Driver Distraction and Using Technology to Improve Transportation Safety

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AAMVA AIC
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Overview

- What is Driver Distraction
- Investigating Driver Distraction with Naturalistic Driving Research
- Mitigating Driver Distraction with Technology
Distracted Driving

• Any non-driving activity engaged while operating a vehicle (www.distraction.gov)
  – Activities that prevent/interfere with the primary task of driving and increase the risk of a crash

• 3 main types of distraction
  – Visual — taking your eyes off the road
  – Manual — taking your hands off the wheel
  – Cognitive — taking your mind off of the driving task

• 60% of all crashes are associated with some form of distraction
How Might Activities Increase Risk?

- To drive safety, drivers must do three things:
  1. Perceive.
  3. Respond.
How Might Activities Increase Risk?

• To drive safety, drivers must do three things:

  1. Perceive.  *Taking eyes off road* prevents perception
  2. Process.  *Activity engagement* interferes with processing
  3. Respond.  *Holding/reaching* prevents/interferes with response
How Might Activities Increase Risk?

- In processing, drivers have a finite amount of attention.

- Attention must be given to the road to drive safely:
  - operational, tacit, and strategic.

- For the most part, driving does not demand drivers’ complete attention:
  - Drivers therefore feel comfortable using their residual attention to engage in other activities.
  - Comfort/safety reinforces behavior.
How Might Activities Increase Risk?

• However, driving task demands constantly change

• Crash risk may increase when a spike in driving demands exceeds the attention that’s been allocated to driving

• Drivers engaged in non-driving activity may have less residual attention available to handle “spikes” in driving difficulty
Investigating Driver Distraction
Naturalistic Driving Approach

• *In Situ* investigation of driver behavior and performance
  – Participants use an instrumented vehicle
    • Data is collected from sensors and unobtrusive video cameras
  – No experimenter present; no specific instructions
  – Data continuously collected for an extended period
  – Over 600 drivers and 7 million miles
  – Collect information on unsafe and routine driving
    • Fills the gap in current data collection methods
Naturalistic Driving Approach

- Example Crashes (Please do not take pictures or videos)
  - Rollover crash
  - 100-car Run of Road Crash
  - Truck lane change crash
  - Truck lane change near-crash
Naturalistic Driving Approach

- Instant replay of what driver, vehicle, and environment did in the seconds prior to a safety critical event

- Also record what drivers do when not in a crash, i.e., baseline driving
Naturalistic Approach and Driver Distraction

- Two large scale heavy vehicle naturalistic driving studies were performed by VTTI

- 4,452 safety-critical events (SCEs) were found
  - 21 crashes, 197 near-crashes, 3,019 crash-relevant conflicts, and 1,215 unintentional lane deviations

- 19,888 baseline epochs (non-events) of normal driving were randomly selected

- The prevalence of specific non-driving behaviors were examined in both datasets
Examples

- Reaching
- Texting
- Dispatching
- Look at Map
- CB Talking
- Hand-Held Phone Talking
Naturalistic Approach and Driver Distraction

• If a specific behavior occurred more frequently in the SCE dataset than in the baseline driving dataset
  — Then it may be said that this behavior contributed to the occurrence of the SCEs

• Estimate the relative risk of a behavior by computing the odds ratio
  — Odds > 1 → increased risk
  — Odds = 1 → no increased risk
  — Odds < 1 → decreased risk
## Naturalistic Approach and Driver Distraction

<table>
<thead>
<tr>
<th>Task</th>
<th>Odds Ratio</th>
<th>LCL</th>
<th>UCL</th>
<th>Frequency of Safety-Critical Events</th>
<th>Frequency of Baselines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text message on cell phone</td>
<td>23.24</td>
<td>9.69</td>
<td>55.73</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>Interact with/look at dispatching device</td>
<td>9.93</td>
<td>7.49</td>
<td>13.16</td>
<td>155</td>
<td>72</td>
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<tr>
<td>Write on pad, notebook, etc.</td>
<td>8.98</td>
<td>4.73</td>
<td>17.08</td>
<td>28</td>
<td>14</td>
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<tr>
<td>Use calculator</td>
<td>8.21</td>
<td>3.03</td>
<td>22.21</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Look at map</td>
<td>7.02</td>
<td>4.62</td>
<td>10.69</td>
<td>56</td>
<td>36</td>
</tr>
<tr>
<td>Dial cell phone</td>
<td>5.93</td>
<td>4.57</td>
<td>7.69</td>
<td>132</td>
<td>102</td>
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<tr>
<td>Talk or listen to hand-held phone</td>
<td>1.04</td>
<td>0.89</td>
<td>1.22</td>
<td>195</td>
<td>837</td>
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<tr>
<td>Talk or listen to hands-free phone</td>
<td>0.44</td>
<td>0.35</td>
<td>0.55</td>
<td>91</td>
<td>901</td>
</tr>
<tr>
<td>Talk or listen to CB radio</td>
<td>0.55</td>
<td>0.41</td>
<td>0.75</td>
<td>50</td>
<td>399</td>
</tr>
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Study limitations were as follows:

- *Relatively* few crashes
- *Relatively* few drivers/trucks/miles
- FMCSA-funded study using DriveCam data was conducted to address these limitations
  - 13,305 vehicles (trucks and buses)
  - 1,085 crashes; 39,036 near-crashes and events
  - 211,171 baselines
## DriveCam Distracted Driving Study

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<tr>
<td>Text message on cell phone</td>
<td>163.59</td>
<td>51.77</td>
<td>516.73</td>
<td>90</td>
<td>3</td>
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<tr>
<td>Reaching for cell phone</td>
<td>3.74</td>
<td>2.97</td>
<td>4.71</td>
<td>128</td>
<td>178</td>
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<tr>
<td>Reaching for headset/earpiece</td>
<td>3.38</td>
<td>2.64</td>
<td>4.31</td>
<td>104</td>
<td>168</td>
</tr>
<tr>
<td>Dialing cell phone</td>
<td>3.51</td>
<td>2.89</td>
<td>4.27</td>
<td>165</td>
<td>256</td>
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<tr>
<td>Any cell phone use</td>
<td>1.14</td>
<td>1.06</td>
<td>1.23</td>
<td>895</td>
<td>4,262</td>
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<tr>
<td>Consuming food or drink</td>
<td>1.11</td>
<td>0.97</td>
<td>1.26</td>
<td>268</td>
<td>1,320</td>
</tr>
<tr>
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Naturalistic Approach and Driver Distraction

• Also studied automobile drivers

• Analysis of 100-Car light vehicle naturalistic driving study
  – 109 cars
  – 12 to 13 months per car
  – 69 crashes; 761 near-crashes, 8,295 incidents
  – 20,000 6-second baselines

• Texting
• Dialing
<table>
<thead>
<tr>
<th>Type of Secondary Task</th>
<th>Odds Ratio</th>
<th>Lower CL</th>
<th>Upper CL</th>
</tr>
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<tbody>
<tr>
<td>Reaching for a moving object</td>
<td>8.8</td>
<td>2.5</td>
<td>31.2</td>
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<tr>
<td>Looking at external object</td>
<td>3.7</td>
<td>1.1</td>
<td>12.2</td>
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<tr>
<td>Reading in vehicle</td>
<td>3.4</td>
<td>1.7</td>
<td>6.5</td>
</tr>
<tr>
<td>Applying make-up</td>
<td>3.1</td>
<td>1.3</td>
<td>7.9</td>
</tr>
<tr>
<td>Dialing hand-held device</td>
<td>2.8</td>
<td>1.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Inserting/retrieving CD</td>
<td>2.3</td>
<td>0.3</td>
<td>17.0</td>
</tr>
<tr>
<td>Eating</td>
<td>1.6</td>
<td>0.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Reaching for non-moving object</td>
<td>1.4</td>
<td>0.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Talking/listening to hand-held device</td>
<td>1.3</td>
<td>0.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Drinking from open container</td>
<td>1.0</td>
<td>0.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Other personal hygiene</td>
<td>0.7</td>
<td>0.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Adjusting radio</td>
<td>0.6</td>
<td>0.1</td>
<td>2.2</td>
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<td>Passenger in adjacent seat</td>
<td>0.5</td>
<td>0.4</td>
<td>0.7</td>
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<td>Passenger in rear seat</td>
<td>0.4</td>
<td>0.1</td>
<td>1.6</td>
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<td>Combing hair</td>
<td>0.4</td>
<td>0.1</td>
<td>2.7</td>
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<td>Child in rear seat</td>
<td>0.3</td>
<td>0.04</td>
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“Vision is King”

Point Estimate Odds Ratio

Mean Duration of Eyes off Forward Roadway (sec)

- Text message on cell phone
- Write on pad, notebook, etc.
- Use calculator
- Look at map
- Dial cell phone
- Other
- Interact with/look at dispatching device
- Use/reach for other electronic device
- Personal grooming
- Reach for object in vehicle
- Look back in Sleeper Berth
- Other
- Simple
- Other
- Moderate
- Personal grooming
- Reading book, newspaper, paperwork, etc.
- Put on/remove/adjust sunglasses
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What About Other Research?

