Naturalistic Driving Assessments of Driver Distraction and Fatigue

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First on-road assessment of in-vehicle navigation: 1984
Overview: VTTI Research Centers

Research Centers
- Center for Automotive Safety Research
  • Jon Hankey, Director
- Center for Infrastructure Safety
  • Ron Gibbons, Director
- Center for Truck and Bus Safety
  • Rich Hanowski, Director
- Center for Sustainable Mobility
  • Hesham Rakha, Director
- Center for Product Development
  • Mike Mollenhauer, Director
- Center for Technology Development
  • Andy Petersen, Director
- Center for Sustainable Roadway Infrastructure
  • Gerardo Flintsch, Director
- Center for Infrastructure Sensing Technology
  • Linbing Wang, Director

Research Collaborations
- Transportation Policy Group
  • Ray Pethtel, Leader (Outreach)
- Center for Injury Biomechanics
  • Warren Hardy, Director (ME)
- Virginia Institute for Performance Engineering and Research
  • Steve Southward, Director (ME)
VT/VTTI Facts

- VT is a larger US university: Approximately 30,000 students
- VT has the 8th largest college of engineering in the US: 350 faculty
- VTTI is VT’s largest research enterprises
  - Almost 350 faculty, staff and students/over 70 projects
  - Large supporter of both undergraduate and graduate students (100-120 depending on time of year)
- VTTI has grown to become the 2nd largest U.S. Transportation Research Institute
- We believe that VTTI has the largest group of driving safety researchers in the world (approximately 200)
Research Impact

VTTI conducts research that has a measurable impact on US National Transportation Policy

- Driver distraction
- Truck driver fatigue
- Connected vehicle safety apps
- Night visibility enhancement
- Intersection crash avoidance
- Teen driving safety
- Evaluation of ITS technologies
- Evaluation of in-vehicle systems
- Transportation policy effects
Data Acquisition System
Data Acquisition System Overview

• Multiple Videos
• Machine Vision
  – Eyes Forward Monitor
  – Lane Tracker
  – Driver ID (post hoc)
• Accelerometer Data (3 axis)
• Rate Sensors (3 axis)
• GPS
  – Latitude, Longitude, Elevation, Time, Velocity
• Forward Radar
  – X and Y positions
  – X and Y Velocities
• Cell Phone
  – ACN, health checks, location notification
  – Health checks, remote upgrades

• Illuminance sensor
• Infrared illumination
• Passive alcohol sensor
• Incident push button
  – Audio (only on incident push button)
• Turn signals
• Vehicle network data
  – Accelerator
  – Brake pedal activation
  – ABS
  – Gear position
  – Steering wheel angle
  – Speed
  – Horn
  – Seat Belt Information
  – Airbag deployment
  – Many more variables…
VT TI Machine Vision Lane Tracking:
VTTI Driver Monitor used for drowsiness detection
(post hoc, compressed video sample)
A New Method of Study: Naturalistic Driving Studies of Crash/Near Crash Risk
Why develop a new methodology?

• Human performance and behavior contribute to over 90% of vehicular crashes.

• A subset of these behaviors create the majority of the crash risk.
  – impairment (primarily alcohol)
  – inattention and distraction
  – drowsiness
  – judgment-related error

• Current methods of studying driver performance/ behavior and their safety impacts have limitations.
  – Frequency of use, conditions of use, and factors in the larger context of driving are key elements of risk which are not observable.
  – Detailed pre-crash information is not available from crash databases.
Why Monitor Drivers Directly?

