ARTICLE IN PRESS

Transportation Research Part F xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part F

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

Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility

Nur Sabahiah Abdul Sukor [a], Ari K.M. Tarigan [b,c,*], Satoshi Fujii [d]

[a] School of Civil Engineering, Universiti Sains Malaysia (USM), Penang, Malaysia
[b] Cofely Fabricom GDF Suez, Kanalsetta 3, 4033 Stavanger, Norway
[c] Resilience Development Initiative (RDI), Bandung, Indonesia
[d] Department of Urban Management, Kyoto University, Kyoto, Japan

ARTICLE INFO

Article history:
Received 26 October 2015
Received in revised form 23 September 2016
Accepted 26 September 2016
Available online xxxx

Keywords:
Motorcycle lane
Speeding
Neglecting helmet
Structural equation model
Motorcyclists' psychological factors

ABSTRACT

Segregated road lanes for motorcyclists are one of the practices implemented by the Malaysian authority to decrease the number of road crashes involving motorcycles. In this study, the motorcycle lanes are divided into three types, exclusive, inclusive, and paved shoulder. This study examined the correlations between motorcyclists' psychological factors and their risky riding behaviors (speeding and neglecting to wear helmet), depending on self-reported usage of different types of motorcycle facilities. The psychological factors discussed in this study were: attitude, desire, perceived behavior control, moral obligation, perceived danger, fear of being caught, and perception of others' behaviors toward the risky behaviors. Quantitative analyses, including Structural Equation Modeling, were used as the analytical tools. The results demonstrated the statistically significant relationship of exclusive road lanes' usage on speeding behavior. However, no statistically significant correlation was found for segregated lanes' usage on helmet wearing behavior. Psychological factors were found affecting the motorcyclists' likelihood of performing the risky behaviors. However, these factors influence speeding and helmet wearing behavior differently. The study offers recommendations and theoretical contributions to explain the complex relationships among the uses of segregated lanes, riders' psychological factors, and their risky behaviors.

1. Introduction

The motorcycle is a very important mode of daily transportation for Malaysian commuters, as it is for others in the Southeast Asia region, including Indonesia (Susilo, Joewono, & Vandebona, 2014), Vietnam (Hung, Stevenson, & Ivers, 2008), Cambodia (Brijs et al., 2014), and Thailand (Limanond, Jomnonkwao, Watthanaklang, Ratanavaraha, & Siridhara, 2011). In Malaysia, motorcycle use is growing rapidly, alongside population and economic growth. This developing country is home to 28 million people, with 8.4 million registered motorcycles as of 2010 (Sanlam, 2012). Thus, there is about one motorcycle for every three individuals, and the ratio of motorcycles to cars is about 50–50 (The Star Online, 2014). According

* Corresponding author at: Cofely Fabricom GDF Suez, Kanalsetta 3, 4033 Stavanger, Norway.
E-mail addresses: cesabahiah@usm.my (N.S.A. Sukor), a.k.m.tarigan@gmail.com, ari.tarigan@hotmail.com (A.K.M. Tarigan), fujii@trans.kuciv.kyoto-u.ac.jp (S. Fujii).

http://dx.doi.org/10.1016/j.trf.2016.09.032
1369-8478/

to the Road Transport Department of Malaysia, 542,000 motorcycles were registered in 2011 alone, and this number increased by 12% the following year. Along with the rapid growth of motorcycle ownership, the number of road accidents, which often involve motorcycles, has increased. The World Health Organization (2013) reported that nearly 60% of the deaths caused by road accidents involved motorcyclists. The Malaysian Institute of Road Safety (2012) revealed that, on average, 18 people are killed on Malaysian roads each day. The study has predicted that, by 2020, 29 people a day would be killed, amounting to 10,000 deaths for the year. Furthermore, according to Manan and Várhelyi (2012), Malaysia suffers the highest number of road fatalities in the ASEAN countries. Their study further demonstrated that 25% of motorcycle accidents occurred when the riders did not wear helmets. Interestingly, about 53% of motorcycle accidents occurred on primary and expressway roads, some of which are segregated and have specific lane markings (Manan & Várhelyi, 2012).

As shown in Fig. 1, the ratio of motorcycle accidents to the number of registered motorcycles did not change much from 2000 to 2010. Similarly, the ratio of motorcycle accident fatalities and total motorcycle accidents did not change much over the given period In addition, there was a stable trend in terms of the ratio total registered motorcycles and total population.

The road authority of Malaysia is concerned with road safety policy, particularly with improving geometric road designs and understanding drivers' psychological factors in relation to risk (for instance, see Radin Umar, Mackay, & Hills, 1995). Since the 1970s, three types of lane have been widely used by motorcyclists in Malaysia. The first type is a segregated one-way lane that completely separates motorcyclists from other road users, and this is considered an "exclusive motorcycle lane" (Radin Umar et al., 1995). In most cases, an exclusive motorcycle lane is built along both sides of an expressway. The width of this lane ranges from 2.0 m to 3.5 m, and the speed limit is 60 km/h (Public Work Department, 1986a).

The second type of motorcycle lane is often constructed on federal or state roads. According to Law and Radin Sohadi (2005), this type is considered an "inclusive motorcycle lane." This type of motorcycle lane has physical barriers in some cases, but some of them only have pavement markings to indicate the specific lanes for motorcyclists. The appropriate width and speed limit for the inclusive motorcycle lane are largely similar to those of the exclusive motorcycle lane.

The paved shoulder lane is another type of road facility. It is actually an extra space along main roads that does not have designated pavement markings and/or physical barriers. According to the Malaysian road authority, the paved shoulder is part of the road facilities for motorcyclists as well as for emergency purposes; it has a width of between 1.5 m and 3 m (Public Work Department, 1986a; Public Work Department, 1986b). In Malaysia, it is also common for motorcyclists to use paved shoulder lanes on a normal basis. Fig. 2 illustrates the three lanes.

The existing challenge is that it is still unclear whether the use of motorcycle lanes correlates to decreasing risky behavior or increasing risky behavior. It has been argued that motorcyclists may acquire a sense of overwhelming confidence when utilizing exclusive lanes, leading them to engage in risky behavior, such as speeding or not using a helmet. According to Wilde's Risk Homeostasis Theory (1998), even when many countermeasures or policies are implemented to improve road safety, people are likely to adapt to the environment and tend to engage in risky behavior. Past studies have revealed that motorcycle crashes still occurred, even in the totally segregated lanes (Ibitoye, Radin, & Hamouda, 2007; Tung, Wong, Law, & Radin Umar, 2008). These studies show when motorcyclists know that there is less likelihood of an accident involving other

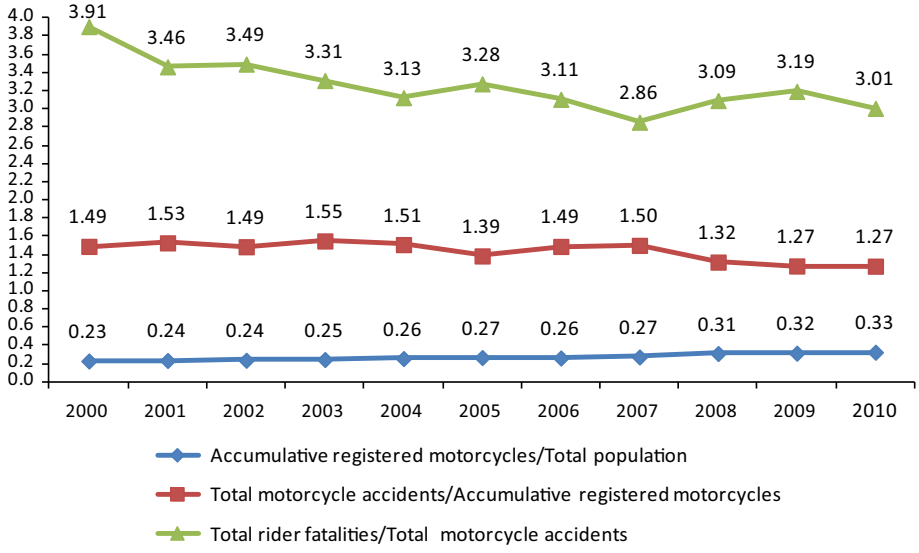

Fig. 1. The longitudinal profile of motorcycle accident indexes in Malaysia (Authors' calculation based on Sarani, Roslan, and Saniran (2011)). *Note:* The unit for *Y*-axis indicates: (1) the fraction of the motorcyclist fatalities and the number of motorcycle accidents (for the green/triangle line); (2) the fraction of the total motorcycle accidents and the accumulative registered motorcycles (for the red/square line); and (3) the fraction of the number motorcycle and the total population (the blue/diamond line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

Fig. 2. Illustrations of: (a) an exclusive road lane, (b) an inclusive road lane, and (c) a paved shoulder road lane.

road users, they tend to feel safe enough to speed and be reckless. Similarly, riders wearing a helmet tend to speed, partly because of their behavioral adaptation toward the environment (Lardelli-Claret et al., 2003; Ouellet, 2011). Past studies have indicated that aggressive driving behavior may be triggered by a complex interaction of attitude (Iversen & Rundmo, 2012; Ulleberg & Rundmo, 2003), hazard perception (Theofilatos & Yannis, 2014; Weissenfeld, Baldock, & Hutchinson, 2014), fear of being caught (Killias, Villettaz, & Nunweiler-Hardegger, 2016; Stanojević, Jovanović, & Lajunen, 2013), desire to speed (Goldenbeld & van Schagen, 2007; Hammond & Horswill, 2001), and moral obligation (Chorlton, Conner, & Jamson, 2012).

