# **ARTICLE POST-PRINT ACCIDENT ANALYSIS AND PREVENTION** Knowledge of and Trust in Advanced Driver Assistance Systems Chelsea A. DeGuzman<sup>a</sup>, Birsen Donmez<sup>a</sup>\* <sup>a</sup> Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, Toronto, ON M5S 3G8, Canada \*Corresponding author. E-mail address: donmez@mie.utoronto.ca

#### 15 Abstract

16 Understanding what drivers know about state-of-the-art advanced driver assistance systems 17 (ADAS), like adaptive cruise control (ACC) and lane keeping assistance (LKA) is important 18 because such knowledge can influence trust in and reliance on the automation. We surveyed 19 ADAS owners (N=102) and non-owners (N=262), with the primary objective of assessing 20 knowledge and trust of ACC and LKA, and investigating the relationship between knowledge 21 and trust among drivers who have not received special training. The survey contained 22 demographic questions, ACC and LKA knowledge questionnaires (assessing knowledge of 23 capabilities and limitations commonly found in owner's manuals), and ACC and LKA trust 24 ratings. From the knowledge questionnaires, sensitivity (i.e., knowledge of the true capabilities 25 of ACC and LKA) and response bias were assessed and used to predict trust. Results showed that 26 owners did not have better knowledge of system capabilities/limitations than non-owners, in fact, owners had a stronger bias in favour of system capabilities. For non-owners, better knowledge of 27 28 system capabilities was associated with lower trust, and those who were more biased towards 29 endorsing system capabilities had higher trust. Neither knowledge nor response bias was 30 associated with trust among owners. Further research is needed to confirm our results with a 31 larger sample of owners, but given that it is also impractical to expect drivers to learn and 32 remember all possible ADAS limitations, it may be beneficial to focus training efforts on 33 improving drivers' overall understanding of the fallibility of ADAS and reinforcing their role 34 when using ADAS to support appropriate trust and reliance.

35 Keywords: driving automation, SAE Level 2 automation, mental models, signal detection theory

36 1. Introduction

37 Advanced Driver Assistance Systems (ADAS) currently available to the public can 38 control the lateral and longitudinal movement of the vehicle, via, for example, a lane keeping 39 assistance (LKA) system and an adaptive cruise control (ACC) system, respectively. While 40 drivers perceive these systems as beneficial for their safety (e.g., Eby et al., 2018; Hagl & 41 Kouabenan, 2020), safety benefits depend on drivers using ADAS appropriately. ACC and LKA 42 are only driver support systems, meaning that drivers are still responsible for the driving task; 43 they should be monitoring the roadway at all times to determine when they need to take over full 44 control of the vehicle (SAE International, 2018). However, naturalistic driving data shows that while using ACC and LKA together, drivers spend more time looking away from the road and 45 46 are five times as likely to browse on their cell phones compared to when ACC and LKA are not 47 active (Noble, Miles, Perez, Guo, & Klauer, 2021). Further, overreliance on ADAS, particularly ACC and LKA, has already contributed to several real-world collisions (National Transportation 48 49 Safety Board, 2020). One approach to reduce overreliance on ADAS and related collisions is to 50 improve drivers' understanding of system capabilities and how ADAS should be used. 51 Research indicates that drivers generally do not have a good understanding of ADAS. 52 Jenness, Lerner, Mazor, Osberg, and Tefft (2008) found that 72% of drivers were unaware of the 53 limitations of the ACC in their vehicle. In a more recent survey, drivers (both those who owned 54 vehicles with ADAS and those who did not) were asked various questions to assess their

understanding of different ADAS systems. Only 17% of respondents correctly answered the

56 question to assess their understanding of ACC (McDonald et al., 2016). Singer and Jenness

57 (2020) found that after training on the capabilities and limitations of a test vehicle with ACC and

58 LKA, most drivers were aware of some of the ADAS limitations (e.g., it does not work in heavy

59 rain or snow, or when lane markings are "badly faded"). However, a majority of their 60 participants thought that the ADAS in the test vehicle would probably or definitely "take action 61 and avoid a collision" if the car ahead suddenly braked hard or if they were approaching a slow-62 moving motorcycle, which are limitations of ACC. Thus, while training may result in increased 63 awareness of some of ADAS limitations, there were still dangerous misperceptions. In addition, 64 these results may not reflect the knowledge of typical drivers who have not been trained by experimenters on ADAS capabilities and limitations. Research, using methods such as surveys, 65 66 is needed to investigate the understanding of current ADAS systems among drivers who have not 67 received any special training. Understanding what drivers know about the state-of-the-art ADAS that is available to 68 69 consumers (and their expectations about how it will perform) is important because such 70 knowledge can influence their trust in and reliance on the automation (Hoff & Bashir, 2015; Lee & See, 2004). In a survey study, drivers who were unaware or unsure of ACC limitations 71 72 reported being more willing to use the automation in situations that were beyond the system's 73 capabilities (Dickie & Boyle, 2009). Victor et al. (2018) found that when driving a vehicle with both ACC and LKA on a test track, 28% of drivers did not take over in time to avoid a collision 74 75 due to an ACC limitation (an inflatable stationary vehicle ahead), despite being trained on the 76 automation's limitations and seeing the hazard prior to impact. Through semi-structured 77 interviews after the test drive, the authors determined that many of the participants who did not 78 avoid the collision trusted or expected that the system could handle the situation. In a simulator 79 study, Körber, Baseler, and Bengler (2018) found that training that minimized the limitations of 80 an automated driving system (i.e., making takeovers seem less likely to occur and less critical) 81 was associated with higher self-reported trust in the system, compared to training that included

82 more emphasis on the system limitations. Further, trust affected how drivers relied on the 83 automation. Drivers with higher self-reported trust looked more at a secondary task display and 84 less at the roadway. When a takeover was required (due to a stationary vehicle ahead), 85 participants who received training that minimized system limitations (and had higher resulting 86 trust) took longer to take over. Overall, these results suggest a relationship between knowledge 87 of ADAS limitations, trust, and reliance. However, it is unclear whether knowledge directly impacts reliance behaviour, or whether it has an indirect impact through its effect on trust. 88 89 Understanding this relationship can inform future research on training to support appropriate 90 reliance on ADAS. For example, if knowledge of ADAS limitations is found to have an indirect 91 impact on reliance, training that aims to support appropriate reliance by improving driver 92 knowledge of limitations would also benefit from assessing trust and considering its other 93 influencing factors.

Drivers may also have biases in their mental model of the system, which may impact their trust and reliance intention. For example, when considering ADAS capabilities, some drivers may have a positive response bias, meaning that they are inclined to view the systems as capable. Signal detection theory is a useful framework to separate sensitivity (i.e., knowledge of the true capabilities of ADAS) from response bias and can be applied to confidence rating data (e.g., Macmillan & Creelman, 2005), which was collected in the current study (see Section 2.2.1).

101 The primary objective of the current study was to investigate drivers' knowledge of ACC 102 and LKA, their self-reported trust in these systems, and the relationship between knowledge and 103 trust. An online survey was used so that we could capture a more realistic view of drivers' 104 current understanding of ADAS and its impact on trust, compared to the simulator studies that

105 have provided participants with training. A secondary objective of this study was to investigate 106 how knowledge of and trust in ADAS impact drivers' reliance intention. Since we could not 107 observe reliance behavior, we asked drivers how likely they would be to engage in various 108 secondary tasks while using no ADAS, ACC only, LKA only, and ACC and LKA combined. 109 These responses were used as a measure of reliance intention (i.e., to what extent drivers think 110 they would rely on the system and disengage from the driving task). We surveyed owners 111 (drivers who own or lease a vehicle with ACC or LKA) and non-owners (drivers who do not 112 own a vehicle with ACC or LKA and have never used either system). While it is important to 113 understand the relationship between knowledge, trust, and reliance among owners, non-owners 114 represent a population that will potentially use these systems in the future as they continue to 115 emerge in the market. Thus, it is also important to understand how their knowledge may impact 116 trust and how they intend to use these systems.

#### 117 **2.** Materials and methods

118 The survey was conducted in two parts: a main survey (approximately 20-25 minutes) 119 and an optional follow-up survey (approximately 10 minutes); the second part was optional to 120 avoid lengthening the survey. As our main focus was investigating drivers' understanding of and 121 trust in ACC and LKA, the main survey consisted of demographics, ACC and LKA knowledge 122 questionnaires, and ACC and LKA trust ratings (see Appendix A). The follow-up survey 123 contained the reliance intention ratings (see Appendix B). The surveys contained brief 124 descriptions of ACC and LKA so that participants knew what systems they were being asked to 125 consider, as the names may differ across manufacturers. 126 Participants were also asked to report the methods they used to learn about ADAS in the

127 past and their experience with ADAS (for owners only) to explore whether these factors may

128 also influence trust. In a previous paper, we reported a preliminary analysis of a subset of the 129 ACC data from the current study (DeGuzman & Donmez, 2021). The results showed that the 130 only learning method that was associated with a better understanding of ACC was trial-and-error. 131 However, we did not investigate whether the different learning methods influenced trust in ACC. 132 Although other learning methods (e.g., reading an owner's manual) did not appear to influence 133 drivers' level of knowledge, information from certain sources may have a greater influence on 134 trust (e.g., from a friend or dealership staff instead of a manual or website). This potential effect 135 is explored in the current paper.

136 In terms of experience and demographics, experience with driving automation has been 137 found to increase trust (e.g., Beggiato, Pereira, Petzoldt, & Krems, 2015). Findings regarding 138 age-related differences on trust in driving automation are mixed. There is some evidence that 139 older drivers trust driving automation more (e.g., Gold, Körber, Hohenberger, Lechner, & 140 Bengler, 2015), and other research suggesting older drivers trust it less (Dikmen & Burns, 2017). 141 Higher education and being an early adopter of technology were associated with greater 142 acceptance of ACC (Lee, Seppelt, Reimer, Mehler, & Coughlin, 2019), but research is needed to 143 explore whether these demographic variables also influence trust in ADAS.

