Effects of Impulsive Sensation Seeking, Aggression and Risk-Taking Behaviors on the Vulnerability of Motorcyclists

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Abstract: While extensive research efforts have been devoted to improve the motorcycle safety, the relationship between rider behaviors and the crash risk is still not well understood. The objective of this study is to evaluate how behavioral factors influence the crash risk and to identify the most vulnerable group of motorcyclists. To explore the rider behaviors, a questionnaire containing 61 items of impulsive sensation seeking, aggression, and risk-taking behaviors was developed. By clustering the crash risk using the medoid portioning algorithm, a log-linear model relating rider behaviors to the crash risk has been developed. Results show that motorcyclists who have been involved in a crash score higher in all three behavioral traits. Aggressive and high risk-taking motorcyclists are more likely to fall under the high vulnerable group while impulsive sensation seeking behavior is not found to be significant. Defining personality types from aggression and risk-taking behaviors, “Extrovert” and “Follower” personality type of motorcyclists are more prone to crashes. The findings of this study will be useful for road safety campaign planners to identify and place more focus on target group. The results may also be useful to those who employ motorcyclists for their delivery businesses.

Keywords: Motorcyclist, Impulsive sensation seeking, Aggressiveness, Risk-taking

1. INTRODUCTION

Motorcyclists are one of the most vulnerable road user groups. Road Traffic Statistics of Singapore from 2001 to 2006 show that, motorcycles constitute about 19% of the vehicle population but account for about 36% of total crashes. Moreover, motorcyclists account for about 50% of all road fatalities and about 53% of injured victims. Furthermore, the fatality and injury rates of motorcyclists in per registered vehicle are respectively 13 and 7 times higher than that of other motor vehicles. Severe motorcycle injuries also often result in tremendous medical costs (Bach and Wyman, 1986). Hence the safety of motorcyclists is one of the great concerns of Singapore. This is also particularly true for most of the Asian countries like Indonesia, Malaysia, and Vietnam, where motorcycle traffic is comparatively higher.

1.1 Motorcycle Safety Research

Motorcycling can be considered as a system including three elements: a machine element (i.e., the motorcycle), an environmental element (e.g., traffic conditions, roadway factors, weather effects), and a human element (i.e., the rider). Extensive research on motorcycle safety has been
devoted to understand the first two elements in several ways. For example, Quddus et al. (2002) and Shankar and Manering (1996) have analyzed severity of motorcycle crashes to identify significant roadway, traffic and environmental factors; Williams and Hoffman (1979) and Yuan et al. (2000) have investigated the motorcycle conspicuity; Haque et al. (2008) have investigated the crash risk of motorcycles due to excess exposure; Chin and Haque (2010) have studied the influence of red light cameras on the motorcycle safety; Haque et al. (2009) and Kim and Boski (2001) have examined the fault of motorcyclists in relation with different roadway, traffic and environmental factors. However, meager studies have been conducted to understand human factors that influence motorcycle safety.

The crash risk of motorcyclists has been found to have a significant association with rider demographics like rider age (Rutter and Quine, 1996), rider gender (Lin et al., 2003), riding experience (Sexton et al., 2004) and the like. However the impact of rider behaviors on the crash risk of motorcyclists has not been well explored. Among the few studies, Elliot et al. (2007) have developed a motorcycle rider behavior questionnaire (MRQB) to understand errors and violations of motorcyclists which may lead them to be involved in crashes. They have reported that control errors and speed violations are significant predictors of crash risk. However, the components of MRQB are mainly considering riding behaviors and/or habits, not human behaviors. In fact several researchers (e.g., Jonah et al. 2001, Lajunen and Parker, 2001) have reported that lifestyle and certain human behaviors such as aggressiveness, impulsivity, and sensation seeking are closely related to their driving behaviors and hence associated crash risks. Therefore the effect of human behaviors on motorcycling could be one of the important aspects of motorcycle safety.

1.2 Influence of Human Behavior on Traffic Safety

Researchers in the traffic safety arena have long discovered that individual characteristics and behaviors play a vital role in crash occurrences. For example, Sabey and Taylor (1980) have reported that human factors, either alone or combination with other factors, contribute to 95% of all crashes. Literature reviews of human behaviors on traffic safety suggest that there are several human related factors which can be explored to examine their impacts on the motorcycle safety. Among these, aggressiveness, sensation seeking, impulsivity, and risk-taking behavioral traits are identified and hypothesized as the most important personality traits to influence the crash risk of motorcyclists. A brief overview of those factors and related influence on the traffic safety has been presented below.

Aggression is any form of behavior directed toward the goal of harming or injuring another living who is motivated to avoid such treatment. Driving theories suggest that aggression originates from an externally elicited drive or motive to harm others. People who often display aggressive tendency in daily activities are most likely to react in similar manner on the road. Many studies (e.g., Lajunen and Parker, 2001, Underwood et al., 1999) have also been found to support the assumption that aggressive people are also aggressive drivers. Aggressive driving has also been found to have associations with feelings of anger, frustration, hostile appraisals of other drivers (Gulian et al., 1989).

