Year 25 Final Report

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Grant Number: DTRT13-G-UTC31

Project Title:

Effectiveness of Various Information Channels on User Training and Learning in Automobiles

Project Number:	Project End Date:	Submission Date:
MITR25-10	12/31/16	4/7/16

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1. Introduction

A number of advanced driver assistance systems are increasingly being implemented into the automobile, and many are now standard in cars that are newly manufactured. These in-vehicle technologies are designed to make driving safer and easier for those who operate the vehicle, as well as making the road safer for other users. In addition to these existing technologies, many automobile manufacturers and technology companies are also working to develop fully automated vehicles, or self-driving cars, which have the potential to relieve the person from manual operation of the vehicle and make the car and its software responsible for sensing, navigation and control.

Technological advancements in the automobile are continued to be tested for performance. However, less is known about how people understand, perceive and accept various features and their potential effects. Also, it is unclear how people currently learn about the advanced features in their cars, if at all, and what methods are more effective for learning and training. In Abraham et al. (2017) it was stated that many drivers have only limited, and often inaccurate, understanding of the advanced systems in their cars, which can reduce the potential benefits of such systems. Furthermore, they found that many automakers don't place a high priority on consumer education and that their dealerships are ill-equipped to offer information about their safety features.

The objective of this study is to investigate how different methods of information presentation can be used to enhance drivers' understanding and acceptance of advanced driver assistance systems in the automobile. An online experiment explored differences between three information media – video-based, text-based and text with accompanying images. This study also employed factors identified by the Technology Acceptance Model (Davis et al., 1989), shown in Figure 1, to understand how the information presented to drivers affect their perceptions, attitudes and behavioral intentions to accept and adopt in-vehicle technologies and the self-driving car.

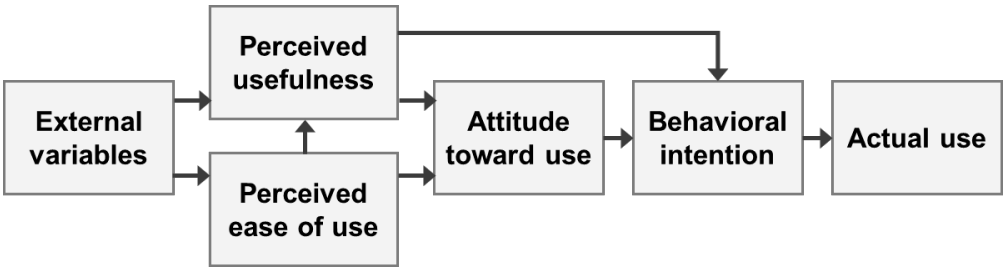

Figure 1. Technology Acceptance Model (Adapted from Davis et al.,1989)

An additional objective was to understand if characteristics of an individual such as age and baseline attitudes toward technology affect the individual's perceptions of the information presentation and acceptance of in-vehicle technologies.

Finally, we were interested in learning about any relationships found through the experiment are specific to the automotive domain, or if the findings are an application of a more general trend. The online experiment also included replications in two additional domains – health management and finance technologies – to see if similar effects are observed across fields.

2. Data collection

2.2. Questionnaire Design

A questionnaire was designed to gather people's attitudes towards automotive technologies before and after being presented with information about various examples, as well as to learn about their baseline technology experience, driving history, learning preferences and demographic characteristics.

The first part of the questionnaire focused on baseline characteristics that may be related to people's attitudes toward automotive technologies and perceptions of different methods of information presentation. These included preferences of learning methods, driving behavior and history, use of various transportation alternatives, experiences with and attitudes toward technology in general, and knowledge of new technologies. Questions were then asked about respondents' self-reported experience with, knowledge of and trust toward smart technologies that are being implemented into the automobile.

Participants were then presented with brief presentations describing six examples of automotive technologies – backover prevention, blind spot warning, lane departure warning, front crash prevention, adaptive headlights and adaptive cruise control. A random assignment was done to divide the sample into three groups which were presented with different methods of presentation. One group saw videos with brief descriptions of the six example technologies. The second group were presented with the same information, but in a text-only format for them to read on their own pace. The third group was also presented with the same text, but accompanied with images captured from the video to visually describe the information shown in the text.

After the information presentation, participants were asked a set of true/false questions to objectively evaluate their understanding of the information that was presented to them. An additional question also asked about perceived ease of understanding regarding the information presentation. The following section included questions about elements of the Technology Acceptance Model. In this section, participants were asked to rate the perceived usefulness, ease of use, preference and level of trust toward automotive technologies, and to rate their behavioral intentions to try using, purchase and recommend to others a car equipped with the technologies shown to them.