144 2.1. Participants

Participants were recruited through Mechanical Turk, online postings (e.g., Facebook;
Kijiji, a website similar to Craigslist), and emails to our lab contact list (consisting of individuals
who previously indicated that they would like to be contacted for research studies). Mechanical
Turk is an online crowdsourcing platform that is commonly used for survey studies (e.g., Ayoub,
Yang, & Zhou, 2021; Rahman et al., 2018). Data from Mechanical Turk has been shown to be of
similar quality to that of traditional data collection methods and represent a more diverse sample

151 than might typically be obtained through recruiting on university campuses (e.g., Casler, Bickel, 152 & Hackett, 2013; Thomas & Clifford, 2017; Walter, Seibert, Goering, & O'Boyle, 2019). 153 However, researchers often use attention checks and monitor survey completion time to screen 154 out potentially unreliable responses and ensure quality data (e.g., Ayoub et al., 2021; Rahman et 155 al., 2018). Attention checks were implemented for all participants in our survey. These items 156 asked participants to provide a specific response (e.g., an item stating "Please answer yes and full 157 confidence" in a list of items in the knowledge questionnaire; see Section 2.2.1). 158 Participants who were recruited through Mechanical Turk were compensated \$4 for the 159 main survey and \$2 for the follow-up survey (all currency reported in USD). Participants 160 recruited through online postings or emails were entered into a raffle to win a \$100 gift card for 161 completing the main survey and received an additional entry into the raffle for completing the 162 follow-up survey. Participants were informed that their chance of winning was approximately 1 in 25 (one gift card was purchased for approximately every 25 participants). 163 164 Participants were required to live in the United States or Canada and have a valid driver's 165 license, so that they were a potential user of ADAS. Initially, participants with all levels of 166 experience with ACC and LKA were recruited. However, initial inspection of the data partway 167 through data collection showed that only 14% of respondents (20 of 138) did not own or lease a 168 vehicle with ACC or LKA but had used at least one of these systems before. Because we did not 169 think we would get a large enough sample for this group, we excluded these participants and 170 continued data collection with the additional inclusion criteria that participants either had to: (1) 171 own or lease a vehicle with ACC and/or LKA (owners), or (2) have never used ACC or LKA 172 (non-owners).

After excluding the previously mentioned 20 participants, 479 participants completed the main survey. Our final sample used in analysis consisted of 102 owners and 262 non-owners. A total of 309 participants completed the follow-up survey. The final sample for the follow-up survey consisted of 43 owners and 150 non-owners. The screening process to obtain our final samples can be found in Figure 1 and descriptive statistics for the owner and non-owner samples can be found in Table 1.



180 Fig. 1. Screening process to obtain final samples for the main survey and follow-up survey.

- 181 \*We were unable to identify whether these responses were due to misunderstanding the item or
- 182 not paying attention to the items, thus these participants were removed to be conservative.

	ADAS non-owner	ADAS owner
Main Survey		
Ν	262 (123 F, 139 M)	102 (48 F, 54 M)
Age ( <i>M</i> , <i>SD</i> )	35.3, 13.4	35.2, 11.5
Number of ADAS Learning Methods (N)		
0	101	0
1	58	26
2	52	30
3+	51	46
Technology Familiarity (M, SD)	7.7, 1.4	8.1, 1.4
Education (N)		
High school, some postsecondary, or college degree	102	26
Bachelor's degree	111	41
Graduate or professional degree	47	35
Income ( <i>N</i> )		
Less than \$40,000 USD	88	13
\$40,000 to \$74,999 USD	100	43
More than \$75,000 USD	74	46
% Recruited through Mechanical Turk	54	48
Follow-up Survey		
N	150 (71 F, 77 M)	43 (18 F, 25 M)
Age ( <i>M</i> , <i>SD</i> )	37.0, 14.4	36.9, 13.0
Number of ADAS Learning Methods ( <i>N</i> )		
0	50	0
1	32	12
2	32	13
3+	36	18
Technology Familiarity (M, SD)	7.8, 1.4	7.8, 1.7
Education ( <i>N</i> )		
High school, some postsecondary, or college degree	65	14
Bachelor's degree	57	15
Graduate or professional degree	28	14
Income (N)		
Less than \$40,000 USD	50	5
\$40,000 to \$74,999 USD	63	15
More than \$75,000 USD	37	23
% Recruited through Mechanical Turk	54	42

Table 1. Descriptive statistics by ownership

183 2.2. Survey design and procedure

# 184 2.2.1 Main survey: Demographics, knowledge, learning methods, and trust

Participants first completed a short screening questionnaire to ensure that they met the inclusion criteria, and then were given information about the study and provided informed consent. In the first section of the survey, participants reported demographic information, driving habits, what methods (if any) they had used to learn about ADAS, and how they would prefer to

189	learn about ADAS. Methods of learning about ADAS (past and preferred) were one question
190	each for which participants were asked to consider both ACC and LKA. ACC owners and LKA
191	owners were also asked how often they used the ACC and/or LKA in their vehicle. The
192	questions in this section were developed based on a review of previous surveys about ADAS
193	(Abraham et al., 2017; McDonald, Carney, & McGehee, 2018; Seppelt, 2009). Data collection
194	began in April 2020, at which point many people were spending more time at home due to the
195	COVID-19 pandemic. Thus, participants were asked to report their driving habits before the
196	pandemic and their yearly income from 2019 as their current income may also have been
197	affected by the COVID-19 pandemic. Data collection concluded in January 2021.
198	The second section of the main survey contained ACC and LKA knowledge
199	questionnaires which were developed based on a review of previous questionnaires assessing
200	knowledge of ACC (Beggiato et al., 2015; Seppelt, 2009) and a review of owner's manuals from
201	various manufacturers to identify the functionality and limitations of each system. Each
202	questionnaire had two parts (ACC total items = 51, LKA total items = 38). In part one,
203	participants were presented with a series of statements about ACC or LKA and were asked
204	whether each statement was true (response options were "Yes", "No", or "I don't know"). In part
205	two, participants were presented with a list of situations and were asked whether the ACC or
206	LKA would have difficulty in each situation (response options: "Yes", "No", or "I don't know").
207	The items were the same for owners and non-owners, but owners were asked to consider their
208	own system, and non-owners were asked whether the statements were true for any ACC or LKA
209	system (part one) and whether any system would have difficulty in a given situation (part two).
210	For all items, participants were also asked to rate their confidence in their answer from 1 (very
211	low confidence) to 7 (full confidence). If participants answered "I don't know", they did not

212 need to rate their confidence, but they were encouraged to do so only if they were completely 213 unsure. In this section, participants also rated their trust in ACC and LKA, using five items from 214 Jian, Bisantz, and Drury (2000): "I can trust the system", "The system is reliable", "I am 215 confident in the system", "I am familiar with the system", and "The system is dependable". 216 Participants were asked to rate their overall agreement with these statements on a Likert scale 217 from Strongly Disagree to Strongly Agree, and rated their trust separately for ACC and LKA. 218 The presentation order of the ACC and LKA questionnaires was randomized, and within the 219 knowledge questionnaires, the order of parts one and two were randomized (but consistent across 220 the ACC and LKA questionnaires). Approximately half of the participants rated trust first and 221 the other half rated trust after the knowledge questionnaires.

## 222 2.2.2 Follow-up survey: Reliance intention

223 At the end of the main survey, participants were informed that there was an optional follow-up survey. Follow-up survey responses were matched to the main survey data using a 224 225 Mechanical Turk Worker ID (for Mechanical Turk participants) or a unique code provided at the 226 end of the main survey (for participants who were recruited through emails or online postings). 227 After consenting to participating in the follow-up survey, participants were asked to rate how 228 likely they would be to engage in various secondary tasks while using (1) no ADAS, (2) ACC 229 only, (3) LKA only, and (4) both ACC and LKA (the list of secondary tasks can be seen in 230 Figure 7). Likelihood was rated on a 5-point scale from "not at all likely" to "extremely likely". 231 2.3. Analysis

232 2.3.1 Main survey

We analyzed the main survey data separately for owners and non-owners because owners were asked to consider the capabilities of the ACC and/or LKA in their own vehicle and non-

235 owners were asked to consider the capabilities of currently available ACC and LKA. Further, we 236 analyzed the data for ACC and LKA separately because it was possible to own (or be aware of 237 owning) only one system. For example, a participant could be considered an ACC owner, but an 238 LKA non-owner (i.e., own a vehicle equipped with ACC but not LKA). Thus, we split the ACC 239 data into two groups (ACC non-owners and ACC owners), and the LKA data into two groups 240 (LKA non-owners and LKA owners). We scored owners' responses on the knowledge questionnaire based on a review of the manual for their vehicle to assess the features (e.g., could 241 242 it slow down to a stop). Because owner's manuals do not always list all of the limitations of 243 current ADAS technology, if any common limitations were not listed in the owner's manual 244 (e.g., difficulty detecting stopped vehicles), those were still considered to be limitations for the 245 given vehicle. ADAS owners owned vehicles from 21 manufacturers, the most common being 246 Toyota (33%) and Honda (14%). Vehicles from all other manufacturers accounted for less than 247 10% of vehicles owned by the ADAS owners in our sample (the percentage of vehicles by 248 manufacturer is provided in Appendix C). 249 As an initial investigation of participants' performance on the knowledge questionnaires, 250 we calculated a confidence weighted knowledge score for ACC and LKA. First, correct 251 responses were given a score of 1, incorrect responses were given a score of -1, and "I don't 252 know" responses were given a score of 0. Then, the scores were multiplied by the confidence 253 rating for each item (from 1 to 7). Thus, final scores for each item could range from -7 to 7. The 254 responses were scored this way to penalize drivers more for incorrect knowledge than not 255 knowing the answer to an item, and to give more weight to items that participants were more 256 confident that they knew, compared to those they were not sure about. In order to make the

scores easier to interpret, after summing the scores for all items in each questionnaire, we turned

the final scores into a percentage out of the total available points for each questionnaire. For
example, on the ACC questionnaire (51 items) the maximum score was 357 (every item
answered correctly with a confidence rating of 7); the minimum score was -357 (every item
answered incorrectly with a confidence rating of 7). The ACC scores were then transformed so
that 0 was the minimum and 714 was the maximum and the confidence weighted percentage
reflected participants' score out of 714.

