literature on each of the respective dimensions, though each was written to be specific to self-driving cars to the extent possible. The dimensions were: (a) perceived reliability of automation/trust; (b) cost of automation; (c) appropriateness of automation/compatibility; (d) enjoyment of to-be-automated task; (e) perceived usefulness of automation; (f) perceived ease of use of automation; (g) experience with automation; and (h) intention to use automation (see Davis, Bagozzi, & Warshaw, 1989; Ghazizadeh et al., 2012; Madigan et al., 2016; Peng, Ghazizadeh, Lee, & Boyle, 2012; Venkatesh et al., 2003). The full SCAS is presented in Table 1. A series of questions about participants' demographic background, driving habits, and exposure to information about self-driving cars also was administered.

Procedure

After volunteering for the experiment, participants were directed to a Qualtrics survey that hosted the experiment. Following informed consent, participants were randomly assigned to a control condition with no vignette ($n = 94$), the realistic vignette condition ($n = 97$), or the idealized vignette condition ($n = 97$). After reading a vignette, participants in the vignettes conditions were instructed "Please answer the following questions and assume the above information is accurate and true." In the control conditions, participants saw no vignette and were simply instructed "Please answer the following questions." Participants then answered each question from the SCAS inventory. Two additional catch questions were presented. The first catch question stated "I am not reading these questions carefully." Participants (n = 10) who did not answer "Disagree" or "Strongly Disagree" were excluded from further analyses. The second catch question stated "This question is a check to make sure you are reading the questions. Please select the answer 'I am reading carefully' below." The correct answer was inserted at the neutral position on the Likert scale. No additional participants were excluded from analyses due to their responses on the second catch question. SCAS questions and the two catch questions were presented in a different random order for each participant. Finally, participants answered the demographic and driving habits questions. Participants (n = 5) who were not currently licensed drivers were excluded from further analyses.

RESULTS

Driving Habits and Self-driving Car Exposure

Participants reported the scenario that best described where they drive most often as urban/city driving (n = 156), rural/small town driving (n = 89), distance/interstate/freeway driving (n = 40), and other (n = 3). Participants reported M = 18.23 years of driving experience (SD = 12.58, mdn = 15, range = 1 to 65). They reported driving a mean of 8.29 hours per week (SD = 7.22, mdn = 6, range = 0 to 54) and spending a mean of 1.79 hours per week delayed in traffic (SD = 4.03, mdn = 1, range = 0 to 40). Participants reported having read a mean of 3.01 articles about self-driving cars in print or online (SD = 5.61, mdn = 2, range = 0 to 60) and having seen a mean of 0.39 commercials for self-driving cars either online or on television (SD = 1.02, mdn = 0, range = 0 to 10). Participants rated their mean familiarity with the current state of technology related to self-driving cars on a scale from 1 (not at all familiar) to 7 (extremely) familiar as 3.85 (SD = 1.64, mdn = 4).

Internal Consistency Reliability of the SCAS

Cronbach's α = .90 for the 24 items of the SCAS. Exploratory analyses showed that values of α would not be affected by removing any individual items from the scale, as new αs ranged from .89 to .91 with the deletion of any individual question. Thus, the SCAS appeared to have good internal consistency reliability with all items included.

Descriptive Statistics for SCAS Items

The means, standard deviations, medians, and modes for all SCAS items across all participants are reported in Table 1. From a strictly descriptive perspective, the central tendencies of responses in this sample tended toward agreement with statements that indicated acceptance of self-driving cars. Further, the data suggested that participants in this sample generally did not endorse statements that implied skepticism or phobia of new technologies. A final notable pattern was participants' strong endorsement of items (i.e., questions 8 and 24) that indicated they felt it would be important for the human driver to be able to take back control from or turn off the automation.

Vignette Results

To test the hypothesis that idealized portrayals would result in higher acceptance of self-driving cars, a 1 X 3 (condition: control, realistic vignette, or idealized vignette) between subjects analysis of variance (ANOVA) examined overall scores on the SCAS. Thirteen items (3, 6, 7, 8, 9, 10, 11, 12, 17, 18, 20, 23, and 24) were reverse-scored (note that scoring of responses was not reversed in Table 1), and mean scores (on the scale from one to seven) were calculated across all items. Higher scores indicated greater acceptance of self-driving cars. The ANOVA showed a significant main effect of condition, $F(2, 285) = 3.10$, p = .047, ω^2 = .014. Fisher's LSD post hoc test showed that participants in the idealized vignette condition showed higher acceptance of self-driving cars (M = 4.40, SE = .08) as compared to the realistic vignette condition (M = 4.14, SE = .08), p = .029, and the control condition (M = 4.15, SE = .09), p = .036. The realistic vignette condition and the control condition were not different from each other, p = .95.

