The Effects of Subjective Knowledge on the Acceptance of Fully Autonomous Vehicles Depend on Individual Levels of Trust

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Abstract. The rapid development of autonomous driving technology has attracted great attention from society nowadays. However, the lack of consumer acceptance might be a prominent barrier to the large-scale adoption of fully autonomous vehicles (FAVs). This study argues that it is critical to predicting FAV acceptance before it is fully popularised. To investigate the relationship between the public FAV subjective knowledge and general acceptance, we conducted an online questionnaire. The results showed that respondents with higher levels of FAV subjective knowledge were more likely to accept FAV. In addition, a significant moderating effect of trust was found. Specifically, in groups with higher level of trust, the same level of subjective knowledge evoked higher level of acceptance. In conclusion, the insights from this study could greatly facilitate ongoing research related to FAV acceptance. And policymakers should consider consumer characteristics, such as subjective knowledge and trust, when formulating AV promotion strategies, so as to effectively improve consumer acceptance of FAV.

Keywords: Fully autonomous vehicles · Subjective knowledge · Trust · Acceptance · Moderation

1 Introduction

The automotive industry is facing a new turning point. In recent years, autonomous vehicle (AV) technology has received more and more attention from the public, whose interest and investment continue to increase. A Self-driving car is a vehicle that can drive to the destination on its own without drivers' operation. SAE International [1] divides autonomous driving into 6 categories according to different degrees of automation, ranging from level 0 (human drivers complete all driving tasks without automation) to level 5 (automatic driving). In level 5, the technical system can perform all under any circumstances, and in terms of driving tasks, humans are just passengers and never need to participate in driving. Safety is an urgent issue in the road transportation system. However, according to data from the World Health Organization [2], more than 1.2 million people die in road traffic accidents worldwide each year, which has a huge

impact on health and development. In response to the aforementioned road safety issues, autonomous vehicle technology is considered to be able to play a significant role [3]. In addition, AV can also increase the mobility of vulnerable traffic groups. For example, it can expand the opportunities for socially vulnerable groups such as elderly drivers and the disabled to participate in society [4, 5]. Furthermore, The AV is also considered to improve traffic efficiency, reduce emissions, save fuel, and thereby reduce social costs. And the new business model brought about by the development of AVs will also create immeasurable market value. In summary, autonomous driving will have a profound impact on society, the environment, and transportation.

Although the benefits of AV are obvious, all these potential social benefits will not be realized if the public does not accept and use this technology. For companies and governments, it is urgent to comprehend the psychological mechanism behind consumers' acceptance of AV, and then formulate corporate strategies and policies. In particular, level 4–5 AVs are expected to account for 49% of the market by 2030, so it is crucial to understand public potential acceptance and its influencing factors before FAV fully enters the market [6]. An increasing number of studies were conducted to examine users' acceptance of AVs and their determining factors [7–9]. In addition, we had tried to explore the relationship between these influencing factors by establishing acceptance models [6, 10, 11], to better understand their direct and indirect influence on acceptance. However, most of these studies focus on the AV rather than the fully autonomous vehicle (FAV). It is believed that similar researches on FAV are also extremely urgent, especially at the moment when it is about to be realized. In addition, although the relationship between consumers' knowledge about the AV and acceptance has attracted the attention of researchers in recent years [12–14], the more detailed relationship between the two has not been explored. Therefore, this research aims to explore the relationship between the public's subjective knowledge and acceptance of FAV. More importantly, this research considers the moderating effect of trust on the relationship between subjective knowledge and acceptance (see Fig. 1), to understand more comprehensively and scientifically the mechanism of the public subjective knowledge on acceptance.
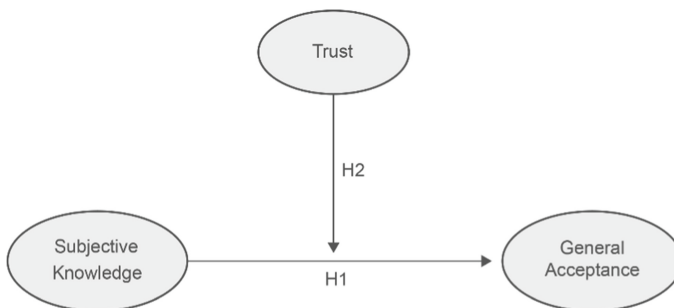

