

Investigating Driving Styles and Their Connections to Speeding and Accident Experience

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Abstract: The present study aimed at identifying the habitual driving styles and evaluating how these styles connected to drivers' sociodemographic factors as well as speeding and accident experience. In a quota sample of 247 Taiwanese individuals, an exploratory factor analysis combined with a confirmatory factor analysis was conducted to derive five valid constructs including aggressiveness, anxiety, misjudgment, distraction, and unawareness. Moreover, four driving styles were identified and analyzed via a K-means cluster and logistic regression analysis. The analytical results showed that the derived constructs significantly differ on their sociodemographic factors, speeding experience, but not on accident involvement. Moreover, the constructs exhibited distinct impacts on the formation of driving styles while exposure factors were controlled. The heterogeneous driving styles explored in this study could reconfirm the heterogeneity of driver personality and accident occurrence found in past studies. General strategies to the sample population and specific strategies to each driving style were discussed.

Key Words: *driving style, factor analysis, K-means cluster, logistic regression*

1. INTRODUCTION

1.1 Motivation

In the past decades, a growing concern has been raised regarding the severe consequences of traffic accidents. This line of research has mainly focused on human factors that are involved in car accidents such as sociodemographic and general personality factors as well as attitudes, and behaviors.

A review of the literature indicated that previous research has mostly dealt with the association between various sociodemographic factors (e.g. age, gender, income, experience) or personality traits (e.g. sensation seeking, anger, normless) and car accident involvement. In this context, numerous sociodemographic factors have been intensively identified using statistical models including Poisson, negative binomial, zero-inflated count models, etc (e.g. Caliendo et al. 2007; Li et al. 2008; Lord et al. 2007; Rodgers 2008; Wong et al. 2007). Among these factors, age and gender may be the most frequently studied and conclusive ones. Young and elder drivers have been concerned as the populations presenting a relatively high level of driving risk, and male drivers are regarded with a higher possibility to be involved in severe accidents (Wong and Chung 2007a). Recently, considering the complicated relationships among factors and the restrictions of data and methods, researchers have been

trying to adopt machine learning methods, especially the tree- and rule-based methods, to link contributing factors and accidents from a chain perspective (Wong and Chung 2007a; Wong and Chung 2007b).

Personality traits have also been shown to be related to risky driving behavior and accident involvement. Personality reflects internal characteristics of individual differences and demonstrates consistent patterns and tendencies in individual reactions to the external environment (Ulleberg and Rundmo 2003). In this context, traits such as sensation-seeking, anxiety, aggression, normlessness, altruism, and driving anger have been intensively studied and shown consistently associated with engagement in risky driving behavior such as speeding, and involvement in car accidents (e.g. Dahlen et al. 2005; Schwebel et al. 2006; Ulleberg 2001; Ulleberg and Rundmo 2003; Wong et al. 2010). For example, by clustering the personality and driving behavior of young drivers, Ulleberg (2001) claimed that high-risk populations share general characteristics of low altruism and high driving anger, normlessness and sensation seeking.

Despite the contributions of the mentioned studies, little information directly underlying risky driving behavior was mentioned. Researchers have been trying to fill this gap by analyzing the habitual style of driving behaviors (Taubman-Ben-Ari et al. 2004). The term “style” is referred to the ways drivers choose to drive or habitually drive. This includes choice of driving speed, headway, and habitual level of general attentiveness and assertiveness. Driving style is expected to be influenced by attitudes and beliefs regarding driving as well as more general needs and values (Elander et al. 1993). It is this aspect of driving that stands in the focus of the present investigation.

Driving styles have been studied mostly in Western countries. Given the distinct country cultures in Eastern Asia including Taiwan, it was still unknown whether the well-developed scales were effective to measure the driving styles in these countries. Meanwhile, it could be found that most of the past studies applied only Exploratory Factor Analyses (EFA) to derive driving styles. Although having excellent ability to induce underlying constructs, EFA has several limitations compared with a Confirmatory Factor Analysis (CFA) including the restricted specification of correlation among all common factors and of the influence from common factors to the observed variables. Furthermore, with a malfitting model in EFA, there is no mechanism for identifying which areas of the model are contributing most to the misfit (Byrne 2005). Therefore, in order to examine the adopted scales, this study employed EFA combined with CFA with independent samples to overcome these issues.

