Exploring Human Factors: The MSF100 Motorcyclists Naturalistic Study

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The paper summarizes how naturalistic research studies can add to our understanding of the role of human factors in traffic safety outcomes. Motorcyclists make choices in the bikes they ride, the types of trips they take, when and where they ride, the reasons they ride, and the gear they wear, to name a few. The paper explores how these human choices can and do affect rider incidents and can inform the ongoing development of rider training systems.
Exploring Human Factors: The MSF100 Motorcyclists Naturalistic Study

Conducted by Virginia Tech Transportation Institute

New York Safety Summit October 2014
Preliminary results only
Human Factors in Traffic Safety

- The application of knowledge about human abilities, limitations, and other human characteristics to the design of equipment, tasks, and jobs.
- How drivers (riders) perform as a system component in the safe operation of vehicles.
- Driver (rider) performance is influenced by many environmental, psychological, and vehicle design factors.

NHTSA
Why Study Human Factors

- Fewer accidents
- Fewer near misses
- Reduced potential for human error and its consequences
- What is possible for humans acting within this traffic environment? What is not?
- What should be included in training? In vehicle design?
Naturalistic Study / Human Factors

- Not an experimental setting or a simulated environment
- Personally-owned motorcycles
- Unobtrusive instrumentation
- Participant-driven riding choices
- Continuous measurement (key on – key off)
- Not dependent on participant recall
- Varying skill levels, experience levels, personality types, motorcycle types
MSF100 Study Overview

- Recruited 100 riders
- Models represented market
- Instrumented personal motorcycles
- No further instructions or interactions
- Notify study sponsor if an incident occurred
- Small stipend for participation
- Ingest data into VTTI system
- Analyze DATA for DECADES!!
Number of Participants in Four Regions

- Irvine, California
  - Year-round riding
  - Mixed traffic densities
  - Geographic overlap with past m/c studies

- Blacksburg Virginia
  - Fall and Winter
  - Two-lane with hills and curves
  - Geographic overlap with automotive studies

- Phoenix, AZ
  - Sports bikes
  - No helmet law

- Orlando, FL
  - Conditioned helmet law
  - Mandatory training
  - Flat and straight roads

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Motorcycle Instrumentation

- 5 Video cameras
- Lane tracking
- Helmet / Gaze tracking
- Front and rear brake
- Accelerometers (3 axes)
- Gyro (3 axes)
- Speed
- Turn signals
- GPS
- Forward radar (speed to lead vehicle/object; distance to lead vehicle – up to 255)
- Continuous collection
- 8-12 month capacity
Instrumentation: Unobtrusive Integration
MSF100 Data Summary

- **Trips**
  - 38,581

- **Minutes of riding**
  - 568,700

- **Miles**
  - 363,000

- **Years (days of participation)**
  - 100.6

- **Data points**
  - At least 40 billion data points not including the video streams
Human Factors

“Static”
- Demographics
- Geographical
- Vehicle design

“Fluid”
- Rider abilities
- Rider judgment
- Rider choices – made moment-by-moment
- WHEN, WHERE, in WHAT Weather, at WHAT Time, with WHAT protective gear
Motorcycle Owners - National

- Median age: 45
- White (75%)
- Married (63%)
- $64,000 annual income
- Owns 1.4 motorcycles
- Educated (76% some college or more)
- Licensed (87%)
- Primary means of transport: 38%
- 3000 annual miles
- Not taken Rider Ed course (49%)

MIC 2012 Motorcycle/ATV Owner Survey

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MSF100 Sample: Age and Gender

- **Women**: 22%
- **Men**: 78%

**Bar Graph**
- Age Groups: 21-30, 31-40, 41-50, 51-60, 61-70, 71-80
- Participants distribution:
  - 21-30: 30%
  - 31-40: 20%
  - 41-50: 15%
  - 51-60: 25%
  - 61-70: 10%
  - 71-80: 5%
Geographic Factors: WHERE to ride
Motorcycle Types

- Touring: 38%
- Sport: 21%
- Cruiser: 41%

Motorcycle Type by Gender

- Male:
  - Touring: 97%
  - Sport: 65%
  - Cruiser: 66%

- Female:
  - Touring: 35%
  - Sport: 34%
  - Cruiser: 3%

<table>
<thead>
<tr>
<th>Engine Size</th>
<th>Touring</th>
<th>Cruiser</th>
<th>Sport</th>
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<tbody>
<tr>
<td>1600 cc</td>
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<td>250 cc</td>
<td>600 cc</td>
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<tr>
<td>1800 cc</td>
<td>650 cc</td>
<td>950 cc</td>
<td>1000 cc</td>
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</table>
Does Personality Matter?