Exploratory Correlational Analyses

Though the effect of the idealized vignette's portrayal was significant, this variable accounted for less than 2% of the variance in acceptance of self-driving cars. To further explore possible relationships between acceptance and other variables, exploratory correlational analyses of SCAS scores with driving habits were undertaken. For all analyses, participants whose scores were greater than 3 SDs above the mean for a given variable were removed from analyses as outliers. Age had a significant negative correlation with SCAS total scores, $r(284)$ = -.12, p = .037, as did years of driving experience, $r(283)$ = -16, p = .006. The number of articles read about self-driving cars, $r(281)$ = .29, p < .001, and the self-rated familiarity with technology related to self-driving cars, $r(286)$ = .21, p < .001, both showed significant positive correlations with acceptance. Number of hours driven per week, $r(277)$ = -.11, p = .079, hours per week delayed in traffic, $r(282)$ = -.08, p = .156, and exposure to commercials about self-driving cars, $r(281)$ = .04, p = .515, were not related to acceptance.

Table 1. SCAS Items and Descriptive Statistics

Item	*M*	*SD*	*Mdn*	*Mode*
Perceived reliability/trust				
1. Self-driving cars will be safe.	5.08	1.27	5	6
2. I would trust a self-driving car to get me to my destination.	5.01	1.46	5	6
3. People will need to watch self-driving cars closely to be sure the computers don't make mistakes.	5.09	1.42	5	5
Cost				
4. I would be willing to pay more for a self-driving car compared to what I would pay for a traditional car.	4.28	1.88	5	6
5. The benefits of a self-driving car would outweigh the amount of money it would cost.	4.30	1.73	4	6
6. The cost of a self-driving car would be the most important thing I would consider before purchasing one.	4.76	1.72	5	6
Appropriateness of automation/compatibility				
7. I do not think that computers should be driving cars.	3.33	1.72	3	2
8. It is important for a human to be able to take back control from a self-driving car.	6.17	1.03	6	7
9. There are some driving scenarios that will be too difficult for a self-driving car to handle.	5.02	1.59	5	6
Enjoyment of to-be-automated task				
10. I enjoy driving a car.	5.33	1.47	6	6
11. I prefer to be the driver rather than the passenger in a car.	4.55	1.86	5	6
12. I enjoy cruising or going for joy rides.	5.07	1.62	5.50	6
Perceived usefulness of automation				
13. A self-driving car would allow me to be more productive.	5.18	1.59	6	6
14. A self-driving car would allow me to be more safe while in the car.	4.82	1.46	5	6
15. Self-driving cars will reduce traffic problems.	4.93	1.57	5	6
Perceived ease of use of automation				
16. Self-driving cars will be easy to use.	5.24	1.28	5	6
17. It will be a lot of work to figure out how to use a self-driving car.	3.38	1.61	3	3
18. It would take me a long time to figure out how to use a self-driving car.	3.14	1.61	3	2
Experience with automation				
19. I like to use technology to make tasks easier for me.	6.09	0.86	6	6
20. I have bad experiences when I try to use new technology instead of doing things "the old-fashioned way".	2.35	1.29	2	2
21. There are tasks in my life that have been made easier by computers doing the work for me.	6.37	0.76	6	7
Intention to use automation				
22. I would like to own a self-driving car.	4.91	1.84	5	6
23. Even if I had a self-driving car, I would still want to drive myself most of the time.	4.29	1.78	5	5
24. In a self-driving car, it will be important to me to have the option to turn off the computer and drive myself.	6.20	0.96	6	7

Notes: *N* = 288. All questions rated on a Likert scale with end anchors 1 = "strongly disagree" and 7 = "strongly agree".

DISCUSSION

People may be more accepting of self-driving cars under idealized rather than (arguably more) realistic scenarios during the initial deployment of the technology. The effect of the idealized depiction was small, but it suggested that idealized descriptions may be able to affect acceptance of self-driving cars before people interact with them. A realistic vignette that emphasized the human's supervisory role in the system did not affect acceptance as compared to a control condition, and overall mean results across participants suggested that the sample had neutral, or perhaps slightly, cautiously optimistic attitudes toward self-driving cars.