Sensation seeking is a personality trait defined as seeking of varied, novel, complex, and intense sensations and experiences and the willingness to take the risks for achieving such experiences (Zuckerman, 1994). Jonah (1997) has reviewed the literature to investigate the relationship between sensation seeking and risky driving such as speeding, driving while
impaired, and following too closely and consequent collision risks. It has been reported that sensation seekers are likely to experience risky driving activities, which in turn, increase their collision rate.

Impulsivity is another important behavioral factor which is closely related to the sensation seeking. Impulsivity or impulsiveness is defined as the tendency to enter into situations, or rapidly respond to cues for potential award, without much planning and considerations of potential punishment or loss of reward. Hence, impulsivity may also affect road safety if drivers behave impulsively in any road traffic situation, especially in any road traffic hazard. Impulsiveness and sensation seeking traits have common behavioral and biological correlates and hence it leads to an evaluation of a combined personality trait called impulsive sensation seeking, the core of the P dimension of personality (Zuckerman, 1993).

Other than impulsive sensation seeking and aggressive behaviors, risk-taking is another human factor which may be significantly related to traffic safety. Risk-taking is any consciously or non-consciously controlled behavior with a perceived uncertainty about its outcome, and/or about its possible benefits or costs for the physical, economic or psycho-social well being of him or others (Trimpop, 1994). Turner and McClure (2004) have concluded that risk-taking behaviors of drivers/riders play a significant role in contributing to car/bike crashes that often result in serious injury.

The above mentioned behavioral factors have been explored to relate with driver behavior and associated crash risks. However, their impacts on the motorcyclists are still not well understood. Moreover, studying these behavioral traits together may be more appropriate to explore the human behavior.

1.3 Research Objective

The objective of this study is to evaluate how behavioral factors influence the crash risk of motorcyclists and to identify the most vulnerable group of motorcyclists from distinct personality combinations. More specifically, this study aims to explore relationship between the impulsive sensation seeking, aggression, and risk-taking behavioral traits of human being to the crash risk of motorcycling.

2. METHODOLOGY

2.1 Contextual Model in Stage One

It is hypothesized that three personality traits namely, impulsive sensation seeking, aggression, and risk-taking contribute to the likelihood of the crash occurrence of motorcyclists (see Figure 1).

In the proposed behavioral model of Figure 1, crash vulnerability of motorcycle is the response variable and the personality traits, impulsive sensation seeking, aggression and risk-taking, are explanatory variables.
2.2 Contextual Model in Stage Two

Human beings do possess multi-personalities. That is why the way a person reacts to the situation very much depends on his dominant personality at that instant. No doubt in many ways similar, different people might react very differently when faced with a similar situation. Due to the multi-personality tendency, the interrelationship between two or more personality traits interfere with their decision making process and ultimately their vulnerability.

To capture the multi-personality tendency, a new model is developed from the findings of the model at stage one retaining the response variable. This model enables the identification of a particular cluster of motorcyclists of distinct personality combination as well as evaluation of the effects of mediating factors like age, education, and riding experience.

The personality type of an individual will be defined from the outcome of the contextual model at stage one. Then several mediating factors will be introduced to examine if the crash involvement can be reduced given the behavioral combination of motorcyclists. The hypothesized links between these variables are presented by a path diagram in Figure 2.

![Figure 1. Proposed behavioral model for crash vulnerability of motorcyclists](image1)

![Figure 2. Crash vulnerability of motorcyclists for distinct combination of personality and mediating factors](image2)
2.3 Analytical Methods

The state-of-the-art analytical methods have been employed to conduct the analysis for this study. The medoid partitioning algorithm has been used for clustering the response variable, i.e. crash vulnerability, into different clusters of vulnerability. The log-linear modeling approach has been used in establishing relationship between behavioral traits and the crash vulnerability. A logit model is used to estimate the magnitude of the effects of different variables on the crash vulnerability.

2.3.1 Medoid Partitioning Algorithm

The medoid of a cluster is defined as that for which the average dissimilarity to all other objects in the cluster is minimal. To measure the dissimilarity between two objects, Euclidean distance measure has been used (Flores-Sintas et al., 2001). Euclidean distance, \( d_{ij} \) can be defined as

\[
  d_{ij} = \left[ \sum_{k=1}^{p} (x_{ik} - x_{jk})^2 \right]^{1/2}
\]

where \( x_{ik} \) and \( x_{jk} \) are respectively the \( k \)-th variable value of the \( p \)-dimensional observations for individual \( i \) and \( j \). To determine the appropriate cluster configuration, Spath’s medoid partitioning algorithm has been used (Spath, 1985). Starting with a random cluster configuration, this method minimizes an objective function by swapping objects from one cluster to another. The objective function \( D \) is defined as the total distance between the objects within a cluster. Mathematically,

\[
  D = \sum_{k=1}^{K} \sum_{i \in C_k} \sum_{j \in C_k} d_{ij}
\]

where \( K \) is the number of clusters, \( C_k \) is the set of all objects in cluster \( k \). Several random starting cluster configurations have been run to ensure that the appropriate solution is achieved.

