Travel Behaviour and Society 22 (2021) 1–9

Contents lists available at ScienceDirect

Travel Behaviour and Society

journal homepage: www.elsevier.com/locate/tbs

Why travelers trust and accept self-driving cars: An empirical study

Huiying Du[a,*], Ge Zhu[a,*], Jiali Zheng[b]

[a] School of Information Management, Beijing Information Science & Technology University, Beijing 100192, China
[b] College of Education, University of South Carolina, Columbia, SC 29208, USA

ARTICLE INFO

Keywords:
Self-driving cars
Trust
Mass media
Self-efficacy
Subjective norms

ABSTRACT

Automated vehicle technology is becoming increasingly mature with the development of Artificial Intelligence and information communications technology. It is important to understand the factors affecting the use of automated vehicles. This study investigates user acceptance and the willingness to use fully driverless cars (self-driving cars). Based on Social Cognitive Theory (SCT), we developed a new acceptance model to explore the impact of mass media on adopting self-driving cars. A survey was designed and distributed, and 173 responded. The results show that 84.4% of the respondents are willing to accept driverless cars. At this early stage, the reports from mass media significantly influence people's perception of self-driving cars. The media affect self-efficacy and subjective norms, and thereby people's trust and behavior change. Moreover, subjective norms, self-efficacy, and trust significantly influence their intention to use self-driving cars. This article provides practical guidance to promote self-driving cars: positive media reports will significantly enhance people's trust and intention to use driverless cars.

1. Introduction

Self-driving cars, which are also termed as driverless cars or autonomous cars (AVs), can sense their environment and navigate without a human operator. These cars have been deemed as one of the key innovations in the next technology revolution along with drones and the Internet of Things, and they have been recognized as a key area for future research (Kaur and Rampersad, 2018). Their implementation relies on communication, sensing, computing and automation technology (Narla, 2013). Six levels of automation of driverless cars are defined by the Society of Automotive Engineers (SAE, 2016). This paper focuses on privately-owned full automation, in which the automated driving system controls all aspects of the dynamic driving task under all roadway and environmental conditions.

The global driverless car market is forecasted to reach $7.03 billion by 2021 and $21 billion by 2035 (Aliababa, 2018). Many high-tech companies are already producing high-level self-driving cars (Madigan et al., 2017). According to Hewitt et al. (2019), many car manufacturers are also incorporating increased levels of autonomous functionality in their vehicles and aggressively researching high-level self-driving cars.

Compared with traditional manually controlled vehicles, self-driving cars can reduce human error-induced crashes, which account for 93% of those in the U.S. (Xu et al., 2018). Furthermore, with better route planning and more efficient vehicle operation, self-driving cars can reduce road congestion and fuel emissions (Fagnant and Kockelman, 2015). Riding in a self-driving car frees the driver from tasks and enables him to engage in his choice of leisure or productive non-driving activities (Clark et al., 2016). Moreover, self-driving cars provide a means of traveling for people unable to drive (e.g., the elderly and the disabled), which can improve their mobility (Zhang et al., 2019).

Despite its advantages, people differ in their attitudes about self-driving cars. Several researches say that most people approve of self-driving cars (Payre et al., 2014; Bazilinskyy et al., 2015; Piao et al., 2016; Kaur and Rampersad, 2018, Zhang et al., 2019). Nordhoff et al. (2018a) indicate that people consider the possibility of automated vehicles and regard them as a supplement to public transport systems. On the other hand, the public's intention to purchase and accept self-driving cars is not high (Abraham et al., 2017), especially among those who hold driving licenses. Schoettle and Sivak (2014) report that public acceptance of vehicle automation decreases as the level of automation increases, and 85.6% of licensed US drivers do not accept fully autonomous vehicles. Similarly, the AAA survey (2016) finds that 75% of Americans are "afraid to allow an autonomous vehicle to drive itself with them in it," and female respondents express more concern (81%).

This paper tries to confirm two reasons why consumers reject the idea of using self-driving cars: recognition of persons and negative report bias. Self-driving cars require individuals to trust mechanisms

* Corresponding authors.
E-mail addresses: huiyingdu@bistu.edu.cn (H. Du), zhuge@bistu.edu.cn (G. Zhu), jiali@email.sc.edu (J. Zheng).

https://doi.org/10.1016/j.tbs.2020.06.012
Received 30 July 2019; Received in revised form 3 March 2020; Accepted 8 June 2020
Available online 19 August 2020

more than themselves, which creates a challenge for human self-perception. Mass media increase consumer perception bias by reporting on crashes, injuries and fatalities related to self-driving cars. This paper investigates how the mass media influence human self-perception as an external stimulation and how subjective norms and self-efficacy affect consumer trust and adoption intention of self-driving cars.

2. Literature review

2.1. Recent research on the acceptance of self-driving cars

Based on the technology acceptance model (TAM), a few studies have explored how intention to use self-driving cars is affected by perceived usefulness and perceived ease of use (Kaur and Rampersad, 2018). The extended TAM results indicate that other variables also predict intention, such as trust (Panagiotopoulos and Dimitrakopoulos , 2018; Xu et al., 2018; Choi and Ji, 2015; Hewitt et al., 2019; Zhang et al., 2019, Buckley et al., 2018a; Buckley, et al., 2018b), perceived safety risk (Benleulmi and Blecker, 2017), personality factors (Payre et al., 2014) and social influence or subjective norms (Panagiotopoulos and Dimitrakopoulos, 2018; Buckley et al., 2018a).

