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Key factors associated with Australian parents' willingness to use an automated vehicle to transport their unaccompanied children

Sjaan Koppel^{1*}, Yi-Ching Lee², Jessica Hafetz Mirman³, Sujanie Peiris⁴ and Patrice Tremoulet⁵

¹ Monash University Accident Research Centre, Monash University, AUSTRALIA; sjaan.koppel@monash.edu

² Department of Psychology, George Mason University, UNITED STATES; ylee65@gmu.edu

³ Department of Clinical and Health Psychology, School of Health in Social Science, University of Edinburgh, UNITED KINGDOM; jessica.hafetz@ed.ac.uk

⁴ Monash University Accident Research Centre, Monash University, AUSTRALIA; sujanie.peiris@monash.edu

⁵ Department of Psychology, Rowan University, New Jersey & Center for Injury Research and Prevention, Children's Hospital of Philadelphia, Pennsylvania, UNITED STATES; tremoulet@rowan.edu

* Corresponding author: sjaan.koppel@monash.edu

Abstract: This study aimed to identify the key factors associated with Australian parents' willingness to use an automated vehicle to transport their unaccompanied child(ren). Seven hundred and seventy-five participants completed the online survey (M=40.7 years, SD=8.9 years, Range=18.0-65.0 years; Female: 56.4%). Most participants reported that they would 'never' use an automated vehicle to transport their unaccompanied child(ren) (43.5%). The results of a logistic regression model showed that participants' age, gender, level of education, propensity for technology adoption, aberrant driving behaviours, awareness of advanced driver assistance safety (ADAS) technologies, perceived knowledge regarding automated vehicles, as well their requirements for assurance-related vehicle features were significantly associated with their willingness to use an automated vehicle to transport their unaccompanied child(ren), $\chi^2(12)=137.41$, $p<0.001$. Overall, the findings suggest that Australian parents are mostly unwilling to use an automated vehicle to transport their unaccompanied child(ren) unless various reassurance features and technologies (i.e., microphones, camera, ability to summon assistance if the vehicle breaks down) are embedded in the vehicle. Therefore, automated vehicle manufacturers are encouraged to consider these requirements when prototyping their designs so that all user groups, including child occupants, can benefit from the impending arrival of automated technologies.

Keywords: Automated vehicle; Parents; Child occupant mobility; Child restraint systems; Vulnerable road user; Road safety

1. Introduction

Automated vehicles will reshape vehicle and road use, including how road users interact with vehicles and their expectations associated with vehicle safety. In preparation for driverless technologies, researchers have investigated the trust that humans have in automated systems (Abraham et al., 2016; Choi & Ji, 2015; Davis, 2019; Garcia, Kreutzer, Badillo-Urquiola, & Mouloua, 2015; Kaur & Rampersad, 2018; Saleh, Hossny, & Nahavandi, 2017; Yan, Xu, & Liu, 2016). These studies have shown that potential users place various levels of trust in automated systems and that different aspects of the technology are scrutinised. Vehicle safety, technology failure, distrust of the connectedness of the technology, and legal liability are often cited as the sources of hesitation associated with trusting a system that can function completely free of human input (Bansal, Kockelman, & Singh, 2016; Haboucha, Ishaq, & Shiftan, 2017; Kyriakidis, Happee, & de Winter, 2015).

Automated vehicles also have the potential to provide access to personal transport for those who cannot currently hold a driver's licence, including ageing adults, adults with medical conditions and/or with physical or cognitive impairments, and children (Koppel et al., 2019). While the potential to use

49 automated vehicles to enhance the mobility of ageing adults and adults with physical or cognitive
50 impairments has been studied to some extent (Abraham et al., 2017; Bradshaw-Martin & Easton,
51 2014; Li, Blythe, Guo, & Namdeo, 2019; Musselwhite, Holland, & Walker, 2015; Reimer, 2014;
52 Souders & Charness, 2016; Yang & Coughlin, 2014), limited research has been conducted that has
53 specifically explored the willingness of parents or legal guardians to use automated vehicles to
54 transport their child(ren) (Lee, Hand, & Lilly, 2020; Lee & Mirman, 2018; Tremoulet et al., 2020). Such
55 research is important because automated vehicles represent an opportunity to enhance independent
56 mobility for children, but also raises questions regarding parents' willingness to trust a driverless
57 system (Haboucha et al., 2017).

58 One of the earliest studies to explore the use of automated vehicles to enhance children's
59 mobility was conducted by Lee and Mirman (2018). With the intent to understand transporting children
60 as a use scenario (Kyriakidis et al., 2015), the authors analysed the perceived benefits and concerns
61 associated with automated vehicles with a convenience sample of participants in the United States
62 whose children relied on their parents or caregivers for mobility. Using an online survey, the authors
63 investigated parents' appraisals and attitudes toward automated vehicles (in general and when
64 transporting children). Results indicated that several factors were important determinants of potential
65 automated vehicle acceptance and impact, including parents' intentions to travel, their technology
66 readiness, parent gender, area of residence, child age, and the requirement for children to use a
67 restraint system. Parents' primary concerns were about losing active vehicle control from within and
68 when interacting with other vehicles and the child being alone in the automated vehicle. Interestingly,
69 the authors reported that male participants, in general, perceived the benefits of an automated vehicle
70 to transport children to be higher than female participants, although they had different concerns.