2.3.2 Log-linear Model

Log-linear model demonstrates the association between variables (see Fienberg, 1977, for detail). The general log-linear model seeks to explain or fit cell frequencies with an additive model incorporating main effects as well as interactions between variables. For example, consider a three-way frequency table with variables \( X, Y, \) and \( Z \). Let \( f_{ijk} \) be the observed frequency and \( m_{ijk} \) be the expected frequency for cell \( ijk \), where \( i, j, k \) designates category \( X, Y, \) and \( Z \) respectively. The saturated log-linear model is as follows

\[
  \log_e (m_{ijk}) = \lambda + \lambda_i X + \lambda_j Y + \lambda_k Z + \lambda_{ij} XY + \lambda_{ik} XZ + \lambda_{jk} YZ + \lambda_{ijk} XYZ
\]
where $\lambda$ is the overall mean of the natural log of expected frequencies, $\lambda_i^X, \lambda_j^Y, \lambda_k^Z$ are the main effects for variables X, Y, and Z, respectively; $\lambda_{ij}^{XY}, \lambda_{ik}^{XZ}, \lambda_{jk}^{YZ}$ are the two-way interaction effects for XY, XZ, and YZ; and $\lambda_{ijk}^{XYZ}$ expresses the three-way interaction effect for XYZ.

Starting with the saturated model, the best fit model is obtained after deleting all insignificant terms one by one by backward elimination technique. A term in the model is insignificant when the difference of fitness of models with or without that term is not statistically significant. The likelihood ratio statistic has been used as a goodness of fit statistics of models. The likelihood ratio statistic is defined as:

$$G^2 = 2 \sum_{ijk} f_{ijk} \ln \left( \frac{f_{ijk}}{m_{ijk}} \right)$$  \hspace{1cm} (4)

The difference between two $G^2$ values from two models is a chi-square value with a degree of freedom equals to the difference of $df$s from those two models. A significance level of 0.15 has been selected for checking the goodness of fit of the models. A higher value has been chosen to reduce the possibility of excluding important terms from the best fit or simplest model.

2.3.3 Logit Model

Log-linear models are fine for studying the relationship among a set of categorical variables. However, when the variables are considered as dependent and explanatory variables, a logit model provide a direct measure of the effects of explanatory variables on the dependent variable. In the logit model, the log of the odds of each category of the dependent variable is explained by additive terms corresponding to main effects and interactions between the independent variables.

To illustrate the link between a log-linear model and a corresponding logit model, consider the three-way table introduced in the previous subsection. Suppose, X and Y are independent variables and Z is the dependent variable. Let’s say, Z has only two categories, denoted $k = 0$ and $k = 1$. Then the logit model for Z is

$$\log_e \left( \frac{m_{y0}}{m_{y1}} \right) = (\lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{ik}^{XZ} + \lambda_{jk}^{YZ} + \lambda_{ijk}^{XYZ}) -$$

$$= (\lambda_0^Z - \lambda_1^Z) + (\lambda_{i0}^{XZ} - \lambda_{i1}^{XZ}) + (\lambda_{j0}^{YZ} - \lambda_{j1}^{YZ}) + (\lambda_{y0}^{XYZ} - \lambda_{y1}^{XYZ})$$

$$= \mu + \mu_i^X + \mu_j^Y + \mu_k^Z$$  \hspace{1cm} (5)

where $\mu$ is the constant term of the logit model, $\mu_i^X, \mu_j^Y, \mu_k^Z$ denote the effect of independent variable X, Y and their interaction XY on the dependent variable Z, respectively. The odds ratios can be computed after exponentiation of the logit parameters from the fitted logit equation (5). That is,

$$(m_{y0}/m_{y1}) = \exp(\mu) + \exp(\mu_i^X) + \exp(\mu_j^Y) + \exp(\mu_k^Z)$$  \hspace{1cm} (6)
where the first factor is the baseline odds and the others are odds ratios for each factor effects on the two categories of Z. If the odds ratio for a factor is greater than 1 then it increases the odds of being in category \( k = 0 \) relative to the category \( k = 1 \) and vice versa. Note that if Z has three or more categories then the odds ratios for different independent variables are calculated after selecting one of them as a reference category.

3. DATASET FOR ANALYSIS

For collecting data of rider behaviors as well as their crash history and demographic profile, a questionnaire was designed and administered to a sample group of motorcyclists.

3.1 Design of Questionnaire

The questionnaire designed for this study has two parts: part 1 attempts to assess the personality level of subjects from the impulsive sensation seeking, aggression and risk-taking behaviors of a human being, and part 2 solicits details about the crash history of motorcyclists as well as their demographics and riding habits.

