Accident Analysis and Prevention 42 (2010) 275–281

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

Determinants behind young motorcyclists' risky riding behavior

Jinn-Tsai Wong[a,1], Yi-Shih Chung[b,*], Shih-Hsuan Huang[c,2]

[a] Institute of Traffic and Transportation, National Chiao Tung University, 4F, 118 Chung Hsiao W. Rd., Sec. 1, Taipei 10044, Taiwan
[b] Department of Logistics and Shipping Management, Kainan University, No.1 Kainan Road, Luzhu Shiang, Taoyuan 33857, Taiwan
[c] Institute of Traffic and Transportation, National Chiao Tung University, 3F, 118 Chung Hsiao W. Rd., Sec. 1, Taipei 10044, Taiwan

ARTICLE INFO

Article history:
Received 14 February 2009
Received in revised form 22 July 2009
Accepted 4 August 2009

Keywords:
Motorcyclist
Risky behavior
Structural equation modeling

ABSTRACT

Young motorcyclists have traditionally been considered a high-risk population. Given the critical influence of riders' behaviors on traffic safety, identifying what riders think can help clarify the nature of accidents. Although psychological studies have explored the relationships among personality traits, attitudes and risky driving behavior, the primary difference this study makes from past studies is incorporating both positive and negative effects in a refined causal framework. This study adopts structural equation modeling to analyze data collected from 683 young motorcyclists aged between 18 and 28. The results conclude three primary personality traits of young motorcyclists, namely sensation seeking, amiability and impatience. While amiable riders represent a group of relatively mature and safe riders, the sensation-seeking riders are extremely self-confident, comfortable with unsafe riding and interested in the utility gained from it. Meanwhile, the sensation-seeking ones also are highly aware of traffic conditions, which may lower the chances of getting into an accident, but the accident could be extremely severe if it ever occurs. Impatient riders, having low riding confidence and traffic awareness deficiency, also seek utility from certain risky riding behaviors. However, their fear of an accident leads them to fail to observe surrounding traffic conditions. The result indicates various mental compromise mechanisms for young motorcyclists in conducting riding behaviors. Thus, corresponding countermeasures, including licensure system and ITS roadway development, should consider the heterogeneous characteristics of young riders.

1. Introduction

Young drivers are considered a high-risk traffic group. Despite their comparatively low exposure to driving, young people are more likely to experience vehicle accidents (Clarke et al., 2005; Machin and Sankey, 2008; Waylen and McKenna, 2008). Early research suggests that immature skills or insufficient experience may account for the high accident rate among young drivers. However, several investigations indicate that experienced young drivers still are exposed to high accidental risk. Inexperience obviously is not the only explanation for accidents; research needs to clarify other factors differentiating young drivers from other drivers (Wong and Chung, 2007, 2008).

Among all human factors, researchers have intensively studied and considered psychological traits as significantly affecting risky driving behavior (Ulleberg and Rundmo, 2003; Dahlen et al., 2005; Kim and Yamashita, 2007). However, it is still unclear how these two are causally related. According to the Theory of Planned Behavior (TPB) proposed by Ajzen (1991), psychological traits including attitude, subjective norm and perceived behavior control affect behaviors via intention. Based on the theory, Ulleberg and Rundmo (2003) incorporated personality traits, attitudes towards safety and risk perception into Structure Equation Modeling (SEM) to discuss the risky driving behavior mechanism among young drivers. The results demonstrate that personality may indirectly influence risky driving behaviors via attitude. Yet, findings did not show risk perception, positively correlated with attitude, to be directly and significantly related to risky driving behaviors. This finding is inconsistent with past study findings that risk perception significantly affects risky or unsafe driving behaviors (Ryb et al., 2006; Harre and Sibley, 2007; Vanlaar et al., 2008).

According to the risk homeostasis theory, risky driving behaviors induce not only costs such as perceived risk, but also benefits such as excitement or time saving (Hoyes et al., 1996). Ignoring potential driver benefits from such driving will likely result in an incomplete understanding of such risky behaviors. By considering the heterogeneous characteristics of young drivers, further research on risky driving behaviors in different young driving

* Corresponding author. Tel.: +886 3 341 2500x6083; fax: +886 3 341 2361.
E-mail addresses: jtwong@mail.nctu.edu.tw (J.-T. Wong), yishih.chung@gmail.com, zest@mail.knu.edu.tw (Y.-S. Chung), andyhuang.tt96g@nctu.edu.tw (S.-H. Huang).
[1] Tel.: +886 2 2349 4959; fax: +886 2 2349 4953.
[2] Tel.: +886 2 2349 4995; fax: +886 2 2349 4953.