71 In a subsequent study, Hand and Lee (2018) explored participants' willingness to use an
72 automated vehicle to transport their unaccompanied child(ren) by gender and parental status. The
73 authors reported that 42.0 percent of participants reported that they would 'never' use an automated
74 vehicle to transport their unaccompanied child. In comparison, 7.0 percent reported that they would
75 'definitely' use the technology for this purpose (with remaining participants being less decisive). This
76 finding was consistent with previous data reported by Haboucha and colleagues (2017), who reported
77 that only 13 percent of participants would be willing to have an empty automated vehicle pick their
78 child up from school. In addition, the authors reported that males were significantly more willing to
79 use an automated vehicle to transport their child(ren) than females (e.g., 11% of males reported
80 'definitely' compared to 3% females). This finding was in line with previous studies that found males
81 to be typically more accepting of the technology than females (Haboucha et al., 2017; Hohenberger,
82 Spörrle, & Welp, 2016; Kyriakidis et al., 2015; Payre, Cestac, & Delhomme, 2014). Hand and Lee
83 (2018) also concluded that parents, as opposed to non-parents, were less inclined to use an
84 automated vehicle to transport their unaccompanied child(ren). This finding was consistent with that
85 reported by Bonnefon and colleagues (2016), who suggested that automated vehicle users are likely
86 to be less concerned about the safety of strangers. Interestingly, Hand and Lee also noted that for
87 participants with children, their unwillingness to use an automated vehicle to transport their
88 unaccompanied child(ren) was positively associated with the number of children in their home. The
89 authors concluded that more research is needed to understand the specific features that parents
90 would like to see in an automated vehicle which would positively influence their decision to use an
91 automated vehicle to transport their unaccompanied child(ren).

92 A recent study attempted to identify the features in automated vehicles that are considered
93 important to improving parents' trust in these vehicles, and how parental or child factors may influence
94 their willingness to use an automated vehicle to transport their unaccompanied child(ren) (Lee et al.,
95 2020). Consistent with the findings from their previous study (Hand & Lee, 2018), the authors reported
96 that participants with lower willingness to use an automated vehicle had more substantial concerns
97 whether the automated vehicle would be able to protect their children. The results from this study also
98 suggested that participants with younger children who used a child restraint system (CRS) were less
99 willing to use an automated vehicle to transport their unaccompanied child(ren). However, adult
100 waiting at destinations, having a camera and microphone within the vehicle improved the perceived
101 safety of a journey in an automated vehicle. The authors also identified that younger participants,
102 male participants, and urban resident participants were more willing to use automated vehicles to
103 transport their unaccompanied child(ren), potentially because they had fewer beliefs or assumptions

104 that prevent them from using automated vehicles. Interestingly, the authors found that the
105 socioeconomic status of participants was not significantly associated with their willingness to use an
106 automated vehicle to transport their unaccompanied child(ren). This finding was inconsistent with the
107 findings of a previous study which found that participants with a higher level of education were more
108 accepting of new technologies (Haboucha et al., 2017).

109 Most recently, Tremoulet and colleagues (2020) attempted to identify factors which impact
110 parents' decisions regarding their willingness to use an automated vehicle to transport their
111 unaccompanied child(ren). Unlike the previous studies which used online surveys, the authors used
112 a driving simulator in an automated mode to demonstrate the concept of automated vehicles, and
113 then interviewed parents regarding their views and the features that would they would require to
114 support their child(ren) in an automated vehicle. The authors concluded that while parents cited
115 convenience as the greatest benefit associated with using an automated vehicle to transport their
116 unaccompanied children, their greatest fear was the fact that the automated vehicle could not protect
117 their child during unplanned trip interruptions. To make the technology appealing for parents, and for
118 them to embrace automated vehicle use for their child(ren), two-way audio communication and video
119 feeds of vehicle interiors, seatbelt checks, automatic locking, secure passenger identification, and
120 remote access to vehicle information would be required. The authors concluded that vehicle
121 manufacturers should incorporate the needs of families when designing automated vehicles from the
122 outset in order to improve parents' likelihood of using this technology to transport their
123 unaccompanied child(ren).

124 Despite these recent studies regarding parents' hesitation and willingness to consider using
125 automated vehicles for mobility purposes, there remain unexplored factors related to the societal and
126 cultural acceptance of this automation technology. For example, these previous studies have not
127 explored whether parents' willingness to use an automated vehicle to transport their child
128 unaccompanied is also related to their willingness to adopt new technologies in their current vehicle
129 (i.e., advanced driving assistance systems [ADAS]), or their willingness to take risks in other travel-
130 related areas of their life (i.e., self-reported driving behaviours). It is important to contextualise child
131 occupant protection behaviours, beliefs and attitudes within the broader sociotechnical milieu in which
132 they occur. Using the concept of behavioural willingness, which is defined as an individual's intention
133 to engage in a target behaviour that varies in risk, given the opportunity to do so (see Pomery,
134 Gibbons, Reis-Bergan, and Gerrard (2009), the current study aimed to extend the previous studies
135 and identify the socio-demographic characteristics, current vehicle technology characteristics, self-
136 reported driving behaviours, and attitudinal factors related to automated vehicles associated with
137 Australian parents' willingness to use an automated vehicle to transport their unaccompanied
138 child(ren).

139 **2. Materials and Methods**

140 *2.1. Participants*

141 Participants were eligible to participate if they: a) were aged 18 years and older; b) were an
142 'active' driver (i.e., drove at least once per week), c) had a least one child (aged 17 years or younger)
143 who currently lives with them, and d) resided in Australia.