To Supplement Police Accident Reports and other Data

Well meaning, nominally trained police officers coming upon a scene is the source of much of our data

- Vehicles have often been moved
- Drivers/Passengers may be deceased or injured
- Drivers/Passenger are almost always dazed
- Pre-crash events happen so fast key elements are forgotten by driver/passenger and left out by witnesses
- Drivers are often trying to avoid prosecution or embarrassment
Driving Safety Research Approaches

- Epidemiological Studies
- PARs
- Simulation
- Test Track
- Lab Experiment

- Missing Piece?
Overview of Light Vehicle NDS at VTTI
• In these studies, drivers are not given any instructions and often there are also no specific evaluations.
• Studies capture a large number of crash events, there has yet to be a single study large enough to capture a statistically significant number of crashes.
• To overcome this limitation several studies have utilized “near crashes” in combination with crashes.
• Near crashes, in this case, are defined as having all of the elements of a crash with the exception that the driver implements a successful evasive maneuver.
• Since the success of an evasive maneuver depends upon factors such as timing and skill, it has been hypothesized that near crashes are predictive of crashes.
• Several studies over the past 15 years have used near crashes as safety surrogates.
• The 100 Car Study showed that near crash involvement is correlated with crash involvement across differing drivers.
• There is a growing body of evidence that combining crash and near crash events provides a valid measure of overall crash risk.
Event Pyramid

- Crashes
- Near Crashes
- Safety-Related Incidents

x10
Analysis Approach

• Data analyses were conducted utilizing the “100 car”, 40 teen and several heavy truck naturalistic driving databases.
• These data were specifically analyzed for the purpose of assessing relative crash/near crash risk.
• From these data, an “event” database of crashes and near crashes was created with over 1,000 crashes, minor collisions and near crashes.
• These data were also used to develop a “non-event” or baseline database to assess exposure.
VT High Performance Computing Center: 1.0 Petabytes + 100 Teraflops dedicated to VTTI
Odds Ratios

<table>
<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Non-Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Baseline</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Point Estimate Odds Ratio_{E} = (A_{E}/C_{E})/(B_{E}/D_{E})
Key Findings

• 10% of drivers create roughly 50% of the crash risk.
  – True for both light and heavy vehicles.
  – Opportunity for driver monitoring for populations under administrative rule (e.g., truck drivers and teens)

• Distraction and inattention are greatly under estimated as a crash causal factor.

• However, If you are awake and looking at something you almost never hit it.
  – Where is cognitive distraction?

• Teens are involved in crashes/near crashes while distracted four times more often than adults.
  – A rising epidemic?

• Fatigue is a much larger (i.e., 20%+) crash risk problem than previously thought.
  – True for both light and heavy vehicles.
100 Car Study Results

The graph shows the frequency of crashes and near crashes per million vehicle miles traveled (MVMT) for three categories of drivers: Safe Drivers, Moderately Safe Drivers, and Unsafe Drivers. The x-axis represents the drivers, while the y-axis represents the frequency of crashes and near crashes per MVMT. The graph displays the median and mean values for each category.
Inattention-Related Relative Crash/Near Crash Risk Estimates (Odds Ratio 0-2)

- Talk/Listen Hand-Held: 0.79
- Adjust Radio: 0.6
- Using CD, Radio, Climate Control: 0.94
- All Hygiene: 1.25
- Drinking: 1.27
- Teen Passenger: 1.54*
- Eating: 1.6
- Adjust Instrument Panel: 1.25
- Check Speedometer: 0.32*
- Talk/Listen to Hands-Free Phone: 0.44*
- Interact Occupant(s): 0.35*
- Talk/Listen to CB: 0.55*
- Look Outside of Vehicle: 0.54*

*Statistically Significant (Note protective effects when OR estimate <1.0)
Are Naturalistic Driving data on cell phone conversations inconsistent with crash data?