1.2 Driving Style

To survey the ways drivers choose to drive or habitually drive while facing various traffic conditions, two approaches have been usually applied including simulator experiments and self-reported surveys. Simulator experiments have the advantages allowing researchers to set up customized environmental conditions; however, these experiments are usually expensive and limit to the reality of virtual environment. Therefore, self-reported surveys have become a rather popular approach.

To conduct a self-reported study, the development of questionnaire is crucial. The Driving Behavior Questionnaire, DBQ, is one of the most widely applied measures (Reason et al. 1990). Fifty measures were developed by Reason *et al.* (1990) to survey aberrant driving behaviors in England, and 520 valid questionnaires were collected. Three types of aberrant

behaviors were explored based on the Exploratory Factor Analysis (EFA) including violations, harmless lapses, and dangerous errors. It was found that male drivers were more likely to conduct violations while female drivers were more likely to present harmless lapses; violation would decrease with the increase of ages; and increase with the exposure. But drivers' dangerous errors would decrease with the increment of their experience.

The measures developed by Reason *et al.* (1990) have been followed by many researchers. For example, Blockey and Hartley (1995) applied the DBQ to investigate the driving behavior of staff and college students in Murdoch University, Australia, and came up with similar results. Based on EFA, they also concluded three aberrant behavior types: general errors, dangerous errors, and dangerous violations. To reduce the complexity of questionnaire survey, Parker *et al.* (1995) chose 24 items from the DBQ and found similar results. Furthermore, based on the modified measures in the previous study, Parker *et al.* (2000) conducted a survey to investigate elder drivers' behavior. The analytical results showed that elder drivers are more likely to conduct lapses due to their degeneration on cognitive ability; periodical reviews of driving skills may improve their cognition on safe driving as well as their familiarity on maneuvering. Sullman *et al.* (2002) adopted the measures developed by Dimmer and Parker (1999), which was also a modification from the DBQ, to investigate the truck drivers' behavior in New Zealand, and concluded four types of aberrant driving behaviors including lapses, violations, errors, and aggressive violations. Rimmö (2002) applied the DBQ and modified it to fit the local culture in Swedish, called DBQ-SWE (Aberg and Rimmo 1998), to investigate the driving behaviors for different populations. The research found no significant difference exists among populations at different ages and genders.

In addition to the DBQ, other measures have also been developed to understand drivers' behavior in different perspectives. For example, the Driver Behavior Inventory, or DBI, was designed to investigate the drivers' aberrant driving behavior under pressure (Glendon *et al.* 1993). Westerman and Haigney (2000) adopted both the DBI and the DBQ (Parker *et al.* 1995) to explore the drivers' behavior who have held a valid license for at least one year. They found that while the DBQ results were similar as past studies, the DBI measures were grouped into driving aggression, alertness, situation-specific tension, dislike of driving, and situation-specific concentration. The combination of the DBQ and DBI showed that driving under high pressure was more likely involved with lapses.

In order to investigate driving behaviors in a comprehensive manner, some researchers tried to combine different measures. For example, Lajunen *et al.* (1998) combined the Driving Anger Scale (DAS) from Deffenbacher *et al.* (1994), the violation measures from Reason's DBQ, the Driving Skill Inventory (DSI) from Lajunen and Summala (1995). The results concluded that less-skilled and overconfident drivers were more likely to be infuriated by the behavior of progress impeded, and less-experienced drivers were more likely to be infuriated by hostile driving behaviors. In addition, Taubman-Ben-Ari *et al.* (2004) summarized various developed measures to a 44-item questionnaire named Multidimensional Driving Style Inventory (MDSI). The results classified driving behaviors into eight types: dissociative, anxious, risky, angry, high-velocity, distress-reduction, patient, and careful. They found that female drivers were more dissociative, anxious, but less careful. Meanwhile, drivers were more careful and patient with the increase of their age. Moreover, drivers would be more likely to conduct anxious behaviors if they had a higher education. Finally, the accident frequency was found to be positively correlated with angry, high-velocity, and risky behaviors.

