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Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age

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ABSTRACT

Fully automated self-driving cars, with expected benefits including improved road safety, are closer to becoming a reality. Thus, attention has turned to gauging public perceptions of these autonomous vehicles. To date, surveys have focused on the public as potential passengers of autonomous cars, overlooking other road users who would interact with them. Comparisons with perceptions of other existing vehicles are also lacking. This study surveyed almost 1000 participants on their perceptions, particularly with regards to safety and acceptance of autonomous vehicles. Overall, results revealed that autonomous cars were perceived as a "somewhat low risk" form of transport and, while concerns existed, there was little opposition to the prospect of their use on public roads. However, compared to human-operated cars, autonomous cars were perceived differently depending on the road user perspective: more risky when a passenger yet less risky when a pedestrian. Autonomous cars were also perceived as more risky than existing autonomous trains. Gender, age and risk-taking had varied relationships with the perceived risk of different vehicle types and general attitudes towards autonomous cars. For instance, males and younger adults displayed greater acceptance. Whilst their adoption of this autonomous technology would seem societally beneficial – due to these groups' greater propensity for taking road user risks, behaviours linked with poorer road safety – other results suggested it might be premature to draw conclusions on risk-taking and user acceptance. Future studies should therefore continue to investigate people's perceptions from multiple perspectives, taking into account various road user viewpoints and individual characteristics.

1. Introduction

The twentieth century witnessed a revolution in passenger transport with the mass production of affordable cars allowing people to drive themselves freely from A to B. In the twenty-first century, technology and automotive companies are working to realise a new passenger transport revolution: fully automated cars, which – by removing the need for a driver – are expected to reduce the number of collisions resulting from human driving error and improve road safety. Although some forms of autonomous vehicles, such as driverless trains (Lo, 2012) and airport shuttles (TRL, 2016), have been in common usage in cities for a number of years, these modes of transport run along enclosed routes and are therefore limited in terms of their movements and interactions with vehicles or people other than passengers. In contrast, autonomous cars will, in theory, be moving amongst other road users along public routes, thus their interactions with people will be, and may be perceived to be, more complex. Some surveys have been conducted in recent years on the public's perception of autonomous cars, but have typically focused on people as users of such vehicles (Bansal et al., 2016; JD Power, 2013; Kyriakidis et al., 2015; Schoettle and Sivak, 2014; Smith, 2016). Perceptions from an external point of view, e.g. as pedestrians in an area with autonomous cars, have received little attention to date. Likewise, there has been little attempt to compare perceptions of autonomous cars with perceptions of other, existing vehicles. This paper reports findings of a survey with participants resident in the UK investigating perceptions of autonomous cars, particularly with regards to road safety and acceptance. Perceptions are compared in relation to road users (i.e. pedestrians as well as occupants of both human-operated and autonomous vehicles), risk (taking and perception), and participant gender and age.

1.1. Road safety

The act of driving is complex. Several motor and cognitive tasks must be performed, sometimes in quick succession, sometimes simultaneously, with drivers having to interact with and react to a variety of vehicular parameters, motorist and pedestrian behaviours, all in varying weather, lighting and road surface conditions. Due to these

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challenges, it is perhaps not surprising that things can go wrong, and the cost when it does is high. Each year, around the world, approximately 1.25 million people are killed and a further 20–50 million injured in collisions, negatively impacting the casualties, their families, employers and, consequently, nations (WHO, 2016). Around three-quarters of these road traffic fatalities are male, while almost half are people aged between 15 and 44 years old.

Human behaviour is a critical factor in road safety (Petridou and Moustaki, 2000). Several forms of road user behaviour have been highlighted as increasing the risk of collisions resulting in casualties. Key risky driving behaviours comprise the consumption of intoxicating substances, travelling at higher average speeds, not wearing protective seat belts or headgear, and distractions, particularly the use of mobile phones (WHO, 2016). Previous research has linked self-reported risky driving behaviour not only with demographic factors, such as male gender and younger age (e.g. Turner and McClure, 2003), but also with individual and personality differences including "sensation seeking", "ego undercontrol" and "present-orientation" (e.g. Zimbardo et al., 1997).

Driving skills, or the lack of them, may also play a role in road traffic collisions. To (attempt to) avoid a collision, a driver must first detect a stimulus, interpret it as a hazard, recognise that action is required, determine an appropriate action, then move to commence the selected action such as braking. The time for this perception and response ("reaction time"), varies depending on situational factors such as expectancy, urgency and cognitive load and possibly also demographic factors such as gender and age (Green, 2000). Further time is then required to carry out the action to its conclusion (e.g. braking to a complete stop). A review by Elander et al. (1993) concluded that, regarding driving skill, the perceptual rather than motor element would appear to be more important regarding collisions, and suggested that advanced training and experience might combat this in part. However, those authors added that risky driving behaviours, given the link with enduring personality traits, might be harder to overcome, at least in the long term. The problem of personality-related risky driving behaviours is further emphasised by studies on driver assistance technology such as anti-lock braking systems (Jonah et al., 2001) and adaptive cruise control (Rudin-Brown and Parker, 2004). While this technology was developed to counter driving skill deficiencies and increase road safety, these studies found suggestive evidence that such technology might in fact heighten risky behaviour from personality types such as sensation seekers.