144 *2.2. Materials*

145 Participants completed an online survey (approximately 20 minutes) which is described below.

146 *2.2.1. Socio-demographic characteristics*

147 Participants provided information about their: age, sex, marital status, residential state, the
148 highest level of completed education and current annual household income.

149 *2.2.2. Child characteristics*

150 Participants were asked to provide information regarding the number (and the age) of any
151 children that were currently living with them. Participants with more than one child were asked to

152 answer the survey in reference to their youngest child and provide information on: sex, the frequency
153 with which this child travels in a motor vehicle when the participant is the driver (where: 1=Daily; 5=<
154 once per week), the type of restraint that the child uses most often when the participant is the driver
155 (i.e., rearward-facing child restraint, forward-facing child restraint, booster seat, seatbelt, no restraint),
156 the frequency that the child uses their restraint when the participant is the driver (where: 1=Always;
157 6=Never), and the location that the child sits within the motor vehicle when the participant is the driver
158 (e.g., front passenger seat, rear seat, etc.).

159 2.2.3. Driving, licensing and vehicle technology characteristics

160 Participants provided information on their licensing history, vehicle characteristics (i.e., make,
161 model, year of manufacture), whether their vehicle has any ADAS technology based on a list of ADAS
162 technologies identified, safety rating [based on Used Car Safety Ratings which reflect the real-world
163 crash performance of vehicles as they interact in the fleet (Newstead, Watson, & Cameron, 2016)],
164 annual mileage, frequency of driving (where: 1=Daily; 5=<once per week), previous crash
165 involvement and/or driving infringements, and frequency of wearing their seatbelt while travelling in a
166 motor vehicle (where: 1=Always, 6=Never).

167 2.2.4. Driving behaviours

168 Driving behaviour was measured using the Driving Behaviour Questionnaire (DBQ) (Reason,
169 Manstead, Stradling, Baxter, & Campbell, 1990). A standard version of the DBQ contains 28-items
170 which relate to four broad types of dangerous driving behaviours: 1) violations, 2) aggressive
171 violations, 3) errors and 4) lapses (Lawton, Parker, Stradling, & Manstead, 1997; Stephens &
172 Fitzharris, 2016). These behaviours have been associated with increased crash risk (Parker, Reason,
173 Manstead, & Stradling, 1995). Within the DBQ, participants are asked to consider each item and
174 indicate how frequently they have engaged in each behaviour while driving on a six-point Likert
175 response scale (where: 0=Never, 5=Always). Higher scores represent higher levels of aberrant
176 driving behaviours. The DBQ has good internal consistency (Composite reliabilities ranging from 0.79
177 to 0.89) (Stephens & Fitzharris, 2016).

178 2.2.5. Technology readiness

179 Technology readiness was measured using the Technology Readiness Index 2.0 (TRI 2.0)
180 (Parasuraman & Colby, 2015). The TRI 2.0 contains 16-items which relate to participants' propensity
181 for technology adoption across four dimensions: 1) optimism, 2) innovativeness, 3) discomfort, and
182 4) insecurity. Within the TRI 2.0, participants are asked to consider each item related to technology
183 and indicate their level of agreement on a five-point Likert response scale (where: 1=Strongly
184 Disagree, 5=Strongly Agree). Higher scores represent a higher propensity for participants to embrace
185 and use cutting-edge technologies. The TRI 2.0 has good internal consistency (Composite reliabilities
186 ranging from 0.70 to 0.83) (Parasuraman & Colby, 2015).

187 2.2.6. Perceived knowledge about automated vehicles

188 Participants were asked several questions about their level of familiarity with automated vehicles.
189 For example, they were asked if they had ever heard of the term 'automated vehicle' (e.g., Yes, Not
190 sure, No).

191 Participants were presented with the following information: "Automated vehicles (i.e., Level 5 —
192 Full Automation (Society of Automotive Engineers, 2018)) are currently being designed and produced
193 and will potentially be available in the market in the near future. These vehicles are programmed to
194 drive themselves and do not require any steering, accelerating, and braking from the vehicle
195 occupant(s). The only input required from the vehicle occupant(s) is the destination." Participants
196 were then asked to indicate the year that they predicted that automated vehicles would be fully
197 integrated into modern roadways.

198 2.2.6. Willingness to use an automated vehicle to transport their unaccompanied child(ren)

199 The construct of behavioural willingness has been successfully leveraged to understand
200 caregivers' willingness to use an automated vehicle to transport their child unaccompanied in prior
201 research (Lee & Mirman, 2018). In keeping with prior research on behavioural willingness in an ADAS
202 context, participants' willingness to use an automated vehicle to transport their child(ren) without
203 another adult in the vehicle was rated on a four-point Likert response scale (where 1=I would never;
204 2=I would be hesitant; 3=I might; 4=I would definitely) (Lee & Mirman, 2018). This variable was the
205 outcome measure of interest and is described in more detail in the Data Analysis section below.

206 2.2.7. Importance of automated vehicle features for transporting their unaccompanied child(ren)

207 The importance of automated vehicle features for transporting their unaccompanied children was
208 measured using the Importance of Automated Vehicle Features scale (Lee et al., 2020). Twenty-six
209 features were included which related to four categories, including route control (i.e., ability to control
210 the destination of the vehicle, GPS tracking to know where the vehicle is at all times), assurance (i.e.,
211 a camera and/or microphone in the vehicle to see/hear your child in the vehicle, ability to summon
212 assistance if the vehicle breaks down), safety (i.e., ability to guarantee that your child is safely
213 restrained, the ability for your child to be released from the vehicle in the case of an emergency) and
214 comfort (i.e., the ability to control the entertainment provided to your child in the vehicle). Within the
215 scale, participants were asked to consider each item and rate the importance of these features on a
216 four-point Likert response scale (where: 1=Unnecessary to have; 2=Like to have; 3=Important to
217 have; 4=Required to have).