From the literature review, it was clear that self-reported surveys have been intensively applied to explore drivers' behaviors, driving styles and their relationships with driving behaviors and/or accident involvement. Moreover, the developed measures could be modified to fit different research purposes, driving populations, countries, and reach reasonable conclusions. With the mature of the development of driving behavior measures, it would be a good experiment to develop a questionnaire which fits the local culture of Taiwan based on extensive literature review. The results could also help identify the features of Taiwanese driving behavior.

The rest of this paper is organized as follows: The methodology including the development of scale and the corresponding items, data collection process, and analysis framework is built in Chapter 2. The analysis results are presented in Chapter 3. Concluding remarks are followed in Chapter 4.

2. METHODOLOGY

2.1 Scale Development

As reviewed in the previous chapter, many scales have been developed based on the purposes and local culture of a study. Among these scales, the MDSI (Multidimensional Driving Style Inventory) contained the most comprehensive aspects of driving styles (Taubman-Ben-Ari et al. 2004), and therefore was adopted in this study as the core structure to develop our own scale.

The core structure consisted of the following four facets to explore the driving styles in Taiwan:

1. **Reckless and careless driving style**
Drivers with this driving style tend to deliberate violations of safe driving norms, and seek for sensations and thrill while driving. These drivers are characterized by driving at high speeds, passing other cars in no-passing zones, and driving while intoxicated, probably endangering themselves and others.
2. **Anxious driving style**
Drivers with an anxious driving style have commonly been examined in studies on driver stress and reflect feelings of alertness and tension as well as ineffective engagement in relaxing activities during driving.
3. **Angry and hostile driving style**
Drivers with an angry and hostile driving style are those who might frequently express irritation, rage, and hostile attitudes and acts while driving; this style also reflects a tendency to act aggressively on the road, and to curse, blow horn, or "flash" to other drivers.
4. **Patient and careful driving style**
Drivers with a patient and careful driving style represent those who are well-adjusted, attentive, patient, polite, calm, planning ahead, and obeying the traffic rules.

In addition to the MDSI, this study also referred to other well-developed scales to develop a driving style questionnaire fitting Taiwanese local culture (Blockey and Hartley 1995; French et al. 1993; Parker et al. 1995; Rimmo 2002; Taubman-Ben-Ari et al. 2004; Yin 2005). Items were initially adopted from the literature, and then translated and modified to fit the need of

this study. The initial questionnaire was tested and checked by college students and transportation professionals to improve its readability and to be sure the items correctly reflect their associated meaning. Each measurement was scaled using a six point Likert Scale to prevent confounds between neutral and undecided choices. Finally, a questionnaire comprising 38 items was developed.

2.2 Data Collection

Besides answering the 38 questions, participants were asked to provide background information including demographic data, driving related information, as well as information on accidents and violations. The target population was the members of Chinese Institute of Transportation, the alumni of the Institute of Traffic and Transportation, Chiao Tung University in Taiwan, and the college students at the transportation or relevant department. Questionnaires were posted on the Internet, and the questions were listed in random to prevent answering bias. Moreover, to reduce the concern of non-randomness, a notice e-mail was sent via the Chinese Institute of Transportation to inform most of the individuals in the population regarding this survey. Participants who completed the questionnaire were qualified for a prize drawing. In total, 247 valid questionnaires were collected.

2.3 Analysis Framework

The analysis consisted of two steps: First, an exploratory factor analysis was adopted with randomly selected 97 samples to explore an optimal set of factors that accounts for the covariance among the measures. Second, a confirmatory factor analysis was applied for the remaining 150 samples based on the derived factors.

