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Traffic climate, driver behaviour, and accidents involvement in China

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ABSTRACT

Traffic Climate Scale (TCS) and Positive Driver Behaviours Scale (PDBS) are new measurement tools. The study aims to translate the TCS and PDBS into Chinese and to assess their factor structures in a large sample of licensed motor vehicle drivers in China. A further aim is to investigate the effects of TCS factors on drivers' behaviours and traffic accidents involvement. Data were collected using an online survey. Participants were 887 fully licensed motor vehicle drivers, including 531 males and 356 females who completed a Chinese translated questionnaire including the TCS, PDBS, Driver Behaviour Questionnaire (DBQ), items related to drivers' driving records and demographic characteristics. The result of the exploratory factor analysis revealed clear three-factor solution ('Functionality', 'External affective demand' and 'Internal requirement') of TCS with high item loadings and acceptable internal consistency coefficients. The convergent validity of the Chinese TCS was supported by its relationship with driver behaviour factors (violations, errors, lapses and positive behaviours), the traffic accidents involvement and demographic characteristics. The results further show that the external affective demand consistently and positively relate to aberrant behaviours and negatively relate to positive behaviours with indirect positive significant effects on accidents involvement. Functionality is concurrently and negatively related to aberrant behaviours and positively related to positive behaviours with no effects on accidents involvement. The internal requirement is negatively related to aberrant behaviours but, positively related to positive behaviours with positive significant direct effects on accidents involvement.

1. Introduction

Road safety has always been a major problem in China. China has the world's largest road traffic fatalities (261 367 as of 2013; WHO 2015). Globally, when it comes to the road traffic deaths per 100 000 population, the rate in China is more than double the average of high-income countries (18.8 relative to 9.2; WHO 2015). Since we are sharing similar car and similar road facilities globally, the vast difference between China and other "safer" countries may encourage researchers and policymakers to rethink the accident prevention strategies. It is known that human behaviour is the major reason (Bener et al., 2007). However, in a driving environment, not all the factors responsible for safety problems can certainly be identified. In recent years, traffic conditions and "safety culture" has attracted more attention (Özkan and Lajunen, 2015).

The conditions of traffic actually could influence driver's affective demands, cognitive and emotional state when participating in traffic. Globally, the concept of safety climate is at the forefront of discussions on ways to improve safety in all settings. Researchers have indicated that current road safety measures cannot be the only way to improve reduction of accidents and fatalities(Ward et al., 2010), rather, the need for inclusion of Traffic Safety Culture and Traffic Safety Climate concepts is essential (Gehlert et al., 2014; Özkan and Lajunen, 2015). Although road accidents contribute the majority of injuries and death compared to all fields with safety implications, it has received little attention concerning the impact and importance of traffic safety climate on driver's behaviours and accident involvement. Hence, scientific studies on traffic safety climate concept and structure are scarce in the available literature(Özkan and Lajunen, 2015). However, the driver's perception of traffic climate may play an important role in maintaining and promoting road safety. Therefore, it is important to conceptualize and study traffic safety climate construct to enhance sustainable countermeasures for promoting road safety.

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1.1. Traffic safety climate

Traffic safety climate is defined as a "function of a person being able to master a situation given its perceived properties and dynamic aspects as well as one's own capabilities"(Gehlert et al., 2014). In this present study, based on the definition of traffic climate by Özkan and Lajunen (2011), we will define traffic safety climate as "the driver's attitudes and perceptions of the traffic in a context at a given point in time" which is subjected to change depending on the features of the traffic environment or conditions that can affect the skills, attitude and driver's behaviour. Traffic safety climate represents the perception of practices, policies, procedures, routines, and sanctions. It could make drivers adjust their behaviours from features within the driving settings. These features include the provision that allows free flow of traffic and a number of resources allocated to promote safety. A positive individual attitude and behaviours towards traffic safety climate describe the capability of individual interacting effectively with other road users (e.g., drivers and pedestrians) and driving rules in traffic conditions. Consequently, a valid and reliable traffic safety climate scale will be a valuable tool for achieving improvement in safety on road.

The original Traffic Climate Scale (TCS) was developed to support three-factor structure and its definition (Özkan and Lajunen, 2011) with high internal validity. The TCS has been translated into German (Gehlert et al., 2014). Performing exploratory factor analysis, the results revealed the existence of three-factor structure representing external affective demands, internal requirements and functionality with high reliability and satisfactory internal validity. The items in the external affective demands factor measured emotional engagement when participating in traffic. The internal requirements factor measured cognitive and social requirements describing individual skills and abilities to successfully participate in traffic. Functionality factor measured perceived requirements for a functional traffic system. According to Gehlert et al. (2014), the relation of TCS factors to road safety attitudes and behaviour interpreted the perceived traffic safety as a function of perceived emotional demands and functional properties of a traffic situation and the cognitive abilities to effectively participate. Given that, the less emotionally and cognitively demanding and the more functional driver's perceived traffic to be, the less risky and safer people feel in traffic while driving. Contrary to actual safety behaviour, they found that the less cognitively demanding and the more functional traffic are perceived to be, the more traffic violations. The aforementioned results may suggest that the perceived traffic safety climate has a significant influence on a drivers' behaviour and is capable of predicting the risk of accidents occurring. It should be noted that the relationship between traffic climate, driver behaviours and accidents has remained mainly unexamined.