0001-4575/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.aap.2009.08.004

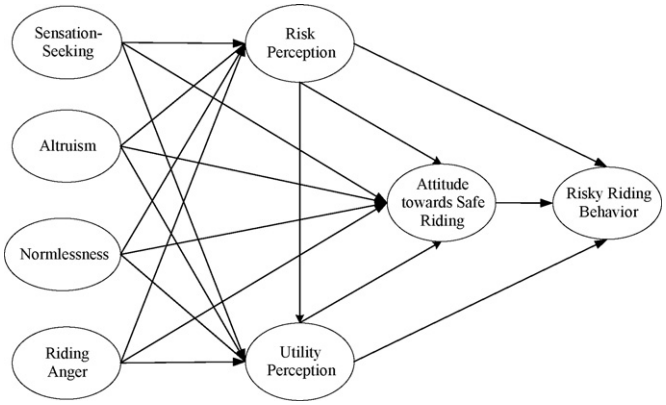

Fig. 1. Conceptual framework of the risky riding behavior model.

groups may enhance understanding of the nature of accidents (Gregersen and Berg, 1994; Chliaoutakis et al., 1999; Sexton et al., 2004). Thus, extending the previously developed model to include utility of risky driving is worthwhile.

This research surveyed young motorcyclists in Taiwan to investigate these relationships. Unlike those in North America or Europe where motorcycles account for only a small portion among all modes, motorcycles, especially mopeds and light motorcycles[3], in Taiwan are the major transportation mode consisting of 67 percent of registered motor vehicles (MTC, 2007a,b). Moreover, due to cost and convenience considerations, motorcycles are used for commuting rather than mere leisure for the young population in Taiwan, which is different from those in developed countries. To better understand the unique characteristics of risk-taking behaviors among young motorcyclists in Taiwan, this study focuses on the interactions of young motorcyclists between latent constructs including personality, attitude, risk perception, and perceived riding utility during their riding decision making process.

Based on the research conducted by Ulleberg and Rundmo (2003) and Hoyes et al. (1996), Section 2 presents the methodology, including a conceptual behavior framework, measurements and data collection process, and an analysis procedure. Section 3 illustrates the results of exploratory factor analysis and SEM. Section 4 follows with discussions.

2. Methodology

2.1. Conceptual framework

This study proposes an explanatory-latent intermediate-dependent framework to investigate underlying mechanisms of young motorcyclist's risk-taking behaviors in traffic. Researchers have considered personality traits as having significant impacts on driving behaviors (Ulleberg and Rundmo, 2003) and adopted personality traits as explanatory constructs to explain risky riding behaviors—the dependent construct. Effectively connecting personality traits and driving behaviors, requires cognitive constructs (Ajzen, 1991). Based on the literature review and the framework proposed by Hoyes et al. (1996) and Ulleberg and Rundmo (2003), this work proposes a preliminary framework in Fig. 1. The four personality trait constructs include sensation seeking, altruism, normlessness and riding anger, as explanatory constructs. Risk perception, attitude towards safe riding and utility perception are treated as latent intermediate constructs. The dependent construct is risky riding behavior.

2.1.1. Explanatory constructs: personality traits

Personality reflects internal characteristics of individual differences and demonstrates consistent patterns and tendencies in individual reactions to the external environment (McCrae and Costa, 1994; Ulleberg and Rundmo, 2003). Personality traits, the explanatory constructs in this research, are comprised of riding anger, sensation seeking, normlessness and altruism. Numerous studies have investigated the direct and indirect effects of personality traits on risky driving behavior (Ulleberg, 2001; Ulleberg and Rundmo, 2003; Dahlen et al., 2005; Oltedal and Rundmo, 2006; Schwebel et al., 2006; Kim and Yamashita, 2007; Machin and Sankey, 2008). By clustering the personality traits and driving behaviors of young drivers, Ulleberg (2001) claimed that high-risk populations share general characteristics of low altruism and high driving anger, normlessness and sensation seeking. Several works also have suggested that high driving anger, sensation seeking and normlessness increase the frequency of risky driving behaviors (Ulleberg, 2001; Ulleberg and Rundmo, 2003; Dahlen et al., 2005; Oltedal and Rundmo, 2006; Schwebel et al., 2006; Machin and Sankey, 2008). Furthermore, possessing both driving anger and sensation seeking characteristics may increase traffic violations.

Anger can be considered a negative emotion when encountering driving interference (Deffenbacher et al., 1994; Sullman, 2006), and angry drivers more frequently engage in risky driving behaviors. Deffenbacher et al. (1994) developed a Driving Anger Scale (DAS) for measuring angry emotion frequency among drivers. Sullman (2006) adopted the scale to analyze the effect of age on driving anger and found a greater tendency in younger drivers to display angry behaviors while driving.

Dahlen, Ulleberg and Rundmo define sensation seeking as a personality trait involving individual desire for excitement and stimuli (Ulleberg and Rundmo, 2003; Dahlen et al., 2005). Altruism displays concern for others. Both constructs can be derived from the NEO-Personality Inventory measurement which measures the degree of agreement among personality trait statements (Ulleberg and Rundmo, 2003). Researchers have also frequently adopted measurements proposed by Ulleberg (2001) to measure normlessness, characterized as the belief that socially unapproved behaviors are an acceptable means of achieving certain goals.

2.1.2. Latent intermediate constructs

Since personality represents a stable condition, which might be formed during personal growth, most studies assume that personality influences social cognitive variables. Hence, this research considers three latent intermediate constructs, including attitude towards safe riding, perceptions of risk and perceptions of utility.