Fig. 1. Conceptual diagram of the moderation model

Our research finds that consumers' subjective knowledge will significantly positively promote general acceptance of FAV, and at the same time, this relationship could be moderated by the level of trust. Specifically, for people with the same subjective knowledge,

the increase in trust could help inspire higher acceptance of FAV. Our research will contribute to the theory and practice in many ways. First of all, our research analyzed the influence of subjective knowledge on FAV acceptance through quantitative investigation and contributed to the AV acceptance literature. Second, we also made contributions by providing insights on how trust regulates the impact of subjective knowledge on acceptance. Finally, we contributed to the policymakers and AV promoters in their public communication by identifying the key factors affecting AV acceptance.

The main purpose of this research is to study the relationship between public subjective knowledge and general acceptance, and to investigate the moderating effect of FAV trust on this relationship. To the end, we suggest a research model and influencing factors based on theoretical background. The organization of this study is as follows: Sect. 2 provides the research model, hypothesis, and literature review, and Sect. 3 introduces our research methods. Section 4 explains the data analysis and results, and Sect. 5 discusses the results. We then continue with the conclusions and limitations in Sect. 6.

2 Related Works

2.1 General Acceptance

The subject of this article is the autonomous vehicle in Level 5, which is called the FAV that may not have a steering wheel, brake, or driver. Looking at the previous studies on the AV acceptance, researchers investigated public acceptance of AVs from different perspectives [15–18]. In recent years, the influencing factors of acceptance have attracted the attention of researchers, and numerous factors have been recognized. Among them, many researchers emphasized the influence of sociodemographic factors on AV acceptance [19–20], such as education, age, and gender. In addition, psychosocial factors are thought to affect general acceptance of FAV [7–8, 21], such as trust, perceived benefit/risk, perceived usefulness/ease. Furthermore, other researchers believe that mobility behavior is also the main factor affecting acceptance [22–24], such as vehicle ownership, driving license, and in-vehicle time. Among these factors, subjective knowledge and trust sparked our interest. The following subsections provide the theoretical foundation and empirical evidence for their relationships with acceptance (see Fig. 1).

2.2 Subjective Knowledge

Public negative attitude to science is often attributed to a lack of knowledge. The influences of knowledge on the acceptance of consumers have been measured in many studies in the growing body of literature. A large-scale survey across countries found that the improvement of the subjective knowledge of genetically modified foods significantly increased consumers' willingness to accept [25]. Among the respondents with a higher extremity of opposition to genetically modified food, the higher level of subjective knowledge, the lower extremity of opposition they held [26]. In the AV domain, it has attracted the attention of researchers that how much consumers know about AVs [14, 27, 28]. These papers focus on subjective knowledge of FAVs, which is how much knowledge of FAVs a person thinks he/she has. The subjective knowledge of AVs has

been instrumental in the prediction of acceptance. Those having previously heard of AVs were more likely to be interested in having this technology on their vehicles [14]. It was found that consumers with higher levels of self-assessed knowledge showed a greater tendency and positive belief towards FAVs over private vehicles [12, 13, 29]. Overall, in the context of FAVs, consumers' acceptance of FAVs may be enhanced with the improvement of subjective knowledge of this technology. Thus, we will continue to verify the relationship between FAV's subjective knowledge and acceptance in this study:

H1. Subjective knowledge of FAV will positively affect general acceptance of FAV.

2.3 Trust

In 1998, trust was regarded as a state of mind, including the intention to accept vulnerability based on positive expectations of the intentions or behavior of others [30]. Later, Pavlou & Fygenson [31] proposed that trust was the belief that it would cooperate to fulfill the expectations of the client without taking advantage of its weaknesses. In summary, trust is the confidence of one party in the specific actions of the other party [32]. In the AV field, trust is particularly important for understanding the relationship between public and AVs. Researchers emphasized its importance for creating a willingness to use and rely on the technology of interest in its early stages [33]. The study found that the introduction of knowledge about automated systems would increase trust [34]. However, according to Hengstler et al. [33], trust is a psychological mechanism that enables us to reduce the awareness of uncertainty and thus is more willing to rely on FAVs to perform tasks. In addition, the trust provides a way to subjective assurance that can ensure that the trust achieves satisfactory results [35]. Therefore, we speculate that the effect of subjective knowledge on general acceptance may change due to changes in the trust level. For example, at a high trust level, subjective knowledge may stimulate higher acceptance and vice versa. In summary, we assume that trust will significantly moderate the impact of subjective knowledge on general acceptance:

H2. Trust will significantly moderate the relationship between subjective knowledge and general acceptance of FAV.