The questionnaire designed in this study was based on the literature review. Since each literature has its own structure and purpose, the measurements used here may overlap. To seek appropriate influencing factors in driving behavior in Taiwan, an Exploratory Factor Analysis (EFA) is necessary for reorganizing and reducing the dimensionality of the numerous questionnaire responses, and for restructuring the model framework. Randomly selected 97 samples were adopted to explore an optimal set of factors that account for the covariance among the measures. Each factor is then reinterpreted and renamed based on the subset of items with high factor loadings. Scree plots were adopted to screen items with low variation explained.

Based on the EFA results, a Confirmatory Factor Analysis (CFA) was followed to verify their fitness. Items were examined for their contributions to common factors. Non-significant items were removed based on the index provided by CFA and the steps suggested by Hatcher (1994). The refined set of items was then returned to EFA as a new input set of items. Such feedback continued until the factor structure was stable in EFA and the goodness of fit in CFA was satisfied. A best set of items was then derived to represent the driving styles in Taiwan.

To further investigate the characteristics of driving behaviors in Taiwan, the participants were grouped on the basis of a K-means cluster analysis of driving style measures. The association between driving style measures, sociodemographic factors and speeding as well as accident involvement experience was analyzed thereafter. The analysis framework was illustrated in Figure 1.

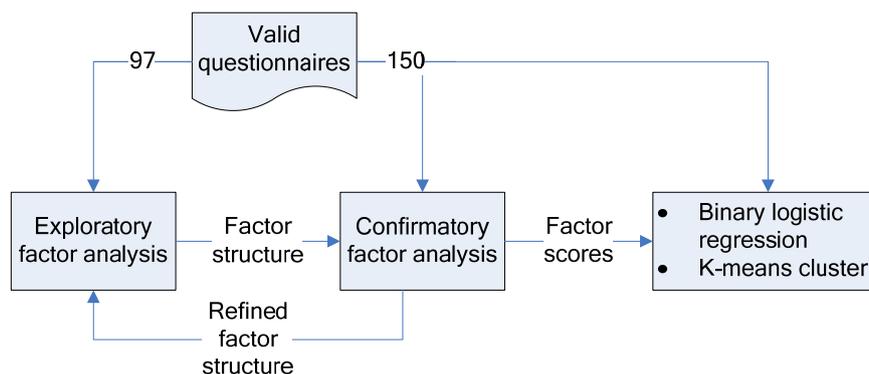


Figure 1 Analysis framework

3. RESULTS

3.1 Participants

Although the survey was conducted via the Internet, which may limit the coverage of the target population, the collected responses should roughly represent the Taiwanese transportation professional's driving behaviors and experience as summarized in Table 1. It was observed that the distribution of participants' age was flat: the percentage of participants aged at 21-30, 31-40, or 41-50 all ranged from 20% to 35%. Only the participants aged older than 50 accounted for less than 20%. Moreover, male participants accounted for about 80% while female participants only accounted for 20%, which was consistent with that most transportation professionals in Taiwan are male. Among those participants, about 65% of the participants were married, and about 60% of them had children. Regarding the education level, about 80% of the participants obtained at least a master's degree, which reflected that the sampling targets were those with high education. As for the occupation, only 9.31% of the participants were students. All of the participants held a valid driving license.

Regarding the driving experience, about 10% of the participants had a job whose responsibility including driving; moreover, more than half of the participants drove to commute. The average driving experience was 13.85 years with a standard deviation of 8.27 years. The participants drove more than four days and about 152 kilometers on average per week. The drivers drove about 1.66 hours per day; that is about 40-50 minutes for one way trip.

As for the accident experience, almost 60% of the drivers have ever been involved in an accident. Half of those accidents occurred more than five years ago, and the drivers did not get injured. Regarding the violation experience, almost 60% of the drivers have ever been caught by a police due to speeding violation.