218 2.3. Procedure

219 The study was approved by the Monash University Human Research Ethics Committee
220 (MUHREC ID 23197). Participants were recruited through a range of online and social media
221 advertising; including the MUARC Facebook page and Twitter feed, the Monash University Insider
222 newsletter etc. The advertising directed participants to an online survey link. In order to improve
223 recruitment, participants who completed the online survey were able to opt into a draw to win one of
224 five \$100 gift vouchers. The online survey was administered from February–March 2020, which was
225 before the COVID19 lockdown in Australia.

226 2.4. Data Analysis

227 Prior to the analyses, the data were screened: 1) participants with missing data were excluded;
228 2) participants with data that were identified as extreme outliers for continuous variables (i.e., more
229 than three standard deviations from the mean) were excluded; and 3) participants who provided
230 nonsensical responses to the free-text questions were also excluded.

231 The outcome measure of interest was the participants' willingness to use an automated vehicle
232 to transport their unaccompanied child. As shown in Table 1, most participants reported that they
233 would 'never' use an automated vehicle to transport their child without another adult in the vehicle
234 (43.5%) (see Table 1).

235 Given the large number of participants who reported that they would 'never' use an automated
236 vehicle to transport their unaccompanied child, the response to this question was dichotomised to
237 reflect lower willingness ('never', n=337, 43.5%) and relatively higher willingness ('definitely', 'might',
238 'hesitant', n=438, 56.5%).

239 Descriptive statistical analyses were conducted to describe the sample. A series of Mann-
240 Whitney U tests and chi-squares analyses were conducted explore the socio-demographic
241 characteristics, driving and licensing factors, as well as attitudes towards automated vehicles that
242 may be associated with parents' willingness to use an automated vehicle to transport their
243 unaccompanied child(ren).

244 To determine the key variables associated with participants' willingness to use an automated
245 vehicle to transport their unaccompanied child, a logistic regression model was conducted following
246 an exploratory method of model building outlined by Hosmer and Lemeshow (2000) (i.e., there were
247 no priori predictions about the strength or direction of the associations). Specifically, a series of
248 univariate logistic regression models were conducted with participants' willingness to use an
249 automated vehicle to transport their unaccompanied child as the dichotomous outcome variable.

250 Predictor variables with a statistical significance value of $p=0.25$ were included in the model,
251 recognising that while a particular variable may not be highly predictive in the univariate sense, it may
252 influence or moderate the effect of another variable. Variables that were not significant at the $p\leq 0.05$
253 level were progressively removed from the model unless they altered the B-coefficient by more than
254 20 percent, whereupon they were deemed confounders and reinserted back into the model (Hosmer,
255 Lemeshow, & Sturdivant, 2013).

256 All statistical analyses were conducted using IBM SPSS v. 26.

257 **3. Results**

258 The findings for this study are presented in three main sections: 1) Participants' socio-
259 demographic characteristics and characteristics of their youngest child; 2) Participants' driving and
260 licensing history, their self-reported driving behaviours, propensity for technology adoption, and
261 attitudes towards automated vehicles, and 3) The identification of the key factors associated with
262 participants' willingness to use an automated vehicle to transport their unaccompanied child(ren).

263 *3.1. Participants' socio-demographic characteristics*

264 Seven hundred and seventy-five participants completed the online survey. Table 2 shows that
265 most participants were aged between 35 and 44 years (41.2%; $M=40.7$ years, $SD=8.9$, $Range=18.0-$
266 65.0 years); were female (56.4%); were in a married/defacto relationship (80.5%); had completed an
267 undergraduate or postgraduate university degree (26.7%, 25.3%, respectively); lived in the Australian
268 state of Victoria (41.9%), and had a yearly household income (\$AUD) of between \$75,001-100,000
269 or \$100,001-\$125,000 before tax (14.2%, 14.1% respectively).

270 As shown in Table 2, participants' age, sex, education level, and yearly household income were
271 all significantly associated with their willingness to use an automated vehicle to transport their
272 unaccompanied child.

273 *3.2. Child characteristics*

274 Most participants reported that they had one or two children currently living with them (1: 42.7%;
275 2: 36.9%; 3: 13.4%; 4: 5.8%; 5: 0.8%; 6: 0.4%). The average age of participants' youngest child was
276 7.8 years ($SD=5.2$, $Range=0.0-17.0$ years). Most of the youngest children were male (53.5%); travel
277 in the vehicle with the parent on a daily basis (39.5%), is restrained by a seatbelt (51.1%), were
278 'always' restrained (93.5%), and were seated in the rear seat (2nd or 3rd row) of the vehicle (72.1%)
279 (see Table 3). Participants who reported that their youngest child was aged eight years and older and
280 using a booster seat or seatbelt tended to be more willing to use an automated vehicle to transport
281 their unaccompanied child ($p>0.05$, Table 3). Only these two child characteristics showed a positive
282 association with parent willingness to use an automated vehicle for transporting a child
283 unaccompanied.

