Travel Behaviour and Society 24 (2021) 164–171

Contents lists available at ScienceDirect

Travel Behaviour and Society

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

Modeling drivers' scrambling behavior in China: An application of theory of planned behavior

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ARTICLE INFO

Keywords:
Scrambling behavior
The theory of planned behavior
Structural equation model
Intervention methods

ABSTRACT

Scrambling behavior is one of the main causes of road traffic accidents in China. This study aimed to investigate the characteristics of drivers' scrambling behavior and its influencing factors based on the theory of planned behavior. A total of 388 drivers answered the questionnaire and 359 provided valid data. The structure equation model of scrambling behavior showed that positive attitudes towards scrambling behavior, subjective norms and perceived behavior control increased the intention of scrambling behavior. Furthermore, the path coefficient of the structural equation model for the scrambling behavior revealed that attitude was the most important factor influencing scrambling behavior. Thus, to prevent drivers from scrambling, traffic regulators should focus on improving drivers' attitude towards this behavior, while auxiliary measures should be enacted to regulate drivers' subjective norms and perceptual behavior control. Implications on intervention strategy and policy to reduce scrambling behavior are discussed.

1. Introduction

The rapid development of social economy, urbanization and motorization result in an upsurge in the car ownership in China in recent years. This continuous increase in traffic volume has led to an increase in crash occurrence. According to the *Road Traffic Safety Development Report (2017)*, China witnessed 8.643 million road traffic accidents in 2016 alone, with an increase by 659,000 (16.5%) compared with the same period in 2015. Previous studies have shown that human factors are the most significant contributing factor in traffic accidents (Qu et al., 2020), which are related to over 95% of road traffic accidents (Sabey and Taylor, 1980). Furthermore, it was found that aggressive drivers are more likely to be involved in traffic accidents (Jovanović et al., 2011; Sansone et al., 2012; Wickens et al., 2016).

1.1. Scrambling behavior

As a typical aggressive driving behavior, scrambling behavior refers to drivers competing with other traffic participants (e.g. vehicles on an intersecting path, pedestrians) for the right of way, usually characterized by a violation of traffic regulations. This phenomenon, though less observed in developed countries, is very common in China (Shi et al., 2011). The dramatic growth in car ownership in recent years and the slowly expanded road facilities lead to a serious imbalance between the transportation supply and demand in urban areas. As a result, drivers usually scramble with one another maliciously for the right of ways in order to obtain the priority of traffic and save travel time. Road traffic safety has always been a major problem in China, which has the highest number of road traffic deaths in the world and the road traffic fatality rate is more than double the average of developed countries (18.8 relative to 9.2). *The Road Traffic Safety Development Report (2017)* shows that there were 8.643 million traffic accidents in China in 2016, of which 18.3% were caused by scrambling behavior. Therefore, to improve traffic safety in China, it is of great significance to study the characteristics of scrambling behavior and its influencing factors.

For research on driver performance and behavior, driving simulators have been widely used in recent years (Hooft van Huysduynen et al., 2018; Obeid et al., 2017; Wu et al., 2020; Xu et al., 2021). Simulators are not total replicates of the real driving situation but offering opportunities to investigate driving under controlled conditions and scenarios. The number of driving simulators studies continues to increase. In the driving behavior literature, driving simulators are a popular tool to monitor driver behavior in a naturalist driving environment (Obeid et al., 2017; Hooft van Huysduynen et al., 2018). For example, Bıçaksız

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https://doi.org/10.1016/j.tbs.2021.03.008
Received 5 May 2020; Received in revised form 6 March 2021; Accepted 26 March 2021
Available online 10 April 2021

et al. (2019) investigated the link between impulsivity and driving style link by measuring driver behaviors on the driving simulator. Li et al. (2020) investigated the effect of mobile phone use on the gap acceptance manoeuvre at intersections by using the driving simulator method. These studies have mainly focused on exploring the actual driving performance of drivers during naturalistic driving, but failed to explore the internal factors, such as the psychological characteristics, motivational factors, and the causes of aberrant driver behavior. Besides, the emergence of scrambling behavior is closely related to the driver's personal cognition, and it is difficult to reproduce in the simulation experiment environment. To examine psychological factors causing scrambling behaviors, we used the self-report questionnaire in the present study.