Susilo et al. (2014) warned, however, that such interactions were found mostly in developed countries, despite the fact that the leading motorcycle sales market is in developing countries. Since developed and developing countries differ in cultural respects as well as in mobility trends, it is important to investigate how the road infrastructures, attitudes, and social norms are associated with risky behaviors in the developing world, like Malaysia. Such efforts may contribute to safe driving literature based on the developing world's context and provide advice for the relevant authorities. Thus, this research attempts to examine the correlation among use of motorcycle lanes, psychological factors (attitude, perceived behavioral control, moral obligation, perceived danger, perceived behavior of others, fear, and desire), and risky behavior (speeding and neglectful helmet usage) among motorcyclists in Malaysia.

2. Theoretical review

Speeding has been widely noted in previous research, as one of the potential risky behaviors that could cause an accident (Aarts & van Schagen, 2006; Fell, 1976). Bellaby and Lawrenson (2001) stated that the riders were actually aware that they must control their speed limit compliance, to be not beyond their riding abilities to safely handle the motorcycle; otherwise, they may be involved in an accident. Elliott, Baughan, and Sexton (2007) demonstrated that the speeding factor is one of the determinants of motorcycle's crash liability. The study demonstrated that the desire to speed was found to have the same influence as the speeding behavior on motorcycle crashes' phenomena. It concluded that a greater desire is likely to result in more fatal injuries.

Helmet usage is another risky behavior linked to accidents involving motorcycles. In Malaysia, helmet usage is mandatory, and the enforcement of helmet laws has led to a 30% reduction in motorcycle fatalities and injuries (Supramaniam, van Belle, & Sung, 1984). Other countries, including those in Southeast Asia, recognize the importance of the policy related to helmet use and its enforcement. For example, Hung, Stevenson, and Ivers (2006) showed that Vietnamese motorcyclists are more likely to use helmet on the national roads rather than on the provincial or rural roads. This study has revealed that the law enforcement is weaker in the countryside, implying to a significant reduction of accidents with major fatalities on the national roads compared to other areas. In Indonesia, Susilo et al. (2014) demonstrated that motorcyclists' violations of helmet laws become a regular habit, and these may contribute to various types of accidents.

To better understand the determinants of motorcyclists' risky behaviors, Groeger and Rothengatter (1998) recommended psychological elements as one of the contributors to risky behaviors. Additionally, as noted by Ajzen's planned behavior theory (1991), the psychological factors such as attitude, perceived behavioral control, and subjective norm, trigger the behaviors. In particular, studies by Steg and Van Brussel (2009) as well as Özkan, Lajunen, Dogruyol, Yildirim, and Ç oymak (2012) used the psychological factors in the Theory of Planned Behavior to explain the effects of attitudes, subjective norm, and perceived behavior control on speeding behaviors among the motorcyclists.

The other psychology–based theory, Schwarz's norm activation theory (1977), reveals that moral obligation measures help predict the behaviors. It is particularly useful to explain individuals' behaviors with great responsibility. For example, the moral obligation factor has been used to explain the relation between altruism and social awareness in transport studies (for example, see Choocharukul, Van, & Fujii, 2006; Fujii & Van, 2009). Another theory that focuses on human behavior is the Normative Social Influence Theory (Asch, 1955). This theory argues that social factors influence individual's behavioral changes and perception of the actions of other people and society influence behavioral changes. In this theory, the action of changing behavior is called conformity. Several studies supported the theory, demonstrating that the level of conformity increased when the pressure from other people increased (Cialdini & Trost, 1998; Zhou, Horrey, & Yu, 2009).

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

In the present study, the Normative Social Influence Theory reflects the perceived behavior of others, demonstrating how this type of perception could pressure the motorcyclists to engage in the same actions as do others. This theory suggests that people have a preferred level of risk they are willing to accept, and they attempt to adjust their behavior to be in line with their preferred level of risk. For example, as the risk increases, so does their caution toward risk. In addition, according to past studies about the perception toward risk, fear and worry related to risk taking are important factors of human behaviors (Adams, 1995; Slovic, 1987; Wilde, 2001). The studies further argue that one may maintain the preferred level of risk that he or she is willing to accept by adjusting his or her behaviors. In other words, risk and caution should be balanced in that as risk increases, caution should also increase.

Overall, it is important to include the given psychological factors, as discussed in the previous paragraphs, when predicting the human behaviors such as speeding and not using helmet. It is also essential to investigate how the human psychological factors and its behaviors (speeding and helmet use) can be related to the existing forms of road infrastructures. Using a combination of aforementioned theories, this study attempts to uncover the correlations among psychological factors, the self-reported usage of different types of road lanes, and risky behaviors of motorcyclists in Malaysia, indicated by speeding and not wearing helmet.

3. Hypotheses and survey procedure

3.1. Hypotheses

Psychological factors are likely to relate to risky behavior. Socio-demographic attributes are expected to relate to risky behavior and to psychological features. The socio-demographic attributes may also indirectly affect speeding and helmet use, through the psychological factors as mediating variables. However, the effects will vary across the given measures. The assertion of this study is that psychological factors, motorcycle lane usage, and socio-demographic characteristics will influence speeding and helmet use (see Fig. 3). Specifically, the hypotheses are as follows.

H1. The use of motorcycle lane type is related to speeding and helmet use. This is based on earlier findings by Pau and Angius (2001), Lewis-Evans and Charlton (2006) and Goldenbeld and van Schagen (2007).

H2. Attitude, perceived behavioral control, fear, perception of danger, and moral obligation are related to speeding and helmet use. This is based on earlier findings by Slovic (1987), Ajzen (1991), Adams (1995), Groeger and Rothengatter (1998), Wilde (2001), Choocharukul et al. (2006), Fujii and Van (2009), Steg and Van Brussel (2009) and Özkan et al. (2012).

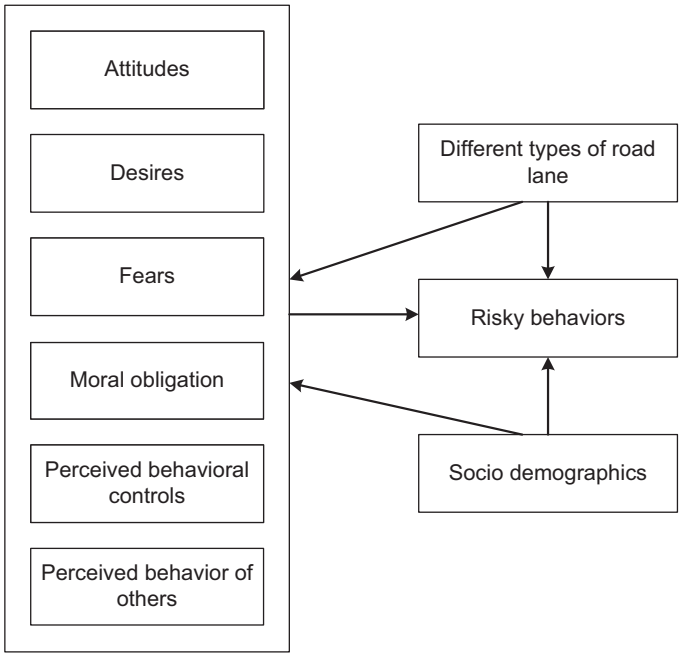

Fig. 3. The conceptual model of correlations between psychological factors and self-reported behavior of motorcyclists and self-reported usage of different types of motorcycle facilities.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

H3. Male and younger riders speed more frequently and use helmets less frequently than do the rest of the rider population. This is based on earlier findings by Brijs et al. (2014).

3.2. Survey procedure

Between June and August of 2009, a self-reported survey was conducted to collect four types of information from motorcycle users, including (1) the use of different types of motorcycle lane, (2) psychological factors related to motorcycle use, (3) socio-demographic characteristics, and (4) self-reported risky behavior, as exemplified by speeding and helmet use. The surveys were carried out in Shah Alam and Muar, two urban areas in Peninsular Malaysia that have the three lane types. The data collection of this study was carried out through a paper-and-pencil survey procedure, and this recruitment process was based on a convenience sampling. The questionnaires were distributed in several strategic and common sites to capture a diversity of respondent characteristics. These sites included gasoline stations, coffee shops, and public parks. Only drivers of motorcycles were permitted to take the survey, and the surveyors always approached the respondents only before or after leaving their motorcycles in the parking lot. This was done to ensure the quality of the results because the respondents were correctly identified and all information about the attitudes and behaviors were gathered from active drivers rather than from passengers. It should be noted that this survey approach did not record the response rate. In total, 600 respondents were approached. However, after excluding missing data and participants who did not completely finish the survey, 575 questionnaires were usable for further analysis.