284 *3.3. Driving and licensing characteristics*

285 All participants were current drivers (i.e. held a valid driver's licence) with 84.3% ($n=653$) of the
286 cohort having no licence conditions or restrictions. Most participants first obtained their driver's licence
287 at the age of 18.0 years ($Q1=17.0$, $Q3=20.0$). Over 70% of participants reported that they drove
288 daily (70.1%), had driven between 10,001 and 15,000 km in their vehicle over the past year (27.6%),
289 'always' wore their seatbelt while driving or travelling in a vehicle (96.3%) and were driving a 5-star
290 rated vehicle (40.9%), see Table 4. Over the past two years, most participants reported that they had
291 not been involved in a motor vehicle crash (84.0%) or an at-fault crash (92.6%), had not been cited
292 for failing to stop (97.0%), speeding (84.6%), or other driving offences such as using a mobile phone
293 illegally while driving (96.5%).

294 No driving characteristics were significantly associated with participants' willingness to use an
295 automated vehicle to transport their unaccompanied child (Table 4).

296 Participants were asked whether they were aware (i.e. yes or no) of 17 Advanced Driver
297 Assistance Systems (ADAS), Figure 1. If they acknowledged being aware of the ADAS technology,
298 they were then asked if this technology was available in their current vehicle (Yes/No/Not sure).

299 Results demonstrate that participants were most aware of Adaptive Cruise Control (73.4%) and least
300 likely to be aware of Intersection Assistance (30.0%). Participants were most likely to report that they
301 had Electronic Stability Control (62.0%) in their current vehicle and least likely to report that they had
302 an alcohol interlock (9.2%).

303 Participants' awareness of these ADAS technology was significantly associated with their
304 willingness to use an automated vehicle to transport their unaccompanied child. Specifically,
305 participants who indicated that they would be willing to use an automated vehicle to transport their
306 unaccompanied child were aware of significantly more ADAS technologies (Median=10.00, Q1=3.00,
307 Q3=16.00) compared to participants who were less willing to transport their unaccompanied child(ren)
308 (Median=5.00, Q1=1.00, Q3=12.00; U=56803.00, Z=-5.46, p<0.001).

309 *3.4. Driving behaviours*

310 Participants' self-reported aberrant driving behaviours, as measured using the DBQ, are
311 presented in Table 5.

312 As shown in Table 5, participants' self-reported aberrant driving behaviours were significantly
313 associated with their willingness to use an automated vehicle to transport their unaccompanied child.
314 Specifically, participants who reported a higher willingness to use an automated vehicle to transport
315 their unaccompanied child also reported higher levels of errors, lapses and violations.

316 *3.5. Technology Readiness*

317 Participants' self-reported technology readiness, as measured using the TRI 2.0, is presented
318 below in Table 6.

319 Specifically, participants who reported a higher willingness to use an automated vehicle to
320 transport their unaccompanied child were also more likely to have an optimistic view of technology,
321 view it as innovative and secure and have a self-reported propensity for technology adoption (Table
322 6).

323 *3.6. Participants' perceived knowledge and attitudes towards automated vehicles*

324 Most participants reported that they had heard of an automated vehicle (79.0%) (see Table 7).
325 Participants who reported that they had heard of an automated vehicle were then asked to predict
326 the year that automated vehicles would be fully integrated into modern roadways. Most participants
327 noted they were unsure of when this would happen (30.3%).

328 As shown in Table 7, participants' perceived knowledge about automated vehicles was
329 significantly associated with their willingness to use an automated vehicle to transport their
330 unaccompanied child. Participants who reported that they had heard of an automated vehicle and
331 who predicted that automated vehicles were likely to be fully integrated into modern roadways earlier
332 (i.e., by 2039 or earlier) were significantly more likely to report that they would be willing to use an
333 automated vehicle to transport their unaccompanied child.

334 In addition, participants were asked to rate various features of an automated vehicle which they
335 considered important for being able to transport their unaccompanied (i.e., ability to monitor the
336 vehicle, the importance of the restraint system available, ability to communicate with the child, have
337 control over emergency situations, Figure 2).

338 **Figure 2.** Importance of automated vehicle features for transporting unaccompanied children.

339 The automated vehicle feature that was most likely to be 'required' or considered essential by
340 participants if their child was to be transported unaccompanied was the ability for their child to be
341 released from the automated vehicle in case of emergency (71.1%). In comparison, the feature least
342 likely to be 'required' by participants was the ability to control the entertainment provided to their child
343 while in transit (31.1%). Each of these automated vehicle features was then classified into four
344 categories, including route control, assurance, child safety and comfort (see Table 8).

345 As shown in Table 8, features within an automated vehicle which were 'required' by participants
346 for transporting unaccompanied children were significantly associated with their willingness to use an
347 automated vehicle to transport their unaccompanied child. Specifically, participants who reported a

348 higher willingness to use an automated vehicle to transport their unaccompanied child were
349 significantly less likely to require features related to route control, assurance, child safety and comfort.

350 3.7. Key variables associated with participants' willingness to use an automated vehicle to transport 351 their unaccompanied child

352 A logistic regression model was conducted to determine the key variables associated with
353 participants' willingness to use an automated vehicle to transport their unaccompanied child. The final
354 logistic regression model identified several key variables associated with participants' willingness to
355 use an automated vehicle to transport their unaccompanied child, $\chi^2(12)=137.41$, $p<0.001$, with the
356 Hosmer–Lemeshow Goodness-of-fit suggesting good model fit, $p>0.05$. The model explained 23.5
357 percent (Nagelkerke R squared) of the variance in participants' willingness to use an automated
358 vehicle to transport their unaccompanied child. The model correctly classified 70.1 percent of
359 participants, with the ROC curve indicating 'acceptable' discrimination (75.0%) (Hosmer &
360 Lemeshow, 2000).