Questionnaire is a very popular tool for studying the psychological characteristics and the triggers of aberrant driver behaviors. The earliest Driver Behavior Questionnaire (DBQ) categorized driving behavior into three different types, including violations, errors, and slips or lapses (Reason et al., 1990). Since then, DBQ has become an effective and powerful tool for studying aberrant driving behavior. Jiang et al. (2016) developed a driver anger scale to study the driving anger in China. Eboli et al. (2017) studied the influence of physical and emotional factors on driving style of drivers. Rolim and Baptista (2018) assessed the drivers' self-perceptions on their driving performance based one the advanced DBQ and driving performance data. Scholars have also studied the scrambling behavior based on DBQ. Shi et al. (2011) examined the effect of drivers' driving skills and attitudes towards violation on scrambling behavior, but they did not consider other potential influencing factors of scrambling behavior, such as perceived behavior control and pressure from important others. The findings in previous work indicate that these potential influencing factors has significant impact on abnormal driver behavior (Jiang et al., 2016; Moan, 2013), and if the psychological mechanisms which motivate drivers to perform the abnormal driver behavior can be identified, then there is a potential to develop interventions which may lead to changes in behavior (Moan, 2013). Thus, in order to explore the potential psychological triggers of scrambling behavior in China, the present study revised Reason's DBQ by adding questions concerning Chinese drivers' scrambling behavior and measured individual psychological factors based on the theory of planned behavior.

1.2. The theory of planned behavior

The theory of planned behavior (TPB), first proposed by Ajzen (1991), is widely adopted to investigate psychological characteristics. It assumes that intentions can be used to predict individual behavior and can be considered as a result from individual attitude towards the behavior, subjective norms, and perceived behavioral control (PBC) over the behavior. Many related studies have applied TPB to study the (abnormal) driving behavior of different traffic participants, such as traffic violations (Castanier et al., 2013), speeding (Elliott and Thomson, 2010), fatigue driving (Jiang et al., 2017), mobile device usage while driving (Bazargan-Hejazi et al., 2016; Piazza et al., 2019; Jiang et al., 2016), and travel mode choice (Gao et al., 2020, 2021a; Lo et al., 2016). Results from these studies reveal that the TPB can improve the predictability of driver's willingness by studying individual traits to analyze a specific behavior, which naturally renders TPB a potential method to scrambling behavior as well. Although no studies have used the TPB to examine the psychological factors influencing drivers' scrambling behavior, driver's attitude towards scrambling behavior, one of the important factors of TPB, has been shown to significantly predict scrambling behavior (Shi et al., 2011). It provides the theoretical background for the present study applying the TPB model to explore different psychological factors that affect drivers' scrambling behavior.

According to the theory of planned behavior, three factors together influence behavior intentions (BI) and behavior: Attitude (AT) refers to one's positive or negative assessment of a specific behavior (Heesup Han, 2015); subjective norm (SN) represents the perceived social influence of family members, friends or others on decision making (Jiang et al., 2017); and perceived behaviour control (PBC) is the perceived level of control that one has over or refraining from engaging in a particular behavior (Frater et al., 2017). TPB indicates that the more favorable attitudes, subjective norms and perceived behavioral control to be held by someone, the greater the intention to perform the behavior. In other words, as long as individuals and their surrounding groups positively evaluate an abnormal driving behavior and realize that there is nothing can stop them from engaging in that behavior, the behavior intention will be stronger (Neto et al., 2020). The TPB also mentions that behavior intention is the proximal determinant of behavior, the stronger the intention to behave, the more likely the behavior will be performed.

1.3. The current study

The current study was conducted in China, where the scrambling behavior can be seen very often. The purposes of the current study are twofold. First, we aim to explore the influence of psychological characteristics on driver's scrambling behavior using TPB, which mainly included SN, AT and PBC. The second aim of the current study is to provide information to understand the socio-cognitive determinants of driver's decisions and scrambling behavior and accordingly propose some intervention measures to prevent drivers' scrambling behavior. It could also be of use when setting up road safety campaigns targeting drivers who perform scrambling behavior.

Based on the TPB, we propose the following hypotheses.

Hypotheses 1. (*(H1):*) *Drivers' AT towards scrambling behavior is positively related to their intentions of scrambling behavior.*

Hypotheses 2. (*(H2):*) *SN is positively related to the intention of scrambling behavior.*

Hypotheses 3 (H3): PBC is positively related to the intention of scrambling behavior.

