The Science and Politics of Cell Phones and Driver Distraction

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Ford Motor Company
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Key Points

- A growing number of drivers are using hand-held electronics while driving.

- Driver distraction is a real concern, though available data indicate that it is a smaller part of the highway safety problem than commonly believed.

- “Naturalistic” real-world driving research indicates that visual distraction – or looking away from the road – is the main contributor to crashes.

- Cognitive distraction plays less of a role in crashes and near miss events.

- Bans on hand-held cell phones and texting with hand-held devices are consistent with the latest research.

- Many studies show that hands-free, voice-based interfaces offer advantages over hand-held.
Crash Statistics and Wireless Device Use

Wireless subscriptions have increased exponentially, but vehicle crash rates have fallen year-over-year.

Cell Phones Up, Crash Rates Down

Sources: Traffic Safety Facts, DOT HS 811 002, NHTSA, 2007
CTIA, ANNUALIZED WIRELESS INDUSTRY SURVEY RESULTS - DECEMBER 1985 TO DECEMBER 2008
Epidemiological Studies of Cellphones and Driving Safety

Case-Crossover Method is not the “gold standard” of cell phone epidemiology.

Redelmeier & Tibshirani (N.E.J.M., 1997): Case-Crossover Methodology

<table>
<thead>
<tr>
<th>Hazard period [T-10 to T-1]</th>
<th>Control day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On telephone</td>
</tr>
<tr>
<td>Day of crash</td>
<td></td>
</tr>
<tr>
<td>On telephone</td>
<td>13</td>
</tr>
<tr>
<td>Not on telephone</td>
<td>24</td>
</tr>
</tbody>
</table>

Risk Ratio (RR) = 157/24 = 6.5
CI (4.50, 9.99)

Adjusted* RR = (0.65)*6.5 = 4.3
CI: (3.0, 6.5)

* Adjustment for intermittency of driving: Only 65% of a survey of 100 participants drove during the selected control period.
Some Problems with the Case-Crossover Design

- Misclassification bias due to uncertainty in collision times
- Intermittency in Driving & recall bias
- Sampling Bias

Bellavance (2005) compared cell phone records (exact) & police records (inexact) for N = 104 cases. He found 61% of emergency calls were made BEFORE the reported collision time.


- **Participants**: N= 36,077
  - Cell phone Users:
    - Males: 9352; Female: 3339
  - Non-cell phone users:
    - Males: 13590; Female: 9797
- **Method**:
  - **Two Cohorts Design** (2 groups)
  - Data sources: SAAQ questionnaire; driving records; cell phone call details
- **Analysis**:
  - Odds Ratio (OR) of having at least 1 crash in a given year calculated for cell phone users relative to non-users
- **Results**:
  - Risk is 1.38 higher for cell phone users
  - Risk ratio drops to 1.11 (CI: 1.02, 1.22) for men and 1.21 (CI: 1.03, 1.40) for women when other factors (e.g., miles driven) are taken into account
  - A dose-response relationship was found between frequency of cell phone use and crash risk
    - Heavy Use: Over twice baseline
    - Minimal use: Similar to baseline

All collisions (PDO & injuries)
- men: **adj. OR = 1.11**; 95% C.I. (1.02; 1.22)
- women: **adj. OR = 1.21**; 95% C.I. (1.03; 1.40)

Collisions with injuries only
- men: **adj. OR = 1.10**; 95% C.I. (0.93; 1.30)
- women: **adj. OR = 1.30**; 95% C.I. (1.00; 1.70)
Recent Naturalistic Data and Results

Visual distraction, not cognitive distraction, is the main contributor to crash and near-crash involvement. Drivers choose to act when driving demand is low.

VTTI 100-Car and Other Large-Scale Naturalistic Driving Studies

- Sophisticated instrumentation w/video
- Drivers own cars/trucks; No specific instructions
- Over 600 drivers; 4 to 18 months each
- Over 100,000 hours of driving
- Over 7 million miles of data collection

Sponsors: FMCSA; NHTSA; NIH; and the National Center for Surface Transportation Safety Excellence; a consortium of FHWA, VDOT, GM, and Virginia Tech
Visual-Manual Distractions Raise Risks

- Visual/Manual Tasks Raise Risk, Talking/Listening Tasks Much Less So
  - Dialing a handheld device has a statistically significant risk ratio of 2.79
  - Looking away from road for more than 2.0 seconds had 2.27 risk ratio
  - Talking/listening was not statistically significant

- Principal Contributor to Crashes, Taking Eyes Off the Road
  - “Almost 80 percent of all crashes and 65 percent of all near crashes involved the driver looking away from the forward roadway.”
  - “93 percent of all lead-vehicle crashes involved inattention to the forward roadway as a contributing factor.”