In addition, several studies are based on the unified theory of acceptance and use of technology (UTAUT). While researchers agree that trust and perceived risk are closely related to accepting self-driving cars (Buckley et al., 2018a), most of them consider social influence to be important (Hewitt et al., 2019; Adnan et al., 2018; Leicht et al., 2018; Madigan et al., 2017). Some use demographic variables to analyze consumers' acceptance of self-driving cars (Payre et al., 2014; Kaur and Rampersad, 2018; Nordhoff et al., 2018a,b). After reviewing 124 empirical studies based on UTAUT and Car Technology Acceptance Model (CTAM), Nordhoff et al. (2019) created a multi-level model of automated vehicle acceptance (MAVA), which proposes that acceptance results from a four-stage decision-making process.

Self-efficacy or confidence in products is a new area from which to study self-driving cars. Existing research has underestimated the impact of human self-perception on product perception and adoption intention. Research also has failed to explore the influences of external information such as mass media and innovation adoption. Because people are only beginning to consider using self-driving cars, the way people access information and the attitude of the information provided by the news media will affect their perception of this new field. Meanwhile, the relationship between media, people, technological innovation and adoption intention is still unclear for self-driving cars.

Table 1 presents previous studies on adoption models of self-driving cars.

2.2. Theoretical foundation

Social Cognitive Theory (SCT) is a framework for understanding, predicting and changing behavior; it describes how human behavior is affected by the interaction between personal factors, behavior and the environment (Bandura, 1986). An individual's perception, beliefs, and expectations will affect his behavior, that is, how he thinks and feels is associated with the person's behavioral intention (Bandura, 1986). The theory also implies that an individual's behavioral intention could be affected by his/her environment. Especially, social environment includes the immediate physical surroundings, social relationships, and cultural milieus within which defined groups of people function and interact (Barnett and Casper, 2001). It also includes social norms, access within the community, peer influence, values, etc. (Bandura, 1986).

Based on SCT, we introduce mass media into the research model of this study. Similar models are placed in SCT to study the attitudes and influences of media on youth smoking (Gidwani et al., 2002), women's drive for thinness (Harrison and Cantor, 1997), safe sex (Martino et al., 2005) and audiences' attitudes and behaviors (Pajares et al., 2009). Using SCT as the theoretical framework for this article, we aim to explore the relationships between environment (media), self-perception (self-efficacy and subjective norms), and behavior (technology trust and intention to use private fully autonomous vehicles). Self-perception, defined as "an awareness of the characteristics that constitute one's self," is used to refer to both self-concept and self-efficacy (Skaalvik and Skaalvik, 2004). Self-concept was defined by Shavelson et al. (1976) as a person's self-perceptions formed through experience with and interpretations of one's environment (e.g., social, physical, and academic), which covers the conception of subjective norms defined by Fishbein and Ajzen (1975). Therefore, self-efficacy and subjective norms are regarded as two dimensions to reflect one's self-perception. The relationships between the variables are progressive. The first level is mass media. Self-efficacy and subjective norms comprise the second level. Trust in self-driving cars is the third level, and intention to use is the last level. The hypotheses will be established in the next section, and the four level relationships will be tested later. Fig. 1 shows the theoretical model of acceptance of self-driving.

3. Constructs and hypotheses

3.1. Mass media

Mass media is defined as communication (written, broadcasted or spoken) that reaches a large audience (Manohar, 2011). It includes broadcasts, films, video games, audio recording and reproduction, internet, blogs, RSS feeds, podcasts, mobile media and print media (Manohar, 2011). The main characteristic of these media is to build awareness and knowledge about new services (Rogers, 2003). However, mass media here do not include self-media (such as private blogs, private social media circle or private media) and word-of-mouth (WOM).

Mass media have proved to be effective in marketing. In the modern information society, although many people have access to interpersonal networks or alternative information systems, mass media remain a central element in people's acquisition of knowledge of areas beyond their direct experience (Jackob, 2010). Several studies have documented the impact of mass media on adoption of technological innovation in an emerging industry. Media play an important role in influencing the actions and decisions of stakeholders (Zavyalova et al., 2012). Gharaibeh and Arshad (2018) indicate that mass media positively affect the adoption of mobile banking services. The CMO Council (2014) reports that one-quarter of car buyers were influenced by social media. Similarly, Darshan (2018) unveils the influence of social media on decisions of customers to purchase a vehicle. However, few articles have explored the influence of mass media in the field of self-driving cars. Research shows that a total of 57% of the respondents say they are generally interested in the topic of autonomous driving, and 78% of these respondents obtain their information on the topic primarily from the mass media (Fraedrich and Lenz, 2016). To research how news headlines influence consumers' perception of self-driving car technology and their willingness to use it, Poczter and Jankovic (2014) point out that whether positive or negative, these types of headlines may influence consumers' attitudes toward self-driving cars. The bias of the mass media can benefit or undermine public perception of self-driving cars, and this bias will likely play a large role in swaying consumer perceptions and behaviors. If consumers see self-driving cars portrayed in a negative light, they may be less likely to utilize them. On the other hand, if consumers are exposed to positive information about the safety and efficiency of the same driverless technologies, they may be convinced to use them (Anania et al., 2018).