Hypotheses 4 (H4): BI is positively related to drivers' scrambling behavior.

Hypotheses 5 (H5): The relationship between AT, SN, PBC and scrambling behavior is mediated by BI.

Based on the above hypotheses, the drivers' scrambling behavior model considering AT, SN, PBC and BI, can be constructed as a structural equation model as shown in Fig. 1.

2. Method

2.1. Participants

After excluding incomplete and quick responses (answer time <3 min), 359 valid samples were included in the data analysis (247 male, 112 female). The sample validity rate was 92.5%. As shown in Table 1, participants were mainly from Guangzhou, China. A total of 220 (61.3%) participants have driven <5 years, with 90.3% self-identified as non-professional. Further, 56.0% of drivers drive <4 days per week on average. According to statistics released by the China Bureau of Statistics, there were 3.64 million professional drivers and 410.3 million non-professional drivers in China in 2018, with professional drivers making up approximately only 1% of drivers population in China. Additionally, there were 225.1 million cars in China in 2019, compared to 123.3 million in 2014 (National Bureau of Statistics of China, 2019), which indicates that about 45% of drivers in China may have less than five years' driving experience. Therefore, the sample structure in this study has represented the typical population of drivers in China.

2.2. Material

2.2.1. The scrambling behavior scale

The scrambling behavior scale was designed based on traffic

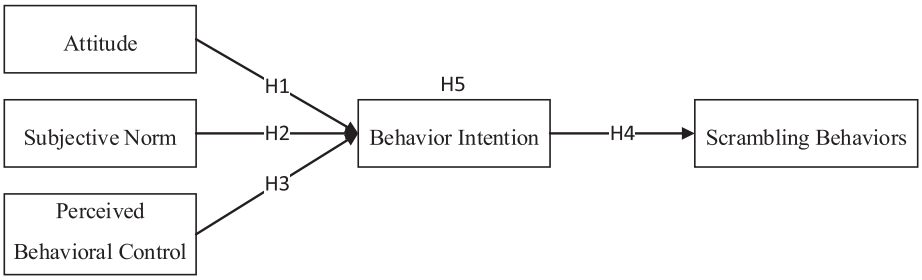

Fig. 1. The driver's scrambling behavior model based on TPB.

Table 1
Participants.

Demographic variables	Value	Frequency	Percentage (%)	Cumulative Percentage (%)
Driver type	Non-professional	324	90.3	90.3
	Professional	35	9.7	100
Gender	Male	247	68.8	68.8
	Female	112	31.2	100
Age	18–25	105	29.2	29.2
	26–35	126	35.1	64.3
	36–45	77	21.4	85.8
	>46	51	14.2	100
Driving experience	<5 yrs	220	61.3	61.3
	6–10 yrs	95	26.5	87.8
	11–15 yrs	29	8.1	95.9
	16–20 yrs	8	2.2	98.1
	>20 yrs	7	1.9	100
Average number of driving days per week	1	106	29.5	29.5
	2	45	12.5	42.1
	3	50	13.9	56.0
	4	18	5.0	61.0
	5	53	14.8	75.8
	6	27	7.5	83.3
	7	60	16.7	100

regulations in China and related studies (Reason et al., 1990; Shi et al., 2011; Jiang et al., 2017). With the assistance of traffic police and experts, seven questions were obtained after three rounds of testing.

2.2.2. The theory of planned behaviour scale (TPB scale)

The TPB scale was designed based on the theory of planned behavior. After three rounds of tests and the guidance of relevant experts, 14 items were finally obtained to measure AT, SN, PBC, and BI.

All the scrambling behavior scale and The TPB scale adopted a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). We asked participants to answer the questions based on their driving experience over the last year. All the items were presented in Table 2.

2.3. Survey implementation

This survey was conducted through both online and offline questionnaires from 2018-06-03 to 2018-06-09. The online questionnaire was published on Wenjuanxing (https://www.wjx.cn/), one of the most popular survey platforms in China. The offline questionnaire was mainly distributed in parking lots of shopping malls or near the traffic hub. It took approximately six minutes for a participant to complete the questionnaire. Participants received five Chinese Yuan (0.7 USD) after finishing this short survey. This survey was completely anonymous for the sake of privacy issues. A total of 388 drivers completed this survey within 6 days, with 147(37.9%) of the sample data coming from offline and the remaining 241(62.1%) from online.