1.2. Aberrant driver behaviours

The behaviour and the number of traffic crashes are largely determined by the manner (style) a driver chose to drive or habitually drives. Driver Behaviour Questionnaire (DBQ) (Reason et al., 1990) seems to be the most popular means of developing a complete model of everyday driving behaviour. According to Özkan and Lajunen (2005), in the DBQ, driver behaviours could be categorized and evaluated under a theoretically sound framework, which seemed to have practical importance. It was found that errors and violations are two empirically distinct classes of behavior comprising three factors (deliberate violations, dangerous errors, and "silly" errors) (Reason et al., 1990). The common feature for both violations and errors were both labelled as aberrant (i.e. negative behaviours) which has been justified in the domain of traffic safety.

Errors were chosen as a general term to comprehend all those instances in which a planned sequence of the cognitive decision or physical activities fails to achieve its intended outcome. According to the study of Sucha et al., (2014), errors may result from actions that are inappropriate in a given situation or are appropriate but executed wrongly. Errors are unintended behaviour, distinguished into slips and lapses according to the potential consequence of the error. Lapses basically involve failures of memory whereas slips are related to attention deficits that do not lead to an increased risk of crash involvement (Stephens and Fitzharris, 2016).

In contrast, violations are intentional aberrations, closely associated with behaviours which deliberately flout safe driving practices (Özkan and Lajunen, 2005). According to the study of Özkan and Lajunen (2005), it is still possible for a driver to commit violations without errors or commit errors without violations. Violations can be categorized into ordinary violations (e.g., deliberate speeding without an aggressive motivation) and aggressive violations, (e.g., Using horn to indicate your annoyance to another road user) based on the reason why drivers commit a violation (Lawton et al., 1997; Özkan et al., 2006).

Several other studies have translated DBQ into different languages and used in different countries, including China (Xie and Parker, 2002; Yang et al., 2013), Turkey (Özkan and Lajunen, 2005), Finland (Mattsson et al., 2015), Czech (Sucha et al., 2014), New Zealand (Sullman et al., 2002), Australia (Stephens and Fitzharris, 2016) and have provided useful results. However, these studies vary in their findings of the number of factor structures required in the measurements. One explanation for the different factor structures could, in part, be attributed to the traffic safety cultural differences among the different driving populations.

1.3. Positive driver behaviours

The DBQ is focused on driver's intentions to aberrant driver behaviours (errors and violations) because of their importance to traffic safety. However, according to the study of Özkan and Lajunen (2005), in everyday driving, there are other behaviours (positive behaviours) that cannot be classified as errors or violations. They further indicated that the positive behaviours do not base on coded rules and regulations, or primarily consider safety, but rather to take care of the traffic environment, help and to be polite. They developed a new scale named "Positive Driver Behaviours Scale (PDBS)" and successfully applied it in studies(Özkan and Lajunen, 2005). "Positive" behaviours can be committed without a violation or an error if the action and the plan were adequate for achieving the intended target. In contrast, "positive" behaviours may sometimes include errors or violations when the intended planned actions are not achieved. It should be noted however that, even though, the psychometric property of DBQ has been validated in China (Xie and Parker, 2002; Yang et al., 2013), it did not include the items of "positive" behaviours scale. Furthermore, the DBQ subscales were used in this study to test the convergent validity of the traffic safety climate. These were also used to assess the indirect effect of TCS factors on accident involvements.

1.4. The contribution of the present study

To the best of our knowledge, TCS and PDBS are new scales and their factor structures have not yet been examined in China. As perceived traffic climate play an important role in driving style, driver's attitudes and behaviours, it is important to conceptualize and study this construct to enhance interventions for promoting road safety. Since safety climate has the potentials to militate driver behaviour to either promote or reduce road safety, and studies have also evidenced the relationship between driving behaviour (e.g., violations) and traffic accidents(Xie and Parker, 2002), we therefore used DBQ and PDBS to test the convergent validity of the TCS as well as its effect on the number of accidents through driving behaviours. Considering the traffic setting and different driving styles among Chinese drivers(Zhang et al., 2006), for China to benefit from the use of traffic safety climate assessment as a proactive means to manage and promote safety, there is

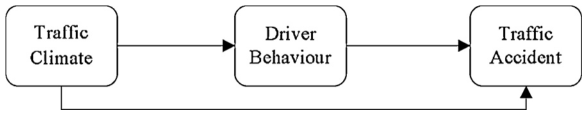

Fig. 1. The contextual model.

therefore an urgent need to develop or evaluate the inherent factor structure, reliability and validity of the Traffic Climate scale.

1.5. Aims of the present study

The main aims of the present study were as follows:

(1) To translate the TCS and PDBS into Chinese and to examine their factor structures in a large sample of licensed motor vehicle drivers in China
(2) To verify the convergent validity of the TCS
(3) To investigate the effects of TCS factors on driver's behaviours and accidents involvement in a contextual model (see Fig. 1).