3   Methods

3.1   Participants

1609 participants completed the survey, 29 among them who failed an attention check were excluded from further analyses. This resulted in 1582 qualified completes used for analysis, with 51.5% (N = 814) male and 48.5% (N = 768) female. The ages of the participants were as follows: 661 were 18–29 years old, 673 were 30–39 years old, 190 were 40–49 years old, and 58 were 50 or older. Among these participants, 81.9% of them had driving experience.

3.2 Procedure

The online survey was administered on Baidu's Data Crowdsourcing Platform, with more than 17,000,000 respondents in its sample database and covering 300 cities in China. At the beginning of the questionnaire, they were told: "This questionnaire will ask you about your understanding and attitude towards Fully Autonomous Vehicles. The questionnaire will be conducted anonymously. All information is guaranteed not to be used for any commercial or personal purposes other than academic research". In addition, we showed them a concise description of the FAV. Subsequently, variable-related items and demographic questions needed to be answered. Participants were allowed to skip questions. However, they were not allowed to return to questions in a previous block after moving to a new block. Afterward, they were thanked for their participation and debriefed.

3.3 Measures

All measures in this survey were adapted and modified from previous literature to fit this research. And, all items are measured using a 5-point Likert scale. The details are as follows.

Subjective Knowledge. The respondents were first instructed to evaluate the subjective knowledge of FAVs adopted from Aertsens et al. [36]. They indicated their agreement with statements such as "I know FAV very well", "Among the people I know, I can be regarded as an 'expert' in the field of FAV", and "I know how to choose and judge FAV".

Trust. Participants were asked to indicate their agreement with the following statements about their trust: "I think FAV is dependable", "I think FAV is reliable", and "Overall, I can trust FAV", which were adapted from Choi and Ji [37].

General Acceptance. In the next section of the survey, participants were asked to assess the agreement of 5 statements about their general acceptance toward FAV, which were adopted from Liu et al. [35] and Xu et al. [15] as well as Yoon and Cho [38]. These items were measured using a 5-point Likert scale as follows: "Please rate your overall attitude toward the FAV" (1 = very negative and 5 = very positive), "Please indicate the acceptability level of the FAV" (1 = very unacceptable and 5 = very acceptable), and 3 items related behavioral intention such as "I intend to ride/buy/recommend the FAV in the future" (1 = strongly disagree and 5 = strongly agree).

4 Data Analysis and Results

Data analyses were performed using SPSS, and we further tested the moderation effect of trust using the plugin PROCESS based on SPSS and SAS developed by Andrew F. Hayes, which is directly able to calculate mediation effects in our proposed model. We first analyzed the measurement model and then tested the hypothesis we proposed.

4.1 Measurement Model

The reliability and validity of our measurement model were tested by SPSS. Cronbach's alpha value of all constructs was higher than 0.7, which indicated that reliability was of good quality. As for discriminant validity, the value of KOM was 0.899, higher than the suggested value of 0.8 (more details see Table 1). In addition, the correlations between variables were also calculated, and the results showed that all variables were significantly correlated (see Table 2). In conclusion, all of these results show that our measurement model has good psychometric performance.

Table 1. Scales for reliability and validity of measurement model.

Construct	Item	M	SD	Range	α
Subjective knowledge (SK)	SK1	3.11	1.048	1–5	0.790
	SK2	2.63	1.164		
	SK3	2.90	1.171		
Trust (TR)	TR1	3.35	0.975	1–5	0.748
	TR2	3.46	1.011		
	TR3	3.41	1.007		
General Acceptance (GA)	GA1	3.80	0.965	1–5	0.807
	GA2	3.62	1.028		
	GA3	3.63	0.973		
	GA4	3.68	0.886		
	GA5	3.66	0.911		
KOM = 0.899					

Note: M = mean, SD = standard deviation, α = Cronbach's alpha

Table 2. Correlation between variables.