Attitude, formed by learning or experience, indicates the continuous tendency of people to like or dislike some behaviors (Ajzen, 1991). The attitude towards safe riding is specifically designed to represent an individual's mental position with regard to safe riding behaviors. Ulleberg and Rundmo (2003) indicated that among the personality traits, only altruism both directly and indirectly affects risky driving behavior. However, all other personality traits influence risky driving behaviors only indirectly via attitude towards safe driving. Regarding the relationship between personality traits and attitude towards safe driving, normlessness and sensation seeking negatively affect attitude towards safe driving while altruism has a positive effect. Likewise, Ulleberg and Rundmo (2003) also indicated that young drivers, who tend to disobey traffic laws, speed, and see driving as recreation, exhibit more frequent risky driving behavior. Scales measuring the

[3] Those with engine capacities less than 150 cm^3.

agreement of specific statements or behaviors to identify driver attitudes are contained in Iversen (2004) and Ulleberg and Rundmo (2003).

Risk perception comprises subjective cognitive perception and affective perception. Subjective cognitive perception includes self-evaluation of likely involvement in an accident, self-efficacy and risk aversion. Affective perception includes concern regarding risky driving behaviors (Machin and Sankey, 2008). Machin and Sankey (2008) found that sensation seeking and self-evaluation of likely involvement in an accident positively affected tendency to speed. Meanwhile, altruism and risk aversion negatively affected speeding. This work proposes a risk perception scale to measure a motorcyclist's concern regarding certain risky riding behaviors, i.e. affective perception. Notably, affective perception may not necessarily reflect actual rider risks in undertaking risky behaviors, but rather reflects the risk they assigned to such behaviors based on their experience.

According to the risk homeostasis theory proposed by Hoyes et al. (1996), risky driving behavior simultaneously induced both costs and benefits. Costs, presented here as risk perception, reflect undesired outcomes of risky behavior, including fines, injuries or fatalities. Meanwhile, benefits indicate positive outcomes of risky behaviors, including time saving or excitement. Provided that the benefits exceed the costs, drivers may choose to engage in high risk driving behaviors. Furthermore, drivers failing to perceive adequate costs for an extended period, are likely to select risky behaviors more frequently (Engstrom et al., 2003). This study uses utility perception to represent risky behavior benefits, measured by accepting certain risky riding behaviors to save time or simply for fun.

2.1.3. Dependent construct: risky riding behavior

This research treats risky riding behaviors as the dependent construct. Although risky riding behaviors do not necessarily result in an accident, such behaviors increase their likelihood. This study adopts the scale devised by Chang and Yeh (2007) to measure risky riding behaviors frequency.

2.2. Data collection

Based on the review of related research, this study used a questionnaire comprising 91 items (Deffenbacher et al., 1994; Ulleberg, 2001; Ulleberg and Rundmo, 2003; Iversen, 2004; Chang and Yeh, 2007; Machin and Sankey, 2008). The current work initially adopted these items from the literature, and then translated and modified them to fit the present study. College students and transportation professionals tested and checked the initial questionnaire to improve its readability and made sure the items correctly reflect their associated meaning. Each item was scaled using a five point Likert Scale. For legitimacy, subjects had to satisfy the following requirements:

- 18–28 years old;
- hold a valid riding license;
- have motorcycle-riding experience during the past month.

This research chose subjects aged between 18 and 28 since this population represents the highest accident rate in Taiwan (Tseng et al., 2001). Besides the 91 questions listed, subjects were asked to provide background information including demographic data, riding related information, as well as information on accidents and violations.

The current investigation posted the questionnaire on the Internet to help reach young riders. Subjects completing the questionnaire qualified for a prize drawing. In total, 683 valid questionnaires were collected.

2.3. Analysis procedure

The analysis consisted of two steps: first, this study adopted an exploratory factor analysis under the aforementioned explanatory-latent intermediate-dependent framework to discover an optimal set of factors accounting for covariance among measures. Second, this work applied a structural equation model with a two-step procedure presented by Anderson and Gerbing (1988), based on the derived factors.

This study designed a 91-item questionnaire, based on the literature review. Since each literature has its own structure and purpose, the adopted items may overlap. To seek appropriate influencing factors in motorcycle riding behaviors in Taiwan, an exploratory factor analysis is necessary for reorganizing and reducing dimensionality of the numerous questionnaire responses, and for restructuring the model framework. Each factor is then reinterpreted and renamed based on the subset of items with high factor loadings. This study considers only those factor loadings greater than 0.4 (Hatcher, 1994).

3. Results

3.1. Subjects

Table 1 summarizes the background information of the subjects, showing that 15.1 percent of them were novel drivers since the legal licensing age in Taiwan is 18. The number of male riders was slightly higher than that of females, similar to the whole population distribution (MTC, 2007a,b). Moreover, the average length of riding experience was 5.24 years and most subjects rode motorcycles 5 days per week. The above statistics imply that most

Table 1
Background information of subjects.