2. Method and materials

2.1. Procedure and participants

A web-based data collection method was used through cooperation with one professional research company in China. A questionnaire together with a cover letter was sent to drivers from companies. The random sampling procedure technique was used to select 908 drivers covering 27 provinces in China to complete the self-reported measure of the questionnaire. After deleting the incomplete and outlier's responses, 887 valid samples representing approximately 98% of the questionnaire administered were retained for further analysis. The participation was done voluntary with confidentiality and anonymity assurance.

The participants were drivers who held valid driving licenses at the time of the study. They included male (N = 531) and female (N = 356) with mean age of 44.59 (SD = 8.5, range = 24–64). The mean mileage since getting license was 95,185.68 Km (SD 105,466.90, range = 16000–1100000) and the mean year of driving licenses was 5.72 (SD = 4.99, range = 5–36 years), with a mean total number of accidents of 1.22 (SD = 1.11) during the last three years.

2.2. Materials

The forward-and-back translation method was used to translate the English versions of TCS and Driver Behaviour Scales to Chinese with the support of two different and independent translation teams composed of professors in psychology, traffic safety, and bilingual experts. A committee approach was used to reach consensus on the translated versions in each phase to avoid the weaknesses of the forward-and-back translation design. The correctness of the translation was assessed by comparing the original and back-translated version. The translated version was then tested on 50 drivers to ensure that the items were clear without any ambiguity. After the testing, the committee made the necessary corrections, changes, and rewording of 9 items of the TCS (item 3, 7, 8, 17, 28, 34, 37, 43 and 44) to resolve any ambiguities based on the feedback from the participants recruited to test the translated version.

2.2.1. Traffic climate scale

The TCS, which has been used in this study, included 44 items adapted from the study of Gehlert et al.(2014) and Özkan and Lajunen (2011, 2015). The scale entails statements that depict traffic conditions (e.g., Making irritated, causing tension, unpredictable, aggressive etc.). The participants were asked to state their thoughts about the extent each item describe the traffic situation in China. Each item was evaluated on 6-point Likert-type scale (Does not describe it at all = 1 to Very much describes it = 6).

2.2.2. Driver behaviour scales

The extended version of the DBQ(Lajunen et al., 2004; Lawton et al., 1997) and PDBS (Özkan and Lajunen, 2005) were used to measure driver behaviours in this study. The DBQ consisted of 28 items with statements that depict aberrant driving behaviours (violations, errors). The PDBS contained 14 items that describe behaviours that cannot be classified as errors or violations but to facilitate smooth driving that take care of the traffic environment or other road users, to help and to be polite with or without safety concerns. The participants were asked to indicate how often they perform a driving behaviour for each item. Each driver behaviour item was evaluated by the drivers on a 6-point Likert-type scale (never = 1, to nearly all the time = 6).

2.2.3. Traffic accidents involvement and demographic variables

Participants were asked to indicate their age, sex, total mileage (km) since getting a license and a total number of accidents involved. The number of traffic accidents drivers involved was defined as all types of crashes drivers experienced over the last three years.

2.3. Statistical analysis

All the data were analysed using the SPSS version 24 and AMOS version 22 software. The data were firstly analysed using descriptive statistics to investigate the demographic characteristics of the participants. Confirmatory factor analysis was performed to check if the factor structure of TCS in literature fit the Chinese data. Principal axis factoring (PAF) analysis followed by parallel analysis and Promax rotation was used to examine the factor structure of the Chinese TCS and Driver Behaviour Scales. The eigenvalue cutoff point for each item was set at 1.0. Cronbach's alpha reliability coefficients were calculated for assessing the internal consistency of the scale scores. Pearson product-moment was also performed to examine the convergent validity of TCS subscales. To examine the effects of TCS factors on driver behaviours and accident involvement, path analysis was performed with accident involvement as dependent variables, driver behaviour factors as mediating variables and TCS factors as independent variables.

3. Results

3.1. Factor structure of the traffic climate scale

A confirmatory factor analysis was first run to see if the supposed factor structure of TCS in literature (Gehlert et al., 2014) replicates in Chinese data. The current study use Chi-square ($\chi2$), RMSEA, GFI, CFI, NFI and AGFI to examine fitness of the data. However, the three-factor model in literature (Gehlert et al., 2014) did not provide a satisfactory fit ($\chi2$ = 3167.96, df = 374 ($p < 0.000$), $\chi2$/ df = 8.47, RMSEA = 0.09, GFI = 0.81, CFI = 0.79, NFI = 0.76 and AGFI = 0.78).

Then a principal axis factoring analysis was performed on all 44 items to analyse the factor structure of the translated Chinese version of TCS. The Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy was 0.95 and Bartlett's Test of Sphericity was significant ($P < 0.001$), indicating that this data was appropriate for factor analysis (Kaiser, 1974) and correlations existed among the items. To optimize the psychometric properties of the scale, Kaiser Criterion of eigenvalues greater than 1.0, the Cattell scree plot test, parallel analyses were used to determine the number of factors to be retained.