264 After this initial investigation, we built four regression models with trust as the dependent 265 variable (two ACC models: owners and non-owners, and two LKA models: owners and non-266 owners). The models were built with the 'lm' function in R. Principal components analysis indicated that all trust items loaded onto the same factor except for "I am familiar with the 267 268 system". Thus, the item related to familiarity was removed and scores for ACC and LKA trust 269 were calculated by averaging the ratings for the other four items. The predictor variables are described in Table 2. All predictors were entered into the model simultaneously and the full 270 271 models are reported. We were mainly interested in the relationship between knowledge and trust; 272 the other variables were included as covariates to explore whether they also influenced trust.

Main Survey: Regre	ssion Model Predicting Trust
Predictor	Description
Sensitivity*	Participants' ability to identify true capabilities of ACC and LKA among items in the knowledge questionnaires, independent of response bias. Measured using area under the receiver operating characteristic curve (AUC). Values range from 0 to 1. A value of 1 indicates perfect performance (i.e., participants correctly answered all items); a value of 0.5 represents chance performance (Stanislaw & Todorov, 1999).
Bias*	A measure of participants' inclination towards a certain response, independent of sensitivity (Stanislaw & Todorov, 1999). Measured using criterion location ( <i>c</i> ). Negative values indicate that participants had a response bias towards "Yes", in other words, they had an inclination to respond that the system was capable regardless of whether the item was true or false.
Number of learning methods used	The number of methods the participant used to learn about ADAS in the past. Participants were asked to select all methods they used from the following: Read the vehicle manual; Asked sales staff at the dealership for information; Staff at the dealership offered information (you did not specifically ask); Asked a friend or family member for information; Friends or family were talking about advanced driver assistance systems (you did not specifically ask); Looked for information on the internet; Searched for online videos; Saw a video or commercial by chance; Drove the vehicle to learn by trial-and-error; Observed the advanced driver assistance systems as a passenger; Other - please specify. This variable was split into two levels for analysis. For non-owners the levels were 0-1 and 2+; for owners the levels were 1-2 and 3+ (there were no owners who used 0 learning methods).
Technology familiarity	An average of three items asking about level of experience with technology, the degree to which participants consider themselves early adopters of technology, and how easy they find it to learn new technology. The first two items were taken from (Chen & Donmez, 2016; Reimer, Mehler, Dobres, & Coughlin, 2013).
Education	Highest level of education completed. This predictor had three levels: high school, some postsecondary, or college degree; bachelor's degree; and graduate or professional degree.
Age	Self-reported age at the time that the survey was completed
Income	The participant's yearly household income for 2019, reported by selecting from nine income ranges. The median income in the U.S. for 2018 was \$63,000 (Rothbaum & Edwards, 2019), which was contained within the "\$50,000 to \$74,999" range in our survey, and Pew Research Center (2016) considers lower income households to be those with an income less than 67% of the median income (\$42,000 for 2018). Thus, we split income into three levels: less than \$40,000, \$40,000 to \$74,999, and \$75,000 or greater. For owners, due to a small proportion of participants who reported earning less than \$40,000, income was split into two levels: less than \$75,000 and \$75,000 or greater.
Experience (for owners only)	Level of experience, rated separately for ACC and LKA. This predictor had two levels: lower (reported using ACC or LKA rarely or sometimes) and higher (reported using ACC or LKA most of the time or almost every time they drove)
Follow-up Survey: M	Aixed Linear Model Predicting Reliance Intention
Predictor	Description

Table 2. Explanatory variables for main survey and follow-up survey analyses

Predictor	Description
ADAS condition	A categorical variable with four levels: no ADAS, ACC only, LKA only, both ACC and
(repeated measure)	LKA
Average trust score	An average of the ACC and LKA trust scores
Average sensitivity	An average of the AUC for ACC and LKA
Average bias	An average of c for ACC and LKA

Note: Full items can be found in Appendix A (main survey) and Appendix B (follow-up survey)

\* To calculate sensitivity and bias, items were recoded so that they reflected a system capability.

273 As presented in Table 2, we used signal detection theory constructs of sensitivity and 274 response bias to isolate the effect of knowledge (e.g., Macmillan & Creelman, 2005; Stanislaw & 275 Todorov, 1999). Bias is a participants' inclination towards a certain response (e.g., a bias 276 towards answering "Yes" that a signal is present regardless of actual signal presence). Sensitivity 277 is the ability to detect a signal among all items and is independent of bias. All knowledge items 278 were recoded so that they reflected the capabilities of ACC and LKA. Thus, the signal to be 279 detected was whether an item reflected a true capability of ACC or LKA, and the sensitivity 280 represented the participant's ability to detect actual system capabilities, which is an unbiased 281 measure of knowledge. A response bias towards "Yes" indicated that a participant was inclined 282 to respond that the system was capable regardless of whether the item was true or false (i.e., they 283 had a favourable view of the system). Sensitivity was measured using the area under the receiver 284 operating characteristic curve (AUC), and criterion location (c) was used to measure response bias (for a description of how to obtain the AUC and c from confidence rating scale data, see 285 286 Macmillan & Creelman, 2005; Stanislaw & Todorov, 1999). 287 To explore the effect of learning methods on trust, we first conducted t-tests to analyze 288 whether trust differed based on whether or not participants used a given learning method. Given 289 the large number of t-tests (one for each learning method), alpha was adjusted according to the

290 Benjamini-Hochberg method (Benjamini & Hochberg, 1995). For ACC non-owners, three

291 learning methods were associated with higher trust in ACC: reading an owner's manual, asking

292 friends for information, and searching for information on websites. For LKA non-owners,

reading an owner's manual, asking friends for information, and getting information from

294 dealership or car rental staff were all associated with higher trust in LKA. ACC owners who

asked staff for information had significantly higher trust in ACC than those who did not ask staff

for information. LKA owners who learned by trial-and-error had significantly lower trust in LKAthan owners who did not learn by trial-and-error.

298 Given that there was not a consistent effect of any given learning method across our 299 sample, we then explored whether the number of learning methods used influenced trust, as 300 drivers may trust the system more if they got information from multiple sources. A t-test showed 301 that non-owners who used two or more learning methods had significantly higher trust than those 302 who used fewer than two learning methods. There were a relatively small proportion of owners 303 (25%) who used fewer than 2 learning methods (see Table 1), thus for owners, number of 304 learning methods was split into two levels (1-2 and 3+) to obtain more balanced groups. There 305 was no significant effect of number of learning methods on trust for owners. To simplify the 306 regression models, number of learning methods was chosen as the relevant predictor over type of 307 method and included in the analysis for non-owners and owners to investigate whether it had an effect on trust when controlling for the other variables in the model. 308

309 2.3.2 Follow-up survey

310 Mixed linear models were used for the reliance intention analysis to account for the 311 repeated measures (participants rated likelihood to engage in secondary tasks four times, once for 312 each ADAS condition). Models were built using the 'nlme' packaged in R, with participant listed as a random effect. Like with the main survey data, the follow-up survey data was analyzed 313 314 separately for owners and non-owners. However, we could not further breakdown the sample 315 based on ACC and LKA ownership given the smaller sample size. Thus, we created two models, 316 one for ADAS owners (owned a vehicle with ACC and/or LKA) and one for ADAS non-owners 317 (did not own a vehicle with either system). The dependent variable was average self-reported 318 likelihood to engage in secondary tasks, which was calculated by averaging the likelihood ratings

across the secondary tasks. The predictor variables are shown in Table 2. Trust was entered into the model before the sensitivity and bias measures given its known relationship with reliance (Lee & See, 2004). Sensitivity and bias were included in the model to assess whether either measure exerted any additional influence on reliance. Likelihood ratio tests were used for model selection. None of the first order or second order interactions significantly improved either model, so they were excluded from the analysis.

325 **3. Results and discussion** 

326 3.1. ADAS knowledge

327 3.1.1 Driver misperceptions

328 Owners and non-owners had a similar level of knowledge based on their confidence 329 weighted scores. For ACC, non-owners and owners had an average score of 53.3% (SD = 7.8) 330 and 55.7% (SD = 9.3), respectively. For LKA, non-owners had an average confidence weighted 331 score of 54.5% (SD = 9.0), while owners had a confidence weighted score of 55.9% (SD = 10.5). 332 We statistically compared owners and non-owners based on the confidence weighted scores for 333 items that had the same correct response across all vehicles (thus responses would be the same 334 for owners and non-owners). There was no significant difference between owners and non-335 owners for ACC, t(139.8) = 1.38, p = .2, or LKA, t(87.7) = -0.21, p = .8. 336 When looking at individual questionnaire items, Figure 2 highlights that non-owners and 337 owners have similar misperceptions about ACC; this information was previously reported in

Figure 1 in DeGuzman & Donmez (2021), and a more detailed discussion of these findings can

- be found there. What we want to highlight in the current paper is that while most participants
- know what the purpose of the system is and that dirty or blocked sensors may cause a problem, a
- 341 large percentage of both non-owners and owners did not correctly identify many of the other

342 ACC limitations. Further, those who did not answer correctly often answered incorrectly (i.e., 343 they thought ACC would *not* have difficulty in these situations or that ACC had full braking 344 power) as opposed to answering "I don't know", indicating that many participants were 345 overestimating the system's capabilities. 346 Figure 3 shows that responses from owners and non-owners were also similar for LKA 347 items. Most participants knew the main function of LKA and that it had difficulty when sensors 348 were blocked/dirty. Compared to ACC, more participants were aware of some of the LKA 349 limitations, for example, that it has difficulty when the road is covered in snow/sand or that it has 350 difficulty when lane markings are faded or missing. However, there were still some common 351 misperceptions among a large portion of participants. For example, many participants thought that LKA would not have difficulty in the presence of glare, which is a limitation of LKA 352 353 systems due to their use of cameras. In addition, 35% of non-owners and 37% of owners 354 incorrectly thought that LKA executed evasive steering maneuvers, another example of 355 participants overestimating ADAS capabilities.