Category	Count (column percentage)		
	Male	Female	Total
Gender	366 (100.0)	317 (100.0)	683 (100.0)
Age			
18–20	58 (15.8)	45 (14.2)	103 (15.1)
21–23	97 (26.5)	122 (38.5)	219 (32.1)
24–26	146 (39.9)	113 (35.6)	259 (37.9)
27–28	65 (17.8)	37 (11.7)	102 (14.9)
Education			
Senior high school and under	36 (9.8)	6 (1.9)	42 (6.1)
College or university	187 (51.1)	230 (72.5)	417 (61.1)
Master's and above	143 (39.1)	81 (25.6)	224 (32.8)
Occupation			
Student	259 (70.8)	203 (64.0)	462 (67.6)
Others	107 (29.2)	114 (36.0)	221 (32.4)
Accident within the last 2 years			
Yes	102 (27.9)	98 (30.9)	200 (29.3)
No	264 (72.1)	219 (69.1)	483 (70.7)
Severity of accidents			
Property damage only	19 (18.6)	19 (19.4)	38 (19.0)
Minor injuries	55 (53.9)	51 (52.0)	106 (53.0)
Serious injuries	28 (27.5)	28 (28.6)	56 (28.0)
Violation experience			
Yes	214 (58.5)	115 (36.3)	329 (48.2)
No	152 (41.5)	202 (63.7)	354 (51.8)
Traffic violation			
Running a red light	52 (23.7)	27 (29.0)	79 (25.3)
Left turn violation	41 (18.7)	23 (24.7)	64 (20.5)
Right turn violation	39 (17.8)	22 (23.7)	61 (19.6)
Speeding	68 (31.1)	15 (16.1)	83 (26.6)
Not wearing a helmet	19 (8.7)	6 (6.5)	25 (8.0)

subjects were experienced riders and rode motorcycles to commute.

Furthermore, when examining the subjects' experience of traffic accidents and violations, we found that approximately 29.3 percent of the subjects had been involved in accidents. Among those, 28 percent suffered serious injury, 53 percent suffered minor injury and 19 percent suffered only property damage. Approximately half of all subjects experienced traffic violations. Red light running and speeding were the most frequent violations. In particular, almost 60 percent of male riders had violations, especially speeding violations. On the other hand, only 36.3 percent of female riders violated traffic rules; a relatively high proportion of these violations occurred near intersections where, compared to road segments, riders need to attend to more complicated information, requiring more skills.

3.2. EFA and CFA

This work divided the 683 samples into two groups: 200 randomly selected samples for an exploratory factor analysis (EFA), and the remainder for a confirmatory factor analysis (CFA). This research adopted the principal component and pro-max approaches in the EFA for abstracting factors from questionnaire responses. To prevent confusion and misinterpretation, four categories of measurements were processed separately, including personality trait, risk perception, attitude towards unsafe riding and utility perception, and risky riding behavior. After the EFA, the current investigation applied the CFA to validate reliabilities and goodness-of-fit for the resulted factors. Table 2 lists the results, and the Appendix A summarizes the corresponding items for each construct.

Table 2 shows the composite reliability of the resulted constructs as all above 0.7, except for the construct *unawareness of traffic conditions*. Moreover, the goodness-of-fit indexes all fit the conventional requirements ($\chi^2/df < 2$; GFI and NNFI both greater than 0.9; RMSEA less than 0.05), indicating a satisfactory model fit (Bentler, 1989; Hatcher, 1994).

Table 2
Factors and associated reliabilities.

Construct	Composite reliability
Personality trait	
Sensation seeking	0.713
Amiability	0.801
Impatience	0.718
Risk perception	
Riding confidence	0.714
Affective risk perception	0.814
Attitude and utility	
Utility perception	0.793
Attitude towards unsafe riding	0.729
Unawareness of traffic conditions	0.684
Risky riding behavior	
Fast riding	0.810
Traffic violation	0.736
Index[a]	
χ^2/df:: 1.860	
GFI: 0.904	
NNFI: 0.906	
RMSEA: 0.038	

[a] The GFI (goodness-of-fit index) measures the amount of variance and covariance in the original correlation matrix predicted by the model. Compared to GFI, NNFI (Non-Norm Fit Index) is further adjusted with the degree of freedom. The value of RMSEA (Root Mean Square Error of Approximation) examines the discrepancy per degree of freedom between this model and the saturated model.

3.3. Structural model

Under the explanatory-latent intermediate-dependent framework, this work adopted the two-step structural equation modeling method recommended by Anderson and Gerbing (1988) to investigate causality among the constructs resulting from CFA. Fig. 2 shows the final risky riding behavior model (dashed line indicates non-significant path). Most performance measures of the overall model satisfy the conventional requirements ($\chi^2/df < 2.11$, GFI = 0.910, NNFI = 0.905, RMSEA = 0.049), which indicate the specified model fits the data at a satisfactory level. Moreover, the composite reliability and the variance extracted estimate for each measure all exceed the conventional threshold, 0.7 and 0.5, respectively, also suggesting that the variance explained for each construct is satisfactory (Hatcher, 1994).