The initial results revealed the presence of six-factor structure with eigenvalues greater than 1. An inspection of the scree plot revealed a clear break after the third component. After using the Cattell's scree test, three-factor structure was retained, as these factors contribute most to the explanation of the variance in the data set. These three factors retained were further substantiated by comparing their eigenvalues exceeding the corresponding criterion values obtained from the parallel analysis (generated data matrix of the same size: 44 variables × 887 respondents). In order to interpret these three components, Promax rotation was performed. (e.g., Gehlert et al., 2014). A three-factor structure was revealed with some of the items different from the results of the previous studies (Gehlert et al., 2014) as external affective demands (EAD), functionalities (FUN) and internal requirements (IRE). Compared to the previous study (Gehlert et al., 2014), except for internal requirement, the number of valid items in the current study factors were more. The items contained in 'External affective demands' describes the emotional engagement required by road users when participating in traffic (e.g. "Annoying"). This factor consisted of 17 valid items with 27% of the variance explained. The 'Functionality' factor items correspond to requirements for a functional traffic system (e.g. "Under enforcement") and is composed of 12 valid items with 18% variance explained. The 'Internal requirements' factor items focus on road users' skills and abilities to successfully participate in traffic (e.g. "Requiring experience") and consisted of 9 items with explained variance of 8%. Cumulatively the three factors explained 53% of the variance. The items which cross-loaded on two factors (e.g. item 3, 6, 15 and 42) or without substantial loadings on any factor (e.g. item 2) and do not fit very well with the dimensions (e.g., item 44) were excluded. These items were ambiguous; therefore, they were not used in further analysis. In Table 1, the factor loadings and percentage of explained variance of each scale were highly satisfactory. The internal consistency for the three subscales of TCS ranges from 0.90 to 0.94. In summary, the results indicated that the TCS had a clear three-factor structure with high item loadings, and acceptable internal consistency coefficients (see Table 1). The means and standard deviations for each of the valid 38 items are also displayed in Table 1.

3.2. Factor structure of the driver behaviour scales

The 42 items, which include DBQ and "positive" driver behaviour, were subjected to principal axis factoring analyses with Promax rotation. The Kaiser criterion of eigenvalues greater than 1.0, the Cattell scree plot test and parallel analysis were used to determine the number of factors. Initially, all the 42 items were run and revealed four-factor structure with eigenvalues greater than 1. An inspection of the scree plot revealed a clear break after the fourth component. However, after Promax rotation, there was no interpretable result suggested.

The 28 items contained in DBQ were run separately and provided three-factor solutions with eigenvalues greater than 1.0. The scree plot and parallel analysis suggested three-factor solution to be appropriate for further analysis. Promax rotation was performed and the result revealed that the three components were interpretable. The first factor included 10 items that measured errors (e.g. "On turning left, nearly hit a cyclist who has come up on your inside"), accounting for 43% of the variance. The second factor was composed of 5 items reflecting violations (e.g. "Race away from traffic lights with the intention of beating the driver next to you") and the third factor consisted 5 items reflecting lapses (e.g. "Forget where you left your car in a car park") and accounted for 6% and 5% variance respectively. Cumulatively, the three factors explained 54% of the variance. Five items (11, 17, 18, 27 and 28) cross loaded on both errors and violations and item 12 on error and lapses. Again, item 3 and 23 were related to violations, but loaded with the errors. These ambiguous items were eliminated and were not considered in further analyses.

The 14 items that measured positive behaviour (e.g. "Do your best not to be an obstacle for other drivers") was run as a separate factor and provided two-factor solutions with eigenvalues greater than 1.0. The scree plot suggested two-factor solution. However, after parallel analysis, the second factor was dropped as the initial eigenvalue was less than the corresponding criterion values obtained from the parallel analysis (Pallant, 2013). Therefore, one factor was retained for further analysis and accounted for 55% of the variance. The results indicated that the DBQ items had a clear three-factor structure with high item loadings and acceptable internal consistency coefficients. The separate factor structure of positive behaviour items also produced interpretable results with high items loadings and acceptable internal consistency coefficients (see Table 2). The Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy for aberrant factors and positive behaviour factor were 0.97 and 0.96 respectively, with significant Bartlett's Test of Sphericity ($P < 0.001$), indicating that this data was appropriate for factor analysis (Kaiser, 1974) and correlations existed among the items. The means and standard deviations for each of the valid items are displayed in Table 2.

3.3. Correlations

Pearson product-moment correlation was used to examine the relationships among the constructs of the TCS and the Driver Behaviour Scales to test the convergent validity (i.e., the degree to which two measures of constructs that theoretically should be related) of TCS. As indicated in Table 3, EAD subscale was positively related to the constructs of aberrant behaviour factors and showed insignificant association with positive behaviour. Additionally, the relationship between FUN and aberrant behaviour factors were negatively related. IRE was negatively related to errors, with violations and lapses found to be insignificant. Furthermore, FUN and IRE had a positive association with positive driver behaviour. Nevertheless, most of the significant correlation coefficient between TCS and behavioural factors were at level $p < 0.001$. Aberrant behaviour variable (violations, errors, and lapses) strongly correlated with each other. The positive driver behaviour had a negative association with the aberrant driver behaviour variables. Consistent with previous studies by Gehlert et al. (2014), the highest correlation between the TCS factors was between external affective demands and internal requirements $r = 0.50$, $p < 0.001$.