The portion on impulsive sensation seeking behavior consists of 26 statements on sensation seeking and impulsivity. Sensation seeking items have been extracted and modified from Form V of Zuckerman’s Sensation Seeking Scale (Zuckerman et al., 1964) and impulsivity items have been extracted from Eysenck’s Impulsiveness Questionnaire (Eysenck et al., 1985). Zuckerman’s sensation seeking scales consists of four subscales: thrill and adventure seeking, experience seeking, boredom susceptibility and disinhibition. Sixteen (16) items out of original 40 items have been selected and modified for this study because of the lifestyle differences and geographical location. For example, skiing down a high mountain slope, diving of high board, and parachute jumping are not common leisure activities in Singapore and hence those have been excluded. Original statement “I would like to go scuba diving” has been rephrased into “Given all expenses paid, I wouldn’t mind going scuba diving”. This is to eliminate the element of financial concern in decision making process. Another statement “When going on a sponsored vacation, I would prefer a backpacking tour trip” has been modified from “I like to explore a strange city or section of town myself, even if it means getting lost”. Eysenck’s Impulsiveness Questionnaire measures impulsiveness, venturesomeness, and empathy. From the original 19 impulsiveness items, only 10 items have been extracted and adopted for this study.

The aggression questionnaire (Buss and Perry, 1992) which measures the physical aggression, verbal aggression, anger and hostility has been adopted in this study to assess the level of aggression among the subjects. Out of the original 29 questions, 20 items have been selected. For measuring risk-taking behaviors, items have been extracted from Risk-Behavior Scale (Weber et al., 2002). The scale consists of five domains of risk: financial, health/safety, recreational, ethics, and social and has a total of 50 items. Relevant items have been selected and rephrased to suit local context of this study. Fifteen (15) items of risk-taking have been selected by taking 3 items from each domain of risk.

Therefore, the first section of the questionnaire consists of 61 statements pertaining three explanatory variables: impulsive sensation seeking, aggressiveness, and risk-taking. The subjects were asked to rate each item on a scale of 1 (strongly disagree) to 4 (strongly agree). Statements in the questionnaire were arranged in a random manner so that the subjects were less susceptible
of responding in a desirable way. Hence it would truly reflect their personality. Moreover, to break the momentum, some items in the questionnaire were rephrased in the negative aspect.

In the part 2, the motorcyclists were asked to answer questions about the last crash they were involved in within the last 2.5 years from the survey date, if any. The definition of a road crash includes both reported and non-reported cases as well as any minor mishap during the event of riding a motorcycle. They were requested to be as truthful as possible. Specifically, respondents with crash records were explicitly told that they would not be liable in the event that the information they provided were additional or contradictory to their previous testimonial. Their cases had been concluded and would not be revoked. They were also requested to fill up their demographics like age, gender, and education. Moreover, questions regarding their riding habits and their knowledge about the traffic penalties were also included in this part. A sample of the questionnaire is included in the appendix.

3.2 Data Collection

A motorcyclist who has a valid riding license and has ridden within last 12 months from the date of survey was eligible to participate in this study. Two distinct groups of motorcyclists were targeted for interview: motorcyclists with road crash encounter within the last 2.5 years from the date of survey, and another group without any road crash encounter. The survey was conducted by sending letters signed by the Singapore traffic police to the motorcyclists as well as interviewing motorcyclists of several motorcycling clubs of Singapore like Harley Owners group, Storm Riders Motorcycling club. After removing the subjects who did not fulfill the requirements of this survey, 120 sample motorcyclists were used for the analysis. Among those 120 samples, 60 motorcyclists have been found with a crash encounter in that stipulated time period and the rest have clean crash record. The distributions of subjects by several demographics like age and education level are found to be quite well distributed (see Figure 3).
4. RESULTS AND DISCUSSIONS

4.1 General Findings

Summary score of an explanatory variable has been obtained by summing up the score of individual items of that variable. Motorcyclists with crash encounter have been found to have average scores 7.48, 4.95, and 3.37 points higher than motorcyclists without crash encounters for impulsive sensation seeking, aggression and risk-taking scale, respectively. The score distribution of each behavioral factor was split at median so that the subjects with scores below and above median are classified as low scorer and high scorer respectively. The cut-off points for impulsive sensation seeking, aggression and risk-taking are 39, 29, and 22 respectively. About 67%, 55% and 63% motorcyclists with crash encounters have been found to have high scores for impulsive sensation seeking, aggression and risk-taking respectively. On the other hand, only about 30% motorcyclists without crash encounters have been found to have high scores for all their behavioral factors.

Internal consistency of items included in each behavioral factor was checked by using Cronbach’s alpha coefficients. Alpha coefficients for impulsive sensation seeking, aggression, and risk-taking are 0.77, 0.75, and 0.57 respectively. This means that items in each behavioral factor are highly correlated and hence likely to reflect the personality of subjects.