Figs. 1 and 2 comparisons show that the resulted constructs were somewhat different from the initial setting. As the explanatory constructs, personality traits were represented by three constructs: *sensation seeking*, *amiability* and *impatience*. The latent intermediate constructs included *riding confidence*, *affective risk perception*, *utility perception*, *attitude towards unsafe riding* and *unawareness of traffic condition*; while the first two were extracted from the risk perception construct, the last one was extracted from the risky riding behavior construct. The construct, *unawareness of traffic conditions*, was considered as an intermediate construct rather than a dependent construct since individual situational awareness in a given riding environment may reflect their prevailing manners or part of their safety culture, but not a decision result (Endsley, 1995). Therefore, this study reassigned the construct, *unawareness of traffic conditions*, as an intermediate construct prior to risky riding behavior. Finally, the dependent construct, *risky riding behavior*, was represented by two second-order constructs including *fast riding*, and *traffic violation*.

Findings reveal both affective risk perception and utility perception as significant, confirming the risk homeostasis theory (Hoyes et al., 1996). Moreover, the model result makes clear that riding confidence representing perceived behavioral control in the Theory of Planned Behavior model (Ajzen, 1991) should be included, which was absent in the framework proposed by Ulleberg and Rundmo (2003).

The different magnitude and signs of path coefficients between these three personality traits and *affective risk perception* as well as *utility perceptions* imply various compromise mechanisms among different types of young motorcyclists. To clarify these mechanisms, this study decomposes and summarizes the effects of personality traits on *unawareness of traffic conditions*, *attitude towards unsafe riding* and *risky riding behavior* in Tables 3–5, respectively. In these tables, total effects are defined to be the sum of direct effects and indirect effects, where the direct effect is the corresponding path coefficient between the two specified constructs, and the indirect effects are the product of all of the coefficients along the paths between the two specified constructs that involve intervening constructs (Kline, 2004).

The effects of personality traits on unawareness of traffic conditions fit with the paths through riding confidence and affective risk perception. As Table 3 shows, the indirect effect of sensation seeking on unawareness of traffic conditions through riding confidence is substantially stronger than that through affective risk perception. Moreover, both riding confidence and affective risk perception kindle traffic condition awareness. The result shows that excessively confident young riders are more aware of traffic conditions (Clarke et al., 1998, 1999). In addition, the indirect effect of amiability on unawareness of traffic conditions was totally through riding confidence rather than affective risk perception, implying

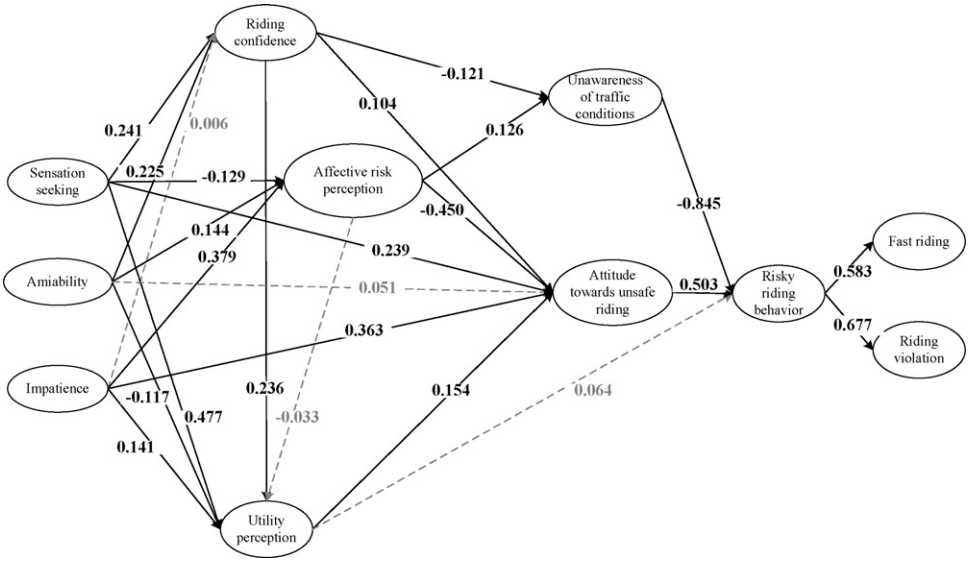

Fig. 2. Refined risky riding behavior model.

Table 3
Effects of personality traits on unawareness of traffic conditions.

Personality trait	Direct effect[a]	Indirect effect[b] through		Total effect[c]
		Riding confidence	Affective risk perception	
Sensation seeking	N/A	−0.029	−0.016	−0.045[d]
Amiability	N/A	−0.027	0.018	−0.009
Impatience	N/A	−0.001	0.048	0.047

[a] Direct effects are the corresponding path coefficients observed in Fig. 2. N/A is represented when this path does not exist.
[b] Indirect effects are the product of all coefficients along the paths between the two constructs that involve intervening constructs. For example, $-0.029 = 0.241 \times (-0.121)$ where the first term on the right hand side of the equation is the path coefficient between sensation seeking and riding confidence and the second term is the path coefficient between riding confidence and unawareness of traffic conditions.
[c] Total effects are defined to be the sum of direct effects and indirect effects.
[d] Note that the (−) sign indicates the drivers are more aware of traffic conditions.

Table 4
Effects of personality traits on attitude towards unsafe riding.