Mass Media to Subjective Norms

Few researches show that mass media have a major impact on subjective norms, but some studies show that media establish a positive relationship between WOM communication and subjective norms (Zolait and Sulaiman, 2017; Sumadi and Muslichah, 2018). For new emerging technology, word of mouth is difficult to be established at the

Table 1
Previous studies on adoption models of self-driving cars.

Author	Object	Model	Antecedents of Intention (R^2/Adjusted R^2)
Deb et al. (2017)	Fully autonomous vehicles	SEM	Attitude, SN, Trust, System Effectiveness, Compatibility → IN (0.60)
Buckley, et al. (2018b)	Drivers' responses to partially driverless cars	Questionnaire	Ability, Helpfulness, Integrity, Individual Difference: (Identity, SN, and SE), Emotive outcome → IN
Kaur and Rampersad (2018)	Driverless cars (Level5)	UTAUT	Trust → Adoption, Reliability → Trust, Security, Privacy → Trust, Performance Expectancy → IN
Madigan et al. (2017)	Automated road transport systems (Level 4)	UTAUT	PE, EE, SI, FC, Hedonic motivation → IN (0.59)
Panagiotopoulos and Dimitrakopoulos (2018)	Autonomous driving (high level)	Extended TAM	PU, PEOU, Perceived Trust, SI → IN (0.44)
Xu et al. (2018)	Driverless cars (Level 3) (Field experience)	TAM	Trust → PU, PEOU, Perceived Safety → IN (0.55), Willingness to re-ride (0.40)
Buckley et al. (2018a)	Driverless cars (Self-driving cars) (Level 3)	TPB TAM	AT, SN, PBC → IN (0.44) PU, PEOU, AT, Trust → IN (0.41)
Zhang et al. (2019)	Driverless cars (Level 3)	Extended TAM	PEOU, PU, Perceived Safety Risk, Perceived Privacy Risk → Initial Trust → Attitude → IN (0.61)
Payre et al. (2014)	Fully automated car (Level 5)	Extended TAM	PU, AT, Personality Factors, Driving Environment, Interesting, Gender (0.67)
Leicht et al. (2018)	Autonomous car (Level 5)	UTAUT	PE, EE, SI, Consumer Innovativeness → IN
Nordhoff et al.(2018a)	Automated shuttle	PCA	Three Components: Intention to Use, Shuttle and Service Characteristics, Shuttle Effectiveness
Adnan et al. (2018)	Autonomous vehicle (level 4 & 5)	Extended UTAUT	EE, PE, SI, Ethical Implications → IN (0.71)
Hewitt et al. (2019)	Self-driving Cars (All levels)	AVAM, UTAUT	PE, EE, SI, FC, Attitude Towards (Using) Technology, SE, Anxiety, Perceived Safety → IN
Nordhoff et al. (2019)	Automated vehicles (level 4 & 5)	MAVA	Socio-demographics, Personality, Travel Behavior, Exposure of Individuals, Instrumental Domain-specific, Symbolic-affective and Moral-Normative Factors → IN
Nordhoff et al. (2018b)	Driverless Shuttles	Exploratory analysis	Usefulness, Ease of Use, Satisfaction with Daily Travel, Enjoyment of Manual Driving, Pleasure, SI, Trust, Liking of Being in Control, Enjoyment of Technology, Knowledge of Mobility, Future Orientation, Wish for Car-Free Future, and Skepticism → IN

Notes: PU = Perceived Usefulness; PEOU = Perceived Ease of Use; AT = Attitude; IN = Adoption Intention; SN = Subjective Norm; PBC = Perceived Behavior Control; PS = Perceived Security; FC = Facilitating Conditions; SI = Social Influence; PE = Performance Expectancy, EE = Effort Expectancy; SE = Self-Efficacy; PCA = Principal Component Analysis; SEM = Structural Equation Modeling TAM = Technology Acceptance Model; UTAUT = Unified Theory of Acceptance and Use of Technology; TPB = Theory of Planned Behavior; AVAM = Autonomous Vehicle Acceptance Model; MAVA = multi-level model on automated vehicle acceptance.