4.2 Personality Traits on Crash Vulnerability

Before establishing the relationship between the vulnerability and personality traits of motorcyclists, vulnerability type have been defined from their last involved crash. From the results of the cluster analysis, the vulnerability of motorcyclists is divided into three clusters or groups: Low, Moderate, and High. The maximum average Silhouette value of 0.77 indicates a very strong cluster structure of vulnerability types. Low vulnerable group of motorcyclists consists of 50% of total sample that have no crash involvements in the last 29 months, Moderate vulnerable group consists of 21% that have no crash involvements in the last 18 months and High vulnerable group consists of the rest 29% that have the crash free period of only 6 months.

Using the log-linear model, the relationship between vulnerability and different behavioral traits has been established. Starting from the saturated model, the best fit model reveals the following relationship: \([\text{Aggression}] \times [\text{Vulnerability}], [\text{Risk-taking}] \times [\text{Vulnerability}], [\text{Impulsive Sensation Seeking}] \times [\text{Aggression}], [\text{Impulsive Sensation Seeking}] \times [\text{Risk-taking}]\). At a degree of freedom of 12, the log-likelihood ratio statistic, \(G^2\) value of 14.1 indicates a good level of fit. The corresponding P-value of 0.2916 indicates that in the best fit model any other term equals to zero is not statistically significant. The relationship between the vulnerability and behavioral factors found from the best fit log-linear model has been presented in Table 1. Moreover, to reveal the effects of aggression and risk-taking on the vulnerability type, a logit model has been estimated with the vulnerability type as the dependent variable. The corresponding logit model estimates are presented in Table 2.

Aggression has been found to have a direct association with the vulnerability type in the best log-linear model. The likelihood of aggressive motorcyclists to be classified under the “Moderate” vulnerability type is the highest \((\lambda = 0.269)\) among other vulnerability types. A logit model estimate of odds ratio provides a clearer interpretation of aggressions to the crash risk (See Table 2). Relative to the “Low” vulnerability group, aggressive motorcyclists are about 1.3 and 1.7
times more likely to be “High” and “Moderate” vulnerable, respectively. Sumer (2003) has reported that aggression expressed in aberrant driving behaviors has an indirect effect on the crash involvement. However, this study shows that aggression has a direct effect on the crash involvement, specifically on the vulnerability of motorcyclists.

Table 1. Relationship between behavioral factors and vulnerability types

<table>
<thead>
<tr>
<th>Crash Vulnerability Type</th>
<th>Factor Effect, λ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Main Effect</td>
<td>-0.073</td>
</tr>
<tr>
<td>Aggression X Vulnerability Type (High)</td>
<td>0.001</td>
</tr>
<tr>
<td>Risk-taking X Vulnerability Type (High)</td>
<td>0.389</td>
</tr>
</tbody>
</table>

Table 2. Logit model estimates of odds ratio predicting vulnerability types

<table>
<thead>
<tr>
<th>Behavioral Factor</th>
<th>Category</th>
<th>Odds Ratio (relative to “Low” Vulnerability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High Vulnerability</td>
</tr>
<tr>
<td>Aggression</td>
<td>High</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>0.77</td>
</tr>
<tr>
<td>Risk-taking</td>
<td>High</td>
<td>2.21</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Risk-taking behavior has also been found to have a significant association with the vulnerability type. Risk-taker motorcyclists are more likely to be in “High” vulnerable group (λ = 0.389). The logit model results show that risk-taker motorcyclists are respectively about 2.2 and 1.5 times more likely to be “High” and “Moderate” vulnerable group than “Low” vulnerable (Table 2). Interestingly, the amount of risk an individual is willing to take is fairly independent of his aggression level. This has been marked from the best log-linear model as there is no interaction between risk-taking and aggression.

Table 3. List of best log-linear models relating riding habits and personality traits

<table>
<thead>
<tr>
<th>Riding Habits</th>
<th>Best Model*</th>
<th>DF</th>
<th>G²-Statistic</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Join in a motorcycling club</td>
<td>IR, IA, H</td>
<td>9</td>
<td>6.39</td>
<td>0.700</td>
</tr>
<tr>
<td>Wear protective jacket while riding</td>
<td>IA, IR, H</td>
<td>9</td>
<td>6.30</td>
<td>0.709</td>
</tr>
<tr>
<td>Wear gloves while riding</td>
<td>IR, IA</td>
<td>10</td>
<td>6.54</td>
<td>0.768</td>
</tr>
<tr>
<td>Prefer a stylish helmet</td>
<td>IR, IA</td>
<td>10</td>
<td>13.70</td>
<td>0.189</td>
</tr>
<tr>
<td>Ride between moving cars</td>
<td>IA, IR, H</td>
<td>9</td>
<td>7.85</td>
<td>0.550</td>
</tr>
<tr>
<td>Ride within 2 hours after drinking</td>
<td>IR, H, A</td>
<td>10</td>
<td>14.00</td>
<td>0.173</td>
</tr>
<tr>
<td>Attempt to find top speed of the bike</td>
<td>IA, IH, IR</td>
<td>8</td>
<td>6.70</td>
<td>0.569</td>
</tr>
<tr>
<td>Ride above speed limit generally</td>
<td>IAH, IR</td>
<td>6</td>
<td>5.71</td>
<td>0.457</td>
</tr>
<tr>
<td>Ride above 120 Km/h on expressway</td>
<td>IR, IH, IA</td>
<td>8</td>
<td>9.08</td>
<td>0.336</td>
</tr>
<tr>
<td>Ride through red lights</td>
<td>IH, IR, A</td>
<td>9</td>
<td>4.74</td>
<td>0.856</td>
</tr>
</tbody>
</table>