Construct	SK	TR	GA
Subjective knowledge (SK)	/	0.486**	0.401**
Trust (TR)	0.486**	/	0.648**
General Acceptance (GA)	0.401**	0.648**	/

Note: Correlation is represented by Wilson coefficient. * $p < 0.05$; ** $p < 0.01$

4.2 Hypothesis Test

Main Effects. To test hypothesis H1, we first performed a regression-based analysis where subjective knowledge served as predictor variable, and general acceptance as outcome variable. As expected, the results showed that higher level of subjective knowledge

led to greater general acceptance toward FAVs ($\beta = 0.303$, $p < 0.001$), which supported H1. For more details see Table 3.

Table 3. Regression model predicting the general acceptance.

	β	SE	t	P
Subjective knowledge (SK)	0.303***	0.017	17.381	0.0000
Constant	2.804***	0.053	58.038	0.0000
R-square = 0.161				

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Moderating Effect of Trust on Subjective Knowledge and General Acceptance. To examine whether trust moderates the effect of subjective knowledge on general acceptance, we performed moderation analysis using the PROCESS by Hayes (model 1), and further calculated the R-square change to the magnitude of the adjustment effect. See Table 4 and Fig. 2 for results. Subjective knowledge served as the independent variable, trust as the moderating variable, and general acceptance as the dependent variable for model analysis. As expected, this model is statistically significant ($P < 0.01$), the regression coefficients of subjective knowledge and trust are statistically significant ($P < 0.05$), and the product term subjective knowledge * trust is statistically significant ($P < 0.05$). Therefore, we believe that the relationship between subjective knowledge and general acceptance is significantly negatively moderated by trust, which supports H2.

Table 4. Regression model predicting the general acceptance – main effect.

	β	SE	t	P
Subjective knowledge (SK)	0.0937***	0.0167	5.5933	0.0000
Trust (TR)	0.5150***	0.0194	26.5846	0.0000
TR * SK	–0.427*	0.0166	–2.5712	0.0102
Constant	3.6932***	0.0150	246.9896	0.0000
R-square = 0.4314				

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Specifically, at different trust levels, including high, medium, and low level, subjective knowledge has a significant effect on the general acceptance of FAVs (see Table 5 and Fig. 3 for more details). In addition, concerning the size of the adjustment effect, we use the product term to estimate the change in the R side of the regression model. Process directly gives the R-square change of 0.0024, that is, the contribution of the adjustment effect to the variation is close to 0.24%.
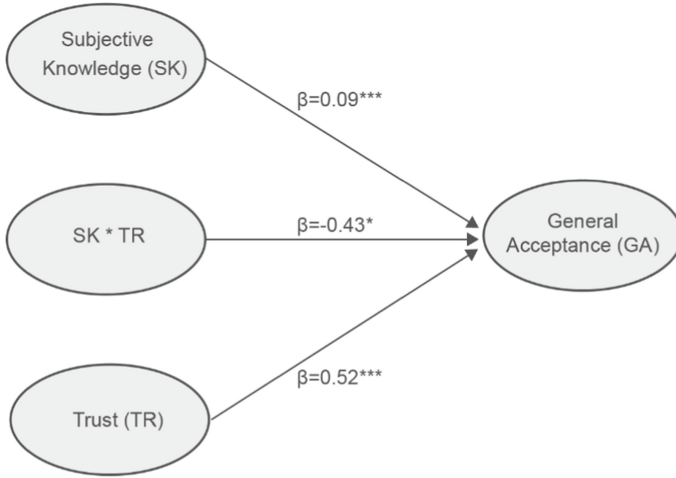
Fig. 2. Statistical plots for moderation model. **Note:** *p < 0.05; **p < 0.01; ***p < 0.001.

Table 5. Conditional effect of subjective knowledge on FAV general acceptance at values of trust.

	Trust (TR)	β	SE	t	P
Low	− 0.8132	0.1284***	0.0234	5.4740	0.0000
Medium	0.0000	0.0937***	0.0167	5.5933	0.0000
High	0.8132	0.0590**	0.0194	3.0456	0.0024