The survey asked directly which lane type the respondents used the most when riding their motorcycles. The answers were 26% for exclusive lane, 28% for inclusive lane, and 46% for paved shoulder. It should be noted that, in most cases, the motorcyclists in the two urban areas had options to plan and choose which types of lane they preferred to use for their trip by motorcycle. The survey further assessed the socio-demographic profiles of the respondents, including age, gender, and motorcycle engine size (see the results in Table 1).

The questionnaire also collected information regarding the psychological attributes of the respondents in relation to speeding and helmet use (Table 2). The aim of the questionnaire was to gather information about desire to speed, attitude toward speeding, perceived behavior control, perceived danger, fear of being caught, moral obligation, and perception of others' behavior. The study required the respondent to describe each tendency according to a 4-point Likert Scale (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree), without allowing for "no opinion" or "neither agree nor disagree" options. It was considered necessary to ask the respondents directly whether they tended to agree or disagree with the statements and to prevent them from skipping questions or not reading them.

To identify riders' perceptions of other riders' behavior, the respondents were asked to estimate the percentages of other motorcyclists that might engage in risky behavior when riding their motorcycle. The questions were measured on a scale of 1–5 (1 = 0–20%, 2 = 30–40%, 3 = 50%, 4 = 60–70%, and 5 = 80–100%).

To measure speeding behavior, the survey asked the respondents how fast, on average, they had ridden their motorcycle over the previous month (1 = "less than 60 km/h," 2 = "60–80 km/h, 3 = "80–100 km/h," and 4 = ">100 km/h"). In Malaysia, there is no exact speed limit for motorcycles. If they are riding in mixed traffic, motorcyclists are subject to the speed limit of cars and heavy vehicles, which varies between 80 km/h and 100 km/h, depending on the geometric design of the roads. However, for motorcycle lanes, a speed limit of 60 km/h is imposed, according to the guidelines for cycle tracks (Public Work Department, 1986b).

The questionnaire also asked the respondents how often they had neglected to use a helmet over the previous month (1 = "never," 2 = "seldom," 3 = "often," and 4 = "always"). The results relating to risky behavior are shown in Figs. 4a and 4b. The mean and standard deviations of speeding and neglectful helmet use behaviors are shown in Table 3.

Table 1
Respondents' profiles based on usage of the three types of motorcycle facilities.

	Exclusive lane (N = 151)	Inclusive lane (N = 159)	Paved shoulder (N = 265)	Total (N = 575)
Age				
16[a]–20 years	31%	22%	44%	34%
21–25 years	47%	20%	24%	29%
>25 years	22%	58%	32%	37%
Gender				
Male	90%	70%	79%	79%
Female	10%	30%	21%	21%
CC				
<100cc	0%	10%	3%	4%
100–135cc	87%	85%	90%	88%
>135cc	13%	5%	8%	8%

[a] The minimum age to apply for a motorcycle' driving license is 16 years old in Malaysia.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

Table 2
Questions assessing psychological factors of risky behaviors.

Abbreviation	Psychological determinant	Question or statement
ATS	Attitude toward speeding	I enjoy speeding my motorcycle beyond the given limit (1–4); 1 = very disagree, 4 = very agree
DTS	Desire to speed	My desire speed is… (1–4); 1 ⩽ 60 km/h, 4 ⩾ 100 km/h
PBCS	Perceived behavior control toward speeding	It is hard to control myself not to speed (1–4); 1 = very disagree, 4 = very agree
PDS	Perceived danger of speeding	For me, riding over the speed limit is not dangerous (1–4); 1 = very disagree, 4 = very agree
FCS	Fear of being caught while speeding	I fear being caught by police while speeding (1–4); 1 = very disagree, 4 = very agree
MOS	Moral obligation toward speed limit	One should obey the rule and follow the given speed limit while riding a motorcycle (1–4); 1 = very disagree, 4 = very agree
POBS	Perceived others' behavior related to speeding	In my opinion, the percentage of other motorcyclists speeding over the given limit is… (1–5); 1 = 0–20%), 5 = 80–100%
ATH	Attitude toward neglecting helmet usage	I enjoy riding my motorcycle without wearing helmet (1–4); 1 = very disagree, 4 = very agree
PBCH	Perceived behavior control toward neglecting helmet usage	It is hard for me to control myself not to wear the helmet while riding my motorcycle (1–4); 1 = very disagree, 4 = very agree
PDH	Perceived danger of neglecting helmet usage	For me, riding without wearing helmet is dangerous (1–4); 1 = very disagree, 4 = very agree
FCH	Fear of being caught without wearing the helmet	I fear being caught by police while I ride without wearing the helmet (1–4); 1 = very disagree, 4 = very agree
MOH	Moral obligation toward helmet usage	In my opinion, one ought to wear a helmet when riding a motorcycle (1–4); 1 = very disagree, 4 = very agree
POBH	Perceived others' behavior related to neglecting helmet usage	In my opinion, the percentages of motorcyclists who are not using the helmet is… (1–5); 1 = 0–20%, 5 = 80–100%

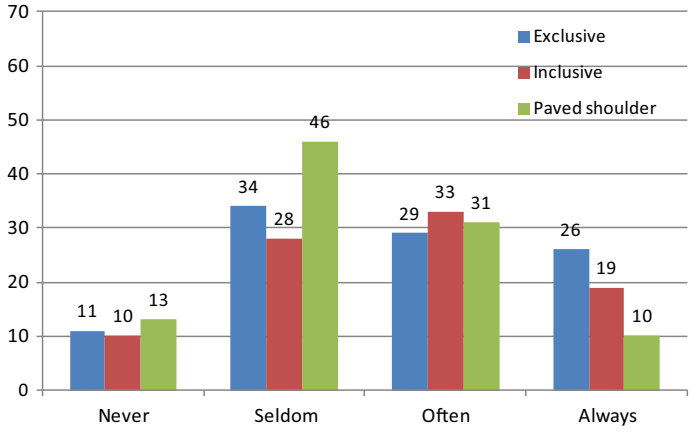

Fig. 4a. The percentage of self-reported speeding behavior across the different types of motorcycle lanes.

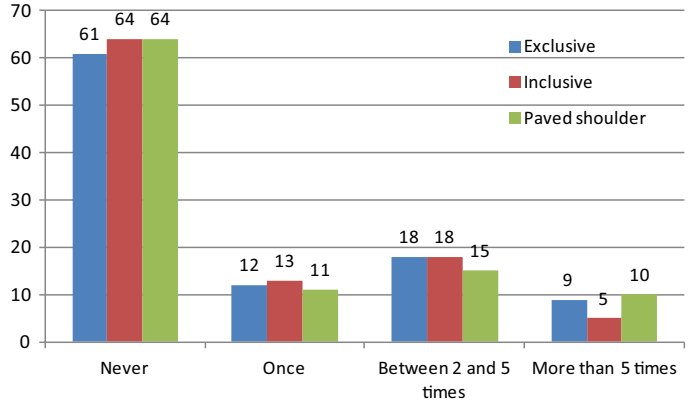

Fig. 4b. The percentage of not wearing helmet across the different types of motorcycle lanes.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

Table 3
Descriptive results of risky behaviors based on usage of the different types of motorcycle facilities.

Risky behavior	Type of lane	Min	Max	Mean	Std. dev.
Speeding	Exclusive	1	4	2.81	0.97
	Inclusive	1	4	2.71	0.98
	Paved shoulder	1	4	2.39	0.84
Neglect helmet	Exclusive	1	4	1.64	0.94
	Inclusive	1	4	1.70	1.05
	Paved shoulder	1	4	1.76	1.04

4. Results

4.1. Descriptive analysis

A Kruskal-Wallis analysis was carried out to test the differences between the psychological variables over the three types of motorcycle lane. It was found that apart from two attributes—fear of being caught (speeding) and moral obligation (helmet)—the differences were not statistically significant across lanes (see Table 4).

In addition, a preliminary analysis was made to test correlations among the given psychological variables. A Pearson analysis was used because the nature of our data is normally distributed. The results indicated statistically significant associations across the given psychological variables for some cases. For example, it was found that the respondents' desire to speed (DTS) was positively associated with attitude toward speeding (ATS). The attitude of perceived behavioral control toward speeding (PBCS) was statistically associated with ATS and DTS. The results can be seen in Table 5.

Table 4
Means and variances of the psychological factors across reported use of the different types of motorcycle facilities.