2.4. Statistical analysis plan

We first carried out the factor analysis, along with the reliability and validity test of each scale. Then, correlation analyses of the drivers' scrambling behavior were carried out to examine the correlations between scrambling behavior and driver types, gender, age, driving experience and driving days per week. Finally, the drivers' scrambling behavior model was tested by a structural equation model. Structural equation modeling is one of the methods to establish, estimate, and examine the causal relationship between variables (Anderson and Gerbing, 1988; Lee et al., 2008). Compared with traditional multivariate techniques, structural equation model is less affected by the unreliability of measurements (Nelson et al., 2009), can model the relationship between both latent and explicit variables. Chen and Donmez (2016); Gao et al. (2021b,c); Scott-Parker et al. (2013); Zhao et al. (2019), and can replace multiple regressions and covariance analysis (Sadia et al., 2018; Kroesen and Chorus, 2018). Further, studies show that structural equation models can help to build more accurate models for driving behavior analysis (Shi et al., 2011). Therefore, we selected it to model scrambling behavior in this study. All analyses were conducted using SPSS Statistics version 21 and AMOS Statistics version 11.

3. Results

3.1. Structure of the driving behavior scale

3.1.1. Exploratory factor analysis

Exploratory factor analysis was used to extract the dimensions of the driving behavior scale. Before the factor analysis, KMO = 0.836 and Bartlett's test showed a significance level of $p < 0.01$, indicating that the data were suitable for factor analysis.

Results of the factor analysis were summarized in Table 2, with four items (DB4, DB5, DB6, DB7) reflecting the scrambling behavior between drivers and pedestrians, and the remaining reflecting the scrambling behavior between drivers and drivers. As shown in Table 2, the factor loadings of each item were above 0.6 (0.719–0.893), indicating that the correlations between the questionnaire variables and each factor were high (Jiang et al., 2017). The mean and variance of each item were also shown in Table 2. A higher mean reflected a higher average level of frequency of conducting the behavior, and variance explained the fluctuations of each item.

3.1.2. Reliability of the scale

The Cronbach's α was calculated to assess the internal consistency of the questionnaire and of each factor. With a total scale α = 0.846, and all two factors had a reliability coefficient greater than 0.6 (see Table 2), indicating the internal reliability was acceptable.

3.2. Structure analysis of the TPB scale

3.2.1. Exploratory factor analysis

Exploratory factor analysis was used to extract the dimensions of the TPB scale. Before the factor analysis, KMO = 0.850 and Bartlett's test

Table 2
Factor analysis results of the driving behavior scale.

Items	Mean	Factors loading	Cronbach's α	Variance explained (%)	Cumulative variance explained (%)
Factor1: Scrambling with pedestrians	1.604		0.887	41.31	41.31
DB6: Avoid pedestrians crossing the road on roadways	1.674	0.893			
DB7: Avoid pedestrians running red lights at signalized intersections	1.649	0.830			
DB4: Avoid pedestrians crossing the road at unsignalized intersections	1.568	0.825			
DB5: Avoid pedestrians who crossing the road while turning right at intersections	1.526	0.757			
Factor2: scrambling with cars	1.541		0.679	27.83	69.14
DB1: Avoid direct traffic in the opposite direction when turning left at the intersection	1.384	0.817			
DB2: Avoid vehicles merging into the main road when driving on auxiliary roads	1.752	0.736			
DB3: Avoid vehicles on the main roads when entering the main roads form auxiliary roads	1.487	0.719			

showed a significance level of $p < 0.01$, indicating that the data were suitable for factor analysis.

Results of the analysis were presented in Table 3, with four items (AT1, AT2, AT3, AT4) reflecting the AT towards scrambling behavior, four items (SN1, SN2, SN3, SN4) reflecting the SN of drivers, three items (PBC1, PBC2, PBC3) reflecting the PBC of drivers, and the remaining (BI1, BI2, BI3) reflecting the BI of drivers to scrambling. As can be seen from Table 3, the factor loadings of all items were above 0.6 (0.692–0.910), indicating that the correlations between the questionnaire variables and each factor were high (Jiang et al., 2017). The means

Table 3
Factor analysis results of The TPB scale.