* I: Impulsive Sensation Seeking; A: Aggression; R: Risk-taking; H: Riding Habit

Impulsive sensation seeking behavior has been found to have no significant association with the vulnerability of motorcyclists. However, impulsive sensation seeking has been found to be strongly associated with aggression and risk-taking behaviors. High impulsive sensation seeker motorcyclists are found to be highly aggressive (λ = 0.278) and highly risk-taker (λ = 0.478). Since impulsive sensation seekers are more likely to be involved in new activities and sports, it is likely that they will be more willing to accept higher risk as well as be aggressive to achieve something to meet their sensation seeking demands.
To validate these findings, a log-linear analysis is conducted to examine the interrelationship between behavioral traits and riding habits. The log-linear analysis reveals that impulsive sensation seekers are more likely to be involved in several risky riding habits (See Table 3). They are more likely to attempt to find the top speed of their recently purchased bike, ride beyond 120 Km/h on expressways. They are also more likely to run the red light and generally ride above speed limit when there is no fear of detection. Hence risky riding habits of the impulsive sensation seekers may result in serious road hazard for them as well as for other road users.

4.3 Effects of Personality Types and Mediating Factors

From the best log-linear model in stage one, risk-taking and aggression are found to be the two main influential factors for the vulnerability of motorcyclists. Hence, personality types of motorcyclists are defined from the scores of aggression and risk-taking scales. A cluster analysis on the scores of aggression and risk-taking reveals four personality types: Extrovert, Leader, Follower, and Introvert.

“Extrovert” personality type can be defined as aggressive and impulsive risk-takers. They are easily bored without high levels of stimulation. They are most likely to take high risk to experience the excitement and thrill. “Leader” personality type refers to cautious and aggressive risk-takers. They have the disposition to act or decide upon deliberate consideration of the pros and cons. They also desire excitement and new experiences but only if the risks involved are minimal. “Follower” type is agreeable and ignorant risk-takers. They are fair, honest and have good intentions. They are considerate, friendly, generous, helpful and willing to compromise their interests with others. “Introvert” personality type refers to self-conscious and fainthearted risk-takers. They tend to be more distant and reserved. They do not feel the strong urge to try new activities as they simply need less stimulation.

To examine if there is any mediating factor that can reduce the vulnerability of motorcyclists of a specific personality type, demographic variables such as age, riding experience, and traffic penalty awareness are introduced to the model (see Figure 2). Due to a large range of riders’ age in the sample, the age has been divided into young/old dichotomy at an age of 25. Ethnic group is divided into two groups: Chinese and Non-Chinese. Similarly, education level is divided into two groups as secondary and tertiary. Riding experience is split into two clusters by medoid partitioning: first cluster has a representative of 5 years riding experience while that of second cluster is 20 years. Traffic penalty awareness is dichotomized into binary categories of high and low by a median split. Motorcyclists who answered at least two traffic penalty questions correctly are considered as high scorers.

Table 4 shows statistics of the respective best model of all proposed log-linear models. Clearly none of the mediating factor has a direct association with vulnerability types, i.e. no VM. In all models, personality types are strongly associated with vulnerability types. This implies that individual’s personality type is dominant in influencing the crash risk of motorcyclists. At a degree of freedom of 8, the log-likelihood ratio statistics, $G^2$ value of 4.43 (P = 0.816) indicates the best fit of the data among all. The best fit model results in the following relationship: [Personality] [Vulnerability], [Personality] [Traffic Penalty Awareness].

A logit model with vulnerability type as a dependent variable has been estimated to examine the effect of personality types on the crash vulnerability of motorcyclists (See Table 5). Results show that “Extrovert” and “Follower” personalities are respectively about 3.3 and 1.6 times more likely to be of high vulnerability than low. Extrovert individuals have strong desire for
excitement and thrill from new activities as a result their vulnerability is compromised. It can also be deduced that “Extrovert” motorcyclists are 8.35 times more likely to have high vulnerability than that of “Introvert” personalities. Interestingly, motorcyclists of “Follower” personality are substantially in the high risk group despite their lower score on the aggression scale. Acting along with crowds without sufficient knowledge of risks may be involved to put them in a dangerous situation. Opposite to the above two personalities, motorcyclists of “Leader” and “Introvert” personality are less prone to crash occurrence and their odds of high vulnerability have been found to reduce by 0.48 and 0.40 times respectively. It is not surprising that “Leader” personality actually make such motorcyclists less vulnerable even though they are also highly aggressive. This is because of their cautiousness in taking risks. “Introvert” motorcyclists, being the least aggressive and minimal risk-takers, are the least likely to be vulnerable.