Additionally, participants were asked about willingness to test-drive a self-driving car, which represented an anticipated extension of the example technologies that they were presented with. This was asked before and after the information presentation to analyze any changes that may have resulted from the descriptions presented to participants. Table 1 summarizes questions asked in the online experiment.

Table 1. Automotive technology questions

Category	Question item	Question statement	Response scale
Baseline characteristics – general	Technology experience	How would you rate your level of technology?	1: Very inexperienced ~ 5: very experienced
	Early adoption behavior	In general, how would you rate yourself as being an avoider or an early adopter of new technology?	1: Avoid as long as possible ~ 5: try as soon as possible
	Overall trust in technology	How would you rate your overall level of trust in technology?	1: Very low trust ~ 5: very high trust
	Technology	How would you rate your overall level of	1: Very low confidence ~ 5:

Category	Question item	Question statement	Response scale
	confidence	confidence in your ability to learn and use new technologies?	very high confidence
Baseline characteristics – automotive	Technology experience – automotive	What is your overall level of experience with smart technologies that are being implemented into the automobile?	1: Not experienced at all ~ 5: very experienced
	Technology knowledge – automotive	What is your overall level of knowledge regarding smart technologies that are being implemented into the automobile?	1: No knowledge at all ~ 5: very much knowledge
Understanding of information presented	Objective recall	Based on what you just saw, please answer if the following statements are true or false.	Percentage of correct answers (18 questions)
	Perceived ease of understanding	How easy was it to understand what's being said in the descriptions?	1: Very difficult ~ 5: very easy
Technology acceptance factors – perceptions	Perceived usefulness	Please indicate the degree to which you think the following technologies will be useful.	1: Not at all useful ~ 5: very useful (averaged over six technology examples)
	Perceived ease of use	Please indicate the degree to which you think the following technologies will be easy to use.	1: Not easy to use at all ~ 5: very easy to use (averaged)
Acceptance – attitudes	Preference	Based on the descriptions you saw, do you like the following technologies? Please indicate how much you like or dislike them.	1: Don't like this at all ~ 5: Like this very much (averaged)
	Trust	Based on the descriptions you saw, how much trust do you have regarding the following technologies?	1: Very low trust ~ 5: very high trust (averaged)
Acceptance – behavioral intentions	Behavioral intentions to try	How likely are you to test-drive a car equipped with the following?	1: Not at all likely ~ 5: very likely (averaged)
	Behavioral intentions to purchase	How likely are you to purchase a car equipped with the following?	
	Behavioral intentions to recommend	How likely are you to recommend a car equipped with the following to someone?	
Acceptance of advanced technology	Behavioral intentions to try a self-driving car	How much would you be willing to test-drive a self-driving car? (Asked before and after information presentation)	1: Not at all willing ~ 5: very much willing

The questions in Table 1, with the exception of items in the general baseline characteristics category, were repeated for two additional conditions. In one condition, participants were presented information about a prototype system for medication management as an example of health management technologies that are being introduced to the market. Right before this information, they were asked their baseline experience and knowledge regarding health management technologies. After the information, they were asked to recall information presented to them, rate the perceived ease of understanding, and answer questions regarding the acceptance factors. The last condition was about financial technologies. In this condition, participants were presented with a brief description of Apple Pay as an example of financial technologies. In order to ensure that a participant is exposed to more than a single method of presentation, the experiment was designed so that everyone alternated between video, text and text with images. For example, a participant who saw a video presentation of the automotive technology examples were presented with a text describing the medication management system in the second condition, and a text with images describing Apple Pay in the last condition.

2.3. Sample Profile

Data collection was completed online with a panel service provided by Qualtrics. The collected data included valid responses from a total of 1,238 adults. A wide range of age groups, as well as a variety of socio-economic statuses, were represented in the data as summarized in Table 2.

Table 2. Participant profile (N = 1,238)