As displayed in Table 3, age, sex and year of driving licenses were all found to be negatively related to functionalities ($r = -0.14$, $p < 0.001$; $r = -0.08$, $p < 0.05$; $r = -0.12$, $p < 0.001$ respectively) with total mileage and accidents having insignificant correlation. Furthermore, none of the demographic variables had a significant relationship with the external affective demands and internal requirements scale. The results show that the number of accident involvement was positively related to aberrant behaviours, there was no significant correlation between the number of accidents and the TCS factors.

3.4. Tests of the effects of TCS factors on driver behaviours and accident involvement: a contextual model

The effects of TCS factors on driver's behaviour and accident involvement was tested using path analysis with age, sex and mileage included as control variables. Fig. 2 presents the results of the structural model of the effects of TCS factors on driver's behaviour and accident involvement with standard path's coefficient between constructs. The paths from IRE, violations, and errors were significant, directly predicting accident involvement. FUN, lapses, and positive behaviours were insignificant. In accordance with previous studies, this confirms the previous findings that, lapses are not critical to road safety(Parker et al., 2000) and positive driver behaviours are not related to traffic offenses or accident (Özkan and Lajunen, 2005) but have the potential to reduce road accident. EAD had no significant direct effect on accident involvement. Notably, however, among the TCS factors, only EAD had significant indirect effects through violations and errors on accidents involvement (see Table 4).

The effects of violations and errors on accident involvement were significant at a level of $p < 0.001$. The path coefficient ($\beta = 0.08$) from IRE to accident involvement was also statistically significant at 0.05. Together these three coefficient paths accounted for 6% of the variance in accidents involvement. The violations were significant, positively related to EAD, and negatively related to FUN and IRE. The

Table 1
Mean and standard deviations for TCS items and the three-factor solution.

Items Codes	Mean/SD	External Affective Demand (EAD)	Functionality (FUN)	Internal Requirement (IRE)	Items
TCS4	3.10/1.28	0.84			Aggressive
TCS5	2.84/1.23	0.80			Exciting
TCS36	3.38/1.31	0.75			Annoying
TCS29	3.33/1.42	0.74			Chaotic
TCS31	3.49/1.33	0.73			Making irritated
TCS25	3.54/1.21	0.70			Putting pressure on you
TCS11	2.55/1.19	0.69			Depends on fate
TCS19	3.74/1.28	0.67			Causing tension
TCS18	3.68/1.23	0.67			Mobile
TCS1	3.44/1.23	0.65			Dangerous
TCS17	3.72/1.39	0.62			Giving a feeling that you are useless
TCS28	3.81/1.18	0.61			Hazardous
TSC7	3.87/1.27	0.59			Demanding
TCS43	3.75/1.28	0.58			Irregular
TCS8	3.06/1.17	0.52			Repetitious
TCS35	4.09/1.21	0.45			Time consuming
*TCS6		0.45	0.31		Fast
TCS9	3.98/1.27	0.38			Depends on luck
*TCS42		0.34		0.32	Directing your behaviours
TCS39	3.66/1.26		0.83		Functional
TCS24	3.44/1.31		0.82		Planned
TCS38	3.59/1.19		0.80		Safe
TCS20	3.56/1.22		0.80		Including preventive measures
TCS40	3.13/1.32		0.78		Free flowing
TCS23	3.33/1.24		0.78		Dependent on mutual consideration
TCS37	3.51/1.23		0.74		Unrestricted
TCS22	3.65/1.17		0.73		Travel easily from place to place
TCS26	3.69/1.16		0.73		Directed to compensate
TCS34	3.60/1.30		0.71		Pleasant
TCS21	3.82/1.30		0.70		Under enforcement
TCS27	3.96/1.26		0.63		Including deterring rules
TCS13	4.68/1.03			0.83	Requiring experience
TCS12	4.75/1.07			0.82	Requiring cautiousness
TCS33	4.84/1.01			0.80	Requiring skillfulness
TCS14	4.74/1.00			0.78	Requiring quickness
*TCS15		−0.34		0.77	Requiring you to obey traffic rules
TCS32	4.61/1.09			0.73	Requiring vigilance
TCS41	4.80/1.05			0.71	Requiring knowledge of traffic rules
TCS30	4.57/1.07			0.69	Requiring patience
TCS10	4.48/1.16			0.63	Requiring you on the alert
*TCS44	4.75/1.09			0.52	Thick
*TCS3		0.35		0.36	Complex
TCS16	4.18/1.20			0.30	What you done becomes a benefit to you
*TCS2					Dynamic
Initial eigenvalues		11.87	7.99	3.57	
Explained Variances		26.97	18.17	8.11	
Cronbach's Alpha		0.94	0.93	0.90	

Extraction Method: Principal Axis Factoring. TCS = Traffic Climate Scale.
Note: Loadings less than 0.3 were suppressed. Items with *were subsequently removed from the scale to optimize the psychometric properties of the TCS.

three paths accounted for 9% of the variance in violations. Particularly, 9% of the variance in errors was explained by EAD and IRE. Errors has a positive significant relation to EAD and negative significant relationship to IRE with an insignificant relationship to FUN. Lapses, on the other hand, were positively related to EAD and negatively related to FUN but insignificant with IRE. The three coefficient paths accounted for 7% of the variance in lapses. Positive behaviours were negatively related to EAD and positively related to FUN and IRE with 12% of the variance explained.