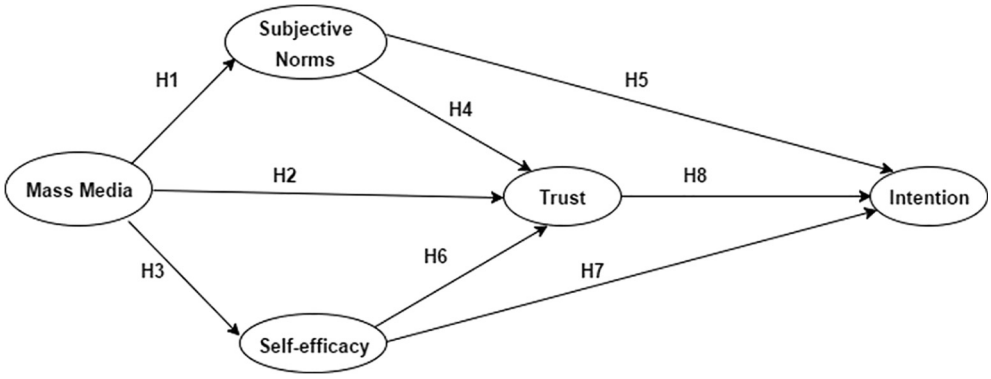

Fig. 1. Theoretical model of accepting self-driving cars.

beginning, so mass media play a more important role for consumer consideration and product purchase reference (Kotler and Keller, 2012; Zolait and Sulaiman, 2017). Without experiencing self-driving cars, the public gains knowledge mainly through media coverage. Their opinions on these technological innovations are further influenced by media reports (Benjamin, 2012). These opinions are then broadcast through individual social circles (e.g., Facebook, Twitter or WeChat), which ultimately affect the public's willingness to operate self-driving cars. We therefore propose:

H1. Mass media significantly influence consumers' subjective norms.

The Effect of Mass Media on Trust

People who have limited experience in making decisions tend to rely more on the media (Kohring and Matthes, 2007). Because self-driving cars are still in the experimental stage, individuals need to rely on information from the mass media. Although there is no definitive evidence that the mass media are related to people's trust in products, some literature discusses the relationship between mass media and innovation. For example, mass media are important for learning about innovations (Rogers, 2003). Moreover, Agha (2003) explores the concept that people exposed to mass media of branded advertising messages were significantly more likely to consider themselves at higher risk of acquiring HIV. Similarly, a research verified the relationship between mass media and perceived risk (Tulloch and Lupton, 2001). However, Ayeh et al. (2013) and Abang Othman et al. (2017) verify that media don't positively affect trust, i.e., mass media cannot directly influence peoples to trust a product.

We therefore propose:

H2. Mass media significantly influences consumers' trust of self-driving cars.

Mass Media to Self-efficacy

Environment is a fundamental component of the SCT (Bandura, 1986; Boateng et al., 2016). As an important component of environment, mass media convey information about new technologies. They promote understanding of new technologies and thereby influence people's confidence in innovative technologies. The media play a key role in reducing the uncertainty of new products by providing information in an understandable format (Benjamin, 2012). Moreover, people can self-reflect and analyze their experiences to better respond to the information received from the mass media (Eastin and LaRose, 2000). A study by Hofstetter et al. (2001) shows that mass media reporting plays a crucial role in people's confidence in using new things. Agha (2003) confirms the significant impact of mass media campaigns to promote confidence. If the mass media convey positive information about self-driving cars, it will have a positive effect on consumers; otherwise, consumers will doubt whether they can master the use of self-driving cars. Therefore, we propose:

H3. Mass media significantly influence consumers' confidence in self-driving cars.

3.2. Subjective norms & Self-efficacy

3.2.1. Subjective norms to trust

Subjective norms are a core part of the social environment in SCT theory (Bandura, 1986). According to Fishbein and Ajzen (1975), subjective norms refer to "perceived pressures on a person to perform a given behavior and the person's motivation to comply with those pressures." Thus, subjective norms reflect how a customer is affected by the perception of some important indicators of his/her behavior (e.g. family, friends, colleagues, etc.). Many psychological studies speculate that subjective norms are important determinants of perceived usefulness (Yi et al., 2006) and adoption intention (Herrero et al., 2008). Another example comes from Kim et al. (2009), who verify that subjective norms are determined to exert significant and positive effects on perceived usefulness, attitude toward use, and intention to reuse airline B2C e-commerce websites.

When subjective norms change a person's value and affect his/her behavior, this also may change his/her trust of a product (McKnight et al., 2002). If consumers haven't used new products such as self-driving cars, the views of others will greatly influence their trust of it. We therefore propose:

H4. Subjective norms positively influence consumers' trust of self-driving cars.

3.2.2. Subjective norms to adoption intention

Early studies show that the internalization process of subjective norms indirectly affects behavioral intention through attitudes (Davis, 1989) and beliefs (Venkatesh et al., 2012). Based on this notion, many scholars indicate that a person's intention for a specific behavior depends on how he/she views social normative pressures or peer beliefs about the behavior (Kim et al., 2011). The rationale for subjective norms that directly affect intention is that people can choose a certain behavior, even if they themselves disapprove of it or its consequences. However, if they believe that other people who are important to them think they should do something, and if they think they have enough motivation to comply with these opinions, they will do so (Venkatesh et al., 2012).

Similarly, some scholars have confirmed that subjective norms significantly impact the adoption intention of self-driving cars (Leicht et al., 2018; Buckley et al., 2018a). Another example comes from Bansal et al. (2016), who indicate that 50% of respondents are especially concerned about the attitudes and expectations of their family, friends or neighbors when considering driverless cars. On this basis, Panagiotopoulos and Dimitrakopoulos (2018) studied the effects of peer pressure on the intention to use autonomous vehicles. Therefore, we propose:

H5. Subjective norms positively influence the intention to use self-driving cars.