		Percent	of Non-Ov	wners and Ov	vners	
	(	) 25	50	) 7:	5	10
Maintains a predetermined speed in an empty lane	Non-owners - Owners -		74 77		12 13	14 10
Adjusts the speed to slower vehicles ahead	Non-owners - Owners -		77 73		9 20	14 7
Keeps a set distance to vehicles driving ahead in the same lane at a slower speed	Non-owners - Owners -		74 77		9 16	17 8
Has difficulty when sensors are dirty/blocked	Non-owners - Owners -		78 68		14 20	8 12
Has difficulty when a vehicle cuts in ahead	Non-owners - Owners -	<u>56</u> 51		34 36		10 13
Has difficulty when approaching pedestrians or cyclists	Non-owners - Owners -	<u>48</u> 50		<u>38</u> 31		14 19
Has difficulty when the vehicle ahead brakes suddenly	Non-owners - Owners -	<u>48</u> 31		40 63		11 6
Has difficulty on curvy roads	Non-owners - Owners -	<u>42</u> 44		49 47		9
Has difficulty when approaching a stopped vehicle	Non-owners - Owners -	<u>33</u> 40		56 46		12 14
Has difficulty when approaching a motorcycle	Non-owners - Owners -	35 36		50 46		15 19
Does not have full braking power	Non-owners - Owners -	20 24	47 5	3	33 2	2
Correct	Incor	rect Ans	wered "I de	on't know"		

356 357

**Fig. 2.** Percent of non-owners and owners who answered correctly, incorrectly, and "I don't

- 358 know" for a subset of ACC knowledge items. Note: this information was previously reported in
- 359 Figure 1 in DeGuzman and Donmez (2021).

		Percent of	f Non-Own	ers and Owi	ners
	0	25	50	75	10
Steers automatically	Non-owners - Owners -	69	) 80	1	6 15 14 7
Has difficulty when sensors are dirty/blocked	Non-owners - Owners -		<u>82</u> 75		8 10 17 8
Has difficulty when road is covered in snow/sand	Non-owners - Owners -	7	7 <u>3</u> 83		15 12 12 5
Has difficulty when lane markings are faded or missing	Non-owners - Owners -	7 66	1		1910258
Has difficulty in construction zones	Non-owners - Owners -	68 59	}	1 25	9 13 15
Has difficulty on unpaved roads	Non-owners - Owners -	<u> </u>		20 27	) 14 14
Has difficulty in poor weather	Non-owners - Owners -	<u>63</u> 64		23 2	13 7 8
las difficulty at road merges/diverges	Non-owners - Owners -	46 56		39 34	16 10
Has difficulty on curvy roads	Non-owners - Owners -	<u>42</u> 39		46 51	12 10
Does not execute evasive steering maneuvers	Non-owners - Owners -	<u>28</u> 46	35	37	37 17
Has difficulty when there is glare on the road surface	Non-owners - Owners -	46 41		38 46	16 14
Has difficulty when there is glare towards the driver	Non-owners - Owners -	30 27	5	1 61	19 12
Has difficulty on city streets	Non-owners -	27		62 71	11

360 361

362

**Fig. 3.** Percent of non-owners and owners who answered correctly, incorrectly, and "I don't know" for a subset of LKA knowledge items.

Overall, these results indicate that owners do not have a better understanding of system limitations compared to non-owners. Previous research showed that limitations that were learned from an owner's manual were forgotten over time if drivers did not encounter them (Beggiato et al., 2015). A survey of Tesla Autopilot users found that 62% of drivers experienced at least one "unexpected or unusual behaviour" while using Autopilot (Dikmen & Burns, 2016). However, only 14% reported experiencing two or more unexpected or unusual behaviours, suggesting that experiencing a system limitation or malfunction may be a relatively rare event. Thus, even if owners in our sample initially learned about ACC and LKA limitations, this knowledge may
have been lost over time due to limited firsthand experience of limitations. Further, when drivers
do experience unexpected system behaviour, they may not be aware of why the unexpected
behaviour occurred enabling them to link the occurrence to a specific limitation. These findings
highlight that experience with ACC and LKA does not appear to be sufficient for supporting
drivers' knowledge of ADAS limitations.

376 3.1.2 To what extent do drivers overestimate ADAS?

377 To further explore the extent to which participants were overestimating ACC and LKA, 378 individual ACC and LKA knowledge items were also categorized as overestimate or 379 underestimate items. Overestimate items were those for which an incorrect response would 380 indicate an overestimation of the system (e.g., ACC does not have difficulty in poor weather), 381 whereas underestimate items were those for which an incorrect response would indicate an underestimation of the system (e.g., ACC does not work on highways). Some of the feature items 382 383 (e.g., relating to how to engage/disengage the system) were not considered overestimate or 384 underestimate items and were left out of this analysis.

We calculated the percent of underestimate and overestimate items that each person answered incorrectly and the average confidence in these incorrect responses (see Figure 4). Participants were fairly confident in their incorrect responses, with average confidence ranging from 4.5 to 5.6 (with 7 corresponding to "full confidence"). Participants answered less than 25% of the underestimate items incorrectly, as opposed to 39-45% of the overestimate items, suggesting that participant misperceptions of ACC and LKA were more frequently overestimations. Overestimating system capabilities is of particular concern because it may lead to drivers over-relying on ADAS, which has been a contributing factor to several collisions that
have occurred while ADAS was engaged (e.g., National Transportation Safety Board, 2020).



Item Type 🖨 Overestimate 🛱 Underestimate

Fig. 4. Proportion of incorrect overestimate and underestimate items (left) and average
confidence for the incorrect overestimate and underestimate items (right). Boxplots represent the
five-number summary, the diamond indicates the mean. At the top, mean (M) and standard
deviation (SD) values are provided.

399 3.1.3 Signal detection theory measures

400 Figure 5 shows the receiver operating characteristic curves (averaged across participants) 401 and the corresponding AUCs. Inspection of the plots shows that participants' sensitivity was 402 higher for LKA than ACC, which is consistent with our findings from the individual survey 403 items showing that participants were more aware of some of the LKA limitations compared to 404 ACC limitations (i.e., Figures 2 and 3). However, consistent with the findings for confidence 405 weighted scores, owners and non-owners did not differ in their sensitivity (Table 3). In other 406 words, owners were not better able to distinguish the actual ACC and LKA capabilities from 407 other items in the knowledge questionnaire. However, ACC owners were significantly different from non-owners in their response bias (Table 3). Owners were biased towards saying "Yes" 408

409	(indicated by the negative c value), indicating that they were more inclined to respond that ACC
410	was capable for any given item regardless of whether it was true or not. Non-owners on the other
411	hand, had a bias towards saying "No" (indicated by the positive $c$ value), indicating that they had
412	an overall inclination to report that the system was not capable. For LKA, both owners and non-
413	owners had a response bias towards saying "Yes", but owners had a significantly larger bias (see
414	Table 3). In combination with the earlier results, these results suggest that not only is experience
415	insufficient for learning ADAS limitations, but it is also associated with having a positively
416	biased view of the system. To the best of our knowledge, previous surveys on drivers'
417	knowledge of system capabilities have not separated sensitivity from response bias. Given that
418	these measures captured differences in our groups (i.e., owners and non-owners differed in their
419	response bias but not in their sensitivity), it may be a valuable approach to explore for future
420	surveys.

**Table 3.** Comparison of sensitivity and bias between owners and non-owners. Significant (p < .05) results are in bold.

2

				Owner	Non-owner	
	t-value	df	p-value	M (SD)	M (SD)	
ACC Sensitivity (AUC)	-1.55	149.1	.12	0.62 (0.14)	0.59 (0.12)	
LKA Sensitivity (AUC)	0.29	83.4	.77	0.64 (0.15)	0.64 (0.13)	
ACC Bias (c)	3.14	252.8	.002	-0.10 (0.47)	0.10 (0.72)	
LKA Bias (c)	2.45	135.8	.02	-0.27 (0.58)	-0.05 (0.90)	
						_



422 423 Fig. 5. Receiver operating characteristic curves and AUCs, averaged across participants within 424 each group (i.e., ACC non-owners, ACC owners, LKA non-owners, LKA owners). Dots 425 represent hit-false alarm pairs at each possible response level. The leftmost point is the hit-false alarm pair for a response of "Yes" with a confidence rating of 7, the next 6 points are for "Yes" 426 427 responses with confidence ratings from 6 to 1, followed by "I don't know", and then the hit-false 428 alarm pairs for "No" responses with confidence ratings of 1 up to 7. For more detail about 429 plotting receiver operating characteristic curves with confidence rating data, see Macmillan and 430 Creelman (2005) and Stanislaw and Todorov (1999).

```
Trust items were rated on a scale from 1 (strongly disagree) to 5 (strongly agree), with 3
corresponding to "neither agree nor disagree". Inspection of the raw data (Figure 6) suggests that
respondents tend to trust ACC and LKA, as the average trust was above 3. In addition, ACC and
```

<sup>431 3.2.</sup> Trust

435 LKA owners had higher trust in ACC and LKA, respectively, compared to non-owners who had 436 never used the system (ACC, t(355) = 3.52, p < .001; LKA, t(347) = 5.47, p < .001). These 437 results are consistent with previous studies showing that experience with ACC and LKA, either 438 as a driver (Beggiato et al., 2015) or passenger (Nylen, Reyes, Roe, & McGehee, 2019), was

439 associated with higher trust in these systems.





Fig. 6. Average trust in ACC and LKA for owners and non-owners. Trust items were rated on a scale from 1 (strongly disagree) to 5 (strongly agree), thus higher average values indicate higher trust. Boxplots represent the five number summary, the diamond indicates the mean. At the top, mean (M) and standard deviation (SD) values are provided.

445 3.2.1 What factors predict trust in ACC and LKA?

446 For non-owners, sensitivity predicted trust in ACC and LKA (see Table 4). Higher 447 sensitivity in detecting ACC and LKA capabilities was associated with lower trust in ACC and 448 LKA, respectively. Conversely, lower sensitivity was associated with higher trust. Response bias 449 also significantly influenced trust, with participants who were more biased towards responding 450 "Yes" (i.e., endorsing the system capabilities) having higher trust. Thus, in the absence of 451 firsthand experience with ACC and LKA, drivers' trust in these systems is influenced by their 452 knowledge of specific system capabilities and limitations and response bias that was captured in 453 the knowledge questionnaire. Among the other predictors, the number of learning methods used

454 and technology familiarity significantly predicted trust in ACC and LKA (see Table 4). Having 455 used more learning methods and having higher technology familiarity were associated with 456 higher trust in ACC. When non-owners who have never used ACC or LKA learned about 457 ADAS, they may have learned basic information like the purpose of the systems and their 458 capabilities. This initial knowledge may have served to increase their trust. Those with higher 459 technology familiarity may have an overall higher propensity to trust technology, including 460 ADAS. None of the other demographic variables (age, education, or income) had a significant 461 impact on trust.