• The National Safety Council summarizes multiple studies that conclude talking while driving is dangerous

• Studies found that drivers while talking had:
  – Longer brake response times of 130 ms - 250 ms
    • Stemming from delays in information processing
  – Did not scan their mirrors as much
  – Reduced their speed
  – Failed to detect objects in the environment
What About Other Research?

• However, disbenefits not observed in crash datasets
  – The jury is therefore still deliberating on cognitive distraction

• What could be going on?
  – Drivers may brake harder to avoid a crash
  – Drivers may not change lanes as much
  – Drivers may increase the headway to a lead vehicle

• Regarding failure to detect objects while talking
  – Studies asked drivers after their trial was over if they remembered seeing an object. This is not the same as failing to see an object
  – Driver may fail to see objects in the periphery though!

• Research needs to address how drivers adapt over time
Mitigating Driver Distraction
Mitigating Driver Distraction

- Educate drivers on dangers of driver distraction
- Ban texting/manual dialing
- Ban all cell phone use for novice drivers
- Tough enforcement required
  - Study found crash reduction in NY counties that had strict enforcement of texting ban
- But can technology help?
Role of Technology

• Personnel subsystem components arranged serially
  – Driver is the only component that can perceive, decide, and initiate driving response for a vehicle
  – Total Reliability = R1 x R2 x R3 x ... x Rn
  – Total reliability always below weakest link
    • Driving task demands can exceed driver capabilities
    • Driver error accounts for 45% - 75% of roadway crashes

• Technology can increase system reliability by arranging components in parallel to driver functions
  – Both driver and vehicle sensors can perceive threats
  – Both driver and algorithms can decide responses
  – \( RT = 1 - (1-R1)(1-R2)(...)(1-Rn) \)
  – Total reliability always greater than most reliable component
  – Key is for driver reliability to not degrade with additional components
  – e.g., Driver reliability dependent on trust in technology
Role of Technology

• Driver Assistance Systems
  – Travel advisory systems to improve driver expectation
    • Route selection, road and weather conditions
    – Indirect viewing systems to improve spatial awareness
    – Collision warning systems to direct attention to crash threat
    – Collision avoidance systems to initiate avoidance if driver fails to

• Driver-Optimized Interfaces
  – Needed to safely deliver information and mitigate distraction

• Workload Management Systems
  – Needed to adjust/deactivate technological components when
    driving task demands are high

• Distraction + Drowsiness Monitoring Systems
  – Alert driver when he is distracted/drowsy

• Combination of Efforts
  – Increase total system reliability
Driver Assistance Systems

Collision Avoidance Systems
Other Driver Assistance Systems

- Camera/Video Imaging Systems
- Help drivers monitor blind-spots around tractor-trailer
Driver-Optimized Interfaces

Voice-Control Interfaces
HMI to Combat Driver Distraction

• Research currently investigating utility of driver-optimized interfaces to mitigate distraction

• **Voice-Control Interface Example**
  – Reduce task complexity
  – Allow drivers to maintain eyes on road and hands on wheel

• US DOT producing guidelines for:
  – Auditory Interfaces (2012)
  – Portable Devices (2013)
Workload Management Systems

Adjust Amount of Information Presented to Drivers
Workload Management Systems

• Use sensors and algorithms to make real-time calculations of the difficulty of the driving situation
  – Suppress display of additional information or prioritize presentation of information
  – This limits the amount of information displayed

• e.g., if a driver is in heavy traffic, in the rain, or on a curvy road
  – An incoming phone call could be automatically routed to voice mail
Distraction Monitoring Systems

Detect when drivers’ eyes are off the road
Distraction Monitoring Systems

- Glances off forward roadway totaling more than 2 seconds increase crash risk

- Machine vision technology can automatically detect when drivers’ eyes are off the forward roadway

- Can alert drivers to return gaze to roadway
Conclusion

• Driver distraction is a prevalent contributing factor in light vehicle and heavy vehicle operations
  – High risk tasks had high eyes off road time
  – Talking/listening tasks (i.e., assumed cognitive distraction) were not nearly as risky as visually intensive tasks
  – Some of these tasks indicated a protective effect

• Countermeasures should not be limited to education, training and PSAs
  – Need policy and legislation
  – Tough enforcement
Conclusion

• and technology:
  – Driver assistance systems
  – Driver-optimized interfaces
  – Workload management systems
  – Distraction + drowsiness monitoring systems

• Combining approaches may reveal that technology in vehicles is not the problem
  – But rather, how the driver interfaces with the technology is the problem

• This is the issue facing the Human Factors Engineer