361 Table 9 presents the odds ratios for key variables associated with participants' willingness to use
362 an automated vehicle to transport their unaccompanied child. Each of these significant predictors is
363 discussed briefly in turn, where participants' willingness (expressed as 'definitely', 'might', 'hesitant')
364 to use an automated vehicle to transport their unaccompanied child is presented as the dichotomous
365 outcome variable (compared to their unwillingness, expressed as 'never', to use automated vehicles
366 to transport their child):

- 367 • Age: For every one year increase in their age, participants' willingness to use an automated
368 vehicle to transport their unaccompanied child significantly increased by 1.022.
- 369 • Gender: Relative to female participants, male participants had 1.701 higher odds of being willing
370 to use an automated vehicle to transport their unaccompanied child.
- 371 • Highest level of completed education: Relative to participants who had completed Primary / High
372 / Technical / Trade school, participants who had completed an Undergraduate or Postgraduate
373 degree had 1.498 higher odds of being willing to use an automated vehicle to transport their
374 unaccompanied child.
- 375 • TRI scores: For every one score increase in their technology readiness, participants' willingness
376 to use an automated vehicle to transport their unaccompanied child significantly increased by a
377 factor of 1.044.
- 378 • DBQ scores: For every one score increase in their aberrant driving behaviours, participants'
379 willingness to use an automated vehicle to transport their unaccompanied child significantly
380 increased by a factor of 1.014.
- 381 • Heard about automated vehicles previously: Relative to participants who reported that they had
382 not heard about (or were not sure they had heard about) automated vehicles, participants who
383 reported that they had heard about automated vehicles had 1.750 higher odds of being willing to
384 use such a vehicle to transport their unaccompanied child.
- 385 • Awareness of ADAS technology: For every one score increase in their awareness of ADAS
386 technology, participants' willingness to use an automated vehicle to transport their
387 unaccompanied child increased by a factor of 1.034.
- 388 • Importance of assurance-related features in automated vehicles: For every one score increase
389 in requiring automated vehicles to have assurance-related features, participants had 10.9
390 percent lower odds of being willing to use an automated vehicle to transport their unaccompanied
391 child
- 392 • Importance of child safety-related features in automated vehicles: For every one score increase
393 in requiring automated vehicles to have child safety-related features, participants' willingness to
394 use an automated vehicle to transport their unaccompanied child increased by a factor of 1.059.

395 4. Discussion

396 Automated vehicles have the potential to enhance the mobility of individuals who have been
397 unable to hold a driver's license, including ageing adults, adults with medical conditions and/or with
398 physical or cognitive impairments, and children (Koppel et al., 2019). However, the extent to which
399 individuals would be willing to use automated vehicles to transport vulnerable road users, including

400 child occupants, has received limited attention. Using the concept of behavioural willingness (see
401 Pomery et al., 2009), the current study aimed to 1) explore Australian parents' willingness to use an
402 automated vehicle to transport their unaccompanied child(ren), and 2) identify whether parents'
403 willingness to use an automated vehicle to transport their unaccompanied child(ren) is related to their
404 socio-demographic characteristics, as well their willingness to adopt new technologies in their current
405 vehicle (i.e., ADAS), or their willingness to take risks in other travel-related areas of their life (i.e., self-
406 reported driving behaviours).

407 In the current study, only 7.7 percent of participants were 'definitely' willing to use an automated
408 vehicle to transport their unaccompanied child, with the majority of participants reporting that they
409 would 'never' use this technology for this purpose (43.5%). These findings are consistent with those
410 reported by Lee and colleagues (2020), who found that approximately seven percent of participants
411 would 'definitely' use an automated vehicle to transport their unaccompanied child(ren). These
412 findings are consistent with research which has reported that there is a lack of trust associated with
413 automated technologies, including automated vehicles, for most individuals (Abraham et al., 2016;
414 Choi & Ji, 2015; Davis, 2019; Garcia et al., 2015; Kaur & Rampersad, 2018; Saleh et al., 2017; Yan
415 et al., 2016). As noted by Lee and colleagues (2020), these responses may reflect the lack of personal
416 experience with automated vehicles and may represent an underestimation of the potential to
417 enhance mobility. It would have been of value to determine if the parents who were unwilling to use
418 AV for their children were generally more protective than those who were more open to the idea of
419 using AVs for the children.

420 The results of the current study demonstrated that several socio-demographic factors were
421 significantly associated with participants' willingness (i.e., 'definitely' / 'might' / 'would be hesitant') to
422 use an automated vehicle to transport their unaccompanied child(ren). The results of the logistic
423 regression model showed that male participants were 1.7 times more likely than female participants
424 to be willing to use an automated vehicle to transport their unaccompanied child(ren). These findings
425 are consistent with that reported by Hand and Lee (2018) who reported male participants were more
426 likely to state that they would 'definitely' use an automated vehicle to transport their child compared
427 to female participants (11.0% vs. 3.0%). The finding that male participants are more accepting of
428 automated vehicles, in general, is well documented. The results from this study further support the
429 researchers who reason that males are typically more interested in, and open to the concept of, using
430 automated vehicles due to their general affective responses towards automotive vehicles (i.e., anxiety
431 and pleasure) compared to females (Abraham et al., 2017; Bansal et al., 2016; Hohenberger et al.,
432 2016; Kyriakidis et al., 2015; Lavieri et al., 2017). In addition, previous research has suggested that
433 females are generally more risk-averse and potentially consider the use of new technologies as being
434 riskier than using conventional transportation modes (Byrnes, Miller, & Schafer, 1999).