462 For owners, neither sensitivity nor bias were significantly associated with trust. The correlation between AUC and trust for non-owners was -.29 for ACC and -0.17 for LKA. Power 463 464 analysis indicated that 26 participants would be needed to detect the ACC effect, and 74 465 participants would be needed to detect the LKA effect, based on 80% power and a significance level of .05. Thus, our sample size was large enough for 80% power for ACC and LKA non-466 467 owners and ACC owners, but not for LKA owners. For LKA owners, number of learning 468 methods and technology familiarity were significant predictors of trust. Similar to the results for 469 non-owners, higher technology familiarity was associated with higher trust. However, in contrast 470 to the non-owner findings, using more learning methods was associated with lower trust. This 471 finding may be due to differences in the reason why owners search for information about ADAS. 472 It may be the case that owners search for information about their system after experiencing 473 unexpected system behaviour. In doing so, they may find out more about the system limitations, 474 which in turn, lowers their trust. Further research could explore not only how drivers learn about 475 ADAS but why they search for information and what information they search for to further 476 investigate the relationship between learning methods and trust.

477 For ACC owners, age was a significant predictor of ACC trust and higher experience was 478 marginally significant (Table 4). Older age was associated with higher trust and a higher 479 experience level (using ACC most of the time or almost every time they drove) was associated 480 with lower trust. Using ADAS more frequently may lead to drivers experiencing more 481 unexpected system behaviour (even if they cannot attribute it to a specific capability/limitation in 482 the questionnaire), which may increase their awareness that ADAS is not always reliable and 483 impact their trust. It is possible that experience was marginally significant for ACC but not LKA 484 due to participants' knowledge of system limitations. As discussed previously (Section 3.1.1, 485 Figures 2 and 3) more participants were aware of some of the LKA limitations, such as its 486 limited capability when lane markings are faded or missing. This awareness may have mediated 487 the effect of experiencing system failures on LKA trust. Prior research has shown that if 488 participants are aware of system limitations, their trust may be less negatively affected when they 489 encounter these limitations (Beggiato & Krems, 2013). However, it should be noted that our 490 sample size of owners (particularly LKA owners) was relatively small and thus we may not have 491 had sufficient power to detect an effect of experience on trust for LKA owners. For ACC owners, 492 the difference in trust between those with higher and lower experience was approximately 0.45 493 (on a scale of 1 to 5). Power analysis indicated that a sample size of 47 participants per group 494 (higher and lower experience) would be needed to detect this effect with 80% power at p < .05. 495 While our sample of ACC owners was overall large enough (N = 94), a group imbalance (higher 496 experience = 27, lower experience = 67) resulted in a power of 71%. Future work with a larger 497 sample of owners is needed to confirm our results and explore the reasons for the different 498 influencing factors on ACC and LKA trust.

	Estimate	Standard Error	<i>t</i> -value	<i>p</i> -value
<b>ACC, Non-owners:</b> $R^2 = .26$ , $F(9, 250) = 9.6$	4, <i>p</i> < .001			
Intercept	3.21	0.38	8.50	<.001
Sensitivity (AUC)	-1.58	0.37	-4.24	<.001
Bias (c)	-0.23	0.06	-3.61	<.001
Number of Learning Methods [0-1]				
2+	0.32	0.10	3.28	.001
Technology Familiarity	0.13	0.03	3.86	< .001
Education [High school, some				
postsecondary, or college degree]				
Bachelor's degree	-0.06	0.10	-0.60	.55
Graduate or professional degree	0.02	0.13	0.18	.85
Age	0.00	0.00	0.37	.71
Income [less than \$40,000]				
\$40,000 to \$74,999	0.08	0.11	0.78	.44
\$75,000 or greater	-0.05	0.12	-0.46	.64
<b>LKA, Non-owners:</b> $R^2 = .18$ , $F(9, 274) = 6.8$	9, <i>p</i> < .001			
Intercept	3.24	0.38	8.45	< .001
Sensitivity (AUC)	-1.38	0.35	-3.97	<.001
Bias (c)	-0.21	0.05	-4.10	<.001
Number of Learning Methods [0-1]				
2+	0.30	0.10	3.03	.003
Technology Familiarity	0.11	0.03	3.44	< .001
Education [High school, some				
postsecondary, or college degree]				
Bachelor's degree	0.05	0.10	0.55	.59
Graduate or professional degree	0.05	0.13	0.42	.67
Age	-0.00	0.00	-0.56	.58
Income [less than \$40,000]				
\$40,000 to \$74,999	-0.01	0.11	-0.13	.89
\$75,000 or greater	-0.12	0.12	-1.00	.32
<b>ACC, Owners:</b> $R^2 = .19$ , $F(9, 84) = 2.21$ , $p =$	.03			
Intercept	3.35	0.83	4.02	<.001
Sensitivity (AUC)	-0.89	0.62	-1.42	.16
Bias (c)	-0.29	0.18	-1.65	.10
Number of Learning Methods [1-2]				
3+	0.18	0.17	1.06	.29
Technology Familiarity	0.08	0.06	1.33	.19
Education [High school, some				
postsecondary, or college degree]				
Bachelor's degree	-0.19	0.22	-0.85	.40
Graduate or professional degree	-0.11	0.22	-0.53	.60
Age	0.01	0.01	2.03	.046
Income [less than \$75,000]				
\$75,000 or greater	0.03	0.17	0.20	.84
Experience [Lower]				
Higher	-0.37	0.19	-1.95	.054
<b>LKA, Owners:</b> $R^2 = .16$ , $F(9, 52) = 1.08$ , $p =$	= .39			

**Table 4.** Results for regression models predicting trust; significant (p < .05) and marginally significant results are in bold. For categorical variables, the reference level is shown in square brackets.

Intercept	2.70	1.07	2.51	.02
Sensitivity (AUC)	-0.42	0.79	-0.53	.60
Bias (c)	-0.27	0.20	-1.35	.18
Number of Learning Methods [1-2]				
3+	-0.45	0.22	-2.04	.047
Technology Familiarity	0.18	0.08	2.17	.03
Education [High school, some				
postsecondary, or college degree]				
Bachelor's degree	-0.00	0.29	-0.01	.996
Graduate or professional degree	0.10	0.28	0.37	.72
Age	0.01	0.01	0.82	.42
Income [less than \$75,000]				
\$75,000 or greater	-0.21	0.23	-0.91	.37
Experience [Lower]				
Higher	-0.25	0.21	-1.16	.25

499

In a previous paper using the same dataset (DeGuzman & Donmez, 2021), we found that only demographic factors predicted the percent of correct responses on the ACC knowledge questionnaire for owners and non-owners. In the current study, the only demographic factor that significantly impacted trust was age for ACC owners. Thus, our results suggest that demographic factors may not directly influence trust but may indirectly affect trust through their impact on knowledge.

506 3.3. Reliance intention

507 Based on inspection of the raw data (see Figure 7), at all ADAS levels, drivers were more 508 likely to engage in secondary tasks that are legal in most jurisdictions (e.g., Ontario Ministry of 509 Transportation, 2019) such as talking to passengers, eating, and making phone calls and texting 510 using voice control. Responses were highly variable, but for most secondary tasks, the average 511 likelihood appears to increase from no ADAS to LKA only to ACC only to both ACC and LKA. 512 For both ADAS owners and non-owners, AUC and bias did not significantly improve the 513 reliance intention model that already included ADAS condition and trust as predictors 514 (determined through likelihood ratio tests), thus they were not included in the final models. For 515 non-owners, using LKA only, ACC only, and both systems together were each associated with

516 higher self-reported likelihood to engage in secondary tasks compared to driving with no ADAS 517 (Table 5). In addition, higher average trust in ACC and LKA was associated with a higher 518 average likelihood to engage in secondary tasks while driving. For owners, using ACC only and 519 ACC and LKA together were associated with higher self-reported likelihood to engage in 520 secondary tasks, but there was no significant difference between using LKA only and no ADAS. 521 Higher average trust was also associated with a higher average likelihood to engage in secondary 522 tasks, but the effect was only marginally significant (Table 5), potentially due to sample size 523 limitations.



ADAS Owner ADAS Non-owner Average likelihood to engage in secondary tasks

- 524
- **Fig. 7.** Average likelihood to engage in secondary tasks by ADAS condition: 1 = not at all likely,
- 526 2 = slightly likely, 3 = moderately likely, 4 = very likely, 5 = extremely likely. Error bars
- 527 represent standard error.

	Estimate	DF	Standard Error	<i>t</i> -value	<i>p</i> -value
<b>ADAS Non-owners</b> ( $N = 150$ )					
Intercept	1.22	447	0.18	6.87	<.001
ADAS condition [no ADAS]					
LKA only	0.21	447	0.03	6.42	<.001
ACC only	0.24	447	0.03	7.24	<.001
ACC and LKA	0.42	447	0.03	12.94	<.001
Average Trust	0.14	148	0.05	2.71	.008
<b>ADAS, Owners</b> $(N = 43)$					
Intercept	1.07	126	0.39	2.72	.008
ADAS condition [no ADAS]					
LKA only	0.11	126	0.07	1.68	.10
ACC only	0.23	126	0.07	3.41	< .001
ACC and LKA	0.34	126	0.07	5.04	< .001
Average Trust	0.20	41	0.11	1.90	.06

**Table 5.** Results for linear mixed models predicting reliance intention; significant (p < .05) and marginally significant results are in bold. For ADAS condition, the reference level is indicated in square brackets.

528

529 While these results reflect self-reported intention to engage in secondary tasks while 530 driving, they are consistent with findings from on-road and simulator studies. In an on-road 531 study, Naujoks, Purucker, and Neukem (2016) found that participants who had experience with 532 ACC engaged more in secondary tasks when using ACC or ACC and LKA together than when 533 driving with no automation. In a simulator study, Körber et al. (2018) found that participants 534 with higher trust in an automated driving system spent more time looking at a secondary task 535 while the automation was engaged. In the current study, neither sensitivity nor bias had a 536 significant impact on reliance intention. However, for non-owners these measures may have an 537 indirect influence on reliance intention through their association with trust.