- Cognitive Distraction Not Significant, as Lab Studies Suggest
  - “It is a rare case that a crash occurs while the driver’s eyes are on the forward roadway, regardless of any other “cognitive demand” that they might be engaged in.”

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**Looking Away From the Road Raises Crash/Near Crash Risk:**

Non-Driving-Task Related Relative Crash/Near Crash Risk Estimates (Odds Ratio)  
(from Dingus, 2009)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust Radio</td>
<td>ns</td>
</tr>
<tr>
<td>Talk/Listen Hand-Held</td>
<td>1.3</td>
</tr>
<tr>
<td>Eating</td>
<td>1.6</td>
</tr>
<tr>
<td>Dialing Hand-Held Device</td>
<td>2.8</td>
</tr>
<tr>
<td>Applying Make-Up</td>
<td>3.1</td>
</tr>
<tr>
<td>Reading</td>
<td>3.4</td>
</tr>
<tr>
<td>Text Message on Cell Phone</td>
<td>23.2</td>
</tr>
<tr>
<td>Interact Occupant/s</td>
<td>0.4</td>
</tr>
<tr>
<td>Look Outside of Vehicle</td>
<td>0.5</td>
</tr>
<tr>
<td>Check Speedometer</td>
<td>0.3</td>
</tr>
<tr>
<td>Talk/Listen to Hands Free Phone</td>
<td>0.4</td>
</tr>
<tr>
<td>Adjust Instrument Panel</td>
<td>1.3</td>
</tr>
<tr>
<td>Talk/Listen to CB</td>
<td>0.6</td>
</tr>
<tr>
<td>Reach for Object in Vehicle</td>
<td>3.1</td>
</tr>
<tr>
<td>Personal Grooming</td>
<td>4.5</td>
</tr>
<tr>
<td>Light Vehicle Data</td>
<td></td>
</tr>
<tr>
<td>Heavy Truck Data</td>
<td></td>
</tr>
<tr>
<td>Heavy Truck Driving-Related</td>
<td></td>
</tr>
</tbody>
</table>

* : Protective; statistically significantly safer than “Just Driving”
ns: Not statistically significantly different than “Just Driving”
RDCW FOT: Distraction Analysis
Sayer, Devonshire, & Flanagan (2005, 2007)

- **Participants:**
  - 36 of 78 Drivers, 4 weeks of driving, average 1062 miles driven per driver
  - 40 video clips each
  - 10 clips per week
  - Randomly sampled

- **1440 video clips**
  - 5 sec in duration at 10 Hz
  - Driver’s face & forward scene

- **Performance data of interest**
  - Mean, variability of lane position
  - Variability of steering wheel angle
  - Speed variability
  - Mean, variability of throttle position
  - Glances away from road, durations

- **Contextual Factors**
  - Road type, curvature, road condition, weather

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RDCW FOT Distraction Study Results:
Driving Performance Effects

From Sayers, et al. (2005)

- **Secondary behaviors are not equal in their frequency of occurrence, nor their effects**

- **Cellular phone use**
  - Had highest steering variance
  - Little differences lane variance
  - No change in speed variance
    - Braking actually smoother
  - Frequency and duration of glances lower than baseline
    - Which could be both good and bad
    - Eating and conversations resulted in more and longer glances
RDCW FOT Distraction Study Results:
Driving Context During Secondary Tasks

From Sayers, et al. (2005)

- Drivers appear to engage selectively in secondary behaviors according to conditions
- When drivers can freely choose, they appear to perform some tasks when their driving skills are least needed
  - Cell phone use occurred more often when not braking and not in a curve
  - Multiple behaviors occurred exclusively on dry roads
  - Eating/drinking occurred primarily during the day
- However, cellular phone use occurred disproportionately on major surface and local roads, as well as at night.
- This may reflect forms of exposure that have not been examined

Hands-Free vs. Hand-Held Interfaces

Hands-free, voice interfaces have significant benefits over hand-held, visual-manual interfaces for command and data entry.

Ford
Tijerina, Parmer and Goodman (1998)

- **16 Participants:**
  - Half 35 years or younger
  - Half 55 years or older

- **Tasks:**
  - Point-Of-Interest (POC) entry
  - 1 voice vs. 3 manual systems
  - Manual cell phone dialing
  - Radio tuning

- **Method:**
  - Driving an instrumented car at 60 mph
  - Accompanied by experimenter
  - 7.5-mile multilane test track, light traffic

- **Results (at right)**

VIRTTEX Research (2003)

Table 1. Front detection event percentages by secondary task, all participants (Source: Greenberg, et al., 2003).