Risky behavior	Psychological variable	Exclusive lane Mean/Std. dev.	Inclusive lane Mean/Std. dev.	Paved shoulder Mean/Std. dev.	Kruskal Wallis test (p-value)
Speeding	Desire	2.98/0.85	2.46/0.95	1.87/0.78	<.001
	Attitude	2.15/0.96	2.63/1.01	3.12/0.74	<.001
	Perceived behavior control	2.02/0.86	2.55/0.96	2.65/0.74	<.001
	Perception of danger	1.99/0.96	1.81/0.94	1.56/0.74	<.001
	Fear of being caught	1.82/0.81	1.75/0.78	1.66/0.71	<.101
	Moral obligation	1.74/0.80	1.66/0.78	1.60/0.71	<.001
	Perceived others' behavior	2.74/0.76	2.79/0.78	2.65/0.87	<.001
Helmet usage	Attitude	3.11/0.82	3.19/0.74	2.91/0.98	<.001
	Perceived behavior control	2.99/0.75	2.99/0.75	3.17/0.72	<.001
	Perception of danger	1.46/0.67	1.67/0.75	1.81/0.81	<.001
	Fear of being caught	1.64/0.86	1.71/0.83	1.66/0.79	<.001
	Moral obligation	1.60/0.72	1.52/0.63	1.59/0.78	<.162
	Perceived others' behavior	2.09/0.96	2.23/0.99	2.31/0.87	<.001

Table 5
Pearson correlations across the given psychological variables.

	ATS	DTS	PBCS	PDS	FCS	MOS	POBS	ATH	PBCH	PDH	FCH	MOH
DTS	.59**											
PBCS	.56**	.57**										
PDS	.13	.23**	.11									
FCS	.10	.20*	.01	.43**								
MOS	−.06	.01	.05	−.11	.02							
POBS	.14	.20*	.22**	.20*	.21*	.13						
ATH	.10	.01	.01	.03	−.06	.16*	.23**					
PBCH	.04	.06	.09	−.39**	−.36**	.11	−.05	.21**				
PDH	.05	.03	.10	−.34**	−.32**	.04	.07	.14	.66**			
FCH	−.01	.05	.13	.47**	.24**	−.18*	.18*	.16*	−.15	−.10		
MOH	.16*	.24**	.25**	.09	.01	−.00	.21*	.43**	.09	.14	.36**	
POBH	−.06	−.11	.10	.21**	−.02	−.01	.12	.20*	−.13	−.02	.34**	.31**

* $p < 0.05$, two-tailed.
** $p < 0.01$, two-tailed.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

4.2. Model fit

A structural equations modeling (SEM) approach was employed to analyze the data. SEM is a familiar analytical tool in transport psychology research because of its advantages, such as the ability to examine simultaneously complex relationships in a single model. SEM is also capable of analyzing multiple regression analysis across latent or endogenous variables and between latent/endogenous and exogenous variables (Golob, 2003).

To obtain statistically significant insights about the determinants of speeding and neglecting to wear a helmet, two analyses were conducted separately for each behavior. Overall, the results of goodness of fit for both models were acceptable (see Table 6), as suggested by Kline (2011) and Hu and Bentler (1999). For the speeding model, the maximum likelihood estimation of the model yielded a χ^2 value of 23.71 with 12 degrees of freedom. The chi-square/df of 1.99 was well below the recommended value of 3.00, and the RMSEA value of 0.04 was lower than the upper limit of 0.10, indicating a good model fit. The NFI and CFI values exceeded the cutoff value of 0.90, indicating that the model fits the data well.

Regarding the helmet use model, the SEM yielded a χ^2 value of 9.30 with 5 degrees of freedom. The chi-square/df of 1.86 was below the recommended value of 3.00. The RMSEA value of 0.08 was lower than the upper limit 0.10, with NFI and CFI values exceeding the cutoff value of 0.90. Thus, the model fits the data well for the helmet use model.

4.3. The speeding model

It should be noted that the two motorcycle lanes (“exclusive” and “inclusive”) were treated as dummy variables in the model system, while the paved shoulder variable was used as the reference. Since the inclusive and the paved shoulder lanes are both non-exclusive lane types, this analysis attempted to focus on the influences of exclusive and inclusive lanes on risky behavior. The model path for statistically significant relationships of speeding behavior is shown in Fig. 5 and Table 7.

As expected, the results showed that the use of exclusive road has a positive and statistically significant effect on speeding behavior (0.13; $p < 0.001$). The use of such lanes further showed an indirect effect on speeding through various psychological variables, particularly “desire to speed” (0.17; $p < 0.01$), “attitude toward speeding” (0.14; $p < 0.001$), “perceived behavior control for speeding” (0.18; $p < 0.001$), and “others’ perceived behavior related to speeding” (0.21; $p < 0.001$).

Table 6
Goodness-of-fit of models ($N = 575$).

	Speeding	Helmet usage
χ^2	23.71	9.30
DF (degree of freedom)	12	5
P-value	0.001	0.001
RMSEA (root mean square error of approximation)	0.041	0.079
NFI (normed fit index)	0.99	0.98
CFI (comparative fix index)	0.99	0.98

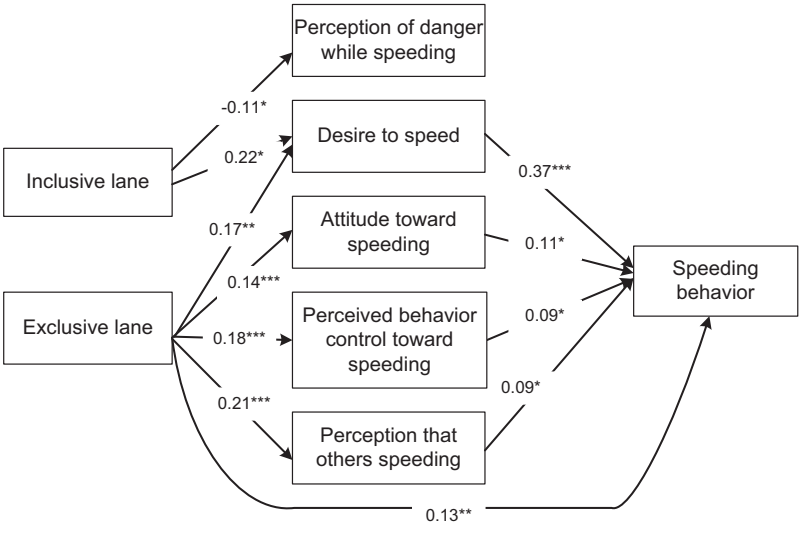

Fig. 5. The path diagram of the speeding behavior model. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

Table 7
The estimated results of the speeding model.

Path from	Path to	Estimated parameter	Standardized	*t*-values
Exclusive lane	Speeding**	0.26	0.13	3.00
Inclusive lane	Speeding	0.01	0.01	0.15
Age	Speeding	−0.01	−0.26	−0.26
Gender	Speeding	0.10	0.04	−3.09
Exclusive lane	Desire**	0.36	0.17	4.36
	Attitude***	0.30	0.14	3.49
	Perceived behavior***	0.38	0.18	4.15
	Perceived danger	−0.11	−0.06	−1.31
	Fear of being caught	−0.02	−0.01	−0.25
	Moral obligation	−0.01	−0.01	−0.12
	Perceived others speeding***	0.93	0.21	4.64
Inclusive lane	Desire to speed***	0.50	0.22	5.82
	Attitude	0.38	0.17	4.25
	Perceived behavior	0.05	0.02	0.51
	Perceived danger*	−0.22	−0.11	−2.46
	Fear of being caught	−0.07	−0.04	−0.91
	Moral obligation	−0.02	−0.01	−0.20
	Perceived others speeding	0.10	0.02	0.50
Desire	Speeding***	0.36	0.37	7.75
Attitude	Speeding*	0.11	0.11	2.12
Perceived behavior control	Speeding*	0.10	0.09	1.98
Perceived danger	Speeding	−0.07	−0.07	−1.49
Fear of being caught	Speeding	−0.02	−0.01	−0.28
Moral obligation	Speeding	−0.06	−0.05	−1.06
Perceived others speeding	Speeding*	0.04	0.09	2.33
Age	Desire***	−0.02	−0.27	−7.43
	Attitude ***	−0.02	−0.26	−6.75
	Perceived behavior control***	−0.02	−0.18	−4.41
	Perceived danger***	0.09	0.11	2.72
	Fear of being caught	0.01	0.04	0.86
	Moral obligation*	0.01	0.11	2.54
	Perceived others's behavior	0.01	0.08	1.88
Gender	Desire***	0.42	0.18	4.94
	Attitude***	0.54	0.22	5.97
	Perceived behavior control**	0.25	0.11	2.64
	Perceived danger***	−0.30	−0.14	−3.37
	Fear of being caught*	−0.20	−0.11	−2.52
	Moral obligation***	−0.21	−0.11	−2.63
	Perceived others's behavior	0.18	0.04	0.86

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$; $N = 575$.

On the other hand, the results suggested that the use of inclusive lanes by motorcyclists was not statistically significantly associated with speeding behavior (0.01; $p > 0.1$). This result suggests that the motorcycle riders use inclusive lanes carefully because there are no physical barriers installed along the inclusive lanes. However, the use of inclusive lanes appears to be statistically significantly associated with "desire to speed" (0.22; $p < 0.05$). The results also showed that the use of inclusive lanes relates indirectly to speeding behavior via "desire to speed" as the mediating variable. This finding indicates that although the riders did not actually engage in speeding, they had a desire and willingness to engage in speeding.