Items	Mean	Factors loading	Cronbach's α	Variance explained (%)	Cumulative variance explained (%)
Factor 1:AT	1.845		0.863	21.97	21.97
AT2:I will scramble if no punishments are imposed	1.730	0.878			
AT4:I will scramble if I am experienced in driving	1.657	0.829			
AT1:I will scramble if no potential safety issues are perceived	1.830	0.786			
AT3:I will scramble if I am in a rush	2.164	0.751			
Factor 2:SN	2.842		0.893	22.34	44.31
SN2:The attitude of friends will affect my scrambling behavior	2.691	0.910			
SN1:The attitude of my families will affect my scrambling behavior	2.850	0.906			
SN3:The attitude of passengers will affect my scrambling behavior	2.721	0.893			
SN4:The attitude of the police will affect my scrambling behavior	3.109	0.692			
Factor 3:PBC	2.776		0.749	14.48	58.79
PBC2:I can react quickly when something unexpected happens	3.181	0.866			
PBC1: I'm experienced enough to handle all kinds of situations when driving	2.571	0.801			
PBC3:I have good control over the traffic around me when I scrambling	2.577	0.699			
Factor 4:BI	2.061		0.855	16.02	74.81
BI1:In the next six months I	2.039	0.818			

(continued on next page)

Table 3 (*continued*)

Items	Mean	Factors loading	Cronbach's α	Variance explained (%)	Cumulative variance explained (%)
will scramble when there is a traffic jam					
BI2:In the next six months I will scramble when I am in a hurry	2.209	0.767			
BI3:In the next six months I will scramble, even if the traffic is smooth and I am not in a hurry	1.936	0.746			

and variance of each project were also shown in Table 3, the higher mean reflected a higher level of frequency to doing the behavior of each item, and variance explained the fluctuations of each item.

3.2.2. Reliability of the scale

The Cronbach's α was calculated to assess the internal consistency of the questionnaire and of each factor. With a total scale $\alpha = 0.871$, and all four factors had a reliability coefficient greater than 0.7 (see Table 3), indicating a high level of reliability.

Table 3. Factor analysis results of The TPB scale

3.3. Correlation analysis

We used Pearson correlation analysis to examine the relationship between driver type, gender, age, driving experience, driving days per week and the factors in the driver behavior scale and the TPB scale. As shown in Table 4, driving experience and the behavior of scrambling with pedestrians were significantly negatively correlated, indicating that the more experienced the drivers were, the lower the frequency that they scrambled with pedestrians. Also, gender (male = 1, female = 2) and the behavior of scrambling with cars were significantly negatively correlated, indicating that male drivers were more frequent than female drivers in scrambling with cars. Driving days per week was also significantly negatively correlated with scrambling with cars behavior. In contrast, age was significantly positively correlated with SN, indicating that the older the driver, the more likely the driving behavior was to be affected by other people. Driving days per week was significantly negatively correlated with PBC ability. Gender was significantly positively correlated with behavior intentions, indicating that women show stronger intentions of scrambling behavior than men. No significant correlations were found between AT and driver type, gender, age, driving experience, and driving days per week, which indicates that the judgement of scrambling behavior may be influenced.

3.4. Model of scrambling behavior based on the theory of planned behavior

The estimated structural equation model was presented in Fig. 2. Results indicated that the estimated model fit data well, with a Comparative Fit Index (CFI) of 0.945, a Tucker-Lewis Index (TLI) of 0.935, a Goodness of fit index (GFI) of 0.905, and a root mean square error of approximation (RMSEA) of 0.061 (Anderson and Gerbing, 1988; Lee et al., 2008; Scott-Parker et al., 2013).

As shown in Fig. 2, all paths in the model were statistically significant, indicating that the hypothesized relationship in Section 2.1 were valid. Specifically, AT toward scrambling behavior had a positive effect on behavioral intention to scramble ($b = 0.56$, $p < 0.001$), supporting H1. SN was found to have a positive effect on intention to scramble ($b = 0.16$, $p < 0.001$), confirming H2. Furthermore, consistent with H3, PBC had a positive effect on behavioral intention ($b = 0.29$, $p < 0.001$). Finally, BI was a significant predictor of their actual scrambling behavior ($b = 0.41$ towards cars, $p < 0.001$; $b = 0.34$ towards pedestrian, $p < 0.001$), which confirmed H4.