4. Discussion

The study aims to translate the TCS and PDBS into Chinese and test their factor structures in a large sample of licensed motor vehicle drivers in China. In accordance with previous studies(Qu et al., 2014), for the convergent validity, we analysed correlations between TCS factors, driver behaviours and demographic characteristics respectively. The effects of TCS factors on driver's behaviours and accidents involvement were further investigated. The facts of this study were based on behavioural and traffic climate studies.

Confirmatory factor analysis revealed that the supposed factor structure of TCS in literature (Gehlert et al., 2014) did not replicate in Chinese data. Exploratory Factor analysis of the Chinese TCS revealed a three-factor structure with some of the items different with the results of the previous studies (e.g., Gehlert et al., 2014). The difference of specific items for each factor between Germany and Chinese study might be because of cultural differences. Cumulatively the three factors explained 53% of the variance which is higher than the previous studies (Gehlert et al., 2014) which explained approximately 40% of the variance. The three structures were external affective demands which measured the emotional engagement by a driver when participating in traffic, functionalities corresponded to perceived requirements/properties for a functional traffic system, and internal requirements measured skills and cognitive abilities to successfully participate in traffic. The DBQ also revealed three-factor structure, namely errors, violations, and lapses. Combining the positive behaviour items with the aberrant behaviour items, the structure could not provide any interpretable results. Therefore, the PDBS was treated as a separate factor. The factor

Table 2
Mean and standard deviations for DBQ items with three-factor solution and positive behaviour as a separate factor.

Items Code	Mean/SD	Factor				
		Errors	Violations	Lapses	Positive Behaviour	Items
DBQ9	1.85/0.93	0.77				Brake too quickly on a slippery road
DBQ13	1.85/0.87	0.67				Turning left, nearly hit a cyclist
DBQ6	1.86/0.98	0.64				Fail to notice pedestrians are crossing
DBQ5	1.97/0.93	0.63				Queuing and nearly hit the car in front
*DBQ28	1.57/0.85	0.58	0.35			Disregard the speed limit on a motorway
DBQ14	1.91/0.88	0.58				Miss “Give Way” signs, and narrowly avoid colliding
*DBQ3	1.29/0.75	0.58				Drink and drive
DBQ8	2.05/1.09	0.55				Fail to view your mirror
DBQ16	1.86/0.89	0.54				Attempt to overtake someone that you hadn’t noticed
DBQ10	1.98/0.92	0.52				Pull out of a junction, forced your way out
*BQ23	1.86/0.93	0.50				Drive so close to the car in front
DBQ1	2.15/0.91	0.48				Hit something when reversing that you had not previously seen
*DBQ12	2.15/1.03	0.47		0.30		Switch on one thing, you meant to switch on something else
*DBQ18	1.70/0.88	0.43	0.36			Stay in a motorway lane, closed ahead, forced into other lane
DBQ15	1.83/1.00	0.42				Attempt to drive away from the traffic lights in third gear
DBQ25	2.12/1.08		0.73			Become angered and indicate your hostility
DBQ21	2.14/1.06		0.70			Race away from traffic lights
*DBQ17	1.62/0.89	0.33	0.59			Become angered and give chase to give a piece of your mind
DBQ24	2.12/1.06		0.57			Cross a junction when traffic lights have already turned on
DBQ7	2.62/1.15		0.56			Sound your horn to indicate your annoyance
DBQ20	2.58/1.16		0.53			Overtake a slow driver on the inside
*DBQ11	1.90/1.02	0.30	0.38			Disregard the speed limit on a residential road
DBQ19	2.62/1.24			0.67		Forget where you left your car in a car park
DBQ26	2.51/1.21			0.63		Realize you have no clear recollection of the road traveling on
DBQ22	2.24/0.99			0.58		Misread the signs, exit from a roundabout on the wrong road
DBQ4	2.34/1.02			0.53		Get into the wrong lane approaching a roundabout or a junction
*DBQ27	2.19/0.98	0.31		0.33		Underestimate the speed of an oncoming vehicle
DBQ2	2.08/1.07			0.31		Find yourself in wrong destination
Initial eigenvalues		**11.95**	**1.58**	**1.29**		
Explained Variances		**42.68**	**5.66**	**4.61**		
DBQ35	4.84/1.15				0.84	Avoid close following not to disturb the car driver in front
DBQ37	4.66/1.13				0.80	Give up overtaking not to block the way of a car approaching
DBQ40	4.97/1.10				0.78	When parking, take into account other road users’ needs space
DBQ42	4.94/1.12				0.77	Pay attention not to splash water on other road users
DBQ32	4.72/1.18				0.77	Do not sound your horn to avoid noise
DBQ31	5.03/1.18				0.76	Use lights less frequently not to disturb the oncoming drivers
DBQ36	4.52/1.15				0.76	Adjust your speed to help someone trying to overtake
DBQ30	4.43/1.03				0.75	Give your right of way to another driver
DBQ39	4.70/1.17				0.75	Let pedestrians cross the road even if it is your right of way
DBQ34	4.79/1.28				0.74	Avoid using the left lane not to slow down traffic on motorway
DBQ41	4.20/1.28				0.60	Do not sound your horn to avoid disturbing
DBQ38	4.31/1.36				0.59	Thank another driver for helping or showing consideration
DBQ33	3.78/1.36				0.56	Use your indicator to help the driver behind
DBQ29	4.59/1.60				0.48	Do your best not to be an obstacle for other drivers
Initial eigenvalues					**7.66**	
Explained Variances					**54.72**	
Cronbach’s Alpha		**0.90**	**0.81**	**0.79**	**0.93**	