Regarding the effects of psychological factors on speeding behavior, the results indicated that the variables of "desire to speed," "attitude to speeding," "perceived behavior control," and "perception that others speed" are statistically significantly related to speeding behavior. In other words, the motorcyclists appear to have a high desire to speed and a positive attitude toward speeding and that they feel that they can easily accelerate in the exclusive lane. They also felt that other people were likely to engage in speeding behavior in the exclusive lane, which influences them to engage in the same behavior.

The results (Table 7) showed that age and gender do not have a statistically significant effect on speeding behavior. However, both factors have indirect effects on speeding behavior through psychological factors. The estimated model indicates that older motorcyclists tend to have lower magnitudes of "desire to speed" (−0.02; $p < 0.001$), "attitudes toward speeding" (−0.26; $p < 0.001$), and "perceived behavior toward speeding" (−0.18; $p < 0.001$) than do their younger rider counterparts. The model also shows that older individuals tend to express greater "perceived danger toward speeding" (0.11; $p < 0.001$) as well as a "moral obligation" to obey the speed limit (0.11; $p < 0.05$) than do their younger counterparts.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

We carried out a number of preliminary analyses using various socio-demographic variables, such as ethnicity, income, and education level. However, the model fit became weaker with those attributes and failed to meet the given requirements. Hence, only two variables were included in the analysis. The results showed that male individuals are more likely to have the "desire to speed" (0.18; $p < 0.001$), "attitude toward speed" (0.22; $p < 0.001$) and "perceived behavioral control toward speeding" (0.11; $p < 0.001$). The possible explanation is that male riders tend to be more aggressive toward speeding than their female counterparts are. The negative relations between the male factor and the variables of "danger toward speeding" (−0.14, $p < 0.001$), "fear of being caught while speeding" (−0.11; $p < 0.01$), and "moral obligation" (−0.11; $p < 0.001$) also seem to amplify this interpretation. These findings demonstrate that male riders feel less responsibility to maintain their speed than do female riders.

4.4. The helmet use model

The statistically significant correlations in predicting helmet use behavior are shown in Fig. 6 and Table 8. Consistent with the speeding model, the helmet use model used the "paved shoulder" variable as the reference, while the exclusive and inclusive lane variables were treated as dummy variables in the proposed model. In addition, the socio-demographic variables included age and gender. The results demonstrated that both variables, i.e., the use of exclusive and inclusive lanes, statistically significantly influenced helmet use attitudes. However, no indirect relation was found between the use of inclusive lane and helmet use behavior. The use of exclusive lanes negatively affected the neglectful helmet use attitude (−0.16; $p < 0.001$). In other words, the use of this lane promotes helmet use. However, there was a positive relation between attitude toward not wearing a helmet and helmet use behavior (0.20; $p < 0.001$). These two results indicate that attitude toward not wearing a helmet was the mediating variable that linked the use of exclusive lanes and helmet use behavior. Overall, the total effect indicated that riders tend to use helmets when riding on the exclusive lane.

Motorcyclists using inclusive lanes are likely to have a more negative attitude toward helmet use than those who use other types of lane, but they demonstrate a greater perception of danger when riding without a helmet (0.11; $p < 0.05$) than did their counterparts who use other lanes. It could be argued that the inclusive lane is much more dangerous to ride without wearing a helmet compared than other, segregated lanes.

A few interesting results emerged regarding the effects of psychological factors on helmet use behavior. First, a more negative attitude toward helmet use is likely to be associated with less frequent helmet use (0.20; $p < 0.01$). Second, an increase in perceived behavior attitude and others' perceived behavior related to a decreased likelihood to wear a helmet (0.12; $p < 0.05$ and 0.30; $p < 0.001$, respectively).

Regarding the roles of gender and age in the model, in line with our expectation, males were likely to neglect wearing the helmet (0.11, $p < 0.01$). This segment of the population is also likely to have a more negative attitude toward helmet use (0.10; $p < 0.05$), "perceived behavior control" (0.17; $p < 0.001$), and "others' perceived behavior of not wearing a helmet" (0.11; $p < 0.01$) than the female motorcycle population has. In addition, the male motorcyclists are likely to have lower levels of perception related to "danger" (−0.13; $p < 0.001$), "fear" (−0.12; $p < 0.01$), and "moral obligation" when not wearing the helmet (0.10; $p < 0.05$) than female motorcyclists have. Older motorcyclists are likely to a more negative "attitude" toward not using a helmet (−0.11; $p < 0.01$) and lower "perceived behavior control" (−0.12; $p < 0.01$) than younger riders have. Older motorcyclists are also more likely to perceive "danger" (0.17; $p < 0.001$) and a "fear" of being caught by authority (0.13; $p < 0.01$) than younger riders are. Moreover, older riders are more likely to feel a greater degree of moral obligation toward helmet use than younger riders are (0.10; $p < 0.05$).

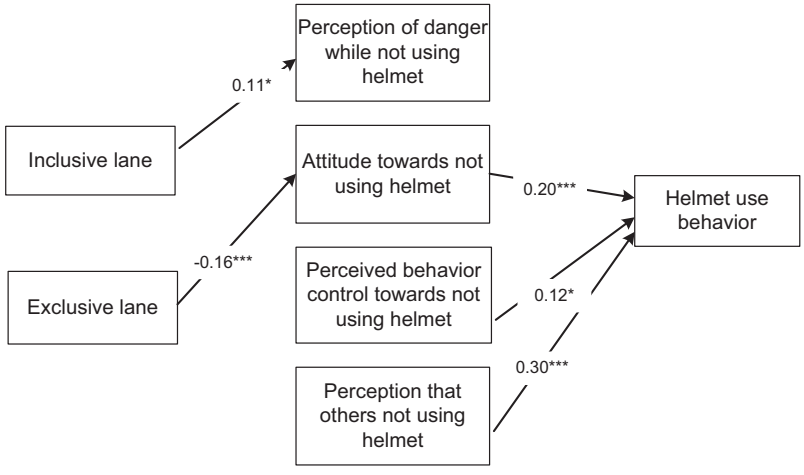

Fig. 6. Path diagram of the helmet usage behavior model. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

Table 8
The estimated results of the helmet usage model.

Path from	Path to	Estimated parameter	Standardized	*t*-values
Exclusive lane	Neglect helmet	−0.01	−0.01	−0.01
Inclusive lane	Neglect helmet	−0.09	−0.04	−0.94
Age	Neglect helmet	−0.01	−0.03	−0.87
Gender	Neglect helmet**	0.27	0.11	2.80
Exclusive lane	Attitude***	−0.29	−0.16	−3.64
	Perceived behavior control	−0.11	−0.06	−1.42
	Perceived danger	0.13	0.08	1.72
	Fear of being caught	0.09	0.05	1.11
	Moral obligation	0.05	0.03	0.75
	Perceived others neglect helmet	−0.13	−0.04	−0.97
Inclusive lane	Attitude	−0.08	−0.05	−1.08
	Perceived behavior	−0.03	−0.02	−0.43
	Perceived danger*	0.19	0.11	2.53
	Fear of being caught	0.03	0.02	0.34
	Moral obligation	0.08	0.05	1.18
	Perceived others neglect helmet	−0.04	−0.01	−0.29
Attitude	Neglect helmet***	0.26	0.20	3.87
Perceived behavior control	Neglect helmet*	0.16	0.12	2.25
Perceived danger	Neglect helmet	−0.08	−0.06	−1.41
Fear of being caught	Neglect helmet	−0.01	−0.01	−0.23
Moral obligation	Neglect helmet	−0.01	−0.06	−1.46
Perceived others neglect helmet	Neglect helmet***	0.24	0.30	7.94
Age	Attitude **	−0.01	−0.11	−2.78
	Perceived behavior control**	−0.01	−0.12	−3.09
	Perceived danger**	0.01	0.14	3.50
	Fear of being caught**	0.01	0.13	3.19
	Moral obligation**	0.01	0.16	3.76
	Perceived others neglect helmet	−0.01	−0.07	−1.67
Gender	Attitude*	0.18	0.10	2.30
	Perceived behavior control***	0.30	0.17	4.00
	Perceived danger***	−0.23	−0.13	−3.13
	Fear of being caught**	−0.25	−0.12	−2.99
	Moral obligation*	−0.15	−0.10	−2.19
	Perceived others neglect helmet**	0.34	0.11	2.58

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$; $N = 575$.

5. Discussion

Malaysia is one of the few countries to provide separate lanes for motorcyclists, which it does to some extent. The ultimate goals of the policy are to prevent traffic collisions with other modes of transport, to minimize the level of fatalities on the roads, and to maintain traffic flow and speed. This study examined the correlations across the different types of motorcycle facility (exclusive, inclusive, and paved shoulder), motorcyclist psychology, and risky behavior (speeding and neglectful helmet use).