Table 1 Background information of participants

Attribute	Category	Count or Value	Percentage (%)
Age	21-30	52	21.05
	31-40	67	27.13
	41-50	85	34.41
	51+	43	17.41
Gender	Male	193	78.14
	Female	54	21.86
Marriage	Single	82	33.20
	Married	165	66.80
Marriage length (Year)	Mean (Standard deviation)	15.54 (9.30)	
	Minimum	1.00	
Children	Yes	148	59.92
	No	99	40.08
Education	Senior high or under	8	3.24
	College or university	37	14.98
	Master's or above	202	81.78
Occupation	Student	23	9.31
	Other	224	90.69
License type	Automobile	241	97.57
	Bus*	6	2.43
Driving to commute	Yes	143	57.89
	No	104	42.11
Driving experience (Year)	Mean	13.85	
	Standard deviation	8.27	
Driving days per week	Mean	4.19	
	Standard deviation	2.20	
Driving hours per day	Mean	1.66	
	Standard deviation	0.87	
Driving kilometers per week	Mean	152.00	
	Standard deviation	154.71	
Accident experience	Yes	148	59.92
	No	99	40.08
Last accident experience	Within one year	13	8.78
	1-3 years ago	28	18.92
	3-5 years ago	23	15.54
	More than five years ago	84	56.76
Accident severity	Not injured	122	82.43
	Injured	26	17.57
Charge of speeding	Yes	145	58.70
	No	102	41.30

* In Taiwan, drivers who hold a valid bus license are also allowed to drive an automobile.

3.2 EFA and CFA

The final constructs, corresponding items, and goodness-of-fit indexes were summarized in Table 2. The measures were adopted from the well-developed questionnaires, exhibiting an acceptable content validity. The *t* statistics for each factor loading were all greater than 1.96, suggesting a satisfactory convergent validity. The goodness-of-fit index GFI was close to the conventional threshold 0.9 and the chi-square/*df* ratio was less than 2; both indicating that the model fits were acceptable. Nevertheless, the Cronbach's α and the composite reliability for each construct ranged from 0.4 to 0.7, indicating only mediocre reliability of measures.

The resulted constructs were aggressiveness, anxiety, misjudgment, distraction, and unawareness. The aggressiveness construct has been intensively studied and is usually characterized by committing traffic offenses which would endanger other persons or property

as shown by the corresponding items in Table 2. This construct could be deemed to cover the angry and high-velocity constructs in Taubman-Ben-Ari's study (2004). The anxiety construct could refer to drivers who feel stress, probably lack self-confidence of their driving skills, and exhibit anxiety during driving. As for the misjudgment construct, it is characterized by making incorrect decisions during driving or exhibiting unexpected ways of responses. This misjudgment may come from their stress or dissociation (Taubman-Ben-Ari et al. 2004).

The remaining two constructs have also been intensively studied. The distraction construct here represented drivers who are easily distracted by doing secondary driving tasks and may result in inattention to traffic regulations. Finally, the unawareness construct refers to drivers who may lack the ability to perceive, understand, and project the information from the traffic conditions which are required for safe driving.

Table 2 Constructs, items, and goodness-of-fit indexes

Construct	Item
Aggressiveness	Try to run through an intersection even though knowing the traffic light is turning red
	Try to push the front car to move if it does not move immediately after the traffic light turns green
	Show dissatisfaction on certain types of drivers
	Violate traffic regulations to pursue shorter travel time such as driving on a one-way road at a wrong direction or making turns at an intersection where is not allowed
Anxiety	Feel anxious or nervous while driving in bad weather
	Turn on a wrong equipment
Misjudgment	Feel anxious when driving after other cars
	Miss an exit ramp on a highway or miss an intersection you should make turns
	Have no ideas about the road you just passed
Distraction	Have no ideas about the roads you have ever driven
	Chat with passengers
	Do other things such as fixing hair/makeup or eating breakfast while driving
	Drive on an inappropriate lane or a road due to inattention of traffic signs
Unawareness	Park your car at a stop-prohibited location
	Run through red lights due to unawareness of the traffic lights
	Ignore the cars on the neighbor lane or scooters while making lane changes or right turns
	Stop in a hurry since you follow the front car too close

$\chi^2 / df = 1.509$; GFI = 0.890; RMSEA = 0.058; RMR = 0.081

3.3 Cluster Analysis

3.3.1 K-means cluster

The standardized cluster means of the constructs were presented in Table 3. Cluster 1 was characterized by low scores on all constructs, which suggested that the driving style of the participants in cluster 1 were relatively calm and well-adjusted. Their low scores on aggressiveness, anxiety, misjudgment, distraction, and, unawareness indicated that they would not exhibit aggressive behaviors even though facing undesired traffic conditions; they would not feel anxious which may result from their self-confidence regarding their own driving skills; their judgments were appropriate and they would be more aware of traffic conditions, which may come from their experience or mature driving skills. These characteristics may also indicate a high degree of conformity and conventionality. This cluster was expected to be a low risk group in traffic situations and was labeled as calm driving style.

