Motorcycle Research at the Virginia Tech Transportation Institute

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Motorcycle Research Group (MRG) & Center for Automated Vehicle Systems (CAVS)
Outline

• Introduction to Motorcycle Research at VTTI
• Select Experimental Motorcycle Studies
• Introduction to VTTI Naturalistic Motorcycle Data
• Select Findings from VTTI Naturalistic Motorcycle Work
  • MSF 100
    • How Often Riders Ride
    • Crashes and Near-Crashes
    • Stopping in Crash\Near-Crash Situations (Cars vs. Motorcycles)
    • Crashes and Near-Crashes in Curves
• Take-home Messages
Motorcycle Research Group

- Motorcycle Research Group located within the Center for Automated Vehicles with the goal to:
  - Reduce motorcyclist fatalities and injuries.
    - Understand rider behavior and performance capabilities in real-world riding.
    - Use a systems approach to optimizing rider experiences.
    - Support riders, policy makers, manufacturers, and roadway designers.
Two Approaches through Research

Experimental
- Controlled and safe experiments
- Lab, Test Track, Simulator
- Manipulate an independent variable
- Measure a dependent variable

Naturalistic

Epidemiological
- Passive collection
- Naturally occurring events
- Sampling strategies
- Health sciences
Experimental Research
NATURALISTIC MOTORCYCLE RESEARCH

• What if we could watch
  • hundreds of riders of different types?
  • thousands of hours of riding?
• What if we could look in detail at
  • crashes and close calls?
  • Intersections
  • Curves
  • Traffic
Two Approaches through Research

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Naturalistic
- Epidemiological
  - Passive collection
  - Naturally occurring events
  - Sampling strategies
  - Health sciences

Crashes
Near-Crashes
Riding
Naturalistic Motorcycle Studies by VTTI

- 260 Participants
  - Over 750,000 miles
  - Over 85,000 trips
- Mileage in over 42 states
  - Riding in clear weather, rain, snow.
  - Various helmet laws
- Sport, touring, and cruising motorcycles.
  - Engine sizes from 250 cc to 1800 cc
MSF 100 Naturalistic Riding Study

• 100 Participants (72 male)
• Personal Motorcycles instrumented for between two months and two years.
• August 2011 through December 2013
• Age ranged from 21 – 79 years old
Data Acquisition

• 5 Camera views
• Machine vision lane tracker
• Accelerometers (3 axes)
• Gyro (3 axes)
• Forward radar
• Speed
• Turn signals
• Brake lever inputs
• GPS
• Continuous collection
• 8-12 mo capacity
• Cellular communication
How Much Did Riders Ride in the MSF 100?

• Riders combined for approximately 350,000 miles of travel over 8,776 hours in the saddle
• The average rider in the dataset rode 4,300 miles per year
  – Low of 89 miles
  – High of 16,228 miles
• Average trip covers 11.7 miles over 17.75 minutes with no differences between low and high frequency riders
They All Call Themselves Riders

- Frequent riders were found to ride, on average, 145 days per year.
- Infrequent riders were found to ride, on average 30 days out of the year.
- Range from two days to 306 days of riding per year
UNDERSTANDING CRASH RISK IN THE MSF 100

Crash: Any part of the bike or rider coming in contact with the ground that is not supposed to. Non pre-meditated roadway departures.
Near-Crash: Rider or another person has to act quickly to avoid a crash
CNC: A crash or a near-crash
10% of the Riders Account for Almost Half the Crashes

<table>
<thead>
<tr>
<th>CNC</th>
<th>Mean</th>
<th>Median</th>
<th>Std.</th>
<th>Mode</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count per participant</td>
<td>1.54</td>
<td>1</td>
<td>2.18</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Rate per 1000 Miles per participant</td>
<td>0.87</td>
<td>0.18</td>
<td>2.85</td>
<td>0</td>
<td>0</td>
<td>27.03</td>
</tr>
</tbody>
</table>