- Looked at Bike Type
  - There don’t appear to be differences between bike types except for Touring bike riders had slightly lower levels on the Neuroticism Scale of the NEO-FFI
  - These measures may become more interesting when considered along with riding data.
Fluid Human Factors

- Motorcyclists make Choices
  - Some reduce / manage risk
  - Others increase risk
- Variation in rider choices
  - Frequency of trips
  - Time of day
  - Speed
  - Gear choices
- Reactions – Proactive Choices
Averages per trip

- Length of trip similar
- Time difference may be due to speed

![Graph showing averages per trip]
### High and Low Frequency Riders

<table>
<thead>
<tr>
<th></th>
<th>Trips</th>
<th>Mean</th>
<th>Minimum</th>
<th>Max</th>
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<td>Trips</td>
<td>722</td>
<td>361</td>
<td>1491</td>
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<td>Miles</td>
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<td>1,241</td>
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<td>Trips</td>
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<td><strong>Total</strong></td>
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<td>Miles</td>
<td>4,340</td>
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### Sample Descriptors: WHEN to ride

#### Trip and Participant Distribution

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Number of Trips</th>
<th>Percentage of Trips</th>
<th>Number of Participants</th>
<th>Percentage of Participants</th>
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<tbody>
<tr>
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<td>51</td>
<td>4.2%</td>
<td>16</td>
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<tr>
<td>Day</td>
<td>653</td>
<td>53.9%</td>
<td>46</td>
<td>100.0%</td>
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<tr>
<td>Twilight PM</td>
<td>219</td>
<td>18.1%</td>
<td>39</td>
<td>84.8%</td>
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<tr>
<td>Night</td>
<td>288</td>
<td>23.8%</td>
<td>36</td>
<td>78.3%</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1211</strong></td>
<td><strong>100%</strong></td>
<td><strong>1211</strong></td>
<td><strong>100%</strong></td>
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Rider Choices: Temperatures and Precipitation

Virginia
Florida
California
Arizona

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October 2014
Rider Choices: In WHAT Weather

- Location has strongest influence
- 95% of rides occurred between 50°F and 90°F
  - \( \bar{x} = 70°F \)
- Extreme warmest rides in data set
  - 2.5% of trips between 90°F and 109°F
- Extreme coldest rides in data set
  - 2.5% of trips 50°F and 15.8°F
- 3% of trips at time of nearby precipitation.

Future: Analysis of extremes
Rider Choices: Mean of Mean, Mean of Max Trip Speed

Mean of Mean Trip Speeds: 31.4 mph

Mean of Max Trip Speeds: 60.2 mph
No significant differences:

Mean or Max

Four participants were recorded riding at speeds in excess of 140 mph, some of them multiple times.
Rider Choices: Protective Gear

- Five video views (rider’s face, forward, rear, left, right)
- Video review to characterize rider clothing
  - Torso clothing / apparel
  - Helmet
  - Gloves
  - Eyewear
- Reductionist coded conditions that existed for most of the trip
Percentage of Participants Observed Wearing Each Clothing Type

Percentage of Participants

Clothing (Torso) Type

- Full Jacket Zipped, Non-leather
- Full Jacket Zipped, Leather
- Shirt, Short-sleeved or Tank
- Shirt, Long-sleeved
- Partial Jacket/Vest Zipped, Non-leather
- Partial Jacket/Vest Unzipped, Leather
- Full Jacket Unzipped, Leather
- Unknown
- Other Categories
Protective Gear Choices are Fluid

- Wide variation in torso clothing
  - 93% of riders at some point wore full zipped jackets
  - 67% at some point wore short-sleeved shirts or tank tops
Promising Practices

- Helmet usage, even in states with no helmet law, was common
  - 78% of participants always wore helmets; no participant was always without a helmet
  - Only 4 out of the 10 riders based in states with no helmet law were observed at some point without a helmet
  - Could be sample bias
Baseline: Intersection Glance Behavior