Furthermore, the path coefficients between AT and SN, AT and PBC, SN and PBC were 0.27 ($p < 0.001$), 0.36 ($p < 0.001$), and 0.35 ($p < 0.001$), respectively, indicating a positive relationship among AT, SN and PBC of drivers in scrambling behavior.

The bias-corrected bootstrap method was used to investigate the mediating effect of BI between AT, SN, PBC and scrambling behavior, with a sampling number of 5000 and a confidence interval of 95%. The results were shown in Table 5. Tests of the mediating effect revealed that BI was the significant mediator of the associations between AT, SN, PBC and scrambling with cars (SC). The indirect effect estimates value were $\beta_1 = 0.229$, $\beta_2 = 0.066$, $\beta_3 = 0.118$. BI was also the significant mediator of the associations between AT, SN, PBC and scrambling with pedestrian (SP). The indirect effect estimates value were $\beta_4 = 0.193$, $\beta_5 = 0.056$, $\beta_6 = 0.100$.

4. Discussion

The present study examined a typical aggressive driving behavior, scrambling behavior, which is less observed in developed countries, but very common in China due to the weak awareness of right of way among drivers in China. The purpose of this study was to develop an effective, reliable, and user-friendly questionnaire to study the psychological determinants of the driver's scrambling behavior based on the theory of planned behavior. According to the results of the model test, the reliability and validity of the questionnaire are good, and it can be effective for the study of scrambling behavior in China. It was shown that AT, SN, and PBC were important predictors of BI to scrambling. Results from the current research can provide theoretical guidance for management departments to formulate targeted interventions to reduce scrambling behavior and improve road safety, and have great significance in ensuring road traffic safety and reducing road traffic accidents.

Table 4
Results of Pearson correlation analysis.

	Scrambling with pedestrians	Scrambling with cars	AT	SN	PBC	BI
Drive type	−0.043	0.013	0.325	0.949	-0.562	0.979
Gender	−0.041	−0.136*	1.759	−1.619	1.344	2.234*
Age	−0.1	0.099	−1.098	3.568***	1.529	1.604
Driving experience	−0.153*	−0.094	1.660	0.059	−1.286	-0.229
Driving days per week	−0.006	−0.184**	1.349	−1.496	−2.411*	-0.747

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

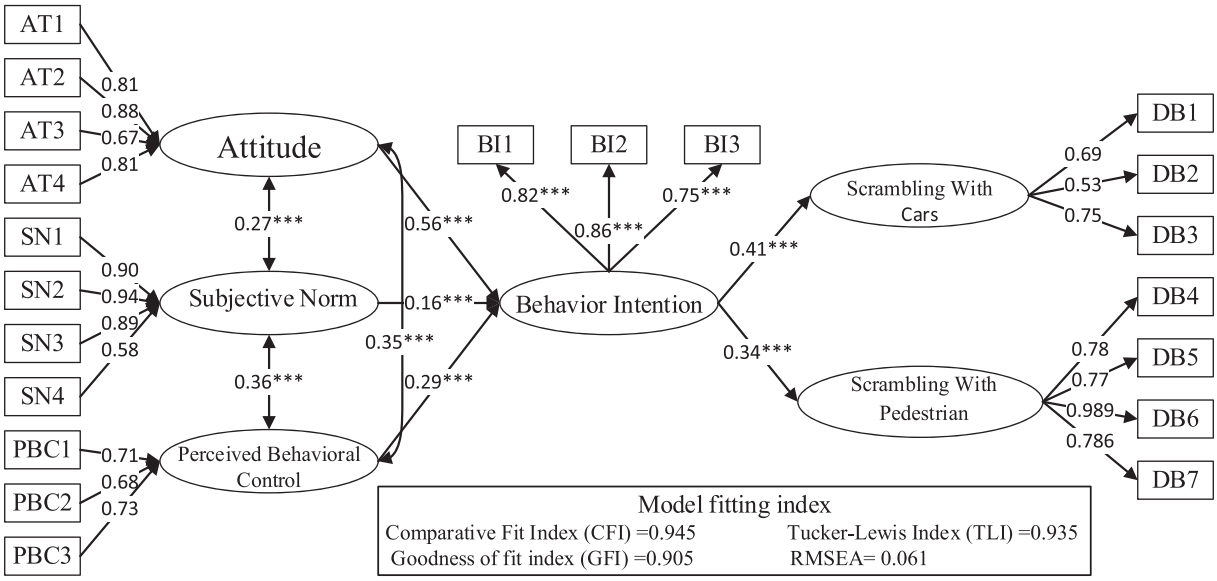

Fig. 2. The driver's scrambling behavior model.