- 55 Riders had at least 1 CNC event
- Across the entirety of the sample participants averaged 1.5 CNC events per rider,
- When expressed as a rate, the average participant noticed a CNC rate of 0.87 per 1,000 miles traveled

<table>
<thead>
<tr>
<th>Riders in MSF 100</th>
<th>1%</th>
<th>2%</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>23%</th>
<th>34%</th>
<th>55%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Total CNCs</td>
<td>8.60</td>
<td>14.47</td>
<td>26.32</td>
<td><strong>42.76</strong></td>
<td>55.92</td>
<td>71.71</td>
<td>86.18</td>
<td>100</td>
</tr>
</tbody>
</table>

- More riders had more than one CNC than had only one
- 45 Riders had no CNC events
CNC Types in the MSF 100

- Rear-End Striking: 25.0%
- Side-impact, same direction: 15.0%
- Poor Curve Negotiation: 12.9%
- Other Vehicle Turn Across Path: 11.4%
- Head-On: 5.7%
- Animal Related: 5.0%
- Other Vehicle Turn into Path (Same...: 4.3%
- Other Vehicle Turn into Path (Same...: 4.3%
- Ground Impact while underway: 3.6%
- Pedestrian: 2.9%
- Road Departure: 2.1%
- Backing into Traffic: 2.1%
- Rear-end Struck: 1.4%
- Rider Turn into Path: 1.4%
- Other: 0.7%
- Bicycle: 0.7%
- Other Vehicle Straight crosses Rider...: 0.7%
Crash Types in the MSF 100

- Ground Impact-Low Speed: 56.7%
- Road Departure: 10.0%
- Other Vehicle Turn across Path: 10.0%
- Rear-End Striking: 6.7%
- Ground Impact-Underway: 3.3%
- Poor Curve Negotiation: 3.3%
- Rear-End Struck: 3.3%
- Other Vehicle Straight Across Path: 3.3%
- Rider Turns Into Path: 3.3%
Counts of CNC by Type

- Rear-End Striking: 35
- Sideswipe, same direction: 21
- Poor Curve Negotiation: 18
- Other Vehicle Turn Across Path: 16
- Head-On: 8
- Animal-Related: 7
- Other Vehicle Turn into Path (Opposite): 6
- Other Vehicle Turn into Path (Same): 6
- Ground Impact while underway: 5
- Pedestrian: 4
- Road Departure: 3
- Backing into Traffic: 3
- Rear-end Struck: 3
- Rider Turn into Path: 2
- Other: 1
- Bicycle: 1

- CNC
- Crash Only
### Scenarios with Increased Crash Risk

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>Odds Ratio</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure to this</strong></td>
<td>Exposure increases risk by this many times</td>
<td></td>
<td>compared to:</td>
</tr>
<tr>
<td>Intersection Influence</td>
<td>Yes, Uncontrolled</td>
<td>40.7</td>
<td>None</td>
</tr>
<tr>
<td>Intersection Influence</td>
<td>Yes, Parking lot, driveway entrance/exit</td>
<td>8.5</td>
<td>None</td>
</tr>
<tr>
<td>Intersection Influence</td>
<td>Yes, Traffic signal</td>
<td>2.9</td>
<td>None</td>
</tr>
<tr>
<td>Rider Behavior</td>
<td>Aggressive riding (only)</td>
<td>17.9</td>
<td>None</td>
</tr>
<tr>
<td>Rider Behavior</td>
<td>Lack of knowledge or skill/inattention (only)</td>
<td>9.3</td>
<td>None</td>
</tr>
<tr>
<td>Rider Behavior</td>
<td>Combination of behaviors</td>
<td>30.4</td>
<td>None</td>
</tr>
<tr>
<td>Pre-incident Maneuver</td>
<td>Maneuvering to avoid object</td>
<td>11.8</td>
<td>Going straight, constant speed</td>
</tr>
<tr>
<td>Surface Type</td>
<td>Gravel/Dirt road</td>
<td>9.4</td>
<td>Paved, smooth</td>
</tr>
<tr>
<td>Roadway Grade</td>
<td>Grade down</td>
<td>4.3</td>
<td>Level</td>
</tr>
<tr>
<td>Roadway Grade</td>
<td>Grade up</td>
<td>1.9</td>
<td>Level</td>
</tr>
<tr>
<td>Traffic Density</td>
<td>Unstable</td>
<td>3.6</td>
<td>Stable</td>
</tr>
<tr>
<td>Roadway Alignment</td>
<td>Curve right</td>
<td>2.1</td>
<td>Straight</td>
</tr>
</tbody>
</table>
CNC Take-Home