538 3.4. Limitations

As described in Section 2.1, approximately 25% of the original data collected was excluded based on reliability checks. The trade-off between sample size and quality is an inherent limitation of crowdsourced data collection. Although others have used similar data collection methods (e.g., Ayoub et al., 2021; Rahman et al., 2018) and research suggests advantages of such an approach (e.g., Walter et al., 2019), future work could explore the use of

544 in-person assessments with fewer participants to obtain qualitative data and reduce data loss. 545 Although we attempted to remove participants with unreliable data, self-report data is still 546 subject to bias. For example, participants' actual likelihood to engage in secondary tasks while 547 using ADAS may be higher than their reported intention to engage in secondary tasks. While the 548 trends found in our results are consistent with previous work, future research could confirm our 549 results with behavioural data. In addition, our knowledge questionnaires had an uneven number 550 of signal present and signal absent items, which may have affected our estimates for the signal 551 detection theory measures. Future surveys could systematically control this parameter to confirm 552 our findings with regards to sensitivity and bias. Finally, our sample consisted of participants 553 from the U.S. and Canada. Further research is needed to explore whether similar results would be 554 found in other populations.

# 555 4. Summary and conclusions

We conducted a survey study with the primary objective of assessing knowledge and trust of ACC and LKA among owners and non-owners and investigating the relationship between knowledge and trust. Our secondary objective was to explore how knowledge and trust impacted reliance intention. The main conclusions are listed below:

560 1. Owning a vehicle with ACC or LKA does not appear to result in a better understanding of561 system limitations.

562 2. For both owners and non-owners, participants tended to overestimate ADAS more than563 underestimate it.

564 3. Prior to system use (i.e., for non-owners, who had no experience with ACC or LKA),

565 knowledge of specific capabilities and response bias affects trust, which in turn, affects

566 reliance intention.

567 4. Once drivers have experience with the system (i.e., owners in our sample), knowledge of
568 specific system capabilities and response bias do not have a significant influence on trust.

5. For ACC owners, using the system more frequently is related to lower trust, which in turn
was associated with a lower reported likelihood to engage in secondary tasks.

571 6. Using LKA more frequently was not associated with lower trust, potentially due to the fact
572 that participants were more aware of some of the common limitations, which reduced the
573 negative impact of system failures on trust.

574 Although we have identified limitations that many drivers are unaware of, our findings 575 suggest that it may be beneficial to shift efforts away from trying to train drivers on all the 576 specific limitations of a system. Owners' knowledge of these limitations was not found to 577 influence trust, and while knowledge of specific capabilities and limitations appears to be 578 beneficial for non-owners, awareness that the system is fallible may be sufficient to support their 579 initial interactions with ADAS. Further, it is impractical to expect drivers to learn and remember 580 all possible limitations. A more feasible training/education strategy may be to focus on 581 improving drivers' overall understanding of the fallibility of ADAS and reinforcing how they 582 should be using ADAS (e.g., their role when using these systems). Future research should 583 investigate the use of such strategies to support appropriate trust in and reliance on ADAS. 584 These findings complement existing research on drivers' attitudes towards currently 585 available ADAS and automated driving technologies that are not yet available in consumer 586 vehicles in North America (e.g., Level 3 driving automation which controls lateral and

longitudinal movement of the vehicle and does not require the driver to monitor the roadway
while the automation is engaged; SAE International, 2018). Prior work has investigated drivers'
acceptance and intent to use ADAS (e.g., Rahman et al., 2018) and Level 3 automated driving

590 systems (e.g., Buckley, Kaye, & Pradhan, 2018; Schoettle & Sivak, 2014; Zhang et al., 2020), 591 but it is also important to understand what drivers' know about the technology to improve the 592 safety of drivers' interactions with automated vehicles. Our findings suggest that even though 593 ACC and LKA have some market penetration, owners who use these systems lack a clear 594 understanding of their capabilities. Further, there have been several collisions involving the use 595 of ADAS that were at least partially a result of drivers' overreliance on the automation (e.g., 596 National Transportation Safety Board, 2020). As higher levels of driving automation (e.g., Level 597 3) are implemented, similar problems will likely occur. Understanding how knowledge is related 598 to trust and reliance with the ADAS systems currently emerging in the market can not only 599 improve safety for ADAS users, but also serve as a foundation to improve the safety of drivers' 600 interactions with more advanced automated driving systems.

#### 601 CRediT Author Contribution Statement

602 Chelsea A. DeGuzman: Conceptualization, Methodology, Validation, Formal analysis,

603 Investigation, Data curation, Writing - original draft, Visualization. Birsen Donmez:

604 Conceptualization, Methodology, Validation, Writing - review & editing, Supervision, Funding605 acquisition.

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## 760 APPENDIX A: Main Survey

## 761 **Demographics**

Q1. What is your age?

[Text entry field]

Q2. What is your sex?

Male; Female

Q3. What country do you currently reside in?

Canada; United States; Other [Exclude if Other]

Q4. What state/province do you currently reside in?

[Drop-down list]

Q5. What city do you currently live in?

[Text entry field]

[For U.S. residents]

Q6. Yearly household income in 2019:

Less than \$15,000; \$15,000 to \$29,999; \$30,000 to \$39,999; \$40,000 to \$54,999; \$55,000 to \$74,999; \$75,000 - \$114,999; \$115,000 - \$149,999; \$150,000 - \$224,999; More than \$225,000

### [For Canadian residents]

Q6. Yearly household income in 2019:

Less than \$20,000; \$20,000 to \$34,999; \$35,000 to \$49,999; \$50,000 to \$74,999; \$75,000 to \$99,999; \$100,000 - \$149,999; \$150,000 - \$199,999; \$200,000 - \$299,999; More than \$300,000

Q7. On a scale of 1 to 10, with 1 being very inexperienced and 10 being very experienced, how would you rate your level of experience with technology (for example, cell phones, automatic teller machines, digital cameras, and computers)?

Very inexperienced 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 Very experienced

Q8. Some people prefer to avoid new technologies as long as possible while others like to try them out as soon as they become available. In general, how would you rate yourself as being an avoider or an early adopter of new technology?

Avoid new technologies 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 Try new technologies as soon as possible

## Q9. I find learning new technology to be:

Very difficult 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 Very easy

## 764 Driving History

## [For U.S. residents]

Q10. What type of driver's license do you currently hold?

Learner's permit or instruction permit; Full license; Other - Please Specify

## [For Canadian residents]

## Q10. What type of driver's license do you currently hold?

Learner's permit or instruction permit (for example, G1, G2); Full license (for example, G); Other - Please Specify

## Q11. How old were you when you got your first learner's permit?

[Text entry field]

## Q12. Before the COVID-19 outbreak, how often did you drive?

Almost every day; A few times a week; A few times a month; A few times a year; Never

## [For U.S. residents]

## Q13. In 2019, what was the average distance you drove per week?

0 – 30 miles (~ under 1600 miles per year); 31 – 60 miles (~ 1600 – 3199 miles per year); 61 – 185 miles (~ 3200 – 9699 miles per year); 186 – 310 miles (~ 9700 – 15999 miles per year); 311 – 434 miles (~ 16000 – 22499 miles per year); 435 – 558 miles (~ 22500 – 28999 miles per year); 559+ miles (~ over 29000 miles per year)

## [For Canadian residents]

Q13. In 2019, what was the average distance you drove per week?

0 – 49 km (~ under 2500 km per year); 50 – 99 km (~ 2500 – 4999 km per year); 100 – 299 km (~ 5000 – 14999 km per year); 300 – 499 km (~ 15000 – 24999 km per year); 500 – 699 km (~ 25000 – 34999 km per year); 700 – 899 km (~ 35000 – 44999 km per year); 900+ km (~ over 45000 km per year)

Q14. In 2019, how much of your driving time was spent on highways/interstates?

0 - 20%; 21 - 40%; 41 - 60%; 61 - 80%; 81 - 100%

## Q15. Do you currently own/lease a vehicle?

Yes; No

# 765

# 766 Current Vehicle/ADAS Experience

### [If Q15 = Yes]

Q16. What is the make and model of the car you currently own/lease? (If your household has multiple vehicles, pick the one that has advanced driver assistance systems, if any).

Make [Text entry field]; Model [Text entry field]; Year [Text entry field]

## [If Q15 = Yes]

## Q17. How long have you owned/leased this vehicle?

Less than 1 year; 1-2 years; 3-5 years; 6+ years

# 767

## $768 \quad [If Q15 = Yes]$

- 769 Some vehicles are equipped with advanced driver assistance systems that can control some of the driving
- tasks for you. The questions throughout the rest of the survey will focus on your experience with and
- understanding of two of these systems: Adaptive Cruise Control (ACC) and Lane Keeping Assist (LKA).
- In some vehicles, ACC and LKA are part of one combined system, whereas in other vehicles, ACC and

- T73 LKA are separate systems. Here we will describe each system separately. If you have experience using a
- combined version of ACC and LKA, when answering a question about ACC or LKA, please think aboutonly that aspect of the system.
- 776

## 777 Adaptive Cruise Control (ACC)

- 778 This system is designed to control the speed of the vehicle, like normal cruise control, but also
- automatically slows down and speeds up based on the behavior of the vehicle ahead.
- 780
- 781 Different automotive manufacturers have different names for this technology and in some vehicles, ACC
- is combined with other advanced driver assistance systems (like LKA, which will be described later).
- 783 Throughout the rest of the survey, we will use the term ACC to refer to any advanced driver assistance
- system (or component of a system) that fits the description above.
- 785

## Q18. To the best of your knowledge, does your current vehicle have ACC?

Yes; No; Not sure

# [If Q18 = Yes]

Q19. Is this the first vehicle you have owned that has an ACC system?

Yes; No; Not sure

## [If Q18 = Yes]

Q20. Can the ACC system in your current vehicle be used in stop-and-go traffic, like in-town driving or heavy traffic on highways?

