Simulator Study of Motorcycle Rider Braking Behavior

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Objectives

The objective of this study is to gain a better understanding of how non-expert motorcycle riders use their brakes in various emergency stopping and maneuvering situations.

• Which brakes do riders use in an emergency – front, rear, or both?

• Does braking behavior predict whether riders crash or not?

• Do rider factors of age, experience, motorcycle preference, and rider training influence braking behavior?
Experimental Design

• The Dynamic Research Inc. (DRI) driving simulator is a dynamically realistic, moving base, "driver-in-the-loop" research device.
• 68 male subjects completed two 30 minute runs, each involving 14 braking events categorized as traffic (braking not required), normal braking (.1 -.2g), urgent braking (.3 -.5g), or emergency braking (.55 - .7g).
• Two motorcycle frame types were used, i.e. sport-touring and cruiser.
• 39 km ride included a suburban portion (intersections every 760 m, posted speed 40 mph) and rural portion (intersections every 3050 m, posted speed 65 mph).
Motorcycle Frame Types

1987 Honda VFR700F and 2008 Harley-Davidson Sportster XL883 Custom

Scale: 2.75 in = 58 in

Handgrip Location

Front of Saddle

Footrest Location

Handgrip Fore-Aft

Footrest Fore-Aft

Handgrip Height

Saddle Height

Ground

Footrest Location wrt VFR:
- 23 inch forward
- 2.6 inch below

Handgrip Location wrt VFR footrest:
- 21 inch forward
- 26 inch above

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Motorcycle Frame Types
Imagery: Suburban Intersection
Simulator Vehicle Measures

- Rider steer torque and steer angle inputs
- Rider hand lever and foot pedal brake force inputs
- Corresponding front and rear wheel brake torques
- Corresponding front and rear longitudinal slip values
- Other hand and foot control inputs, such as clutch and shift lever
- Accelerator position
- Motorcycle pitch, roll, and yaw angles and angular rates
- Path angle
- Motorcycle lateral and longitudinal acceleration
- Forward speed
- Stopping distance
- Lateral lane deviation
- Position and motion of obstacle and other interacting vehicles
- Video recording of rider head, arms, and legs

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Rider Variables

- Time delay between the initial visual stimulus and the rider's initial control response (braking RT),
- Rise time (slope) of rider's initial control response,
- Peak control force of rider's initial control response,
- Peak control force overall,
- Duration of control input (time from initial control response to end of braking maneuver; either point at which control is released or speed goes to zero, whichever comes first),
- Mean control force over duration of control input,
- Mean square deviation of control force about the mean control force over the duration of control input,
- Energy spectrum (FFT) of the control input waveform providing a center frequency, spectral width, and perhaps a "spectral shape" metric.
## Rider Principal Components

<table>
<thead>
<tr>
<th>Rider Factors</th>
<th>Component</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
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<tr>
<td>Miles Ridden in 2008</td>
<td>.969</td>
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<tr>
<td>Group Riding Miles in 2008</td>
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<tr>
<td>Avg. Miles / Year 2006-2008</td>
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<tr>
<td>Age</td>
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<tr>
<td>Total Years Riding</td>
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<tr>
<td>Skill Rating</td>
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<tr>
<td>Ride Frequency Rating</td>
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<tr>
<td>Commuting Miles in 2008</td>
<td>.018</td>
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<tr>
<td>Aggressiveness Rating</td>
<td>.202</td>
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Simulator Study Findings

- In emergencies most riders used a combination of front and rear brakes. No rider used only the rear brake.
- In general, riders used a front brake bias. The remaining few riders mostly used the front brake only.
- The speed reduction at 2 seconds is a better predictor of collision than the total speed reduction; initial braking strongly determines the outcome (95% correct, $R^2=.859$).
- As more force is developed in either lateral or longitudinal axes there is a reduced capacity to produce force in the other.
- There were overall weak correlations between collision probability and rider factors. Rider Aggressiveness Rating was significant, but the correlation was low.
Simulator Study Conclusions

• Cruiser riders and sport touring riders have similar braking behavior, and neither is more or less likely to use only the rear brake in an emergency.
• Rider factors such as age, years experience, recent riding experience, etc. are not good indicators of probability of an in-path collision.

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