3.2.3. Self-efficacy to trust

According to SCT, Bandura (1986) defines the characteristics of self-efficacy as the ability to understand, predict, and regulate the environment, people, and others. People have varying beliefs about self-efficacy according to individual emotions, thoughts, and feelings. However, negative emotional experiences such as stress and anxiety can have a negative impact on self-efficacy (Kelleher, 2016). Thus, self-efficacy is a major determinant of individual task performance, and studies have found it has different psychological and behavioral effects in many areas of human psychosocial function (Bandura, 1986; Pajares et al., 2009; Tsai, 2014).

Trust in self-driving cars is based on the characteristics of automation itself (i.e. performance and reliability) (Beller et al., 2013). However, it is increasingly recognized that trust in automation may also be influenced by self-efficacy and other individual characteristics (Schaefer and Scribner, 2015). Similarly, Cassidy and Eachus (2002) find technical experience may influence subsequent trust behavior by establishing self-efficacy. Self-efficacy also can be seen as a cognitive process in which individuals have the confidence to perform tasks, such as the efficiency and ease of using self-driving cars (Neubauer and Schauer, 2017). In some cases it can increase trust and thereby regulate the anxiety associated with the willingness to use driverless cars (Schaefer and Scribner, 2015; Hohenberger et al., 2016; Buckley et al., 2018a,b). On this basis, we hypothesize that:

H6. Self-efficacy positively influences consumers' trust in self-driving cars.

3.2.4. Self-efficacy to adoption intention

Self-efficacy is seen as a fundamental determinant of behavior because it directly or indirectly affects behavior (Bandura, 1986). Highly self-motivated people believe that they can accomplish specific tasks, invest more energy, and are more willing to face challenges and solve problems rather than avoid them (Graham, 2011). In addition, they can set goals for themselves and expend enough effort to achieve them. They are also more likely to be confident when they face obstacles because they believe in their abilities (Pajares et al., 2009).

Meanwhile, previous researchers have conceptualized self-efficacy as a precursor to certain factors in the theory of planned behavior (TPB) models (Hsu and Chiu, 2004), TAM-related models (Venkatesh et al., 2012; Alalwan et al., 2016), and specific self-efficacy studies (Zhu et al., 2017). A few studies on self-driving cars incorporate self-efficacy into the SCT framework. Studies have indicated that self-efficacy may affect self-perception, which significantly influences people's intention to use self-driving cars (Hohenberger et al., 2016; Neubauer and Schauer, 2017; Schaefer and Scribner, 2015; Hewitt et al., 2019). We therefore hypothesize that:

H7. Self-efficacy positively influences consumers' intention to use self-driving cars.

3.3. Trust in driverless cars

Trust in technology can be defined as (1) a person's willingness to place himself in a dependent position and expect good results or (2) enthusiasm for future behavior (Mayer et al., 1995). Trust has also been identified as a key factor in determining the interaction between people and automation (Lee and See, 2004), which helps regulate social relationships between people and minimizes uncertainty of human behavior in certain situations (Boateng et al., 2016). Trust is frequently incorporated into technology adoption literature in various contexts, such as e-commerce (Srivastava et al., 2010), online banking (Kesharwani and Bisht, 2012), e-government (Mou et al., 2017), mobile

banking services (Gharaibeh and Arshad, 2018) and social networking sites (Shin, 2010).

In addition, defects in automation will decrease trust (Lee and See, 2004). Choi and Ji (2015) and Adnan et al. (2018) conclude that trust is the main factor influencing the acceptance of self-driving cars. Xu et al. (2018) also determined that trust and perceived security are stable and direct predictors of accepting self-driving cars. This same conclusion was confirmed in other studies about willingness to accept self-driving cars. Because driving is a demanding activity and self-driving is an emerging technology, people's sense of security and initial trust in the technology will significantly influence their acceptance of self-driving cars (Bazilinskyy et al., 2015; Ghazizadeh et al., 2012; Buckley et al., 2018b; Rahman et al., 2017; Panagiotopoulos and Dimitrakopoulos, 2018; Zhang et al., 2019; Zmud et al., 2016; Hergeth et al., 2017). However, in the Kaur and Rampersad (2018) study, the relationship between trust and adoption of self-driving cars is not statistically significant. Therefore, we propose:

H8. Trust positively influences consumers' intention on self-driving cars.

4. Methodology

The measurement items were developed from previous acceptance model literature (see Table 2). For all the measures, a 7-point Likert scale was used, with anchors ranging from strongly disagree (1) to strongly agree (7). The questionnaire was translated from English to Chinese and then back-translated to ensure translation equivalence.

We introduced "self-driving cars" as "fully autonomous cars serving for personal use, the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that a human driver cannot manage" at the beginning of the questionnaire. The questionnaire is divided into two main parts. The first part of the questionnaire concerns familiarity with and concerns about autonomous vehicles; the second part concerns the personal information of the participants.

The participants were college students who majored in Information Technology. We believe that these students are the persons most likely to use driverless cars, because they know information technology and are very innovative. Data were collected in a university classroom during class time and kept anonymous. Altogether 200 paper questionnaires were distributed, and we received 173 valid questionnaires.