Our results demonstrated that there is a statistically significant correlation between speeding behavior and use of exclusive motorcycle lanes. This evidence is congruent with past studies (see Goldenbeld & van Schagen, 2007; Hatfield, Murphy, & Job, 2008; Lewis-Evans & Charlton, 2006; Manan & Várhelyi, 2012; Pau & Angius, 2001), which showed that speeding behavior is likely to occur in an environment in which the road conditions are straight, wide, segregated, and considerably safe. Nevertheless, no statistically significant relation has been found between use of inclusive lanes and speeding behavior. Furthermore, the use of segregated lanes was not associated with helmet use behavior. There are two possible explanations for these findings. First, this lack of association may be due to the strong enforcement of helmet use and campaigns that have been carried out in Malaysia over the course of the past few years (Paiman et al., 2013). Second, helmet use may be related to speeding behavior. Motorcyclists who ride motorcycles in segregated lanes intend to ride fast. Indirectly, they will take the precaution of wearing a helmet to decrease the chances of fatality in the case of a speeding accident. A separate study can be carried out in the future to clarify these interpretations.

As expected, the use of segregated lanes is likely to relate to the motorcyclists' attitude, desire, and perceived behavior control while riding the motorcycle. In the speeding model, these results seem to suggest that riders may enjoy speeding when they ride in a lane that totally segregates them from other road users, rather than when they ride in a lane shared with other vehicle users.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

We found little information regarding correlations of inclusive lanes and psychological factors. The strongest evidence suggests that those who prefer to use the inclusive lane are likely to perceive the danger associated with speeding. Naturally, riders may take extra care when there are no physical barriers because they sense a higher possibility of crashes with other motorized modes along the lane, thereby leading to a greater perception of danger when speeding on an inclusive lane.

A few important results pertaining to the helmet use model need to be discussed. First, the use of exclusive lanes is likely to increase helmet use. One possible interpretation is that not wearing a helmet is not as enjoyable as the speeding behavior. We also found that use of the inclusive lanes, rather than other types of lane, statistically significantly increases the fear of not wearing a helmet. The absence of physical barriers may contribute to these feelings.

The results revealed that "attitude" toward and "desire" to speed are likely to affect speeding behavior. Speeding is also strongly triggered by two perceptions: (1) the feeling that it is difficult to have personal control over speeding and (2) the feeling that other riders speed. These four factors contribute to speeding behavior.

Consistent with the speeding model, the helmet use model also showed that "attitude" toward helmet use and the "perception" that others do not wear helmets seem to negatively affect helmet use. These results are in line with the Theory of Planned Behavior (Ajzen, 1991) as well as the findings of other studies (for instance, see Ali, Saeed, Ali, & Haidar, 2011; Li, Li, Cai, Zhang, & Lo, 2008; Mohamad Baharin, Kamarudin, Ahmad, & Nur Sabahiah, 2013), which demonstrated that a greater degree of attitude and desire may increase the likelihood of engaging in risky behavior.

The psychological aspects of male motorcyclists seem to be the critical issue because they tend to have a more aggressive attitude and the desire to engage in risky behavior. They also have a greater problem refraining from not speeding than do female riders. At the same time, male motorcyclists feel less of a moral obligation not to speed than do female motorcyclists. Similarly, the results showed that younger riders tend to have a greater attitude and desire to engage in risky behavior than do older riders. Younger riders are also less likely to perceive danger, to fear being caught by the authorities, or to feel a moral obligation not to speed or to wear a helmet than are older riders. All these findings are consistent with previous studies conducted in other countries (Chang & Yeh, 2007; Chesham, Rutter, & Quine, 1993; Lin, Chang, Pai, & Keyl, 2003; Rhodes & Pivik, 2011). These results clearly demonstrate that traffic authority and traffic safety scholars need to pay significant attention to research and actions, such as campaigns, for these segments of population to change their risky behavior. These efforts can be aimed at educating, campaigning, and producing regulations that may affect a shift in their attitudes, desires, perceptions, and sense of moral obligation in a more positive direction, leading to a significant reduction in risky behavior.

6. Study limitations and future studies

This study has limitations that require consideration for future research avenues. First, this study is not able to capture actual relations across road infrastructures, riders' psychological factors, and risky behavior over a given time period, because this analysis was based on cross-sectional data. Thus, any future study needs to employ longitudinal data. This dataset may gain better insights of research into the variability or stability of the relationships across the given factors. Second, this study cannot detect the hidden relationships between speeding and not neglectful helmet use, because we used two separate models to investigate the determinants of risky behavior. Thus, there is the possibility of developing an analytical model based on the two behavioral factors in the future studies. Third, different motorcycle types could give different sensations of speeding; thus, any future study should expand the analysis to include the roles of motorcycle types, such as motorcycle brand and engine type. The effects of weather and travel period could also contribute to improving our current model system. These aspects of analysis are missing in the present study. Finally, the survey technique of convenience sampling used in our study may not represent the perfect picture of our case study's population due to limitations in its data collection method. Thus, future studies may need to consider a simple perfect random sampling approach. It is an unbiased survey technique that attempts to ensure that each individual is randomly chosen. Each individual also has the same probability of being selected as a respondent during all process stages of the survey.

7. Recommendations

This empirical study demonstrated, surprisingly, that the current segregated lanes could even foster risky behavior that may lead to significant fatalities. For example, the study demonstrated that use of exclusive lanes could influence the speeding behavior and that use of exclusive lanes also negatively affects helmet use. Since the current maximum speed limit is already high for segregated lanes in Malaysia (60 km/h), it is unlikely that higher speed limits will be introduced on existing roads. In fact, the Malaysian road authority has allocated at least RM10 million (USD 2.3 million) since 2013 to enhancing safety and comfort in exclusive motorcycle lanes ("RM10m needed," 2013). This budget allocation includes countermeasures for speed reduction. We therefore propose several strategies that should be part of this road safety program. First, the use of electronic enforcement cameras, also known as the Automated Enforcement System (AES), has been widely implemented within Malaysia. However, this type of device has been used for car motorways only and should be used for motorcycle lanes. Rahim, Jamil, Musa, Isah, and Voon (2014) have shown that AES cameras have a positive effect on driver compliance with the speed limit on car roadways, leading to a change in negative attitudes toward driving. AES is capable of identifying any traffic offenses, including speeding along areas where the technology is installed. Information is sent in real time to the operator for

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

further processing, which indirectly encourages people to engage in proper behavior when driving their vehicles. The same advantage is to be expected if this technology is introduced to motorcycle lanes.

Second, the installation of specific forms of lane marking could help to reduce speeding behaviors in motorcycle lanes. For example, past studies have revealed that transverse or lateral pavement markings on the road were found to be effective in reducing speeds in single lanes or straight roads (Katz, 2007; Yotsutsuji, Kitamura, & Kita, 2015). Similarly, Katz (2007) found that peripheral transverse lines applied on multi-lane roadways in the United States' urban environments were able to reduce speeding by between 24% and 59%, compared to the baseline speed. Thus, a similar approach could be adopted for the segregated lanes in Malaysia. The installment points could be focused on locations that have had a high number of traffic collisions.

Finally, we recommend continuing road safety campaigns related to risky behavior. On the basis of our results, male and young riders should be the main targets of such campaigns. According to Elvik, Høye, Vaa, and Sørensen (2009), road safety campaigns have positive effects in changing behavior to some extent (e.g., to avoid speeding and to use a helmet). The use of personal communications (e.g., two-way discussions between safety experts and road users) and roadside media (e.g., billboards or fixed message signs on the road) in campaigns were also found to contribute to a reduction in road accidents (Phillips, Ulleberg, & Vaa, 2011). Such road-safety campaigns should be short, informative, clear, and unambiguous. The approaches should also use different forms of media and be published repeatedly (KfV-EU, 2007).

8. Conclusions

The results of this study are substantial for the global context, especially for countries that attempt to apply strategies on road infrastructure that are similar to those in Malaysia. The study suggests that the installment of segregated lanes alone, especially exclusive lanes, can increase risky behavior among motorcyclists. This type of infrastructure development must accommodate additional road strategies that are able to prevent riders from engaging in risky behavior.

The results further indicate that psychological factors trigger risky behavior. Our results are not very different from those of past studies that highlighted the effects of attitude, desire, perceived behavioral control, and the perception of others' behavior on engaging in risky behavior (Brijs et al., 2014; De Pelsmacker & Janssens, 2007; Fleiter, Lennon, & Watson, 2010; Haglund & Åberg, 2000; Jonah, Thiessen, & Au-Yeung, 2001; Sarma, Carey, Kervick, & Bimpeh, 2013). However, it may be suggested that road infrastructures like segregated lanes can strengthen or weaken the relationship between psychological factors and human behavior. Our study demonstrated that it is fruitful to incorporate the road infrastructure factor in a road safety behavior analysis.

Acknowledgments

The authors would like to thank to the three reviewers and the editor (Åse Svensson) who carefully reviewed this manuscript. The late Professor Ryuichi Kitamura (Kyoto University, Japan) made a central contribution to strengthen the genesis of this research idea. This work was partly supported by Ministry of Higher Education, Malaysia, through IPTA–Academic Training Scheme Scholarship.