- **Looking forward**
  - Riders look forward the majority of the time
  - All traversals include time looking forward
  - 85% of time through the intersection was spent looking forward

- **Looking to the sides (duration .87 sec)**
  - 51% of intersections show rider looking LEFT
  - 40% looking RIGHT

- **Checking mirrors – 30%**

- **Looking behind - negligible**
Summary

- Further analysis will tell us whether these choices resulted in overall safer or less safe riding outcomes.
- Complex data set requires layered approach
- Many more will be coming.
  - Over the next many years. e.g., The 100 Car Study was conducted in 2003/2004 and still being used to answer research questions.
Training Systems Development

Crashes
Near-Crashes

Critical Incidents

Baseline

Crash Causation
Human Factors
Traffic Safety
Motorcycle Safety
Learning

Gross Skills
Finer Skills
Incidents: A Key to Human Factors

- Understanding loss of control sequence
- 23 crashes involving 19 riders
- 16 single vehicle
  - 15 were “tip overs” – slow speed, not underway
  - Only 1 single vehicle crash was at speed
- 7 other vehicles (OV) + study vehicle (SV)
  - 2 rear end
  - 4 OV turns into path of SV
  - 1 track-based crash
- Left turning OV
- Pedestrian
- Well trained rider

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<th>seconds</th>
<th>mph</th>
<th>kph</th>
<th>ft</th>
<th>m</th>
<th>TTC (s)</th>
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</thead>
<tbody>
<tr>
<td>POV begins LTAP</td>
<td>112.784</td>
<td>41.6</td>
<td>66.9</td>
<td>214</td>
<td>65.1</td>
<td>3.7</td>
</tr>
<tr>
<td>POV brakes in lane</td>
<td>114.800</td>
<td>40.3</td>
<td>64.8</td>
<td>98</td>
<td>29.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Rider lets go of left handlebar</td>
<td>116.388</td>
<td>33.6</td>
<td>54</td>
<td>20</td>
<td>6.1</td>
<td>0.6</td>
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</tbody>
</table>
# Rear-End Crash – Step by Step

<table>
<thead>
<tr>
<th>Action</th>
<th>seconds</th>
<th>accel_x g</th>
<th>speed mph</th>
<th>speed kph</th>
<th>range ft</th>
<th>range m</th>
<th>TTC (s)</th>
<th>HDW (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2g braking starts</td>
<td>304.510</td>
<td>-0.064</td>
<td>24.27</td>
<td>39</td>
<td>110</td>
<td>33.4</td>
<td>-33.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Gaze returns forward</td>
<td>307.647</td>
<td>-0.099</td>
<td>26.39</td>
<td>42.41</td>
<td>88</td>
<td>26.7</td>
<td>5.3</td>
<td>2.3</td>
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<tr>
<td>SV decel starts</td>
<td>308.982</td>
<td>-0.061</td>
<td>26.39</td>
<td>42.41</td>
<td>59</td>
<td>18.1</td>
<td>2.6</td>
<td>1.5</td>
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<tr>
<td>Max SV decel (-0.52g)</td>
<td>309.850</td>
<td>-0.520</td>
<td>26.03</td>
<td>41.83</td>
<td>42</td>
<td>12.8</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Impact from following vehicle</td>
<td>312.120</td>
<td>0.548</td>
<td>11.65</td>
<td>18.72</td>
<td>19</td>
<td>5.7</td>
<td>9.6</td>
<td>1.1</td>
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<tr>
<td>Peak accel from impact</td>
<td>312.320</td>
<td>1.041</td>
<td>11.65</td>
<td>18.72</td>
<td>19</td>
<td>5.9</td>
<td>3.3</td>
<td>1.1</td>
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**Front**

- LV 0.2g braking starts
- Gaze returns forward last time
- SV decel starts
- Max SV decel (-0.52g)
- Impact from following vehicle
- Peak accel from impact

**Rear**

- Clutch
- Throttle/Brake
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<tr>
<th>Action</th>
<th>seconds</th>
<th>accel_x</th>
<th>speed</th>
<th>range</th>
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Front | Rear

Clutch | Throttle/Brake
<table>
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<tr>
<th>Action</th>
<th>seconds</th>
<th>accel_x (g)</th>
<th>speed (mph)</th>
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Questions?

swilliams@msf-usa.org
Instrumentation: Unobtrusive Integration