The respondents' average age was 19, and 58.5% of them were male. When they were asked about the willingness to use the driverless cars in the future, 84.4% were willing to accept driverless cars, while only 15.6% still preferred traditional cars. Moreover, the mean score for self-efficacy was 5.21 (SD = 1.43), for mass media was 4.75 (SD = 1.73), for subjective norms was 3.76 (SD = 1.44), for trust was 4.25 (SD = 1.28), and for adoption intention was 4.93 (SD = 1.42).

5. Results

5.1. Test of the measurement model

Partial least squares path modeling (PLS-PM) was recommended to analyze the structural equation model (SEM) for its advantages to handle the small sample size, complex models and non-normal data distributions. In order to ensure the performance of the instrument, the reliability and validity of the measurement model were verified before the structural model was adopted. The psychometric properties of the measurement scales for the factors were assessed in terms of reliability, convergent validity, and discriminant validity. For all five factors, Cronbach's alphas are above the threshold of 0.7, indicating high reliability. Convergent validity was established because the composite reliability (CR) scores for all constructs were higher than 0.7, and the factor loadings for all items were above the recommended threshold (0.70), ranging from 0.81 to 0.96. Meanwhile, the average variance extraction (AVE) of each construct was greater than 0.5, ranging from 0.77 (mass media) to 0.93 (subjective norms) (see Table 3). Since the AVE value of each factor was greater than all square correlations, the discriminant validity of the construct was also confirmed. Discriminant validity can also be established if all indicators' outer loading on the associated constructs is greater than all its loadings on other constructs. The results show that no items cross-loaded higher on another construct than they did on their own construct. Another support for discriminating validity is the heterogeneity of the correlation, namely the single trait ratio (HTMT). As shown in Table 4, all values for HTMT are significantly lower than the threshold of 0.85 proposed in the literature (Henseler et al., 2015). This proves the discriminant validity of the measurement structure. Therefore, all measurement items are retained for further analysis.

To evaluate the PLS-PM structural model, the effect size f^2 is evaluated to examine the predictor effect in the structural model with a value of about 0.02, 0.15 or 0.35, indicating whether the exogenous latent variable has a small, medium or large effect. In the present study, the results show that self-efficacy and trust strongly influence adoption intention (f^2 = 0.25 and 0.15); also, self-efficacy and subjective norms strongly affect trust (f^2 = 0.22 and 0.27). Mass media significantly influences self-efficacy (f^2 = 0.18), and moderately influence subjective norms (f^2 = 0.07) and adoption intention (f^2 = 0.05). However, mass media have a small effect on trust (f^2 = 0.02).

5.2. Test of the structural model

After establishing the reliability and validity of the data, this study

Table 2
Scales of indicators.

Primary indicator	Source of adoption	Secondary indicators
Self-efficacy (SE)	Hsu and Chiu (2004); Zhu et al. (2017)	SE1: I believe that I can master the skills required for using self-driving cars. SE2: I believe I can give instructions to the self-driving cars based on the system prompts. SE3: I believe that I can complete a trip by using self-driving cars. SE4: Overall, I believe that I can use self-driving cars.
Mass Media (MM)	Tran and Corner (2016)	MM1: I have seen information about self-driving cars from the mass media. MM2: I have read reports on self-driving cars in the mass media. MM3: Through the mass media, I have a better understanding of self-driving cars.
Subjective Norms (SN)	Rahman et al. (2017)	SN1: People who influence my behavior would think that I should use self-driving cars. SN2: People who are important to me would think that I should use self-driving cars.
Trust (TR)	Choi and Ji (2015), Zhang et al. (2019)	TR1: Self-driving cars are reliable. TR2: Self-driving cars are dependable. TR3: Overall, I can trust self-driving cars.
Adoption Intention (IN)	Davis (1989)	IN1: I predict I will try to use self-driving cars in the future. IN2: I would like to use self-driving cars now if I had the opportunity to drive one. IN3: I intend to purchase self-driving cars in the future if the price is suitable.

Table 3
Results of measurement model.

Construct	Items	Item mean	Factor loading	STDEV	T-Values	AVE	CR	Cronbach's alpha
Adoption Intention(IN)	IN1	5.13	0.93	0.01	69.08	0.83	0.94	0.90
	IN2	4.90	0.90	0.02	42.38			
	IN3	4.77	0.91	0.01	62.98			
Mass Media (MM)	MM1	5.07	0.92	0.02	52.58	0.77	0.91	0.85
	MM2	4.94	0.91	0.03	26.94			
	MM3	4.25	0.81	0.04	20.67			
Self-efficacy (SE)	SE1	5.01	0.86	0.04	24.49	0.82	0.95	0.93
	SE2	5.46	0.92	0.02	55.82			
	SE3	5.24	0.93	0.01	64.85			
	SE4	5.10	0.91	0.02	58.80			
Subjective Norms (SN)	SN1	3.78	0.96	0.01	72.84	0.93	0.96	0.92
	SN2	3.75	0.96	0.01	90.15			
Trust (TR)	TR1	4.25	0.93	0.03	28.06	0.87	0.95	0.93
	TR2	4.27	0.96	0.01	95.58			
	TR3	4.23	0.91	0.02	44.20			

Table 4
Correlation matrix of latent variables with AVE and the HTMT.