References

Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis and Prevention, 38*(2), 215–224. http://dx.doi.org/10.1016/j.aap.2005.07.004.

Adams, J. (1995). *Risk*. London, U.K.: UCL Press.

Ajzen, I. (1991). The theory of planned behavior. *Organisational Behavior and Human Decision Processes, 50*, 179–211. http://dx.doi.org/10.1016/j.drugalcdep.2011.10.011.

Ali, M., Saeed, M. M. S., Ali, M. M., & Haidar, N. (2011). Determinants of helmet use behavior among employed motorcycle riders in Yazd, Iran based on theory of planned behavior. *Injury, 42*(9), 864–869. http://dx.doi.org/10.1016/j.injury.2010.08.030.

Asch, S. E. (1955). Studies of independence and conformity: I. A minority of one against a unanimous majority. *Psychological Monographs: General and Applied.*. http://dx.doi.org/10.1037/h0093718.

Bellaby, P., & Lawrenson, D. (2001). Approaches to the risks of riding motorcycles: Reflections on the problem of reconciling statistical risk assessment and motorcyclists' own reasons for riding. *Sociological Review, 49*(3), 368–388. http://dx.doi.org/10.1111/1467-954X.ep4890182.

Brijs, K., Brijs, T., Sann, S., Trinh, T. A., Wets, G., & Ruiter, R. A. C. (2014). Psychological determinants of motorcycle helmet use among young adults in Cambodia. *Transportation Research Part F: Traffic Psychology and Behavior, 26*, 273–290. http://dx.doi.org/10.1016/j.trf.2014.08.002.

Chang, H. L., & Yeh, T. H. (2007). Motorcyclist accident involvement by age, gender, and risky behaviors in Taipei, Taiwan. *Transportation Research Part F: Traffic Psychology and Behavior, 10*, 109–122. http://dx.doi.org/10.1016/j.trf.2006.08.001.

Chesham, D. J., Rutter, D. R., & Quine, L. (1993). Motorcycling safety research: A review of the social and behavioral literature. *Social Science & Medicine, 37*(3), 419–429. http://dx.doi.org/10.1016/0277-9536(93)90272-6.

Choocharukul, K., Van, H. T., & Fujii, S. (2006). Psychological determinants of moral obligation of car use reduction and acceptance of car use restriction in Japan and Thailand. *IATSS Research, 30*(2), 70–76. http://dx.doi.org/10.1016/S0386-1112(14)60171-0.

Chorlton, K., Conner, M., & Jamson, S. (2012). Identifying the psychological determinants of risky riding: An application of an extended Theory of Planned Behaviour. *Accident Analysis & Prevention, 49*, 142–153. http://dx.doi.org/10.1016/j.aap.2011.07.003.

Cialdini, R., & Trost, M. (1998). Social influence: Social norms, conformity and compliance. *The Handbook of Social Psychology, 2*. http://dx.doi.org/10.2307/2654253.

De Pelsmacker, P., & Janssens, W. (2007). The effect of norms, attitudes and habits on speeding behavior: Scale development and model building and estimation. *Accident; Analysis and Prevention, 39*(1), 6–15. http://dx.doi.org/10.1016/j.aap.2006.05.011.

Elliott, M. A., Baughan, C. J., & Sexton, B. F. (2007). Errors and violations in relation to motorcyclists' crash risk. *Accident Analysis and Prevention, 39*(3), 491–499. http://dx.doi.org/10.1016/j.aap.2006.08.012.

Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). *Handbook of road safety measures* (2nd ed.). Emerald Group Publishing.
Fell, J. C. (1976). A motor vehicle accident causal system: The human element. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 18*(1), 85–94. http://dx.doi.org/10.1177/001872087601800109.
Fleiter, J. J., Lennon, A., & Watson, B. (2010). How do other people influence your driving speed? Exploring the "who" and the "how" of social influences on speeding from a qualitative perspective. *Transportation Research Part F: Traffic Psychology and Behavior, 13*(1), 49–62. http://dx.doi.org/10.1016/j.trf.2009.10.002.
Fujii, S., & Van, H. T. (2009). Psychological determinants of the intention to use the bus in Ho Chi Minh City. *Journal of Public Transportation, 12*(1), 6.
Goldenbeld, C., & van Schagen, I. (2007). The credibility of speed limits on 80 km/h rural roads: The effects of road and person(ality) characteristics. *Accident; Analysis and Prevention, 39*(6), 1121–1130. http://dx.doi.org/10.1016/j.aap.2007.02.012.
Golob, T. F. (2003). Structural equation modeling for travel behavior research. *Transportation Research Part B: Methodological, 37*, 1–25. http://dx.doi.org/10.1016/S0191-2615(01)00046-7.
Groeger, J. A., & Rothengatter, J. A. (1998). Traffic psychology and behavior. *Transportation Research Part F: Traffic Psychology and Behavior, 1*(1), 1–9. http://dx.doi.org/10.1016/S1369-8478(98)00007-2.
Haglund, M., & Åberg, L. (2000). Speed choice in relation to speed limit and influences from other drivers. *Transportation Research Part F: Traffic Psychology and Behavior, 3*, 39–51. http://dx.doi.org/10.1016/S1369-8478(00)00014-0.
Hammond, T. B., & Horswill, M. S. (2001). The influence of desire for control on drivers' risk-taking behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour, 4*(4), 271–277. http://dx.doi.org/10.1016/S1369-8478(01)00028-6.
Hatfield, J., Murphy, S., & Job, R. F. S. (2008). Beliefs and behaviors relevant to the road safety effects of profile lane-marking. *Accident; Analysis and Prevention, 40*(6), 1872–1879. http://dx.doi.org/10.1016/j.aap.2008.07.004.
Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. http://dx.doi.org/10.1080/10705519909540118.
Hung, D. V., Stevenson, M. R., & Ivers, R. Q. (2006). Prevalence of helmet use among motorcycle riders in Vietnam. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention, 12*, 409–413. http://dx.doi.org/10.1136/ip.2006.012724.
Hung, D. V., Stevenson, M. R., & Ivers, R. Q. (2008). Barriers to, and factors associated, with observed motorcycle helmet use in Vietnam. *Accident; Analysis and Prevention, 40*(4), 1627–1633. http://dx.doi.org/10.1016/j.aap.2008.05.002.
Ibitoye, A. B., Radin, R. S., & Hamouda, A. M. S. (2007). Roadside Barrier and Passive Safety of Motorcyclists along exclusive motorcycle lanes. *Journal of Engineering Science and Technology, 2*(1), 1–20.
Iversen, H. H., & Rundmo, T. (2012). Changes in Norwegian drivers' attitudes towards traffic safety and driver behaviour from 2000 to 2008. *Transportation Research Part F: Traffic Psychology and Behaviour, 15*(2), 95–100. http://dx.doi.org/10.1016/j.trf.2011.12.006.
Jonah, B. A., Thiessen, R., & Au-Yeung, E. (2001). Sensation seeking, risky driving and behavioral adaptation. *Accident; Analysis and Prevention, 33*(5), 679–684. http://dx.doi.org/10.1016/S0001-4575(00)00085-3.
Katz, B. J. (2007). *Peripheral transverse pavement markings for speed control* Doctoral dissertation. NY: Virginia Polytechnic Institute and State University. Source: Retrieved from: (retrieved 06.03.16) http://scholar.lib.vt.edu/theses/available/etd-05172007-135959/.
KfV-EU (2007). Best practice in road safety. Handbook for measures at the country level. <http://ec.europa.eu/transport/roadsafety_library/publications/supreme_c_handbook_for_measures_at_the_country_level.pdf> (retrieved 06.03.16).
Killias, M., Villettaz, P., & Nunweiler-Hardegger, S. (2016). Higher fines—fewer traffic offences? A multi-site observational study. *European Journal on Criminal Policy and Research*, 1–16. http://dx.doi.org/10.1007/s10610-016-9301-6.
Kline, R. B. (2011). Principles and practice of structural equation modeling. *Structural Equation Modeling, 156*. http://dx.doi.org/10.1038/156278a0.
Lardelli-Claret, P., de Dios Luna-del-Castillo, J., Jiménez-Moleón, J. J., García-Martín, M., Bueno-Cavanillas, A., & Gálvez-Vargas, R. (2003). Risk compensation theory and voluntary helmet use by cyclists in Spain. *Injury Prevention, 9*, 128–132. http://dx.doi.org/10.1136/ip.9.2.128.
Law, T. H., & Radin Sohadi, R. U. (2005). Determination of comfortable safe width in an exclusive motorcycle lane. *Journal of the Eastern Asia Society for Transportation Studies, 6*, 3372–3385.
Lewis-Evans, B., & Charlton, S. G. (2006). Explicit and implicit processes in behavioral adaptation to road width. *Accident Analysis and Prevention, 38*(3), 610–617. http://dx.doi.org/10.1016/j.aap.2005.12.005.
Li, L. P., Li, G. L., Cai, Q. E., Zhang, A. L., & Lo, S. K. (2008). Improper motorcycle helmet use in provincial areas of a developing country. *Accident Analysis and Prevention, 40*(6), 1937–1942. http://dx.doi.org/10.1016/j.aap.2008.06.019.
Limanond, T., Jomnonkwao, S., Watthanaklang, D., Ratanavaraha, V., & Siridhara, S. (2011). How vehicle ownership affect time utilization on study, leisure, social activities, and academic performance of university students? A case study of engineering freshmen in a rural university in Thailand. *Transport Policy, 18*(5), 719–726.
Lin, M.-R., Chang, S.-H., Pai, L., & Keyl, P. M. (2003). A longitudinal study of risk factors for motorcycle crashes among junior college students in Taiwan. *Accident; Analysis and Prevention, 35*(2), 243–252. http://dx.doi.org/10.1016/S0001-4575(02)00002-7.
Malaysian Institute of Road Safety (2012). Pelan Keselamatan Jalan Raya Malaysia 2014-2020. Putrajaya, Malaysia.
Manan, M. M. A., & Várhelyi, A. (2012). Motorcycle fatalities in Malaysia. *IATSS Research, 36*(1), 30–39. http://dx.doi.org/10.1016/j.iatssr.2012.02.005.
Mohamad Baharin, A., Kamarudin, A., Ahmad, R., & Nur Sabahiah, S. (2013). Helmet usage among adolescents in rural road from the extended theory of planned behavior. *Journal of Applied Sciences, 13*(1), 161–166.
Ouellet, J. V. (2011). Helmet use and risk compensation in motorcycle accidents. *Traffic Injury Prevention, 12*(1), 71–81. http://dx.doi.org/10.1080/15389588.2010.529974.
Özkan, T., Lajunen, T., Dogruyol, B., Yildirim, Z., & Çoymak, A. (2012). Motorcycle accidents, rider behavior, and psychological models. *Accident Analysis and Prevention, 49*, 124–132. http://dx.doi.org/10.1016/j.aap.2011.03.009.
Paiman, N. F., Isa, M. H. M., Jawi, Z. M., Ariffin, A. H., Solah, M. S., Rahman, M. K., . . ., Kassim, K.A.A., Safety helmet use rate and child pillion riders' characteristics in Selangor (Research Report), MR: 121. Malaysian Institute of Road Safety Research.
Pau, M., & Angius, S. (2001). Do speed bumps really decrease traffic speed? An Italian experience. *Accident Analysis and Prevention, 33*(5), 585–597. http://dx.doi.org/10.1016/S0001-4575(00)00070-1.
Phillips, R., Ulleberg, P., & Vaa, T. (2011). Meta-analysis of the effect of road safety campaigns on accidents. *Accident Analysis & Prevention, 43*(2011), 1204–1218.
Public Work Department (1986a). *A guide on geometric design of roads: Arahan Teknik (Jalan) 8/86*. Kuala Lumpur, Malaysia.
Public Work Department (1986b). *A guide on the design of cycle track: Arahan Teknik (Jalan) 10/86*. Kuala Lumpur, Malaysia.
Radin Umar, R. S., Mackay, G. M., & Hills, B. L. (1995). Preliminary analysis of exclusive motorcycle lanes along the federal highway F02, Shah Alam, Malaysia. *Journal of IATSS Research, 19*(2), 93–98.
Rahim, S. A., Jamil, H. M., Musa, M., Isah, N., & Voon, W. S. (2014). *Impact studies of automated enforcement system implementation*. Kajang, Selangor.
Rhodes, N., & Pivik, K. (2011). Age and gender differences in risky driving: The roles of positive affect and risk perception. *Accident; Analysis and Prevention, 43*(3), 923–931. http://dx.doi.org/10.1016/j.aap.2010.11.015.
RM10m needed to upgrade Federal Highway motorcycle lanes, says ministry (2013, June 13) *The Malay Mail Online*, Retrieved from <http://www.themalaymailonline.com/malaysia/article/rm10m-needed-to-upgrade-federal-highway-motorcycle-lanes-says-ministry>.
Sanlam (2012). Sanlam seals Malaysian deal (retrieved: 28.02.16) http://www.fin24.com/Companies/Financial-Services/Sanlam-seals-Malaysian-deal-20121210.
Sarani, R., Roslan, A., & Saniran, N. (2011). Motorcycle ADSA Fact sheet Vol. 1 [Fact Sheet]. Retrieved from <https://www.miros.gov.my/1/page.php?id=17&k=factsheet> (retrieved 28.02.16).