Table 5
The estimated indirect effects in the final model.

	Estimates	SE	Lower Bounds	Upper Bounds	Two Tailed Significance
AT → SC	0.229	0.054	0.133	0.342	<0.001
SN → SC	0.066	0.023	0.024	0.116	<0.001
PBC → SC	0.118	0.034	0.062	0.197	<0.001
AT → SP	0.193	0.044	0.117	0.291	<0.001
SN → SP	0.056	0.021	0.020	0.102	<0.001
PBC → SP	0.100	0.034	0.044	0.177	<0.001

4.1. Efficacy of the TPB

The findings of this study show that the TPB is a useful framework for identifying key determinants of the scrambling behavior intention. As expected, AT, SN and PBC have important effects on driver's intention to scrambling. Individuals who hold positive attitudes towards reducing their scrambling behavior, believe that they cannot control the behavior, or do not think that important others expect them to scramble are less likely to perform the scrambling behavior.

The results show that the most important determinant of driver's scrambling intention is AT, with a coefficient of 0.78 in the driver's scrambling behavior structural equation model, *which is consistent with previous research (Shi et al., 2011)*. It reveals that when a driver takes a positive AT towards scrambling, his intention to scramble will increase, which is consistent with findings from previous applications of the TPB to other driving behaviors (Elliott and Thomson, 2010; Jiang et al., 2017; Piazza et al., 2019). Different from previous studies, this paper also discusses the effect of SN and BC on scrambling behavior. It is shown that SN has the weakest influence among the three factors, which means that drivers' intention to scrambling is less affected by social norms than individual attitudes and perceived behavior control.

This study also confirms that the driver's intention to scrambling has a positive impact on the driver's scrambling behavior. That is to say, the stronger the driver's intention to scramble, the more likely the driver performs the behavior. Tests of the mediating effect indicate that BI plays a partial mediating role between AT, SN, PBC and scrambling behavior. This finding is consistent with the TPB theory that AT, SN and PBC not only directly predict BI but also influence the occurrence of scrambling behavior through BI. These results indicate that the intervention of driver's scrambling behavior should be carried out from multiple perspectives, focusing on the driver's AT, and taking auxiliary measures from SN and PBC.

4.2. Practical implications

The results of model estimation show that psychological factors significantly influence the driver's scrambling behavior. In addition, the influence level of different psychological factors on driver's intention of scrambling behavior is different. Therefore, we need to develop the intervention strategy from a combination of multiple perspectives. We suggest it can be carried out from three aspects: driver training, traffic education and traffic enforcement.

4.2.1. Driver training

Driving in traffic is a social activity that requires close coordination between different participants and requires drivers to regularly monitor the behavior intention of other road users (Deppermann, 2019, Broth et al., 2018). Therefore, driver training should not only focus on the development of driving skill, but also to improve the hazard perception and the traffic rules (Isler et al., 2011). However, driver training in China currently mainly focuses on how to operate the vehicle, but ignores the knowledge of traffic rules and perception skills, as well as learning about the right-of-way. Drivers with limited experience may not be aware of what scrambling is or the consequence of scrambling. In the future, it is of great significance to include both driving skills and safety awareness in the driver training program.

Many studies have evaluated driver training programs and suggested that experienced drivers do not always equal to safe drivers. Advanced skills training may lead to overconfidence, which may reduce the cautiousness in driving, but increase the willingness to take risky driving behavior (Gregerson, 1997). Consistently, the present study shows that the driver's PBC has a positive impact on the driver's intention to scrambling. From this point of view, driver training should focus on risk perception and cognitive shortage rather than teaching emergency responses and anticipatory skills only (Mayhew and Simpson, 2002). It means that skill training should be complemented with risk perception training, thus provide drivers emergency maneuver training without increasing the overconfidence.

4.2.2. Traffic education

AT is the most important influencing factor of scrambling behavior; thus, the intervention of scrambling behavior should focus on changing the attitude of drivers. Attitude is based on people's understanding of the advantages and disadvantages of the specific behavior (Ajzen, 1991). The negative consequence of scrambling behavior is obviously traffic accident, which will cause serious losses of personal safety and property; the most obvious benefit drivers getting from scrambling behavior is to obtain the right of way and to save the travel time (Shi et al., 2011). Therefore, we should strengthen the consciousness of the consequences of scrambling behavior, and weaken the belief that scrambling behavior will bring benefits to the driver.