Extraction Method: Principal Axis Factoring. DBQ = Driver Behaviour Questionnaire.
Note: Loadings less than 0.3 were suppressed. Items with *were subsequently removed from the scale to optimize the psychometric properties of the DBQ.

Table 3
Pearson Correlations among TCS and DBQ Factors and Demographics (N = 887).

Factors	EAD	FUN	IRE	Violations	Errors	Lapses	Positive B	Age	Sex	Y.License	T.Mileage
EAD	–										
FUN	−0.25***	–									
IRE	0.50***	0.07*	–								
Violations	0.23***	−0.20***	0.01	–							
Errors	0.18***	−0.13***	−0.10**	0.68***	–						
Lapses	0.18***	−0.14***	0.06	0.59***	0.68***	–					
PositiveBehaviour	−0.05	0.15***	0.26***	−0.21***	−0.23***	−0.08*	–				
Age	0.01	−0.14***	−0.03	0.05	−0.05	−0.07*	0.01	–			
Sex	0.05	−0.08*	−0.02	0.12**	−0.01	−0.14***	−0.04	0.18***	–		
Years of License	0.02	−0.12***	−0.01	0.10**	−0.03	−0.03	0.02	0.54***	0.16***	–	
Total Mileage	−0.04	−0.03	−0.04	0.05	0.02	−0.04	−0.01	0.26***	0.08*	0.42***	–
Total Accidents	0.05	−0.05	0.05	0.23***	0.21***	0.17***	−0.01	−0.02	0.09**	0.01	0.10**

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

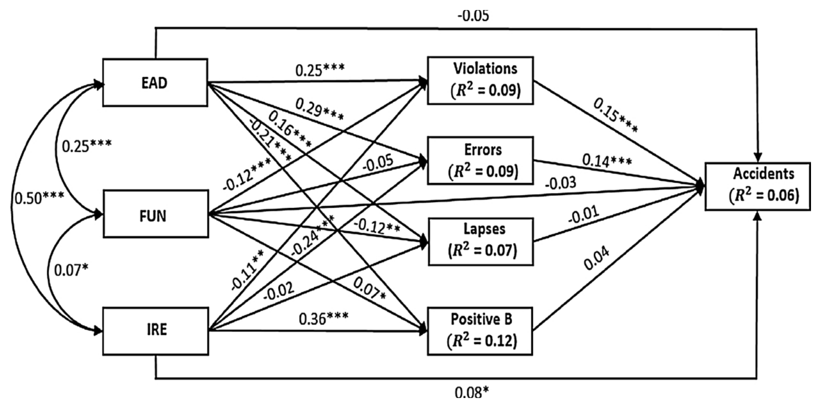

Fig. 2. The estimated model for the sample.
Note: EAD = External affective demands, FUN = Functionalities, IRE = Internal requirements.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 4
The effects of TCS Factors on Driver Behaviours and Accident Involvement.

Constructs	Direct effects	Indirect effects	Total effects
External affective demands (EAD)	−0.06	0.07^{*}	0.01
Functionalities (FUN)	−0.03	−0.02	−0.05
Internal requirements (IRE)	0.08^{*}	−0.04	0.04
Violations	0.15^{***}	N/A	0.15^{***}
Errors	0.14^{***}	N/A	0.14^{***}
Lapses	−0.01	N/A	−0.01
Positive behaviours	0.04	N/A	0.04

loadings and percentage of explained variance for traffic safety climate and driver behaviour subscales were acceptable. The internal consistency reliabilities for each subscale were relatively high, indicating that, the data is appropriate for analysis.