Personality trait	Direct effect	Indirect effect through		Total effect
		Affective risk perception	Utility perception	
Sensation seeking	0.239	0.058	0.073	0.370
Amiability	0.051	−0.065	−0.010	−0.024
Impatience	0.363	−0.171	0.022	0.214

that riding confidence is the key characteristic contributing to traffic condition awareness for amiable young riders. By contrast, the indirect effect of impatience on unawareness of traffic conditions went purely through affective risk perception. This suggests that unawareness of traffic conditions in impatient drivers may result from their worry or concern about surrounding conditions, indicating they might be nervous and easily distracted riders.

This work conducted a similar analysis to analyze the effects between personality traits and *attitude towards unsafe riding*. As Table 4 shows, the effects between *sensation seeking* and *attitude towards unsafe riding* were decomposed into direct effect and two indirect effects. While the constructs of *sensation seeking* and *impatience* play a direct key role on determining young riders' *attitude towards unsafe riding*, the indirect effect of *amiability* on *attitude towards unsafe riding* through *affective risk perception* are more critical than its direct effect or indirect effect through *utility perception*. In other words, sensation seeking or impatient riders think of unsafe riding intrinsically, yet amiable riders think of unsafe riding largely due to their worry or concerns about traffic risks.

Furthermore, besides the indirect effects via *affective risk perception* and *utility perception* constructs, the characteristics of *sensation*

Table 5
Effects of personality traits on risky riding behavior.

Personality trait	Direct effect	Indirect effect through		Total effect
		Unawareness of traffic conditions	Attitude towards unsafe riding	
Sensation seeking	N/A	0.038	0.186	0.224
Amiability	N/A	0.008	−0.012	−0.004
Impatience	N/A	−0.040	0.108	0.068

Table 6
Determinants behind young motorcyclists' risky riding behavior.

Personality trait	Riding confidence	Affective risk perception	Utility perception	Awareness of traffic conditions	Attitude towards unsafe riding	Risky riding behavior
Sensation seeking	High	Low	High	Highly aware	Highly comfortable	Highly likely
Amiability	High	Medium	Low	Aware	Uncomfortable	Unlikely
Impatience	Low	High	Medium	Unaware	Comfortable	Weakly likely

seeking and *impatience* significantly and positively affect *attitudes towards unsafe riding* directly, confirming the hypothesis that riders who are impulsive or seek excitement have higher acceptance of unsafe riding (Hoyes et al., 1996). However, the *amiability* construct does not significantly affect *attitude towards unsafe riding*; instead, it exerts the indirect effects via latent intermediate constructs.

Finally, Table 5 shows that the indirect effects of *sensation seeking*, *amiability* and *impatience* on *risky riding behaviors* ran purely or mostly through *attitude towards unsafe riding*. This reinforces the profound impact of attitudes on behaviors as declared in the Theory of Planned Behavior (Ajzen, 1991).

4. Discussions

This research develops a framework based on Ulleberg and Rundmo (2003) and Hoyes et al. (1996) for analyzing the nature of risky riding behavior among young motorcyclists in Taiwan. The results demonstrate that personality traits indirectly and significantly relate to risky riding behavior. On the basis of paths from each personal trait to each intermediate and dependent construct, Table 6 summarizes the underlying features of determinants behind young motorcyclists' risky riding behaviors explored in this study.

4.1. Determinants behind young motorcyclists' risky riding behavior

Although past studies suggest overconfidence as one of the primary reasons why young motorcyclists express risky riding behaviors (e.g. Clarke et al., 2005), this research further clarifies that confidence is only a partial determinant for risky riding behaviors.

Different determinants drive risky riding behaviors in young motorcyclists with distinct personality traits. The sensation-seeking population consists of riders with low affective risk perception and high riding confidence. These riders are highly comfortable with unsafe riding and interested in the utility gained from it, making them highly likely for risky riding behavior. Interestingly, the extremely confident riders also are highly aware of traffic conditions, possibly suggesting that the sensation-seeking population tends to be experienced and skillful riders; those with risky riding habits pay more attention to traffic in order to protect themselves. Although they may not frequently encounter accidents, the accident for this group could be extremely severe once it occurs.

Meanwhile, amiable young motorcyclists also are confident and aware of traffic conditions; yet they are uncomfortable with unsafe riding and thus not likely to conduct risky riding behaviors. Unlike the sensation-seeking ones, these amiable young riders feel confident in riding but have only a low interest in utility obtained from risky riding behaviors. They may represent a relatively mature population among young motorcyclists.

Riders with impatience characteristics not only perceive greater danger but also try to seek utility from certain risky riding behaviors. Their low confidence in riding and deficient traffic condition awareness, however, may suggest their immature riding skills. Such riders can be considered nervous riders, whose fear of an accident leads them to neglect observing surrounding traffic conditions. Although such riders appear to have less risky riding behaviors, they may more frequently expose themselves to risky situations, especially if they are agreeable with unsafe riding but without sufficient skills to support such behaviors.