The results showed that other yet to-be-determined factors will account for most of the variance in people's a priori acceptance of self-driving cars. The exploratory correlational analyses suggested that the effects of age and driving experience on self-driving car acceptance should be examined further, as the data suggested a tendency for less acceptance among older, more experienced drivers. Familiarity with self-driving car technology and exposure to articles about self-driving cars were both positively related to acceptance, which suggested that having more information about self-driving cars (or perhaps seeking out more information due to interest) may predict greater acceptance of self-driving cars.

This research also presented a new, brief questionnaire that may be useful to assess acceptance of self-driving cars in future research. Few attempts have been made to measure acceptance of self-driving cars. Payre et al. (2014) previously used a novel scale to examine acceptance of fully automated vehicles. Although their scale featured some items that were similar to the items reported here, their analyses revealed a major contribution of a dimension they described as "interest in impaired driving," which accounted for 25% of the variance in their data. Although it remains possible that interest in impaired driving will be a prominent factor in acceptance of self-driving cars, this factor may have emerged as a result of idiosyncrasies in their questions or sample.

Reliability and Validity of the SCAS

The current study demonstrated high internal consistency reliability of the SCAS. Although this result was promising, other forms of reliability (e.g. test-retest) may also be relevant for the acceptance of self-driving cars construct, and further research is needed to demonstrate validity of the instrument. On-going research is underway to examine the underlying dimensionality of the SCAS and, in particular, to examine whether the factor structure aligns with the eight a priori hypothesized dimensions of the SCAS. Such analyses may inform future revisions to the items and content of the scale. Future research could also examine construct validity, perhaps by investigating the convergence of this instrument with other measures of acceptance of self-driving cars (e.g., Payre et al., 2014). More important, however, will be to establish that questionnaires to measure acceptance of self-driving cars show predictive validity with respect to behaviors related to the adoption of this emerging technology.

Generalizability of the AMT Sample

The AMT sample cannot be viewed as representative of the general population. A particular concern for the generalizability of these results is the fact that the sample was recruited from an online service. AMT workers are people who not only use the internet, but also have embraced online work as a source of income. As such, it is reasonable to expect that AMT workers likely feel more comfortable and proficient with technology than the general population of potential self-driving car users.

Conclusions

A new scale was presented to measure acceptance of self-driving cars. An experiment showed that people were more accepting of self-driving cars after reading a vignette featuring an idealized portrayal of perfect automation in self-driving cars as compared to both a control condition and a scenario that described a more realistic scenario in which the human driver played a monitoring role and occasionally intervened during vehicle automation. Idealized portrayals may establish unrealistic performance expectations for self-driving cars. Acceptance of self-driving cars may be harmed if people must perform monitoring tasks during automation when they expected to experience a windfall of time for rest or secondary leisure or work tasks. Human factors research (Beggiato & Krems, 2013) has shown that unrealistic expectations about automation performance indeed increases initial acceptance, but trust and acceptance may be irreparably harmed after interactions with imperfect automation reveal its previously undisclosed shortcomings to users. Much more research is needed to understand the factors that will influence both initial and long-term acceptance of self-driving cars.

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APPENDIX: VIGNETTES

Realistic Vignette

Imagine a close, trusted friend or family member recently purchased a self-driving car. She has owned the car for about six months. Initially, she was very nervous when the car was in self-driving mode. After getting used to the car, she still does not feel completely relaxed when the car is driving itself. Though she can sometimes catch up on emails, read, and even watch movies while the car is driving itself, she spends most of her time watching the car to make sure it is driving properly. She still has to pay lots of attention to the driving scene when the car is in self-driving mode. Often her eyes are on the road and her hands are on the wheel, even when she is not driving. Twice in the last 6 months, the car has encountered a difficult driving situation, and she needed to take control of the vehicle to successfully avoid an accident. In general, she knows that the self-driving car is as safe or even safer than a human driver, but she still feels nervous in the car.

Idealistic Vignette

Imagine a close, trusted friend or family member recently purchased a self-driving car. She has owned the car for about six months. Initially, she was very nervous when the car was in self-driving mode. After getting used to the car, she now feels relaxed when the car is driving itself. She is able to catch up on emails, read, and even watch movies while the car is driving itself. She barely has to pay any attention to the driving scene when the car is in self-driving mode. Usually, her eyes are not even on the road and her hands are not on the wheel. Twice in the last 6 months, the car has encountered a difficult driving situation, but it was able to successfully avoid an accident without her intervention. In general, she knows that the self-driving car is as safe or even safer than a human driver, so she feels safe in the car.