Cluster 2 was characterized by high scores on all constructs. The driving style of these drivers was usually aggressive, anxious, ill-judging, distracted, and frequently unaware of traffic conditions. They could be regarded as a relatively high risk group and was therefore labeled as risky driving style.

Unlike the above drivers, the participants in cluster 3 and 4 showed distinct specialties on styles. The participants in cluster 3 displayed low misjudgment but very high distraction; they were somewhat aggressive, little anxious, and did not pay much attention to traffic conditions. This suggested these drivers may be confident regarding their driving skills; yet they may overestimate their own skills since they didn't concentrate entirely on the traffic conditions. This type of driving style was named as incautious driving style. On the other hand, the participants in cluster 4 were not aggressive and highly focused on driving; however, they were anxious, frequently exhibited misjudgment, and tended to be unaware of traffic conditions. These characteristics implied that these drivers may be nervous drives; they try to drive carefully, but they may not have sufficient confidence for their required driving skills. This group of drivers was labeled as nervous driving style.

Table 3 Cluster (driving style) means of the constructs

Construct	Cluster			
	(Driving style)			
	1	2	3	4
	(Calm)	(Risky)	(Incautious)	(Nervous)
Aggressiveness	-0.608	1.181	0.236	-0.014
Anxiety	-0.758	0.939	0.004	0.597
Misjudgment	-0.605	1.476	-0.419	0.412
Distraction	-0.528	0.759	0.992	-0.585
Unawareness	-0.707	1.018	0.466	0.029

3.3.2 External validation of the clusters

To further understand the possible causes behind these driving styles, external validations were conducted. An external validation of a cluster result is obtained by applying significance tests on relevant criteria variables that are not used to generate the cluster result (Ulleberg and Rundmo 2003). The four clusters of participants were compared on their sociodemographic and risky behavior measures. The one-way ANOVA, chi-square test, and Fisher's exact test were applied depending on whether the variable was continuous or categorical.

As shown in Table 4, all the cluster differences were significant except the crash experience. Regarded as a driving group with the lowest risk, participants in cluster 1 were relatively old and experienced represented by their age, mean experience length, and percent driving to commute. Moreover, most of the drivers in this group have been married and had children; therefore, they bore more responsibility for their family and may tend to drive more carefully. On the other hand, the participants in cluster 2, which has been concerned as a high risk group, were relatively young, inexperienced; a relatively small portion of them needs to take responsibility to their family. Regarding the participants in cluster 3, as a group of incautious drivers, they were experienced and most of them have been married like those in cluster 1; yet a relatively small portion of them has had children. Finally, the participants in cluster 4 were the least experienced; this group also accounted for the largest portion of female drivers. In

addition, most of them were not married and had no children. These descriptions were consistent with the statement in the previous section that this group of drivers may be nervous or conservative drivers.

The experience of being charged due to speeding was proportional to the drivers' driving exposure. Clusters with a higher mean of driving experience length and proportion of driving to commute tended to have a higher proportion being charged by speeding. These groups included cluster 1 and 3. Regarding the crash experience within three years, the participants in cluster 1 had the lowest proportion as expected even though they had relatively high exposure. On the other hand, the drivers in cluster 4 should be paid more attention to since they displayed the largest proportion of crash experience among the four groups even with the least exposure.