Characteristics	Descriptive statistics
Age (year of birth)	Silent Generation (born on or before 1945): 311 (25.1%) Baby Boomers (born 1946-1964): 310 (25.0%) Generation X (born 1965-1980): 308 (24.9%) Millennials (born 1981-1989): 309 (25.0%)
Gender	Male: 628 (50.7%) Female: 608 (49.1%) Other or no answer: 2 (0.2%)
Education	Some high school or less: 7 (0.6%) High school diploma: 197 (15.9%) Some college: 245 (19.8%) Trade/technical/vocational school or associate's degree: 125 (10.1%) College degree: 376 (30.4%) Some post-graduate work: 65 (5.3%) Post-graduate degree: 223 (18.0%)
Marital status	Single, never married: 252 (20.4%) Married or living with a partner: 769 (62.1%) Divorced or separated: 118 (9.5%) Widowed: 92 (7.4%) Other: 7 (0.6%)
Ethnicity	White: 1002 (80.9%) Black or African-American: 80 (6.5%) Hispanic or Latino: 46 (3.7%) Asian or Asian-American: 66 (5.3%) Other or multiracial: 36 (2.9%)
Employment	Employed full-time: 532 (43.0%) Employed part-time: 108 (8.7%) Not employed: 54 (4.4%) Self-employed: 58 (4.7%) Retired: 381 (30.8%) Student: 35 (2.8%) Homemaker: 74 (6.0%)
Annual household income	Less than 25,000 USD: 189 (15.3%) 25,000 USD or more but less than 50,000 USD: 217 (17.5%) 50,000 USD or more but less than 75,000 USD: 218 (17.6%) 75,000 USD or more but less than 100,000 USD: 193 (15.6%) 100,000 USD or more but less than 150,000 USD: 213 (17.2%) 150,000 USD or more: 208 (16.8%)
Residential environment	Urban: 334 (27.0%) Suburban: 670 (54.1%) Rural: 234 (18.9%)

Participation was limited to people with a current, valid driver's license. The sample was largely self-reported frequent and safe drivers, with 71.6% driving at least 5 days a week and 77.7% never having received a citation or ticket for a moving violation.

3. Result

3.1. Effect of Information Presentation Though Various Methods

An objective of the study was to see if providing relevant information to drivers can positively influence their acceptance of self-driving cars. Result from a t-test for comparison between responses prior to and after the information presentation showed a significant increase in willingness to try a self-driving car. On a 5-point scale, the average score increase by 0.389 (t = 8.018, p = 0.000), indicating that participants were more accepting of self-driving cars after they were presented with descriptions about existing technologies that are provided for driver assistance.

In order to investigate differences in the effects of different presentation methods (e.g., video-based, text-based and text with image), an analysis of variance (ANOVA) was carried out on related outcome measures, which are shown in Table 3.

Table 3. Statistical comparison between effects of different methods - automotive

Category	Question item	Total	Video	Text only	Text with images	*F*	Sig.
Understanding of information presented	Objective recall (% correct)	0.634	0.662	0.638	0.605	8.082	0.000
	Perceived ease of understanding	4.104	4.271	4.040	4.022	9.111	0.000
Technology acceptance factors – perceptions	Perceived usefulness	4.179	4.262	4.114	4.174	3.682	0.025
	Perceived ease of use	4.198	4.262	4.143	4.199	2.112	0.121
Acceptance – attitudes	Preference	4.090	4.095	4.047	4.133	1.023	0.360
	Trust	3.840	3.875	3.773	3.882	1.747	0.175
Acceptance – behavioral intentions	Behavioral intentions to try	3.861	3.836	3.829	3.919	0.720	0.487
	Behavioral intentions to purchase	3.672	3.718	3.581	3.730	2.043	0.130
	Behavioral intentions to recommend	3.649	3.710	3.556	3.696	2.234	0.108
Acceptance of advanced technology	Behavioral intentions to try a self-driving car	3.422	3.423	3.404	3.443	0.086	0.918

As shown by the ANOVA results summarized in Table 3, the three presentation did not significantly differ in their effects on drivers' responses to acceptance measures, except for perceived usefulness. Significant differences, however, were observed in the objective effectiveness. Participants who saw a video presentation of information related to six in-vehicle technology examples performed significantly better in recalling the information shown to them, compared to those who received the same descriptions in a text-only or text-with-images format. The group who saw the video presentation also felt that the information shown to them was easier to understand, significantly more so than the other groups. While significant effects were not observed in the adoption factors, a trend was observed in that the text-only version was received poorly compared to the other methods. As shown in Table 3, the group that saw the text-only presentation was less likely to rate the in-vehicle technology as easy to use, less likely to like or trust them, less willing to test-drive, purchase or recommend cars with them, and less likely to try a self-driving car.

3.2. Correlations between Acceptance Factors

In addition to looking at direct effect of the different information channels, we were also interested in understanding the associations between various technology acceptance factors. In order to describe the relationships between the ordinal measures, a correlation analysis was conducted using the Kendall rank correlation coefficient. The results are shown in Table 4.