435 The findings of the current study also suggest that increasing age was significantly associated
436 with participants' willingness to use an automated vehicle to transport their unaccompanied child(ren).
437 This finding is consistent with that reported by Tremoulet and colleagues (2020) who suggested that
438 older participants may be more willing to use an automated vehicle to transport their unaccompanied
439 child(ren) because they are more likely to have an 'older' youngest child. It should be noted that this
440 finding is inconsistent with the findings of Lee and colleagues (2020). They reported that younger
441 participants were more willing to use automated vehicles to transport their unaccompanied child(ren),
442 possibly because they have fewer concerns about the reliability of automated technologies. However,
443 it should be noted that there is considerable debate within the literature regarding the relationship
444 between age and propensity for technology adoption (Mouloua, Smither, Vincenzi, & Smith, 2002).

445 The findings of the current study also suggest that participants' level of completed education is
446 significantly associated with their willingness to use an automated vehicle to transport their
447 unaccompanied child(ren). Specifically, participants who had completed an Undergraduate or
448 Postgraduate degree were 1.5 times more likely to be willing to use an automated vehicle to transport
449 their unaccompanied child(ren) compared to participants without a degree. This finding is consistent
450 with recent research which has reported that individuals who have completed higher levels of
451 education are more likely to be familiar with the concept of automated vehicles or are more willing to
452 accept new technologies (Bansal et al., 2016; Haboucha et al., 2017; Lavieri et al., 2017; Schoettle
453 & Sivak, 2014; Steck, Kolarova, Bahamonde-Birke, Trommer, & Lenz, 2018). It is also possible that
454 familiarly and exposure to technology during years of education can influence perceptions of new

455 technologies and appear more appealing than to those who have had little exposure to technology
456 through education. However, this finding is inconsistent with that recently reported by Lee and
457 colleagues (2020) who reported that there was no relationship between parents' willingness to use
458 automated vehicles to transport children and their education level.

459 Within the current sample, more than three-quarters of participants (79%) reported that they had
460 previously heard of an automated vehicle. This finding is consistent with that previously reported by
461 other researchers (Lee & Mirman (2018): 81%; Lee et al. (2020): 91%). While this is not surprising
462 given the media attention which automated vehicles have received in recent years, it was found that
463 participants who reported that they had previously heard of an automated vehicle were 1.75 times
464 more likely to be willing to use an automated vehicle to transport their unaccompanied child than
465 participants who reported that they had not heard of (or were not sure) an automated vehicle. In
466 addition, consistent with studies conducted by Lee and colleagues, the findings of the current study
467 suggest that participants' technology readiness is significantly associated with their willingness to use
468 an automated vehicle to transport their unaccompanied child(ren). Specifically, participants who
469 reported a higher willingness to use an automated vehicle to transport their unaccompanied child
470 were also more likely to have higher technology readiness scores (i.e., an optimistic view of
471 technology, and view it as innovative and secure). This finding is consistent with recent research
472 conducted by Lavieri and colleagues (2017), who reported that tech-savvy individuals were more
473 likely to be early adopters of automated vehicle technologies. While Lee and Mirman (2018) found
474 the majority of their study participants noted they were tech-savvy and liked to try new technologies,
475 the authors cautioned that self-reports of technology acceptance might be inflated due to social
476 desirability (Grimm, 2010; Lee & Mirman, 2018).

477 This is the first study to investigate how participants' willingness to use an automated vehicle to
478 transport their unaccompanied child(ren) is related to their willingness to adopt or awareness of other
479 vehicle technologies (i.e., ADAS technologies). The findings from the current study suggest that
480 participants who were aware of more ADAS technologies were significantly more likely to be willing
481 to use an automated vehicle to transport their unaccompanied child. This finding is consistent with
482 recent research which has shown that individuals who are more technology-aware are more willing
483 to consider using it (Lavieri et al., 2017), and that increased exposure to, or knowledge of, systems
484 can increase appreciation and attitudes and decrease concerns (Crump et al., 2016; König &
485 Neumayr, 2017). Given this, is it likely that with increasing exposure to technology, trust in technology
486 will increase over the coming years. Parents are likely to be more open towards using automated
487 vehicles for themselves, and by extension, to transport their children unaccompanied. However, it
488 should be noted that this trust and/or acceptance will only be achieved if the technology is shown to
489 be safe and reliable (Lee, Seppelt, Abraham, Reimer, Fitzgerald, Mehler, & Coughlin, 2018).

490 This is also the first study to investigate the connection between participants' willingness to use
491 an automated vehicle to transport their unaccompanied child(ren) and their willingness to take risks
492 in their driving behaviours (i.e., errors, lapses, violations, aggressive violations). The findings from the
493 current study suggest that participants with higher aberrant driving behaviours were significantly more
494 likely to be willing to use an automated vehicle to transport their unaccompanied child. These findings
495 are consistent with a recent study conducted by Böhm, Kocur, Firat, and Isemann (2017) who
496 reported that participants with more lenient attitudes towards driving violations to have more positive
497 attitudes towards using autonomous vehicles. However, these findings are inconsistent with that
498 reported by Platt (2017), who noted that that confident, aggressive drivers were least likely to
499 surrender control to automated vehicles. However, it should be noted that neither of these studies
500 were related to the use of automated vehicles for transporting their unaccompanied child(ren).