A rider is a mixture of these personal traits. This mixture results in heterogeneous riding behaviors that could not be distinguished simply by socio-economic conditions of a rider. For example, compared with young female riders, findings show young male riders in Taiwan to be more confident of their riding skills, more comfortable with unsafe riding, more interested in the utility gained from unsafe riding, more easily ignoring traffic condition, and more likely to conduct risky riding behaviors. These features suggest that male riders, compared to female riders, are more sensation seeking as well as impatient. This result confirms the previous finding that personal traits play a certain role in explaining heterogeneous riding/driving behaviors (Ulleberg, 2001), and suggests further studies to group samples into different types based on personality traits and to examine associated causal processes.

4.2. Policy implications

The distinct determinants of risky riding behaviors discussed above clearly suggest that various strategies should be developed for each young riding population. While the amiable riders represent relatively mature and safe riders, both the sensation-seeking and impatient riders are regarded as a high-risk population and cause different hazards.

The hazards caused by the sensation-seeking population are obvious and can be frequently observed. This group of riders enjoys the utility gained from risky riding behavior; as long as the traffic condition seems favorable, they conduct certain risky riding behaviors such as fast riding or squeezing between vehicles. Since traffic laws and regulations do not allow most of these behaviors, they could be prohibited to some degree by police enforcement. However, considering their relatively low level of affective risk perception and extremely high level of utility perception, educating this population regarding potential traffic risks and terrible consequences of an accident could be more effective.

On the other hand, hazards caused by the impatient population arise from their lack of riding confidence and immature skills regarding traffic awareness and their acceptance of risky riding behavior. This may partially reflect the inappropriate current licensure system in Taiwan, which requires no safety education and practical training to obtain a riding license for motorcycles with engine capacities less than 250 cm^3, accounting for more than 99.9 percent of total registered motorcycles in Taiwan. Under the current licensing policy, riding skills are acquired by self-learning and a trial-and-error process. This is especially harmful for impatient riders. Although these riders may not conduct risky riding behaviors as frequently as the sensation-seeking ones, their inexperience, nervousness, or even unfamiliarity with traffic culture produces accident risks, particularly when they face complex or highly stressed traffic conditions. It is therefore necessary to enhance their driving skills by a well-designed licensure system. In addition, road environments, as part of ITS (Intelligent Transport Systems) development, should also help identify and alert people to traffic risks on roads.

Acknowledgments

The authors would like to thank the anonymous referees for their helpful suggestions and comments. This work was partially supported by the National Science Council of Taiwan (NSC 97-2221-E-009-116-MY3 & NSC 98-2410-H-424-018).

Appendix A.

Table A.1.

Table A.1
Questionnaire items for each construct.

Explanatory constructs: personality traits
Sensation seeking
I often crave excitement.
I sometimes do things just for kicks or thrills.
It's OK to get around laws and rules as long as you don't break them directly.
Amiability
Few people think I am selfish and egotistical.
Few people think of me as calm and calculating.
Impatience
Pedestrians block my way while I'm riding in an alley.
I am stuck in a traffic jam.
I am riding behind a truck and my views are blocked.
Latent intermediate constructs
Riding confidence
I can handle any unexpected situation even when riding on unfamiliar roads.
If I run into danger while riding, I have the skills to get out of it safely.
Affective risk perception
Ride between two lanes of fast moving traffic.
Ride so close to the front vehicle that it would be difficult to stop in an emergency.
Merge onto major roads from a minor road when there is coming traffic.
Ride so fast into a corner that I feel like I'm losing control.
Utility perception
Riding is not only for transportation but also for fun or recreation.
Riding a motorcycle makes me feel relaxed.
Attitude towards unsafe riding
It is acceptable to ride on the opposite lane of a two-lane road for convenience.
With good skills, speeding is OK.
I think it is OK to speed if the traffic condition allows me to do so.
Unawareness of traffic conditions
Do not use mirror to check surrounding vehicles while riding or turning.
Do not use turn signals when turning.
Dependent constructs: risky riding behavior
Fast riding
In order to ride faster, I squeeze through an extremely narrow space between one vehicle and another.
Compared to the surrounding traffic flow, I ride much faster.
Disregard the speed limit late at night or in early morning.
Riding violation
Drink and ride.
Run through red lights.
Do not wear a helmet while riding.