	IN	MM	SE	SN	TR
Adoption Intention (IN)	0.91	0.39	0.66	0.57	0.77
Mass Media (MM)	0.34	0.88	0.44	0.28	0.41
Self-efficacy (SE)	0.61	0.39	0.90	0.36	0.60
Subject Norms (SN)	0.52	0.25	0.33	0.96	0.60
Trust (TR)	0.71	0.36	0.56	0.56	0.93

Notes: Lower left diagonal is correlation matrix of latent variables; diagonal elements are the square root of AVE; the HTMT is printed in the upper right diagonal in italics.

used the SmartPLS 3.0 test to propose the model and the corresponding assumptions. A bootstrap estimation hypothesis model was based on 5,000 subsamples. Fig. 2 provides a graphical depiction of the model. The results of the study indicate that the model explains 58.4% of the variation in adoption intention.

At the first level of relationship, mass media are positively related to subjective norms ($\beta = 0.25$; $p < 0.05$), which is consistent with hypothesis 1 and findings of existing research (e.g., Zolait and Sulaiman, 2017; Kotler and Keller, 2012; Sumadi and Muslichah, 2018). Likewise, consistent with hypothesis 3, mass media positively affect self-efficacy ($\beta = 0.39$; $p < 0.001$). The results are consistent with those of Hofstetter et al. (2001), Eastin and LaRose (2000) and Klimmt and Hartmann (2006). However, results for hypothesis 2 (H2: Mass media significantly influences consumers' trust of self-driving cars.) is not significant ($\beta = 0.11$; p greater than 0.05), which is consistent with the results of Ayeh et al. (2013) and Abang Othman et al. (2017).

At the second level of relationship, hypothesis 4 states that subjective norms positively affect consumers' trust of self-driving cars. Our results support this hypothesis ($\beta = 0.40$; $p < 0.001$). The same results can be seen in Beggiato and Krems (2013) and Hergeth et al. (2017). Our results also support hypothesis 6, which theorizes a positive relationship between self-efficacy and trust ($\beta = 0.38$; $p < 0.001$). This reflects the results of Hohenberger et al. (2016), Buckley et al. (2018a) , Buckley et al., (2018b), Cassidy and Eachus (2002) and Schaefer and Scribner (2015).

At the third level of relationship, hypothesis 5 states that subjective norms are positively related with intention to use self-driving cars ($\beta = 0.17$; $p < 0.05$), which is consistent with those of Deb et al. (2017), Madigan et al. (2017), Panagiotopoulos and Dimitrakopoulos (2018), Xu et al. (2018), Leicht et al. (2018), Adnan et al. (2018) and Hewitt et al. (2019). These findings support hypothesis 7, which theorizes that self-efficacy positively influences intention to use self-driving cars ($\beta = 0.30$; $p < 0.001$). Hohenberger et al. (2016) and Hewittet al. (2019) also confirm these results.

The findings also support Hypothesis 8, as the last level of relationship, ($\beta = 0.44$; $p < 0.001$), which states that there is a positive relationship between trust and intention to use self-driving cars. The results are consistent with those of Deb et al. (2017), Molnar and Ryan (2018), Panagiotopoulos and Dimitrakopoulos (2018), Xu et al. (2018) and Zhang et al. (2019).

6. Discussion

6.1. Theoretical implications

To explore the impact of mass media on innovation adoption, this article proposes a new theoretical model and empirically verifies that it can largely explain ($R^2 = 0.58$) why potential users adopt self-driving cars. Given the early stage of self-driving without commercially available application, this research focuses on environmental determinants

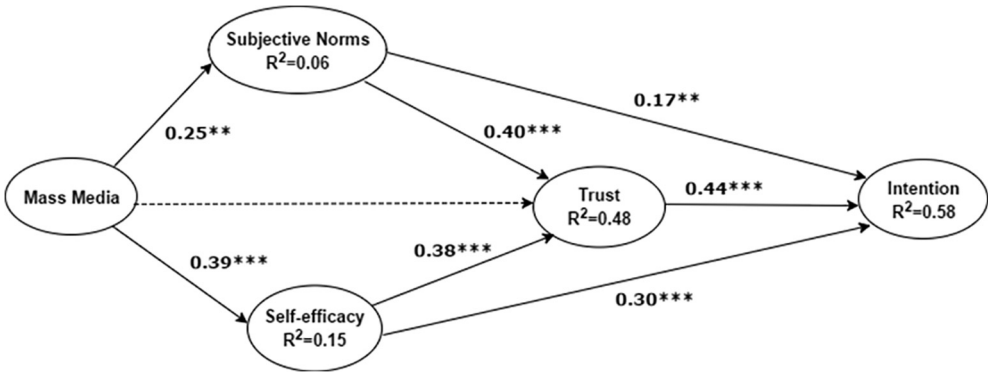

Fig. 2. Tested self-driving cars acceptance structural model Note: * P-value < 0.05, ** P-value < 0.01, *** P-value < 0.001.