Yes; No; Not sure

## [If Q18 = Yes]

Q21. When driving on a highway or interstate, how often do you use the ACC in your vehicle?

Almost every time; Most of the time; Sometimes; Rarely; Never

## [If Q21 = Never]

Q22. You indicated that you do not use the ACC system in your vehicle when driving on the <u>highway or interstate</u>. Please check all that apply to indicate why you do not use the technology when driving on the <u>highway/interstate</u>.

I don't understand it; I don't trust it; I think it is dangerous; It makes me nervous/anxious; It is annoying; It doesn't work on the highway/interstate; It is distracting; I don't need/want it; Other - please explain

## [If Q20 = Yes OR Not sure]

Q23. When driving in <u>stop-and-go traffic</u>, like in-town driving or heavy traffic on highways, how often do you use the ACC in your vehicle?

Almost every time; Most of the time; Sometimes; Rarely; Never

# [If Q23 = Never]

Q24. You indicated that you do not use the ACC system in your vehicle when driving in <u>stop-and-go traffic</u>, like in-town driving or heavy traffic on highways. Please check all that apply to indicate why you do not use the technology when driving in <u>stop-and-go traffic</u>.

I don't understand it; I don't trust it; I think it is dangerous; It makes me nervous/anxious; It is annoying; It doesn't work in stop-and-go traffic; It is distracting; I don't need/want it; Other - please explain

## 788 [If Q15 = No OR (Q15 = Yes AND Q18 = No OR Not sure)]

- 789 Some vehicles are equipped with advanced driver assistance systems that can control some of the driving
- tasks for you. The questions throughout the rest of the survey will focus on your experience with and
- understanding of two of these systems: Adaptive Cruise Control (ACC) and Lane Keeping Assist (LKA).
- 792 In some vehicles, ACC and LKA are part of one combined system, whereas in other vehicles, ACC and
- LKA are separate systems. Here we will describe each system separately. If you have experience using a
- 794 combined version of ACC and LKA, when answering a question about ACC or LKA, please think about 795 only that aspect of the system.
- 796

## 797 Adaptive Cruise Control (ACC)

- 798 This system is designed to control the speed of the vehicle, like normal cruise control, but also 799 automatically slows down and speeds up based on the behavior of the vehicle ahead.
- 800
- 801 Different automotive manufacturers have different names for this technology and in some vehicles, ACC
- 802 is combined with other advanced driver assistance systems (like LKA, which will be described later).
- 803 Throughout the rest of the survey we will use the term ACC to refer to any advanced driver assistance
- 804 system (or component of a system) that fits the description above.
- 805

# Q25. Have you ever used ACC?

Yes; No; Not sure [Exclude if Yes]

#### 806 807 [If Q15 = Yes]

## 808 Lane Keeping Assist (LKA)

- 809 This system is designed to automatically steer the vehicle to stay within the current lane. Some systems
- 810 steer the vehicle once it begins to approach the lane boundary while others steer continuously to keep the 811 vehicle in the center of the lane.
- 812
- 813 Different automotive manufacturers have different names for this technology and in some vehicles, ACC
- and LKA are combined. Throughout the rest of the survey we will use the term LKA to refer to any
- advanced driver assistance system (or component of a system) that fits the description above.
- 816

# Q26. To the best of your knowledge, does your current vehicle have LKA?

Yes; No; Not sure

# [If Q26 = Yes]

# Q27. How does your vehicle's LKA system work?

It steers the vehicle once it begins to approach the lane boundary; It steers continuously to keep the vehicle in the center of the lane; Not sure

### [If Q26 = Yes]

## Q28. Is this the first vehicle you have owned that has an LKA system?

Yes; No; Not sure

# [If Q26 = Yes]

# Q29. When driving on a highway or interstate, how often do you use the LKA in your vehicle?

Almost every time; Most of the time; Sometimes; Rarely; Never

817

### [If 29 = Never]

Q30. You indicated that you do not use the LKA system in your vehicle when driving on the <u>highway or interstate</u>. Please check all that apply to indicate why you do not use the technology when driving on the <u>highway or interstate</u>.

I don't understand it; I don't trust it; I think it is dangerous; It makes me nervous/anxious; It is annoying; It doesn't work on the highway/interstate; It is distracting; I don't need/want it; Other - please explain

#### [If Q26 = Yes]

Q31. When driving in <u>stop-and-go traffic</u>, like in-town driving or heavy traffic on highways, how often do you use the LKA in your vehicle?

Almost every time; Most of the time; Sometimes; Rarely; Never

#### [If Q31 = Never]

Q32. You indicated that you do not use the LKA system in your vehicle when driving in <u>stop-and-go traffic</u>, like in-town driving or heavy traffic on highways. Please check all that apply to indicate why you do not use the technology when driving in <u>stop-and-go traffic</u>.

I don't understand it; I don't trust it; I think it is dangerous; It makes me nervous/anxious; It is annoying; It doesn't work on the highway/interstate; It is distracting; I don't need/want it; Other - please explain

## 819

## 820 [If Q15 = No OR (Q15 = Yes AND Q26 = No OR Not sure)]

#### 821 Lane Keeping Assist (LKA)

822 This system is designed to automatically steer the vehicle to stay within the current lane. Some systems

823 steer the vehicle once it begins to approach the lane boundary while others steer continuously to keep the 824 vehicle in the center of the lane.

825

Bifferent automotive manufacturers have different names for this technology and in some vehicles, ACC
and LKA are combined. Throughout the rest of the survey we will use the term LKA to refer to any
advanced driver assistance system (or component of a system) that fits the description above.

## 829

## Q33. Have you ever used LKA?

Yes; No; Not sure [Exclude if Yes]

[If (Q21 = Almost every time OR Most of the time OR Sometimes OR Rarely) AND (Q29 = Almost every time OR Most of the time OR Sometimes OR Rarely)]

Q34. When driving on a <u>highway or interstate</u>, how often do you use both the ACC and LKA at the same time in your vehicle?

Almost every time; Most of the time; Sometimes; Rarely; Never

### [If Q34 = Never]

Q35. You indicated that you have used the ACC and LKA systems in your vehicle separately when driving on the <u>highway or interstate</u>, but that you have never used the ACC and LKA system at the same time in your vehicle when driving on the <u>highway or interstate</u>. Please check all that apply to indicate why you have not used the technology at the same time when driving on the <u>highway or interstate</u>.

I don't understand it; I don't trust it; I think it is dangerous; It makes me nervous/anxious; It is annoying; It doesn't work on the highway/interstate; It is distracting; I don't need/want it; Other - please explain

[If (Q23 = Almost every time OR Most of the time OR Sometimes OR Rarely) AND (Q31 = Almost every time OR Most of the time OR Sometimes OR Rarely)]

Q36. When driving in <u>stop-and-go traffic</u>, how often do you use both the ACC and LKA at the same time in your vehicle?

Almost every time; Most of the time; Sometimes; Rarely; Never

#### [If Q36 = Never]

Q37. You indicated that you have used the ACC and LKA systems in your vehicle separately when driving in <u>stop-and-go traffic</u>, like in-town driving or heavy traffic on highways, but that you have never used the ACC and LKA system at the same time in your vehicle when driving in <u>stop-and-go traffic</u>. Please check all that apply to indicate why you have not used the technology at the same time when driving in <u>stop-and-go traffic</u>.

I don't understand it; I don't trust it; I think it is dangerous; It makes me nervous/anxious; It is annoying; It doesn't work on the highway/interstate; It is distracting; I don't need/want it; Other - please explain

#### [If Q18 = Yes OR Q26 = Yes]

Q38a. How did you learn about the advanced driver assistance systems in your vehicle? Check all that apply.

Read the vehicle manual; Asked sales staff at the dealership for information; Staff at the dealership offered information (you did not specifically ask); Asked a friend or family member for information; Friends or family were talking about advanced driver assistance systems (you did not specifically ask); Looked for information on the internet; Searched for online videos; Saw a video or commercial by chance; Drove the vehicle to learn by trial-and-error; Observed the advanced driver assistance systems as a passenger; Other - please specify; None of the above

#### [Each item from Q38a displayed]

Q38b. How much did information from each source contribute to your understanding of the advanced driver assistance systems in your vehicle? [Rated for each item]

Not at all 1 - 2 - 3 - 4 - 5 - 6 - 7 A lot

## 832 Past/Preferred Learning about ADAS

[If (Q25 = No OR Not sure) AND (Q33 = No or Not sure)]

Q39. How much do you know about advanced driver assistance systems?

### A lot; A little bit; Nothing

#### [If Q39 = A lot OR A little bit]

#### Q40a. How did you learn about advanced driver assistance systems? Check all that apply.

Read the vehicle manual; Asked sales staff at the dealership for information; Sales staff at the dealership offered information (you did not specifically ask); Asked a friend or family member for information; Friends or family were talking about advanced driver assistance systems (you did not specifically ask); Looked for information on the internet; Searched for online videos; Saw a video or commercial by chance; Observed the advanced driver assistance systems as a passenger; Other - please specify; None of the above

[Each item from Q38a displayed]

Q40b. How much did information from each source contribute to your understanding of the advanced driver assistance systems in your vehicle? [Rated for each item]

Not at all 1 - 2 - 3 - 4 - 5 - 6 - 7 A lot

## 833

# Q41. How would you prefer to learn about advanced driver assistance systems? Select up to three answers.

Reading the vehicle manual; Learning by trial-and-error (driving the vehicle); From staff at the dealership, or car rental staff; Asking a friend or family member; Reading information on websites; Watching online videos; The car teaches you (for example, a tutorial on your dashboard or infotainment system); Other - please specify

#### 834

#### Q42. Understanding advanced driver assistance technology is:

Very difficult 1 - 2 - 3 - 4 - 5 - 6 - 7 Very easy

Q43. Do you think your understanding of ACC is correct?

Not at all correct 1 - 2 - 3 - 4 - 5 - 6 - 7 Fully correct

Q44. Do you think your understanding of ACC is complete?

Not at all complete 1 - 2 - 3 - 4 - 5 - 6 - 7 Fully complete

Q45. Do you think your understanding of LKA is correct?