Note: Values for trust are the mean and plus/minus one SD from mean. * p < 0.05; ** p < 0.01; *** p < 0.001
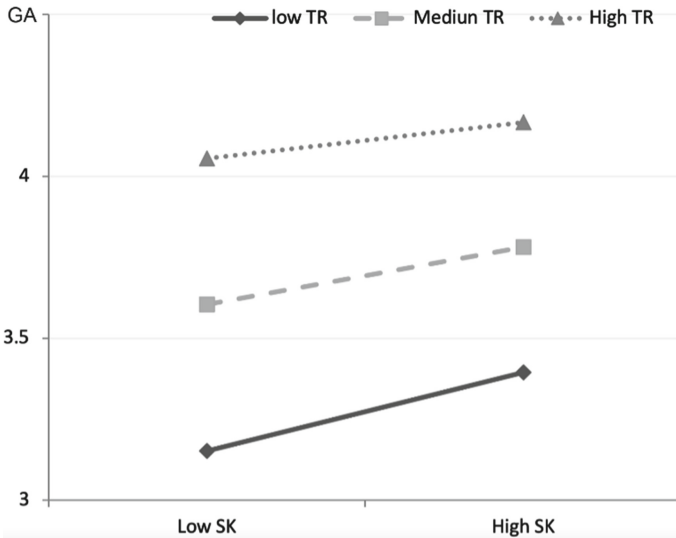

Fig. 3. Statistical diagram of the moderation model. **Note:** GA = general acceptance, SK = subjective knowledge, TR = trust.

5   Discussion and Implication

5.1   Discussion of the Results

The main purpose of this study is to comprehensively analyze the impact of the public subjective knowledge on FAV general acceptance through analyzing direct influence and moderating effect. Overall, the empirical results show that all of our hypotheses hold true.

Our results show that the subjective knowledge of FAVs significantly positively predicts its general acceptance. Specifically, higher level of subjective knowledge means higher level of general acceptance, which is consistent with previous findings [12]. Furthermore, with moderation, we tested whether the relationship between subjective knowledge and FAV general acceptance depended on the individual's level of trust in FAV. The findings show that the significant effect of subjective knowledge on general acceptance applies to groups of all trust levels (low, medium, high). Building on this, we also found that trust does increase the level of subjective knowledge that positively affects general acceptance of FAVs. Specifically, the same level of subjective knowledge inspires higher level of FAV acceptance as trust increases. Therefore, we can say that trust can further enhance the positive effect of subjective knowledge on the acceptance of FAVs. We speculate that this may be due to the role of the psychological mechanism of trust, which helps the public to overcome uncertainty and provides a subjective assurance to the public to a certain extent (Liu et al., 2019), thus people having the same with subjective knowledge, the higher trust level, the more willing to accept the FAV.

5.2   Contributions

Our findings have profound theoretical and practical implications. First, about theoretical contributions, our study partly fills the literature gap on FAV acceptance. We took the subjective knowledge as an independent variable, trust as a moderator variable, and general acceptance as an outcome variable, and obtained the statistical relationship between the three through data analysis, which is helpful for a more detailed and comprehensive understanding of public FAV acceptance mechanism. Secondly, concerning the practical significance, our research explores the moderating role of trust in the process of subjective knowledge-acceptance influence, which means that in the future when FAV popularization is conducted to the public, in addition to improving public subjective knowledge through educational exchanges, it is also necessary to develop appropriate strategies to increase public trust and thus more effectively improve FAV acceptance.

5.3   Limitations and Future Works

First, the generalizability of the study is limited by the distribution and size of the survey sample, and these users generally have high computer performance, but we believe they are largely representative of the user population of future technologies. Second, the experiment was done through an online questionnaire, whose form might lead to distraction thereby leading to experimental bias. In the future, a real car environment can be created for respondents to provide a more realistic experience. Finally, FAV has

yet to gain real popularity, as our respondents can only make judgments by imagining the future, which inevitably leads to bias to some extent. Therefore, after the popularization of FAVs in the future, further updated investigations need to be obtained more accurate results.

6   Conclusion

In this study, we investigated the combined effect of an important factor (subjective knowledge) and its moderator (trust) on FAV general acceptance, which is the most discussed. In this paper, we verify that subjective knowledge has a significant effect on the general acceptance of FAVs. In addition, the study found that trust could significantly moderate the relationship between the two. Specifically, in people with higher level of trust, subjective knowledge stimulates FAV acceptance to a greater extent. We urge FAV practitioners and researchers to build on our findings to develop appropriate outreach and communication strategies to improve FAV acceptance by future users. Furthermore, we also hope that this work will advance research on FAV acceptance to help the public better understand the psychological mechanisms behind FAV acceptance.

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