Table 4 Cluster differences on sociodemographic and risky behavior measures

Measure	Cluster				<i>p</i> -value
	1 (<i>n</i> = 57)	2 (<i>n</i> = 23)	3 (<i>n</i> = 34)	4 (<i>n</i> = 36)	
Mean age	42.74	38.91	41.97	36.50	0.032**
Percent females	12.28%	26.09%	20.59%	33.33%	0.093*
Mean experience length (years)	15.65	12.50	16.12	9.78	0.001**
Percent married	73.69%	56.52%	73.53%	50.00%	0.063*
Percent having children	73.69%	43.48%	58.83%	44.45%	0.015**
Percent driving to commute	64.92%	52.18%	61.77%	36.12%	0.043**
Percent speeding	64.92%	56.52%	73.53%	38.89%	0.020**
Percent crash experience within three years	12.28%	13.04%	17.65%	19.44%	0.759

**0.05 significant level; *0.10 significant level

3.4 Binary Logistic Regression

To further clarify the impact of each latent construct and drivers' sociodemographic conditions on driving performance, this research applied a binary logistic regression analysis. Two dependent variables were chosen in this study including the accident experience within three years and the experience of being charged by a police due to speeding. Since these two dependent variables were both binary (i.e. yes or no), a binary logistic regression analysis was appropriate. The best model was selected based on the significance of coefficients and the value of AIC.

The analytical results of accident experience showed that none of the latent constructs, drivers' socioeconomic characteristics, and their combinations had significant impacts. This may result from the scarceness of accident occurrence or the lack of key contributing factors such as road geometry or weather condition which have been regarded as effective variables to explain accident occurrence.

The analytical results of the experience of being charged due to speeding for the whole dataset and for each driving style were shown in Table 5. It was found that the signs of the variables were consistent among all models. In other words, the signs of coefficients for the whole data set as well as for each cluster were the same. Drivers who were aggressive or less anxious were more likely to have the experience of being charged by speeding. Furthermore, drivers who were older, had extensive experience or drove to commute also had a tendency to be charged by speeding. In addition, male drivers were more likely to have such experience than

female drivers. Finally, drivers who have been married were less likely to have this experience. This consistent result reflected the general characteristics of drivers' experience of being charged due to speeding.

At least one exposure-related variable could be found for each model. For the Whole model, driving experience and driving to commute were included. The variable Age was found significant for cluster 1, 2 and 3. While the variable Driving experience was significant for cluster 2, the variable Driving to commute was significant for cluster 4. This reinforced the finding in the previous section that the charge of speeding highly related to driving exposure no matter the driving styles.

Despite the impacts of exposure, the derived latent constructs had distinct impacts on participants for each cluster as shown in Table 5. For cluster 1, aggressiveness and unawareness were the two significant constructs contributing to their experience of being charged due to speeding. Although drivers belonging to cluster 1 were considered as a relatively low risk group, it was aggressiveness and unawareness leading some of these drivers being more frequently charged due to speeding. On the other hand, although the participants in cluster 2 were recognized as a high risk group, their anxiety could prevent them from being involved in the charge due to speeding. In other words, some of these aggressive, ill-judged and distracted drivers could display less speeding behaviors because of their "insufficient" confidence when driving under undesired conditions such as driving behind a car or under a bad weather condition. Moreover, since no significant driving styles affected the experience for drivers in cluster 3, exposure became the primary cause. Finally, misjudgment was a significant factor to a speeding charge for cluster 4 drivers. As these drivers felt more stressful or dissociative while confronting with the traffic conditions, less speeding behavior would be conducted.

Table 5 Binary logistic regression of the experience being charged by speeding

Variable	Whole	Cluster			
		1 (Calm)	2 (Risky)	3 (Incautious)	4 (Nervous)
Aggressiveness	0.977**	1.534**			
Anxiety	-0.607*		-3.057**		
Misjudgment					-2.094*
Unawareness		1.927*			
Age		0.080	0.105*	0.191**	
Gender (Male) ^a	-1.086**			-2.577**	
Driving experience	0.133**	0.115*			
Married (Single)	-0.935			-3.219*	
Driving to commute (Yes)	-1.498**				-4.352**
Constant	-0.712	-11.294**	6.069	-3.618	7.808**
Null deviance	200.880	73.871	31.492	39.299	48.114
Residual deviance	139.630	56.157	18.664	29.019	24.881
AIC	153.630	66.157	24.664	37.019	30.881

**0.05 significant level; *0.10 significant level

^a Value in the parenthesis indicates the reference category.