1.2. Autonomous vehicles

One proposed solution for reducing collisions resulting in casualties is to eliminate the human element from driving; i.e. work towards fully automated passenger cars. These autonomous cars – also referred to as "self-driving" or "driverless" cars – go beyond currently available semi-autonomous models with driver assistance technology. Autonomous cars will, once started up, operate without human intervention, utilising computerised systems to detect and collect information about the environment, identify paths and hazards, as well as control functions such as acceleration and steering, to navigate the vehicle accordingly. Without the need for a human driver, occupants of autonomous cars would become passengers, who could engage in some of the identified key risky behaviours without theoretically posing a threat to themselves or others. Note, autonomous vehicles do not completely remove the human element from driving; people must develop the algorithms and write the code that control them. Thus, human error may still result in collisions and casualties, albeit potentially at a lower incidence rate.

The concept, and practice, of an autonomous vehicle is not a new one. Other forms have existed for several decades. Train examples include the SkyTrain in Vancouver, Canada, the Docklands Light Railway (DLR) in London, UK, and the Yurikamome in Tokyo, Japan (Lo, 2012). While there are anecdotal reports in the media regarding public fears about safety on autonomous trains, hardly any actual studies of public opinion exist in the academic literature. One small survey (N = 50) that does (Fraszczyk et al., 2015) found that the majority of participants were not worried about using a driverless train. This generally positive attitude is reflected in other, non-scientific collections of public opinion (e.g. travel website reviews of the DLR; TripAdvisor, 2016) and in the increasing number of passengers using autonomous rail systems (e.g. Department for Transport, 2016a). More than 1.5 million passengers have also used driverless shuttles such as Heathrow Airport's Ultra pods, which transport people short distances between Terminal 5 and the business car park (TRL, 2016). However, both these autonomous shuttles and the aforementioned trains run on enclosed roadways or tracks, separate from the public roads, and so do not interact with other vehicles or pedestrians. In contrast, autonomous cars would encounter various road users, thereby resulting in complex interactions and the possibility of conflict. Would people therefore be as accepting of autonomous cars as they appear to be of existing autonomous transport?

1.3. Public opinion of autonomous cars

As a growing number of governments take actions to support the testing and production of autonomous cars (Department for Transport, 2015a), attention has turned to gauging public perceptions of these vehicles. Schoettle and Sivak (2014) engaged 1533 participants aged 18 years or older from the UK, USA and Australia in an online survey using SurveyMonkey's Audience tool. The majority of participants thought it somewhat likely that autonomous vehicles would result in both fewer and less severe collisions. However, they also revealed numerous concerns about travelling in autonomous vehicles. Of most concern was system or equipment failures resulting in safety consequences. Furthermore, participants were unanimously very concerned about autonomous vehicles offering no controls for them to take over driving and the thought of other types of road vehicle being autonomous, although the concern seemed to lessen somewhat the smaller the vehicle got (i.e. heavy goods vehicles > buses > taxis). While there were some differences in survey responses according to participant age (e.g. older participants more likely than younger participants to say they would not ride in an autonomous vehicle), gender differences were detected on almost all questions, with females less convinced by autonomous vehicles than males.

Further online surveys have been conducted subsequently with samples of the public in different parts of the world: for example, 347 adults recruited through neighbourhood associations in Austin, USA (Bansal et al., 2016); 1661 adults in Great Britain recruited via internet polling company YouGov (Smith, 2016); and 4886 adults from 109 countries recruited through crowdsourcing company CrowdFlower (Kyriakidis et al., 2015). These surveys have, with the exception of the British poll, also detected signs of recognition that autonomous vehicles may bring road safety benefits but, in addition, all three surveys reported several concerns including possible system/equipment failure and hacking or misuse. However, there are two notable issues with surveys conducted to date: (i) they focus on autonomous road vehicles of the future without comparing opinions on existing transport, and (ii) they focus on opinion from the perspective of users of autonomous vehicles, overlooking the perspective of external road users, such as pedestrians.

Almost half of the people killed around the world each year in collisions are more vulnerable road users, i.e. motorcyclists, cyclists and pedestrians (WHO, 2016). However, research indicates that, while road users like pedestrians may be vulnerable to becoming victims of these incidents, their risky behaviours, just like drivers' risky behaviours, may also contribute to such outcomes (King et al., 2009). Moreover, research has suggested that gender and age differences in risky pedestrian behaviour could exist, albeit not always consistently (Holland and Hill, 2007; Rosenbloom, 2009; Rosenbloom and Wolf, 2002), and linked collisions to individual and personality differences in pedestrians such

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