It has been widely documented that China is a collectivist and interdependent society, which shapes individuals' values, cognition and behavior (Markus and Kitayama, 1991; Nisbett et al., 2001; Wang et al., 2021; Yang et al., 2019). As compared with other independent and individualistic societies, Chinese society places much value on interdependence and connections with others. In addition, others and groups exert strong control on the individuals' behavior in collectivist Chinese society (Menon et al., 1999). They are greatly influenced by others' expectation (Li et al., 2019) and social norms (Chen & Hong, 2015). Accordingly, non-punitive strategies such as educational or persuasive communication strategies are useful measures to change driving behavior. In particular, advertising has been proven to be a very efficient method among them (José et al., 2012). Generally, the advertisements in road safety can be split into two categories, the positively framed advertisements and the fear-arousing advertising. The positively framed advertisements aim at showing how to do the right and safe things to drivers (Sibley and Harré, 2009), while the fear-arousing advertising aim at illustrating the bloody consequences which resulted from illegal driving behavior (Lewis et al., 2007). Both of these two categories advertisements can effectively change the driver's perception and attitude about illegal behavior, thus to intervene the driver's scrambling behavior, the positively framed advertisements and the fear-arousing advertising could both be efficiencies ways.

4.2.3. Traffic enforcement

Traffic enforcement is an imperative component in mitigating dangerous driving behavior, which provide the driver with the feeling that they are likely to be caught and sanctioned when carrying out risky driving behavior (Stanojević et al., 2013). Based on the results of factor analysis, traffic enforcement is an important factor affecting the driver's attitude towards scrambling. Currently, it lacks regulation of the scrambling behavior in China, which increases chances of drivers to scramble, because they will not be punished due to scrambling (Jiang et al., 2017). Therefore, to change the scrambling behavior, scrambling behavior should be clearly defined in the regulations, and specific laws are needed to more effectively prosecute drivers who carried out scrambling behavior. In some cities, for example, Hangzhou, drivers who do not yield to pedestrians will be punished.

4.3. Limitations of the present study

There are some limitations of this study. Firstly, data collected for this study were all self-report, which may not reflect the actual behavior on the road. Secondly, the internal reliability of the subscale scrambling with cars was not high, which requires further improvement of the measure in future studies. Thirdly, there were other factors that lead to scrambling but are not included in this study, such as risk perception, motivation, and personality traits. In the future, it would be worthwhile to examining these individual factors of scrambling behavior. Last, this study only used data in China to examine influencing factors of the scrambling behavior. Due to variance in policy and culture, we must be careful when applying the conclusions and policy recommendations obtained from the research to other countries.

5. Conclusion

In this study, TPB was shown to be effective in explaining scrambling driving behavior. It was shown that attitudes, subjective norm, perceived behavior control, and behavior intention were all significantly associated with scrambling driving behaviors. Considering the high frequency of scrambling behavior in China, and the seriousness of traffic accidents caused by scrambling behavior in general, it was very important to investigate why drivers perform scrambling behavior and how to reduce the likelihood of this risky and unsafe behavior. These findings can help us better understand scrambling behavior, provide valuable suggestions on intervention strategies, thus reducing drivers' scrambling behavior and improving road traffic safety in China. In addition, the scrambling behavior questionnaire based on the theory of planned behavior can be used as a benchmark for psychological testing of scrambling behavior, and management departments can conduct periodic tests of drivers' scrambling behavior based on this questionnaire, so as to modify and improve the related intervention measures.

CRediT authorship contribution statement

Weiwei Qi: Methodology, Formal analysis, Writing - original draft. **Bin Shen:** Data curation, Formal analysis, Writing - original draft. **Ying Yang:** Conceptualization, Methodology, Resources, Supervision, Writing - review & editing. **Xiaobo Qu:** Conceptualization, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The study is supported by the National Natural Science Foundation of China (NO. 71701070 & 52072131), the Science and Technology Project of Guangzhou City (NO. 201804010466), the Fundamental Research Funds for the Central Universities (NO. 2019MS120), and the Key Research Projects of Universities in Guangdong Province (NO. 2019KZDXM009).

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