4. CONCLUDING REMARKS

This research investigated the habitual driving styles in Taiwan by conducting a self-reported survey. An Exploratory Factor Analysis (EFA) combined with a Confirmatory Factor Analysis (CFA) was applied to derive five valid constructs including aggressiveness, anxiety, misjudgment, distraction, and unawareness. The satisfactory validity and goodness of fit suggested the appropriateness of the developed scale. Furthermore, a K-means cluster analysis was adopted and four distinct driving styles were found including calm, risky, incautious, and nervous. Finally, a binary logistic regression was used to investigate the relationships between the driving styles and the experience of being charged due to speeding. While exposure-related factors were significant to all driving styles, each driving style was explained by various latent constructs. This suggested that their speeding behavior may be triggered by distinct reasons.

The mediocre reliability of the resulted constructs may come from the internet survey approach used in this study and the sample restriction. Most surveys in past studies were conducted by phone or mail, and only a few studies conducted their surveys using the Internet. Two advantages of internet survey were found from this study. First, the monetary and time costs were reduced since an internet survey is conducted without a physical questionnaire, and participants could finish a survey by following the instructions on the website. Second, the questions could be randomly arranged, which was expected to reduce some biases. However, an internet survey eliminated the opportunity to directly contact with a participant, which also eradicated the opportunity to explain the items listed on the questionnaire to a participant. Moreover, most of the samples came from the participants with a high education degree; this would somewhat restrict the derived latent constructs and driving styles. Further research on the issue of applying internet survey and a broader survey of participants were suggested.

The significant cluster results verified the heterogeneity of drivers from the perspective of driving styles. The heterogeneity of drivers have been studied and found from various aspects. For example, Ulleberg and Rundmo (2003) identified the heterogeneity of young drivers in Norway from the perspective of personality. Moreover, Wong and Chung (2008) investigated the heterogeneity from the perspective of accident occurrence. The present study suggested the significant heterogeneity of driving styles, which further improves the understanding of the heterogeneity of drivers. The heterogeneity of drivers starts from drivers' intrinsic characteristics, i.e. personality traits (such as norms, beliefs, and attitudes), which in turn forms their heterogeneous driving styles and consequently leads to heterogeneous accident patterns.

In general, to effectively reduce drivers' speeding behaviors, lowering their aggressive driving behaviors and adjusting their anxiety were suggested by the analytical results. Strategies corresponding to reducing aggressive driving behaviors have been introduced and evaluated in many studies. Some effective strategies include specific traffic-enforcement programs (such as speed camera or a visible standing of police car at the roadside), or the reduction of nonrecurring delays and the provision of better information about these delays (Al-Ghamdi 2006; Neuman et al. 2003). On the other hand, strategies corresponding to adjusting drivers' anxiety are those which can help drivers recognize the severe consequence related to speeding behaviors and accidents (Ulleberg and Rundmo 2003). This could be achieved by conducting educational and public information safety campaigns.

Despite the aforementioned general strategies, distinct specific safety campaigns could be suggested to each driving style as implied by the various significant contributing factors. Drivers with a calm driving style conducted speeding behavior due to their temporary aggressiveness and unawareness of traffic conditions. Regular road safety campaigns with a special focus on improving the driving environment to reduce the external triggers of aggressive driving should be sufficient for these well-adjusted drivers. On the other hand, the speeding behavior conducted by drivers with a risky driving style could be reduced by adjusting their anxiety by strategies suggested previously. As for the incautious drivers, periodical reviews of driving skills and of the severe consequence of accident involvement could be effective. Finally, regarding the nervous drivers, an improvement of current driving education program in Taiwan is expected to help them to rectify their incorrect understanding of driving risks on roads or improve their insufficient skills as suggested by other studies (Chang and Yeh 2006; Wong et al. 2010). Moreover, the ITS development should also be designed to help identifying and alerting traffic risks on roads.

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