The validity of the Chinese TCS was tested through the indices of convergent validity, given its relationship with self-reported aberrant and positive driver behaviours. It was found that all the TCS constructs were significantly related to the DBQ, a widely used instrument that measures aberrant driving behaviours (violations and errors and lapses) and positive driver behaviour across countries. Therefore, the Chinese version of the TCS showed acceptable convergent validity. As expected, functionality and internal requirement consistently and negatively related to aberrant driver behaviours and positively related to positive driver behaviours. This result is in line with previous studies (Gehlert et al., 2014), revealing that internal requirements and functionality consistently related to road safety behaviour. Seemingly, the appropriate properties of the traffic system, skills, and cognitive capability are regarded as a measure to reduce aberrant behaviours and promote positive driver behaviours in China. As positive driver behaviour has been shown to reduce aberrant behaviours and then accidents involvement(Özkan and Lajunen, 2005). This might imply that better traffic system and driving skills/cognitive capability will help achieve sustainable accidents interventions to promote road safety in China. However, Gehlert et al.(2014) found functionality consistently related to red-light running in Germany and indicated that traffic violations of other road users were regarded as a property of the traffic system. In our opinion, based on the results, traffic safety could be formed, maintained and address the extent drivers are exposed to situations and effectively interact with other road users. It greatly depends on functional and cognitive indicators in the traffic environment providing information that helps the road user to respond appropriately to conditions and take actions to achieve desired outcomes or avoid undesirable outcomes. In accordance with the study of Gehlert et al. (2014), this imply that the less cognitive demanding and more functional traffic system drivers perceived to be, the less aberrant behaviour and more positive behaviours and the safer driver feel in traffic. The external affective demand was consistently and positively related to aberrant behaviours. This could be that when drivers perceived traffic to be more emotionally demanding, their positive attitude towards traffic rules violations becomes high, which has the greater potentials to increase the risk of an accident. The association of the traffic safety climate factors to the driver's behaviours seem to support the observation of Gehlert et al.(2014) that, perceived traffic safety is a function of perceived emotional demands, functional properties of the traffic conditions and the cognitive abilities to effectively participate in the traffic system.

The functionalities were negatively related to age, sex, and total mileage but the external affective demands and internal requirements had no relation. Similarly, the age and sex were related to lapses. However, the result confirmed that age and year of driving license were positively related to the violation. This could mean that older drivers with a longer year of driving may see themselves as better drivers than other drivers they share the road with. However, this result is different with literature that young people and those who drive a lot commit more violations(Parker et al., 1995; Reason et al., 1990). Nevertheless, these finding is worthy of further investigation.

Studies have shown that safety climate has a significant relation to accidents and injuries rates (Clarke, 2006; Johnson, 2007). Furthermore, the present study correlation analysis shows that aberrant behaviour factors were significantly related to TCS factors and the number of accidents. These findings motivated the testing of the effects of Traffic Safety Climate on driver's behaviours and accidents involvement using structural model. Internal requirements, violations, and errors significantly and directly affected accident involvement. Notably, the external affective demands had no direct significant effects on accidents' involvement but had indirect effects through the mediation of violations and errors. These results support the previous studies that, traffic safety climate perceptions relate to traffic violations (Gehlert et al., 2014). Hence, the result means that traffic violations and accidents involvement could increase when drivers perceived traffic system to be more emotionally demanding. Interestingly, the internal requirement does not motivate drivers to involve in aberrant behaviour, but it directly affects accidents involvement. This implies that less internal requirements (skill/cognitive ability) has the potential for buffering aberrant behaviours, but could also increase the risk of an accident. The functionality was negatively related to aberrant behaviours and positively related to positive behaviours and had no effects on accident involvement. Aberrant behaviours become less while positive behaviours increase, which eventually prevent or reduce accidents when drivers perceived traffic system to be more functional. Obviously, traffic infrastructure designed system could have significant effects on the flow of traffic. In summary, these results explain that perceived functional traffic system is the more robust means of promoting positive driver behaviours and alleviating aberrant behaviours for sustainable road safety. Therefore, we infer that the requirements for functional traffic system should be an area of interest to all stakeholders for promoting traffic safety in China.

4.1. Conclusion and practical implications

For academic researchers, this study has demonstrated that Traffic Climate Scale is reliable instruments that can effectively and efficiently assess driver behaviours, risky driving behaviours, and accident involvement. This Traffic Climate Scale contributes to a theoretical understanding of the factors that promote road safety and this present study has demonstrated that it can be equally applied in other countries. The study has further evidence in support of the previous study that, current road safety measures cannot be the only way to improve reduction of accidents and fatalities (Ward et al., 2010), rather, there is a need for the inclusion of traffic safety climate concepts.

Safety experts are more concern for improving positive behaviours and reduction of the accident. This study results consistently evidenced the importance of functional traffic systems as key determinants for road accident reduction. Thus, drivers cannot always be blamed for any undesirable behaviours or accidents when policy makers do not provide the necessary requirements or properties for a functional traffic system for maintaining and promoting effective interaction in traffic.

5. Limitations of the study

The present study has some methodological limitations that should be taken into account when interpreting the results. First, the data set were gathered in provinces, specifically cities, without the inclusion of rural participants. Therefore, the sample might not represent the Chinese driver population. Second, while this study successfully investigated the traffic climate attitudes and driving behaviours among 887 drivers in China, the samples recruited might be small considering the population of China. Third, the participants state their thoughts about the extent to which each item describes the traffic situation in China. It is possible that, because of fear or worry, some respondents will report a low or high level of behaviour. However, because the respondents completed the questionnaires anonymously, this approach hopefully reduces the presence of biased responses.

On the other hand, the predictive validity of the Traffic Climate Scale has to be tested across age and sex and in different countries in future studies.

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