What one would expect the crash rate to be from the growth of cell phones if conversation imposed substantial risk:

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>vehicle miles traveled (100 millions)</td>
<td>29,740</td>
</tr>
<tr>
<td>number of police reported crashes (total)</td>
<td>5,811,000</td>
</tr>
<tr>
<td>Actual rate of crashes per 100mvmt</td>
<td>195.34</td>
</tr>
<tr>
<td>Predicted CR per 100mvmt if 10% cell and 4x</td>
<td>254.01</td>
</tr>
<tr>
<td>Predicted CR per 100mvmt if 10% cell and 7x</td>
<td>312.63</td>
</tr>
</tbody>
</table>
Cell Phones Trends and Crash Rates

Police Reported Crash Rates and Wireless Subscription Growth
1988-2008

Sources: Traffic Safety Facts, DOT HS 811 002, NHTSA, 2007
CTIA, ANNUALIZED WIRELESS INDUSTRY SURVEY RESULTS - DECEMBER 1985 TO DECEMBER 2008
Inattention-Related Relative Crash/Near Crash Risk Estimates (Odds Ratio 4-6)

- Locating/Reaching/Answering 4.68*
- Reaching for In-Vehicle Object 4.99*
- Dialing Hand-Held Device 5.95*
- Personal Grooming 4.48*

*Statistically Significant
Inattention-Related Relative Crash/Near Crash Risk Estimates (Odds Ratio Greater than 6)

- Moderate Fatigue 6.2*
- Reaching for Moving Object 8.8*
- Look at Paper Map 7.02*
- Write on Pad, Notebook, etc. 8.98*
- Use/Reach for Electronic Device 6.72*
- Use Calculator 8.21*
- Interact w/Look at Dispatching Device 9.93*
- Text Message on Cell Phone 23.24*

*Statistically Significant
**Key Findings: What we know is NOT true**

- Talking on a cell phone is worse than driving drunk.
- Since a cell phone conversation happens outside of the driving context, it is *substantially* more dangerous than a conversation with a passenger.
- Truck drivers can use fully functional Mobile Data Terminals because they are highly trained professionals.
  - That is, no one can drive safely and type, text, read or dial.
- “Headset” use with a conventional cell phone is significantly safer than “hand-held” use.
  - The primary risk of either method is manual answering, dialing, and other tasks that require eyes to be off the road.
**Key Findings: What we know is NOT true**

- Teens can text and drive because they are highly trained texting experts.
- Teens primarily have higher crash risk because they lack knowledge, skills and abilities.
  - Teens drive just like their parents when their parents are present.
- Fatigue is only a heavy truck, long trip and/or truck issue
Low Rates of Elevated G-Force Event Rates With Adult Passengers

Simons-Morton et al., Journal of Adolescent Health, in press
VTTI Results Summary

- Driving is a visual task and non-driving-related, visually-demanding tasks should always be avoided.
  - Includes hand-held cell phone texting and dialing, nomadic MP3 manipulation, and internet access, among others.

- Texting, typing, reading, and dialing have the potential to create a true crash epidemic as highly capable nomadic devices continue to rapidly grow in popularity.

- “Headset” use with a conventional cell phone is not substantially safer than “hand-held” use.
  - The primary risk of either method is manual answering, dialing, and other tasks that require eyes to be off the road.
VTTI Results Summary

• “True hands-free” voice activated systems are less risky.
  – Must be designed well enough so the driver does not have to divert visual attention away from the driving task for long periods.
• Teens engage in complex, non-driving tasks much more frequently, and in riskier situations, than adults.
Recommendations

• A primary law banning the use of hand-held, wireless devices in a moving vehicle is required. The law should:
  – Preclude manual use of: Cell phones, MP3 players, Blackberry, iphone, etc., and headset use with conventional cell phones
  – Exclude “true-hands-free” and in-vehicle devices that are simple to operate and do not require substantial “eye-off-road time”
  – Carry a significant monetary fine and “points”
  – Include a total cell phone ban for newly-licensed teens and for special cases like school buses
  – Exclude emergency communications for all users
Recommendations

• A regulation limiting functionality of visually-demanding, in-vehicle devices in a moving vehicle is necessary.
  – Includes manual destination entry and all “keyboard” tasks
  – Includes all complex reading tasks
• Standards for testing of potentially distracting devices prior to market introduction need to be broadly applied.
Questions?
Thanks!