Table 4. Correlation analysis among acceptance measures – automotive (**: $p < 0.01$)

Category		1	2	3	4	5	6	7
Technology acceptance factors – perceptions	1. Perceived usefulness							
	2. Perceived ease of use	0.619**						
Acceptance – attitudes	3. Preference	0.772**	0.684**					
	4. Trust	0.672**	0.649**	0.760**				
Acceptance – behavioral intentions	5. Behavioral intentions to try	0.558**	0.539**	0.632**	0.605**			
	6. Behavioral intentions to purchase	0.573**	0.550**	0.653**	0.683**	0.774**		
	7. Behavioral intentions to recommend	0.617**	0.576**	0.696**	0.711**	0.660**	0.745**	
Acceptance of advanced technology	8. Behavioral intentions to try a self-driving car	0.399**	0.347**	0.416**	0.459**	0.528**	0.484**	0.477**

As shown in Table 4, all of the technology adoption factors asked in the online experiment were strongly and significantly related to one another. Also, as indicated by the last row of Table 4, it was found that positive perceptions, favorable attitudes and increased behavioral intentions to accept various in-vehicle technologies are associated with higher likelihood of being willing to try a self-driving car.

3.3. Role of Age and Baseline Technology Experience

Associations between the technology acceptance measures and individual characteristics such as age and baseline technology attitudes were also investigated using a correlations analysis. Table 5 shows results describing relationships between age of participants, baseline technology attitudes (general and domain-specific), recall performance regarding information presented, and technology adoption measures.

Age was found to be significantly associated with participant's baseline technology attitudes and experiences, which were measured prior to the information presentation. For both general and automotive-specific questions, older respondents were less likely to be experienced, knowledgeable, trusting or confident of using technology. Age also showed negative correlations with willingness to try using, purchase and recommend in-vehicle technology examples and willingness to try using a self-driving car. Older respondents, however, performed better when they were asked to recall information presented to them about in-vehicle technology examples.

Baseline technology attitudes – both general and automotive-specific – were found to be positively and significantly associated with acceptance. Those who were more experienced with technology, more likely to be early adopters, more trusting and confident were more likely to rate the in-vehicle technologies to be useful, easy to use, preferable and trustable, and more willing to try using, purchase and recommend them, as well as being more willing to try a self-driving car.

Table 5. Correlation analysis between baseline characteristics and acceptance measures – automotive (**: $p < 0.01$)

Category	Question item	Age	1	2	3	4	5	6	7
Baseline characteristics – general	1. Technology experience	-.315**							
	2. Early adoption behavior	-.307**	.600**						
	3. Overall trust in technology	-.192**	.537**	.547**					
	4. Technology confidence	-.214**	.599**	.541**	.551**				
Baseline characteristics – automotive	5. Technology experience – automotive	-.317**	.469**	.520**	.400**	.368**			
	6. Technology knowledge – automotive	-.276**	.500**	.507**	.415**	.416**	.789**		
Understanding of information presented	7. Objective recall	.234**	-.146**	-.146**	-.079**	-.024	-.178**	-.124**	
Technology acceptance factors – perceptions	Perceived usefulness	.024	.127**	.164**	.230**	.138**	.139**	.157**	-.007
	Perceived ease of use	.014	.144**	.164**	.234**	.207**	.134**	.152**	.082**
Acceptance – attitudes	Preference	.037	.136**	.180**	.255**	.164**	.144**	.163**	.010
	Trust	-.032	.187**	.227**	.325**	.209**	.232**	.252**	-.033
Acceptance – behavioral intentions	Behavioral intentions to try	-.112**	.209**	.260**	.272**	.227**	.256**	.260**	.013
	Behavioral intentions to purchase	-.108**	.223**	.283**	.296**	.219**	.309**	.300**	-.033
	Behavioral intentions to recommend	-.070**	.189**	.260**	.301**	.194**	.258**	.252**	-.054**
Acceptance of advanced technology	Behavioral intentions to try a self-driving car	-.226**	.301**	.368**	.353**	.289**	.303**	.311**	-.101**

Table 6. Statistical comparison between effects of different methods – health and finance