501 In terms of increasing an individual's trust in automated systems, Winikoff (2017) has proposed
502 three necessary prerequisites: 1) a social framework that provides recourse; 2) a system's ability to
503 provide explanations of its behaviour, and 3) verification and validation of the system to provide
504 assurance that the system satisfies key behavioural properties in all situations. Building on this
505 proposition, participants in the current study were asked to rate the features that would be required
506 to be included in an automated vehicle when transporting their unaccompanied child(ren). The feature
507 most likely to be required by participants was the 'ability for their child to be released from the
508 automated vehicle in case of emergency' (71%), and the feature least likely to be required was the
509 'ability to control the entertainment provided to their child while in transit' (31%). In addition, the

510 findings of the current study suggested that participants who require the automated vehicle to have
511 more assurance-related features, as opposed to safety-related features, were significantly less likely
512 to be willing to use an automated vehicle to transport their unaccompanied child. This finding is
513 consistent with the findings of Lee and colleagues (2020) who reported that participants who rated
514 having a designated adult waiting at destinations and having a camera and a microphone in the
515 vehicle as relatively optional (as opposed to required), were associated with an increased willingness
516 to use an automated vehicle to transport their unaccompanied children. Similarly, Tremoulet and
517 colleagues (2020) reported that communication features such as the ability to call or establish a video
518 link with passengers and the ability for emergency contact (based on a provided list) to be notified in
519 the event of an unplanned event, increased their willingness to use an automated vehicle to transport
520 their unaccompanied children.

521 Several limitations should be noted. First, given the large proportion of participants who stated
522 that they would 'never' use an automated vehicle to transport their unaccompanied child(ren), the
523 remaining participants were classified as being willing to use an automated vehicle (i.e., 'definitely' /
524 'might' / 'would be hesitant'). However, it is likely that participants who stated 'definitely' may be
525 different from those who stated 'might' or 'would be hesitant'. Future research will incorporate
526 qualitative methodologies to explore the reasons for stating 'might' and 'would be hesitant'. It is also
527 important to note that the findings from the current study are based on participants' anticipated
528 willingness to use an automated vehicle to transport their unaccompanied child(ren), without having
529 experienced travelling in an automated vehicle in the real world. These attitudes will likely change as
530 increasing levels of automated vehicles become integrated into modern roadways. For example, a
531 recent study by Sims, Matthews, Bopp, Rovniak, and Poole (2018) suggested that individuals can
532 make better predictions about a travel mode once they have experienced it. Similarly, Penmetsa,
533 Hudnall, and Nambisan (2019) recently reported that vulnerable road users who had direct
534 experience interacting with automated vehicles reported significantly higher expectations of the safety
535 benefits of the transition to automated vehicles than individuals with no interaction experience. Also,
536 the findings from the current study are based on self-reported behaviour. However, it should be noted
537 that previous research has suggested that participants tend to minimise the extent or frequency of
538 their behaviours if they are not considered to be socially acceptable (e.g., speeding, nonuse of
539 restraints) (Adams et al., 2005). Technology is rapidly developing in this space and there is
540 uncertainty about the timeline for when these new features will become available, or if different
541 features other than what were presented to participants might end up featuring more prominently in
542 the market. This highlights the importance developing strong academic-industry partnerships and co-
543 production involving end-users. Finally, the findings from the current study are based on a
544 convenience sample and maybe the result of a volunteer bias (i.e., individuals who agreed to
545 participate in the online survey may be more interested in automated vehicles or road safety more
546 generally).

547 **5. Conclusions**

548 Despite the potential for automated vehicles to revolutionise personal transportation, especially
549 for those who cannot currently hold a driver's license, automated vehicle manufacturers are currently
550 faced with concerns associated with trusting a system that can function completely free of human
551 input (Bansal et al., 2016; Haboucha et al., 2017; Kyriakidis et al., 2015; Lopez-Valdes et al., 2020).
552 Indeed, the findings of the current study suggest that parents are mostly unwilling to use an automated
553 vehicle to transport their unaccompanied child(ren) unless various reassurance features and
554 technologies (i.e., microphones, camera, etc.) are embedded in the vehicle. Automated vehicle
555 manufacturers are encouraged to consider these features and technologies when prototyping
556 automated vehicle designs so that all user groups, including child occupants, can benefit from the
557 impending arrival of automated vehicles. Finally, the study uniquely leveraged the behavioural
558 willingness construct to a new behavioural domain, use of emergent transportation technologies. As
559 such, our results provide a bridge between theory and practice on this topic. Future research can be
560 conducted to continue to explore how theories of behavioural prediction and change can inform plans
561 for technology design and ultimately their safe use.
562

563 **Author Contributions:**

564 S.K: Conceptualisation, Methodology, Ethics application, Formal analysis, Writing—original draft preparation,
565 Writing—review and editing, Project administration Y-C.L.: Conceptualisation, Methodology, Writing—review and
566 editing J.H.M: Conceptualisation, Methodology, Writing—review and editing P.T: Conceptualisation,
567 Methodology, Writing—review and editing S.P: Writing—original draft preparation, Writing—review and editing

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572 **Conflicts of Interest**

573 The authors declare no conflict of interest.

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