• 10% of riders account for nearly 50% of CNCs
• If you’ve had one, you’re more likely to have more than one
• Riders almost run into the back of another vehicle more often than any other CNC type
• Crash avoidance starts before the ride
  – Single-vehicle crashes are not uncommon
  – Crash risks for bad behaviors are additive
COMPARING CNC DECELERATION FOR MOTORCYCLISTS AND DRIVERS
Previous Work with Non Safety Critical Situations

• How is experience defined?
  – Novice
    • Less than 50000 lifetime miles
    • AND less than 2000 miles in the previous year.
  – Experienced
    • Less than 50000 lifetime miles
    • AND less than 2000 miles in the previous year.

• Using all decelerations, both safety critical and not
  – Experienced motorcyclists tended to be able/more comfortable braking harder when decelerating from surface street driving speeds.
  – There is no difference between experience levels when braking in Crash and Near Crash situations.
The Question

Do motorcyclists brake as hard as drivers during crashes and near-crashes?

• Motorcycles are inherently unstable
  – Requires three separate movements to successfully stop

• Passenger vehicles are:
  – Inherently stable
  – Only require a single movement to successfully stop
  – Often equipped with a variety of driver safety systems (ABS, ESC, etc.)
Definition of a Deceleration of Event

- Used CNCs where braking is an appropriate response
- Found average and peak deceleration for each event
The types of CNCs experienced by Riders and Drivers
Max Braking Decelerations - Near Crash

Max Event Decelerations for Near-Crashes

Deceleration (g)

- Driver
- Motorcyclist

Animal-Related
Opposite Direction
Pedestrian Related
Rear End, Striking
Sideswipe, Same Direction
Straight Crossing Path
Turn Across Path
Turn into Path (Opposite Direction)
Turn into Path (Same Direction)
Average Braking Decelerations-Near Crash

Average Event Decelerations for Crashes and Near-Crashes

- Driver
- Motorcyclist
Summary

• Previous work shows experienced riders brake harder than novices, but not in critical situations

• **Motorcyclists** appear to **not** brake as hard as drivers in near-crash situations.

• **Drivers** appear to out-brake riders in all but one scenario we looked at
ARE CURVES A RISK FACTOR FOR MOTORCYCLISTS
Event Types

• Single vehicle conflict - A crash\near-crash type involving only the participant rider.
  – Near Crash – taking a curve wide
    • Rider taking a right curve too wide and crossing the traffic divider.
      ─ Link
  – Crash – Run off the road
    • A rider leaving paved surface of the road or shoulder while negotiating a curve.
      ─ Link
Results

• Riders are 2.7 times more likely to be involved in a CNC in a curve than while on straight road segments.

• Novice riders are 3x more likely to have a single vehicle conflict in a curve than non-returning experienced riders.

• Riders are 15 times more likely to experience a single vehicle conflict in a curve when riding with one or more other motorcyclist than they are while riding solo.
OVERALL RESULTS
What the Data are Telling Us

• Riders do not accumulate experience at the same rate as drivers
• A small percentage of riders make up a large percentage of the problem
• Crash avoidance starts before the ride
• Experience lets a rider brake harder during normal riding, but not when it matters most
• Drivers stop harder than riders
• Riders are more likely to crash in curves with one or more other riders in a group than by themselves
Questions
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Thanks!