Not at all correct 1 - 2 - 3 - 4 - 5 - 6 - 7 Fully correct

## Q46. Do you think your understanding of LKA is complete?

Not at all complete 1 - 2 - 3 - 4 - 5 - 6 - 7 Fully complete

## 836 ACC Knowledge Questionnaire

rt 1	Owners	<b>Is the following statement about ACC true <u>for your vehicle</u>?</b> Yes; No; I don't know <b>Please rate your confidence in this response</b> 1 = Very low confidence to 7 = Full confidence, or NA if they answered I don't know
Pai	Non-owners	<b>Is the following statement about ACC true <u>for any system</u>?</b> Yes; No; I don't know <b>Please rate your confidence in this response</b> 1 = Very low confidence to 7 = Full confidence, or NA if they answered I don't know

Maintains a predetermined speed in an empty lane; Keeps a set distance to vehicles driving ahead in the same lane at a slower speed; Has full braking power; Allows you to choose how closely you would like to follow the vehicle ahead; Adjusts the speed to slower vehicles ahead; Works at very low speeds (under 30 km/h or 19 mph); Activates the brake lights when braking to slow the vehicle; Allows you to drive faster than the set speed by pressing the accelerator (gas) pedal; Can slow down to a complete stop; Can be deactivated by pressing the brake pedal; Returns to the predetermined speed after manually pressing the accelerator (gas) pedal; Can only be activated when Lane Keeping Assist is also active; Can be deactivated by turning the steering wheel; Alerts you when you are looking away from the road for too long; Deactivates if you look away from the road for an extended period of time; Alerts you when you have your hands off the wheel or do not steer for an extended period of time; Warns when exceeding the current speed limit; Warns in case you need to intervene; Reacts to traffic lights and/or signs; Reacts to oncoming traffic; Adjusts speed before bends

t 2	Owners	<b>Do you think the ACC</b> <u>in your vehicle</u> might have difficulty in this situation? Yes; No; I don't know <b>Please rate your confidence in this response</b> 1 = Very low confidence to 7 = Full confidence, NA if they answered I don't know
Par	Non-owners	<ul> <li>Do you think any ACC system might have difficulty in this situation?</li> <li>Yes; No; I don't know</li> <li>Please rate your confidence in this response</li> <li>1 = Very low confidence to 7 = Full confidence, NA if they answered I don't know</li> </ul>

Dirty or blocked vehicle sensors; Curvy roads; Construction zones; Approaching pedestrians or cyclists in the same lane; Vehicle cutting-in ahead of you; Approaching a very slow-moving vehicle ahead in the same lane; Approaching a stationary vehicle in the same lane; Approaching a motorcycle in the same lane; Vehicle ahead brakes suddenly; Hills; Very narrow lane; Very wide lane; City streets; Lane markings are faded or missing; Highways/freeways; Unpaved roads; Road merges or diverges (for example, entrance or exit ramps); Approaching a vehicle partially in the lane ahead; Heavy traffic; Approaching cross traffic; When the front and rear of the vehicle are not level (for example, due to heavy weight in the trunk); Road is wet due to rain or puddles; Extremely hot or cold weather; Poor weather (for example, heavy rain, snow, fog, etc.); Road is covered in snow, sand, etc.; Glare on the road surface (for example, from the sun); Glare towards the driver (for example, from the sun or oncoming vehicle headlights); GPS data is unavailable

Note: Items in each part were randomized

# 838 ACC Trust

837

**Please rate your overall agreement with the following statements regarding ACC** Strongly disagree – Disagree – Neutral (neither agree nor disagree) – Agree – Strongly Agree

I am confident in the system; The system is dependable; The system is reliable; I can trust the system; I am familiar with the system

## 839 LKA Knowledge Questionnaire

<b>t 1</b>	Owners	<b>Is the following statement about LKA true <u>for your vehicle</u>?</b> Yes; No; I don't know <b>Please rate your confidence in this response</b> 1 = Very low confidence to 7 = Full confidence, or NA if they answered I don't know
Раг	Non-owners	Is the following statement about LKA true <u>for any system</u> ? Yes; No; I don't know <b>Please rate your confidence in this response</b> 1 = Very low confidence to 7 = Full confidence, or NA if they answered I don't know

Changes lanes automatically; Steers automatically; Works at low speeds (for example, below 60 km/h or 35mph); Works at high speeds (for example, above 60 km/h or 35 mph); Allows you to choose how abruptly you would like the vehicle to steer; Does not allow you to manually steer the vehicle; Warns in case you need to intervene; Executes evasive steering manoeuvres; Deactivates if your turn signal is on; Deactivates if you are pressing the gas pedal; Can be deactivated by pressing the brake pedal; Can only be activated when Adaptive Cruise Control is also active; Can be deactivated by turning the steering wheel; Deactivates if you look away from the road for an extended period of time; Deactivates if you have your hands off the wheel or do not steer for an extended period of time; Alerts you when you are looking away from the road for too long; Alerts you when you have your hands off the wheel or do not steer for too long

t 2	Owners	<ul> <li>Do you think the LKA in your vehicle might have difficulty in this situation?</li> <li>Yes; No; I don't know</li> <li>Please rate your confidence in this response</li> <li>1 = Very low confidence to 7 = Full confidence, NA if they answered I don't know</li> </ul>
Par	Non-owners	<ul> <li>Do you think <u>any LKA system</u> might have difficulty in this situation?</li> <li>Yes; No; I don't know</li> <li>Please rate your confidence in this response</li> <li>1 = Very low confidence to 7 = Full confidence, NA if they answered I don't know</li> </ul>

Curvy roads; Highways/freeways; City streets; Construction zones; Hills; Unpaved roads; Lane markings are faded or missing; Road merges or diverges (for example, entrance or exit ramps); Very narrow lane; Very wide lane; Heavy traffic; Dirty or blocked vehicle sensors; When the front and rear of the vehicle are not level (for example, due to heavy weight in the trunk); Poor weather (for example, heavy rain, snow, fog, etc.); Road is wet due to rain or puddles; Road is covered in snow, sand, etc.; GPS data is unavailable; Extremely hot or cold weather; Glare on the road surface (for example, from the sun); Glare towards the driver (for example, from the sun or oncoming vehicle headlights); Driving through a tunnel

Note: Items in each part were randomized

# 840

# 841 <u>LKA Trust</u>

**Please rate your overall agreement with the following statements regarding LKA** Strongly disagree – Disagree – Neutral (neither agree nor disagree) – Agree – Strongly Agree

I am confident in the system; The system is dependable; The system is reliable; I can trust the system; I am familiar with the system

## 843 APPENDIX B: Reliance Intention Items from Follow-up Survey

**If you were driving with <u>NO advanced driver assistance systems</u> (that is, you are in control of all aspects of driving), <u>how likely</u> would you be to do the following things? Not at all likely – Slightly likely – Moderately likely – Very likely – Extremely likely** 

Manually text on a smartphone; Text using a voice control system (for example, Siri, Apple CarPlay, Android Auto); Manually make phone calls using a smartphone; Make phone calls using voice control (for example, Siri, Apple CarPlay, Android Auto); Manually send e-mails using your smartphone; Use social media; Browse the internet; Watch a video; Read something on a device (for example, smartphone, tablet); Read something not on a device (for example, book, newspaper); Talk to passengers; Eat; Sleep

If you were driving with <u>NO advanced driver assistance systems</u> (that is, you are in control of all aspects of driving), <u>how confident</u> would you be in your ability to do the following things without significantly affecting your driving?

Not at all confident - Slightly confident - Moderately confident - Very confident - Fully confident

Same list as the first item in Appendix B.

#### 844

If you were driving with <u>NO advanced driver assistance systems</u> (that is, you are in control of all **aspects of driving**), <u>how safe</u> would you feel if you were to do the following things? Not at all safe – Slightly safe – Moderately safe – Very safe – Fully safe

Same list as the first item in Appendix B.

## 845

**If you were driving with ONLY ACC engaged, how likely would you be to do the following things?** Not at all likely – Slightly likely – Moderately likely – Very likely – Extremely likely

Same list as the first item in Appendix B.

#### 846

If you were driving with <u>ONLY ACC engaged</u>, <u>how safe</u> would you feel if you were to do the following things?

Not at all safe - Slightly safe - Moderately safe - Very safe - Fully safe

Same list as the first item in Appendix B.

#### 847

**If you were driving with** <u>ONLY LKA engaged</u>, <u>how likely</u> would you be to do the following things? Not at all likely – Slightly likely – Moderately likely – Very likely – Extremely likely

Same list as the first item in Appendix B.

# 848

# If you were driving with <u>ONLY LKA engaged</u>, <u>how safe</u> would you feel if you were to do the following things?

Not at all safe - Slightly safe - Moderately safe - Very safe - Fully safe

Same list as the first item in Appendix B.

849

# If you were driving with <u>BOTH ACC and LKA engaged</u>, <u>how likely</u> would you be to do the following things?

Not at all likely - Slightly likely - Moderately likely - Very likely - Extremely likely

Same list as the first item in Appendix B.

#### 850

Are there any other tasks that were not listed above that you would be more likely to engage in while using both ACC and LKA than if you were driving with no advanced driver assistance systems? (Optional)

[Text entry field]

851

# If you were driving with <u>BOTH ACC and LKA engaged</u>, <u>how safe</u> would you feel if you were to do the following things?

Not at all safe - Slightly safe - Moderately safe - Very safe - Fully safe

Same list as the first item in Appendix B.

## 852

Are there any other tasks that were not listed above that you would feel more safe performing while using both ACC and LKA than if you were driving with no advanced driver assistance systems? (Optional)

[Text entry field]

- 854
- 855

# 856 APPENDIX C: ADAS Owner Vehicles

# Table C.1

Vehicles owned by ADAS owners

Vehicle Make	Number of Owners	Percent of Owners
Acura	2	2%
Audi	1	1%
BMW	7	7%
Cadillac	1	1%
Chevrolet	2	2%
Ford	4	4%
Honda	14	14%
Hyundai	4	4%
Infiniti	1	1%
Jeep	2	2%
Kia	3	3%
Lexus	5	5%
Lincoln	1	1%
Mazda	3	3%
Mercedes Benz	3	3%
Nissan	3	3%
Subaru	4	4%
Tesla	2	2%
Toyota	34	33%
Volkswagen	3	3%
Volvo	3	3%
Fotal	102	