References

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211.
Anderson, J.C., Gerbing, D.W., 1988. Structural equation modeling in practice: a review and recommended two-step approach. Psychol. Bull. 103 (3), 411–423.
Bentler, P.M., 1989. EQS Structural Equations Program Manual. BMDP Statistical Software, Los Angeles.
Chang, H.L., Yeh, T.H., 2007. Motorcyclist accident involvement by age, gender, and risky behaviors in Taipei, Taiwan. Transp. Res. Pt. F: Traffic Psychol. Behav. 10 (2), 109–122.
Chliaoutakis, J.E., Darviri, C., Demakakos, P.T., 1999. The impact of young drivers' lifestyle on their road traffic accident risk in greater Athens area. Accid. Anal. Prev. 31 (6), 771–780.
Clarke, D.D., Forsyth, R., Wright, R., 1998. Machine learning in road accident research: decision trees describing road accidents during cross-flow turns. Ergonomics 41 (7), 1060–1079.
Clarke, D.D., Forsyth, R., Wright, R., 1999. Junction road accidents during cross-flow turns: a sequence analysis of police case files. Accid. Anal. Prev. 31 (1–2), 31–43.
Clarke, D.D., Ward, P., Truman, W., 2005. Voluntary risk taking and skill deficits in young driver accidents in the UK. Accid. Anal. Prev. 37 (3), 523–529.
Dahlen, E.R., Martin, R.C., Ragan, K., Kuhlman, M.M., 2005. Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. Accid. Anal. Prev. 37 (2), 341–348.
Deffenbacher, J.L., Oetting, E.R., Lynch, R.S., 1994. Development of a driving anger scale. Psychol. Rep. 74 (1), 83–91.
Endsley, M.R., 1995. Toward a theory of situation awareness in dynamic-systems. Hum. Factors 37 (1), 32–64.
Engstrom, I., Gregersen, N.P., Hernetkoski, K., Keskinen, E., Nyberg, A., 2003. Young Novice Drivers, Driver Education and Training, VTI Report, 491A.
Gregersen, N.P., Berg, H.Y., 1994. Life-style and accidents among young drivers. Accid. Anal. Prev. 26 (3), 297–303.
Harre, N., Sibley, C.G., 2007. Explicit and implicit self-enhancement biases in drivers and their relationship to driving violations and crash-risk optimism. Accid. Anal. Prev. 39 (6), 1155–1161.
Hatcher, L., 1994. A Step-by-step Approach to Using the SAS System for Factor Analysis and Structural Equation Modeling. SAS Institute Inc., Cary.
Hoyes, T.W., Stanton, N.A., Taylor, R.G., 1996. Risk homeostasis theory: a study of intrinsic compensation. Saf. Sci. 22 (1–3), 77–86.
Iversen, H., 2004. Risk-taking attitudes and risky driving behaviour. Transp. Res. Pt. F: Traffic Psychol. Behav. 7 (3), 135–150.
Kim, K., Yamashita, E.Y., 2007. Attitudes of commercial motor vehicle drivers towards safety belts. Accid. Anal. Prev. 39 (6), 1097–1106.
Kline, R.B., 2004. Principles and Practice of Structural Equation Modeling. The Guilford Press.
Machin, M.A., Sankey, K.S., 2008. Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour. Accid. Anal. Prev. 40 (2), 541–547.
McCrae, R.R., Costa, P.T., 1994. Trait explanations in personality psychology. In: Presented at the Symposium on Structure and Causality in Personality and Behavior, at the 7th European Conference on Personality, Madrid, Spain, John Wiley & Sons Ltd.
MTC, 2007a. Monthly Statistics of Transportation and Communications. Ministry of Transportation and Communications, Executive Yuan, Taipei, Taiwan.
MTC, 2007b. Special Report: Survey of Motorcycle Usage in Taiwan. Ministry of Transportation and Communications, Executive Yuan, Taipei, Taiwan.
Oltedal, S., Rundmo, T., 2006. The effects of personality and gender on risky driving behaviour and accident involvement. Saf. Sci. 44 (7), 621–628.
Ryb, G.E., Dischinger, P.C., Kufera, J.A., Read, K.M., 2006. Risk perception and impulsivity: association with risky behaviors and substance abuse disorders. Accid. Anal. Prev. 38 (3), 567–573.
Schwebel, D.C., Severson, J., Ball, K.K., Rizzo, M., 2006. Individual difference factors in risky driving: the roles of anger/hostility, conscientiousness, and sensation-seeking. Accid. Anal. Prev. 38 (4), 801–810.
Sexton, B., Baughan, C., Elliott, M., Maycock, G., 2004. The Accident Risk of Motorcyclists. Publication TRL607, D. F. T. Road Safety Division, U.K.
Sullman, M.J.M., 2006. Anger amongst New Zealand drivers. Transp. Res. Pt. F: Traffic Psychol. Behav. 9 (3), 173–184.
Tseng, P.-Y., Huang, Y.-S., Jiang, S.-Y., 2001. Analysis of accident risks by driver age. In: Presented at the International Conference of Traffic Safety and Enforcement, Taoyuan, Taiwan.
Ulleberg, P., 2001. Personality subtypes of young drivers. Relationship to risk-taking preferences, accident involvement, and response to a traffic safety campaign. Transp. Res. Pt. F: Traffic Psychol. Behav. 4 (4), 279–297.
Ulleberg, P., Rundmo, T., 2003. Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. Saf. Sci. 41 (5), 427–443.
Vanlaar, W., Simpson, H., Robertson, R., 2008. A perceptual map for understanding concern about unsafe driving behaviours. Accid. Anal. Prev. 40 (5), 1667–1673.
Waylen, A.E., McKenna, F.P., 2008. Risky attitudes towards road use in pre-drivers. Accid. Anal. Prev. 40 (3), 905–911.
Wong, J.T., Chung, Y.S., 2007. Rough set approach for accident chains exploration. Accid. Anal. Prev. 39 (3), 629–637.
Wong, J.T., Chung, Y.S., 2008. A rule comparison approach for identifying causal factors of accident severity. Transp. Res. Rec. 2083, 190–198.