Motorcycles entering from access points and merging with traffic on primary roads in Malaysia: Behavioral and road environment influence on the occurrence of traffic conflicts

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Introduction (1/5)

• Malaysia
  – Population = 28.4 million
  – Registered vehicle = 17.8 million
  – Road traffic death = 7,085
  – Road traffic death per 100,000 = 25 (19th highest)
  – % registered motorcycle = 47%
  – % of motorcycle accident fatalities = 58.7%

» 5th in the world among countries with a high percentage of motorcycle accident fatalities

» > 50% on primary road,
The most typical automobile-motorcycle fatal crash in developed countries, e.g. Western countries, is one in which an automobile violates the motorcycle’s right of way (ROW) (Pai 2011).
Introduction (3/5)

Figure 1: Percentage of motorcycle accident fatalities on two lane undivided primary roads from 2008 to 2010 based on road geometry and collision type (ADSA 2011, Abdul Manan and Várhelyi 2012)
Introduction (4/5)

\[ MCFatal_{/km} = \exp(-4.891) \cdot ADTMC^{0.404} \cdot Access\_per\_km^{0.262} \]

- Motorcycle fatalities per kilometer on Malaysian primary roads are statistically significantly affected by the number of average daily traffic of motorcycles (ADTMC) and the number of accesses per kilometer (Access_per_km)

Introduction (5/5)

- Observation study at access points on straight sections of primary roads in Malaysia in 2012

800 Observation of motorists

537 interactions

56 serious conflict

64% motorcycle from access point

Rate of serious traffic conflict: MC = 10.3%  Veh = 10.7%

Research question

• What behavioral (motorcyclists entering from the access point) and road environment factors that influence the occurrence of serious traffic conflicts involving motorcycles entering from access points and merging with traffic on primary roads in Malaysia?
Data (1/5)

• Observed sites = 8 sites with an access point on straight road section (typical) with history of fatal motorcycle accidents

• Observation data was from Abdul Manan and Várhelyi (2014)
  – 350 out of 800 observations was selected
  – Only those where motorcyclists entering the primary road from the access point were involved
  – Outcome: serious traffic conflict (n=36)
Data (2/5)

• Road environment attributes
  – Built up area (Rural, Residential, Commercial)
  – Traffic volume category (Low, Medium, High)
  – Speed limit (70kph, 80kph, 90kph)
  – Lane width category (2.5m, 3.0m)
  – Road shoulder (No shoulder, With shoulder)
  – Type of interacting vehicle (MC, Car, Heavy vehicle)
  – Location of vehicle interaction (Nearside lane, Farside lane)
Data (3/5)

• Motorcyclists’ attributes and behavior
  – MC gender (Male, Female)
  – MC head movement (No movement, Left only, Right only, Left and Right)
  – MC occupancy (Rider only, Rider with Passenger)
  – MC headlight usage (On, Off)
  – MC helmet usage (with helmet, without helmet)
  – MC turning indicator (On, Off)
  – MC stopping behavior (Stop at stop line, Does not stop)
  – MC entering direction (Left turn, Right turn, OIRT)
  – MC manner of entering
Data (4/5)

- The Opposite Indirect Right Turn (Abdul Manan, Varhelyi (2014))
  - 18% to 26% of right turning motorcyclists
Data (5/5) – Manner of entering

Legend:

\( t_G \) : Gap between 2 vehicles (sec)

\( t_L \) : Time lag between an approaching vehicle on the primary road and vehicle entering from the access point (sec)

\( M_A \) : Motorcycle from access point

\( V_{1,2} \) : Vehicles passing along the primary road

Note: Malaysia is a country with left-hand traffic
Method (1/3)

• Bootstrapping method of re-sampling was used
  – Due to the small number of serious conflicts (n = 36) the probability of positive occurrence will be underestimated and result in low sensitivity.