Category	Question item	Health management technology						Financial technology					
		Total	Video	Text only	Text w/ images	*F*	Sig.	Total	Video	Text only	Text w/ images	*F*	Sig.
Understanding of information presented	Objective recall (% correct)	0.534	0.541	0.531	0.530	0.232	0.793	0.598	0.630	0.555	0.605	10.456	0.000
	Perceived ease of understanding	3.410	3.551	3.313	3.365	4.469	0.012	3.684	3.708	3.672	3.668	0.176	0.839
Technology acceptance factors – perceptions	Perceived usefulness	3.382	3.421	3.469	3.276	2.727	0.066	3.658	3.653	3.712	3.606	0.776	0.460
	Perceived ease of use	3.233	3.319	3.252	3.141	1.910	0.149	3.808	3.802	3.837	3.783	0.241	0.786
Acceptance – attitudes	Preference	3.133	3.200	3.162	3.052	1.311	0.270	3.330	3.318	3.357	3.313	0.117	0.889
	Trust	3.174	3.282	3.162	3.089	2.285	0.102	3.123	3.080	3.207	3.084	1.122	0.326
Acceptance – behavioral intentions	Behavioral intentions to try	2.950	2.975	3.000	2.887	0.703	0.495	3.180	3.178	3.165	3.198	0.053	0.948
	Behavioral intentions to purchase	2.641	2.666	2.655	2.609	0.195	0.823	3.056	3.087	3.039	3.037	0.154	0.857
	Behavioral intentions to recommend	2.928	2.960	2.931	2.898	0.204	0.815	3.076	3.062	3.121	3.044	0.300	0.741
Acceptance of advanced technology	Behavioral intentions to try a self-driving car	3.059	3.057	3.093	3.033	0.225	0.798	2.746	2.731	2.764	2.744	0.054	0.948

3.4. Comparison with Different Domains

Similar to findings from the automotive domain, introduction to a technology example had a significant and positive effect on increasing people's willingness to adopt finance technologies (0.174 point increase on a 5-point scale, $t = 7.238$, $p = 0.000$). However, in the health technologies domain, a drop of 0.390 point was observed (on a 5-point scale, $t = 12.539$, $p = 0.000$). A possible explanation for the decrease in willingness to adopt health management technology is that the example presented to participants was a working prototype that is not currently in the market, while the technologies introduced for the automotive and finance domains were all commercial systems.

Differences between the three presentation methods – video-based, text-based and text with images – were also compared for the health and finance domains as summarized in Table 6. As shown in Table 6, the difference between the presentation methods were mostly insignificant with the exceptions of ease of understanding for the health domain and the recall performance for the finance domain. The overall trend, although not statistically significant, showed that the video-based presentation had the most positive effect on acceptance measures for the health management technology, which is similar to the automotive domain. However, in contrast to the automotive domain, the text-only methods showed more positive effects on acceptance compared to the image-assisted text mode in both health and finance examples. Possible explanations include brand effects, since the financial technology example had a brand and company name attached while the other two domain examples did not, and effects of text length and number of examples.

Similar to the analysis for the automotive domain, correlation analyses were carried out to investigate relationships among acceptance measures, as well as between individual characteristics and acceptance measures. Similar to the automotive domain, strong and significant correlations were found among all acceptance measures asked for the health management and financial technology examples. A general trend also showed negative associations between age and acceptance measures in the two additional domains similar to the automotive examples.

4. Discussion and conclusion

This study looked at the impact of providing introductory presentations on drivers' understanding of various advanced driver assistance systems, as well as their perceptions of, attitudes toward and behavioral intentions to accept them as well as a related and more advanced form of technology – the self-driving car. An online experiment was administered, and a nationwide sample of 1,238 American adults provided complete and valid responses. In the online experiment, participants were asked about their baseline technology attitudes concerning technology in general prior to a brief presentation of information about six examples of advanced driver assistance systems. After the information presentation, they were asked about their understanding of the contents, perceptions of the technologies shown to them, attitudes toward adoption, and behavioral intentions to accept the examples. A question about willingness to try a self-driving car was asked before and after the presentation to see if the intervention had any significant effect. The information presentation was given using three different methods – video-

based, text-based and text with image – and participants were randomly assigned to one of the three conditions.

Results showed that while drivers' willingness to try a self-driving car significantly increased after receiving information about examples of in-vehicle technologies, the differences between three methods – video, text and text with images – were mostly insignificant. However, a trend showed that drivers were more accepting of the technology examples, as well as the self-driving car, if they were provided with a video introduction, and that drivers who were presented with the text-only version were the least accepting. Those who saw the video-based version were also significantly more likely to recall information from the presentation correctly and perceive the presentation as easy to understand.

Correlation analyses showed that various acceptance measures were strongly interrelated, regardless of the method of information presentation. Also, age was found to be negatively associated with willingness to accept the in-vehicle technology examples as well as self-driving cars, and baseline technology experience and attitudes – both general and automotive-specific – were found to be positively related to acceptance of advanced automotive technologies.

The online experiment was replicated for two additional domains – health management and financial technologies – in order to understand the generalizability of the findings. While results from correlations analyses among acceptance measures, as well as between baseline characteristics and acceptance measures, were similar across domains, the effects of various information presentation methods showed minor differences. The findings suggest a need for further investigation into understanding domain differences, and to describe how selection of examples and design of training and education materials may have different effects.

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