**Table 4. List of log-linear models relating personality types, mediating factors and vulnerability**

<table>
<thead>
<tr>
<th>Mediating Factors</th>
<th>Best Model*</th>
<th>DF</th>
<th>$G^2$-Statistic</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>PV, M</td>
<td>11</td>
<td>11.9</td>
<td>0.367</td>
</tr>
<tr>
<td>Religion</td>
<td>PV, M</td>
<td>11</td>
<td>7.56</td>
<td>0.753</td>
</tr>
<tr>
<td>Ethnics Group</td>
<td>PV, M</td>
<td>11</td>
<td>4.49</td>
<td>0.953</td>
</tr>
<tr>
<td>Education</td>
<td>PV, PM</td>
<td>8</td>
<td>6.94</td>
<td>0.543</td>
</tr>
<tr>
<td>Riding Experience</td>
<td>PV</td>
<td>12</td>
<td>15.3</td>
<td>0.227</td>
</tr>
<tr>
<td>Traffic Penalty Awareness</td>
<td>PV, PM</td>
<td>8</td>
<td>4.43</td>
<td>0.816</td>
</tr>
</tbody>
</table>

* P: Personality Types; M: Mediating Factor; V: Vulnerability Types

**Table 5. Logit model estimates of odds ratio relating personality types and vulnerability**

<table>
<thead>
<tr>
<th>Personality Types</th>
<th>Odds Ratio (relative to “Low” Vulnerability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Vulnerability</td>
</tr>
<tr>
<td>Extrovert</td>
<td>3.34</td>
</tr>
<tr>
<td>Leader</td>
<td>0.48</td>
</tr>
<tr>
<td>Follower</td>
<td>1.56</td>
</tr>
<tr>
<td>Introvert</td>
<td>0.40</td>
</tr>
</tbody>
</table>

It is worthy to note that personality is associated with a mediating factor, namely traffic penalty awareness. From the fourth model of Table 4, it can be seen that personality also has a direct association with the education level of an individual. It cannot be concluded, however, that since personality affects vulnerability, education, and traffic penalty awareness directly, there is an indirect effect of education and traffic penalty awareness on vulnerability. If this is the case, there should be a three-way interaction term in the best log-linear model.

**5. CONCLUSION**

This study has successfully identified two behavioral factors, namely aggression and risk-taking as significant contributors to the crash involvement of motorcyclists. Despite the fact that the level of impulsive sensation seeking behavior of a motorcyclist does not have a significant effect on his vulnerability, it has been found to be highly associated with aggression and risk-taking. Moreover, the impulsive sensation seeking is highly correlated with risky riding behaviors, such as speeding and beating the red light, which may impose serious safety hazard on them as well as on other road users. It has been found that the probability of involvement in a crash after a crash-free period of six months is higher for “Extrovert” and “Follower” personality type motorcyclists.
Mediating factors, such as age, riding experience and traffic penalty awareness, incorporated in the model are not found to be significant in reducing the vulnerability of motorcyclists. Therefore, the dominant factor leading to high crash risks lies in the personality traits of motorcyclists.

The findings of this study are particularly useful to the traffic enforcers and road safety planners for planning road safety campaigns. With improved knowledge of the behavioral aspects in crash involvements, road safety campaigns can to be modified to better focus on the high-risk groups. For example, Extrovert motorcyclists can be targeted for road safety campaigns and seminars. Moreover, by incorporating a behavioral questionnaire as a part of the riding course syllabus, potential high-risk individuals can easily be identified. Hence instructors or examiners of riding schools can pay special attention to these individuals during their courses for better riding behaviors on the road. Furthermore, courier delivery providers can use the same approach to identify potential personnel for their delivery businesses. “Leader” and “Introvert” personality type of motorcyclists can be potential candidates for doing delivery jobs.

The developed behavioral models of this research can easily be applied to motorcyclists of any country and/or region. The application of the developed models in developing countries like Indonesia, Vietnam, and Thailand would be interesting and useful. Behavioral traits of riders of those countries may be different from that of Singapore. However the developed behavior questionnaire for riders can be easily administered over a sample of riders of developing countries. After conducting this research for other countries, a comparison on the behavioral traits of riders could be made for different countries. It would be helpful for developing global motorcycle safety programs as well as improving motorcycle safety for a specific country.

A limitation of this study is that the number of subjects who completed the questionnaire is low. However, the number of cases covered is still comparable with some other studies (e.g., Turner and McClure, 2004). A large sample size would be desirable if the contextual models are to include other external factors such as lifestyle, rule violations, and the like. As an extension of this study, behavior change of motorcyclists after having been in a crash could be taken into consideration while developing theoretical models. This may be helpful to explore the uncertainty of the behavior-based road safety.