• Number of re-sampling = 3,500
Method (2/3)

Level 2: Primary road environment attributes surrounding the access point

Level 1: Motorcyclists entering the primary road from the access point
Method (3/3)

- Mixed-effect logistic regression, i.e. multilevel regression

\[ y_{ij} = \beta_0 + \beta x_{ij} + u_j + e_{ij} + v_j x_{ij} \]

- Mixed effect Logistic regression:
  - It is sufficient to analyzed the fixed parameters and
  - The random effects are not directly estimated, but are summarized according to their estimated variances and covariances

Jones and Jørgensen (2003), STATA (2013)
Results (1/3)

• Two statistically significant models (Model 2 and Model 3) are produced

• Fixed effect parameters:
  – The risk of motorcyclists being involved in a serious traffic conflict is 2 to 4 times more likely if
    » Manner of entering: $t_g < 4s$
    » Manner of entering: $t_L < 4s$
    » Narrow lane (2.5m) (Model 2)
    » Stop at the stop line (Model 3)
Result (2/3)

• Random parameters
  – Traffic volume and Speed limit (Random Slope Parameter)
  – Model 2 has 74% variations on behavioral factor of the MCs and 26% variation on road environment factor
    » Manner of entry and Lane width
  – Model 3 has 71% variations on behavioral factor of the MCs and 29% variation on road environment factor
    » Manner of entry and MC stopping behavior
### Fixed effects parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1 (intercept only)</th>
<th>Model 2 **</th>
<th>Model 3 **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept (Constant)</td>
<td>-1.699 ** (0.602)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Manner of entry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_0 &lt; 4s$</td>
<td>0.834 (0.509)</td>
<td>2.302*</td>
<td>1.060 (0.567)</td>
</tr>
<tr>
<td>$t_L &lt; 4s$</td>
<td>1.461 (0.441)</td>
<td>4.310**</td>
<td>1.417 (0.473)</td>
</tr>
<tr>
<td>Lane width category</td>
<td>-2.040 (1.197)</td>
<td>0.130*</td>
<td></td>
</tr>
<tr>
<td>Stopping behavior</td>
<td>-0.768 (0.439)</td>
<td>0.464*</td>
<td></td>
</tr>
</tbody>
</table>

### Random (Hierarchical) effects parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1 (intercept only)</th>
<th>Model 2 ▲</th>
<th>Model 3 ▲</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 (Motorcyclists entering primary road from the access point)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random Intercept (Constant)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proportion of residual variability</td>
<td>ICC Level 1 83%</td>
<td>74.1%</td>
<td>71.0%</td>
</tr>
<tr>
<td>Level 2 (Traffic volume category)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random Intercept (Constant)</td>
<td>-</td>
<td>0.635</td>
<td>1.151**</td>
</tr>
<tr>
<td>Random slope</td>
<td>0.403 (3.005)</td>
<td>1.324** (0.418)</td>
<td>1.800** (0.335)</td>
</tr>
<tr>
<td>Proportion of residual variability</td>
<td>ICC Level 2 16%</td>
<td>25.9%</td>
<td>29.0%</td>
</tr>
</tbody>
</table>
Discussion

• Why ‘stopping at the stop line’ influence serious traffic conflict occurrences for motorcyclists?
Time to enter ($t_E$, sec) the flow of the primary road by motorcyclist

Far side lane from the access approach
Near side lane of the access approach

Note: $t_E = \text{time to enter}$

MC = motorcycle

<table>
<thead>
<tr>
<th>Scenario 1: Motorcyclist stops at the stop line (n=100)</th>
<th>Scenario 2: Motorcyclist does not stop at the stop line (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.48 s</td>
</tr>
<tr>
<td>Stand Dev.</td>
<td>1.01</td>
</tr>
<tr>
<td>Median</td>
<td>3 s</td>
</tr>
<tr>
<td>Variance</td>
<td>1.02</td>
</tr>
<tr>
<td>85th Percentile</td>
<td>4 s</td>
</tr>
<tr>
<td>CI lower 95</td>
<td>3.28 s</td>
</tr>
<tr>
<td>CI upper 95</td>
<td>3.68 s</td>
</tr>
<tr>
<td>CI upper 95</td>
<td>2.46 s</td>
</tr>
<tr>
<td>t-test (p-value)</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Opposite Indirect Right Turn
Opposite Indirect Right Turn
Opposite Indirect Right Turn
Opposite Indirect Turning
Questions?

THANK YOU.