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032

Sarma, K. M., Carey, R. N., Kervick, A. A., & Bimpeh, Y. (2013). Psychological factors associated with indices of risky, reckless and cautious driving in a national sample of drivers in the Republic of Ireland. *Accident Analysis and Prevention, 50*, 1226–1235. http://dx.doi.org/10.1016/j.aap.2012.09.020.

Schwarz, S. H. (1977). Normative influences on altruism. In L. Berkowitz (Ed.). *Advances in experimental psychology* (Vol. 10, pp. 222–280). New York: Academic Press.

Slovic, P. (1987). Perception of risk. *Science, 236*(4799), 280–285. http://dx.doi.org/10.1126/science.3563507.

Stanojević, P., Jovanović, D., & Lajunen, T. (2013). Influence of traffic enforcement on the attitudes and behavior of drivers. *Accident Analysis & Prevention, 52*, 29–38. http://dx.doi.org/10.1016/j.aap.2012.12.019.

Steg, L., & Van Brussel, A. (2009). Accidents, aberrant behaviors, and speeding of young moped riders. *Transportation Research Part F: Traffic Psychology and Behavior, 12*(6), 503–511. http://dx.doi.org/10.1016/j.trf.2009.09.001.

Supramaniam, V., van Belle, G., & Sung, J. F. C. (1984). Fatal motorcycle accidents and helmet laws in Peninsular Malaysia. *Accident Analysis and Prevention, 16*, 157–162. http://dx.doi.org/10.1016/0001-4575(84)90009-5.

Susilo, Y. O., Joewono, T. B., & Vandebona, U. (2014). Reasons underlying behavior of motorcyclists disregarding traffic regulations in urban areas of Indonesia. *Accident; Analysis and Prevention, 75C*, 272–284. http://dx.doi.org/10.1016/j.aap.2014.12.016.

The Star Online (2014). Miros: Road safety in Malaysia matter of concern http://m.thestar.com.my/story.aspx?hl=Miros+Road+safety+in+Malaysia+matter+of+concern&sec=news&id={0E6C87A7-86A9-4A29-AA3C-962C95848E10} (retrieved 28.02.16).

Theofilatos, A., & Yannis, G. (2014). Relationship between motorcyclists' attitudes, behavior, and other attributes with declared accident involvement in Europe. *Traffic Injury Prevention, 15*(2), 156–164. http://dx.doi.org/10.1080/15389588.2013.801554.

Tung, S. H., Wong, S. V., Law, T. H., & Radin Umar, R. S. (2008). Crashes with roadside objects along motorcycle lanes in Malaysia. *International Journal of Crashworthiness*. http://dx.doi.org/10.1080/13588260701788534.

Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science, 41*(5), 427–443. http://dx.doi.org/10.1016/S0925-7535(01)00077-7.

Weissenfeld, A., Baldock, M., & Hutchinson, T. P. (2014). Motorcyclist perceptions of risk when riding. 2012 Australasian College of Road Safety Conference – "A Safe System: The Road Safety Discussion" Retreived from <https://digital.library.adelaide.edu.au/dspace/bitstream/2440/82805/1/hdl_82805.pdf> (retrieved 15.06.16).

Wilde, G. J. S. (1998). Risk homeostasis theory: An overview. *Injury Prevention, 4*(2), 89–91. http://dx.doi.org/10.1136/ip.4.2.89.

Wilde, G. J. S. (2001). *Target risk 2: A new psychology of safety and health: what works, what doesn't and why?* Toronto: PDE Publications.

World Health Organization (2013). *Global status report on road safety 2013: supporting a decade of action*. Geneva, Switzerland.

Yotsutsuji, H., Kitamura, K., & Kita, H. (2015). An experimental study on the effect of sequential transverse and lateral markings on perceived speed on a single-lane straight road. *Journal of Ergonomics*. http://dx.doi.org/10.4172/2165-7556.S3-010.

Zhou, R., Horrey, W. J., & Yu, R. (2009). The effect of conformity tendency on pedestrians' road-crossing intentions in China: An application of the theory of planned behavior. *Accident; Analysis and Prevention, 41*(3), 491–497. http://dx.doi.org/10.1016/j.aap.2009.01.007.

Please cite this article in press as: Sukor, N. S. A., et al. Analysis of correlations between psychological factors and self-reported behavior of motorcyclists in Malaysia, depending on self-reported usage of different types of motorcycle facility. *Transportation Research Part F* (2016), http://dx.doi.org/10.1016/j.trf.2016.09.032