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REFERENCES


**APPENDIX**

**Questionnaire**

**Part 1:**
The motorcyclists were asked to rate for the following items in a four point scale: 1) Strongly Disagree, 2) Disagree, 3) Agree, and 4) Strongly Agree. The rating scale had been attached to each item. The items in each personality trait are presented here:

**Impulsive Sensation Seeking**
1. Given all expenses paid, I wouldn’t mind going scuba diving.
2. I shout back when people shout at me.
3. I usually don’t bother to check after completing my work.
4. I sometimes like to do things that are a little frightening.
5. I would like to try new foods that I have never tasted before.
6. I usually think twice before any purchase.*
7. I will try different styles of dressing even if the effects are sometimes strange.
8. I wouldn’t mind making friends with homosexuals.
9. I like to attend theme poolside parties.
10. I sometimes do things on the spur of moment.*
11. I do get so “carried away” by new and exciting ideas that I never think of possible consequences.
12. I feel much relaxed after taking a couple of drinks.
13. I sometimes do buy accessories on impulse.
14. I would like to attempt the Reverse Bungee Jump during its free-trial promotion.
15. I generally do and say things without stopping to think.
16. I like to date members of opposite sex who are physically exciting.
17. I enjoy watching many of the “sexy” scenes in movies.
18. I wouldn’t mind attending an airplane flying course at an affordable price.
19. I usually think carefully before making any decision.*
20. I prefer friends who are excitingly unpredictable.
21. I sometimes get involved in things that I soon regret about it.
22. I like people who are sharp and witty even if they do sometimes insult others.
23. I get very restless if I have to idle around home for any length of time.
24. I am an impulsive person.
25. When going on a sponsored vacation, I would prefer a backpacking trip.
26. I can’t stand watching a movie that I’ve seen before.

**Aggression**
1. Under no circumstances, I will hit another person.*
2. Given enough provocation, I may hit another person.
3. If somebody hits me, I hit back.
4. If I have to resort to violence to protect my rights, I will.
5. I have become so mad that I have broken things.
6. I tell my friends openly when I disagree with them.
7. I often find myself disagreeing with people.
8. When people annoy me, I simply walk away.*
9. I can’t help getting into arguments when people disagree with me.
10. I am an argumentative person.
11. I flare up quickly but get over it quickly.
12. When frustrated, I show my irritation.
13. I am an even-tempered person.*
14. Sometimes I flare up for no good reason.
15. I have trouble controlling my temper.
16. I am sometimes eaten up with jealousy.
17. I am suspicious of overly friendly strangers.
18. When people are especially nice, I wonder what they want.
19. I wonder why sometimes I feel so bitter about things.
20. I sometimes feel that people are laughing at me behind my back.

Risk-taking
1. I will take up a job where I am paid exclusively on a commission basis.
2. I wouldn’t mind giving my friend a loan equivalent to a week’s income.
3. I may invest 10% of my annual income in a very speculative income.
4. I disagree with my boss in front of other co-workers.
5. I do speak my mind about an unpopular issue at a social occasion.
6. I may wear unconventional clothes.
7. I will do personal stuffs during office hours.
8. I might cheat in tests or examination.
10. I smoke a pack of cigarette daily.
11. I am not seeing the doctor just for some persistent physical pain.
12. I consume more than 2 servings of alcohol in a single evening.
13. I do engage in a dangerous sport periodically (e.g., rock climbing etc.).
14. I love to explore an unfamiliar city overseas.
15. I may go on a vacation overseas without prearranged travel and hotel accommodations.

* Symbol stands for the items whose scoring is reversed.

Part 2:
In this part, questions related to their crash history (if any), demographics, riding habits as well as traffic penalty awareness have also been included. The questions related to riding habits and traffic penalty awareness is shown here:

Riding Habits
The following questions were asked to motorcyclists only with Yes/No options.
1. Are you a member of any Motorcycling Club/Alumni?
2. Do you usually wear jackets while riding?
3. Do you usually wear gloves while riding?
4. Do you prefer a stylish helmet to a plain-colored one?
5. Have you ever ridden between moving cars to get through traffic?
6. Have you ever ridden within 2 hours after drinking an alcoholic beverage?
7. Have you ever attempted to find the top speed of your recently purchase bike?
8. Where you fear no detection, do you generally ride above the speed limit?
9. Have you ever ridden 120 Km/h or faster on expressways?
10. Have you ever ridden through red lights?

Traffic Penalty Awareness
The following 5 questions were asked to evaluate the level of awareness of traffic offences. For each question, 3 choices were given with only one correct answer.

What are the penalties and fines for?:
1. Reckless or dangerous driving.
2. Driving without due care or reasonable consideration for other road users.
3. Driving under influence of drink or drugs.
4. Exceeding speed limit of road/vehicle by 1-20 Km/h.
5. Failing to conform to traffic light signals.