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

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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), $\chi2(12)=137.41$, $p<0.001$). 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

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

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

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

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

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

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

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

2. Materials and Methods

2.1. Participants

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

2.2. Materials

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

2.2.1. Socio-demographic characteristics

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

2.2.2. Child characteristics

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

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

2.2.3. Driving, licensing and vehicle technology characteristics

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

2.2.4. Driving behaviours

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

2.2.5. Technology readiness

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

2.2.6. Perceived knowledge about automated vehicles

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

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

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

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

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

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

2.3. Procedure

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

2.4. Data Analysis

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

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

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

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

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

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

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

3. Results

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

3.1. Participants' socio-demographic characteristics

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

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

3.2. Child characteristics

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

3.3. Driving and licensing characteristics

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

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

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

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

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

3.4. Driving behaviours

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

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

3.5. Technology Readiness

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

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

3.6. Participants' perceived knowledge and attitudes towards automated vehicles

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

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

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

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

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

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

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

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

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

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

- Age: For every one year increase in their age, participants' willingness to use an automated vehicle to transport their unaccompanied child significantly increased by 1.022.
- Gender: Relative to female participants, male participants had 1.701 higher odds of being willing to use an automated vehicle to transport their unaccompanied child.
- Highest level of completed education: Relative to participants who had completed Primary / High / Technical / Trade school, participants who had completed an Undergraduate or Postgraduate degree had 1.498 higher odds of being willing to use an automated vehicle to transport their unaccompanied child.
- TRI scores: For every one score increase in their technology readiness, participants' willingness to use an automated vehicle to transport their unaccompanied child significantly increased by a factor of 1.044.
- DBQ scores: For every one score increase in their aberrant driving behaviours, participants' willingness to use an automated vehicle to transport their unaccompanied child significantly increased by a factor of 1.014.
- Heard about automated vehicles previously: Relative to participants who reported that they had not heard about (or were not sure they had heard about) automated vehicles, participants who reported that they had heard about automated vehicles had 1.750 higher odds of being willing to use such a vehicle to transport their unaccompanied child.
- Awareness of ADAS technology: For every one score increase in their awareness of ADAS technology, participants' willingness to use an automated vehicle to transport their unaccompanied child increased by a factor of 1.034.
- Importance of assurance-related features in automated vehicles: For every one score increase in requiring automated vehicles to have assurance-related features, participants had 10.9 percent lower odds of being willing to use an automated vehicle to transport their unaccompanied child
- Importance of child safety-related features in automated vehicles: For every one score increase in requiring automated vehicles to have child safety-related features, participants' willingness to use an automated vehicle to transport their unaccompanied child increased by a factor of 1.059.

4. Discussion

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

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

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

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

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

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

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

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

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

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

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

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

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

5. Conclusions

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

Author Contributions:

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

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Conflicts of Interest

The authors declare no conflict of interest.

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