(such as mass media), human determinants (such as self-efficacy and subjective norms) and product determinants (such as trust) to explore their effects on adoption intention as well as the relationships between the determinants. It is interesting that mass media fail to directly influence trust and behavior, but they indirectly influence user's attitude and adoption intention through self-efficacy and subjective norms. In this model seven predicted relationships are supported. The detailed theoretical implications are stated next.

The influence of mass media on product cognition and adoption intention is achieved through self-perception. Mass media greatly influence self-perception, especially on self-efficacy and subjective norms. These results are not surprising because at this stage of self-driving cars, most consumers have not used one, so they get most of their information from mass media reports (Fraedrich and Lenz, 2016). This reasoning agrees with findings of most research studies. An example of such support comes from Hofstetter et al. (2001) which provides evidence for the use of television, newspapers, and interpersonal communication to monitor the constructive and discriminant validity of political self-efficacy measurements in everyday life. As the possibility to operate a self-driving car becomes greater, many people should become more willing to drive one, especially those who have been involved in crashes, injuries and/or deaths (Poczter and Jankovic, 2014). Furthermore, in contrast to Hofstetter et al. (2001), mass media do not directly influence trust, just like what Ayeh et al. (2013) and Abang Othman et al. (2017) have determined. Trust may, however, be indirectly influenced by subjective norms and self-efficacy. According to this result, if most mass media reports on self-driving cars are positive, people's self-efficacy will be improved. It combines the belief in two aspects of personal behavior: (a) belief that one can successfully operate a self-driving car, and (b) belief that if it performs well, self-driving cars will have positive consequences (Bandura, 1986; Payre et al., 2014).

Moreover, self-efficacy and subjective norms such as self-perception will influence people's perception of products, such as trust. According to the proposed SCT extended research model, the self-efficacy of self-driving cars plays a major role in determining the consumers' intention to use them. This agrees with our hypothesis. In addition, the "subjective norms" variable has a positive impact on adoption intention, indicating that other important people's choices will affect consumer's acceptance of self-driving cars. This is consistent with the studies of Zmud et al. (2016), and Panagiotopoulos and Dimitrakopoulos (2018).

In the meantime, trust can create a willingness to use new or unfamiliar emerging technologies (McKnight et al., 2002). Based on this view, the technology of self-driving cars appears to be positively correlated with people's willingness to use them (Choi and Ji, 2015; Noy et al., 2018; Shariff et al., 2017). As expected, trust in this study also positively influences adoption intention, which suggests that perceptions of the credibility of system effectiveness would influence consumers' decisions to accept the technology of self-driving cars. In this way, if individuals find that they can trust this technology, they will buy these cars (Ghazizadeh et al., 2012; Panagiotopoulos and Dimitrakopoulos, 2018).

6.2. Practical implications

We provide practical guidance for the promotion of self-driving cars. The promotion and reporting of media for positive self-perception (e.g., I can, I should) will significantly enhance people's trust in driverless cars and intention to use them. Moreover, higher trust in self-driving cars is associated with higher intention to use them. Although researchers in the field of human automation interaction warn about excessive trust and overdependence (Lee and See, 2004), they should pay more attention to addressing the current distrust issues. Public distrust may be the biggest obstacle to large-scale adoption of these cars (Hutson, 2017). At this stage, few people have been exposed to real self-driving cars. The public can only access media reports, so this mistrust will mainly come from the reports of mass media on self-driving cars, especially the negative reports. Therefore, it is recommended to adopt certain strategies, such as guiding the mass media to report more positive reports (e.g., mature technology and perfect experience) to win public trust. This will enhance the public's attitude toward reliability, usability and comprehensibility of this technology (Hengstler et al., 2016).

All in all, the results can significantly contribute to ongoing research related to the acceptance of self-driving car technology. It helps technology developers, policy makers and implementers to improve products and services, designing interventions to promote acceptance and gain competitive advantages in the global market.

7. Limitations and future work

Although the present study has made some theoretical and practical contributions to explain factors influencing people's intention to use self-driving cars, there are limitations which should be addressed in future research. First, participants of our survey are young Chinese college students, so the results may not be generalizable. While the demographic profile of the sample is consistent with potential users of driver-less cars, the convenience sample of students may affect the validity of the results. Therefore, to strengthen the results of our current research, future research should target larger, more diverse populations and also check attitudes based on gender, education level, occupation, household income, driving experience, involvement in accidents, etc.

Another limitation of the study is that the participants had no experience using driverless cars; therefore, the survey results depend to a large extent on their imagination of driving fully autonomous vehicles. Besides, intentional acceptance is measured instead of actual acceptance of driverless cars. There might be discrepancy between intention and behavior. Future research also should measure actual acceptance once self-driving cars enter the market.

Finally, future research could investigate how vehicle-related (e.g., no driver intervention and driver intervention) and context-related factors (e.g., short-term and long-term experience) influence each other, further advancing our understanding of acceptance of this technology.

CRediT authorship contribution statement

Huiying Du: Writing - original draft, Methodology, Supervision, Project administration. **Ge Zhu:** Data curation, Visualization, Investigation. **Jiali Zheng:** Software, Writing - review & editing.

Acknowledgement

The acknowledging information is National Natural Science Foundation of China (NSFC), Grand ID is 71571021.

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