<table>
<thead>
<tr>
<th>Device</th>
<th>Missed</th>
<th>Detected</th>
<th>Total</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dialHf</td>
<td>vmHf</td>
<td>inches</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.11</td>
<td>11.14</td>
<td>11.48</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>98.89</td>
<td>98.86</td>
<td>98.52</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>95.08</td>
<td>94.52</td>
<td>94.92</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>88.65</td>
<td>88.52</td>
<td>88.52</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>91.35</td>
<td>91.35</td>
<td>91.35</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>77.15</td>
<td>77.15</td>
<td>77.15</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>91.04</td>
<td>91.04</td>
<td>91.04</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>98.41</td>
<td>98.41</td>
<td>98.41</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>96.85</td>
<td>96.85</td>
<td>96.85</td>
<td>444</td>
</tr>
</tbody>
</table>

N 54 59 61 61 61 57 67 63 444

Figure 3. Percentage of front events not detected by teen drivers, grouped by in-vehicle task. (Source: Greenberg et al., 2003).

<table>
<thead>
<tr>
<th>Task</th>
<th>Total Task Time</th>
<th>Total Eyes-Off-Road Time</th>
<th>Standard Deviation of Lane Position</th>
<th>Percent of Trials with a Lane Exceedance</th>
<th>Maximum Speed Difference</th>
<th>Pedestrian Detection Task Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Song</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Artist</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Phone Book</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Incoming Call</td>
<td>V</td>
<td>M</td>
<td>G</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>Digit Dial</td>
<td>M</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Text Review</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Text Send</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>

SYNC supports better driving by keeping eyes on the road and hands on the wheel.

Studies: Hands-Free Better than Hand-Held

<table>
<thead>
<tr>
<th>Study</th>
<th>Venue</th>
<th>Task Duration</th>
<th>Total Task Time</th>
<th>Total Eyes-Off-Road Time</th>
<th>Standard Deviation of Lane Position</th>
<th>Percent of Trials with a Lane Exceedance</th>
<th>Maximum Speed Difference</th>
<th>Pedestrian Detection Task Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serafin, Wen, Paelke, &amp; Green (1993)</td>
<td>Simulator</td>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Tijerina, Parmer, and Goodman (1998)</td>
<td>Track</td>
<td>Nav: V or N</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Graham &amp; Carter (2001)</td>
<td>Simulator</td>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Gartner, Konig, and Wittig (2001)</td>
<td>Road</td>
<td>M</td>
<td>M</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Ikhida and Matsuda (2001)</td>
<td>Track</td>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Balsevic and Macqua (2001)</td>
<td>Simulator</td>
<td></td>
<td>M</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Harney, Hashke, Smith, Husner, Parmer, and Backman (2003)</td>
<td>Track</td>
<td>M</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Urgoiti, Tipton, Last, and Stilley, Kochhar, Kozak, Blommer, &amp; Grant (2003)</td>
<td>Simulator</td>
<td></td>
<td>V</td>
<td>N</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Ishida, Yoshitaka, Kubo, and Mashino (2004)</td>
<td>Simulator</td>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Tsimhoni, Smith, and Green (2004)</td>
<td>Simulator</td>
<td></td>
<td>V</td>
<td>V</td>
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<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Chiang, Brooks, and Wer (2005)</td>
<td>Road</td>
<td>M</td>
<td>M</td>
<td>V (small)</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Argulli, et al. (2006a, 2006b)</td>
<td>Road &amp; Track</td>
<td>M</td>
<td>N</td>
<td>N</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Modenicka and Kun (2007)</td>
<td>Simulator</td>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Schreiner, Bianco, and Harkey (2004a)</td>
<td>Track</td>
<td>M</td>
<td>N</td>
<td>N</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Schreiner, Bianco, and Harkey (2004b)</td>
<td>Road</td>
<td>M</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Schreiner (2006)</td>
<td>Simulator</td>
<td>M</td>
<td>M or N</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Harney, Watson, Mazze, Pappas, Ahmed, &amp; Wrightman (2005)</td>
<td>Simulator</td>
<td></td>
<td>M or N</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>

Notes: V = Voice interface resulted in better performance than Manual interface  
M = Manual interface resulted in better performance than Voice interface  
N = No difference  
Blank = not addressed in the report

Colors:
- Green: SYNC voice interface statistically better  
- Yellow: Manual, Hand-Held statistically better  
- White: No significant difference (at 0.05 alpha)
Why Don’t Laboratory and Simulator Research Agree with Real-World Findings?

Unusually difficult materials, methodological biases, and absence of driver choice and compensation threaten external validity.

Examples of Cell Phone Research Conversations

- **Underspecified**
  - e.g., ‘Topics of interest to the participant’

- **Mental Arithmetic (or variations)**
  - Incoming message: “How many miles will you travel in 2.5 hrs if you average 40 mph?” Driver: “100 mi”

- **Baddeley Grammatical Reasoning (GR) Test (or variations)**
  - Incoming message: “B is not followed by A – BA.” Driver (correct response): “False”

- **Working Memory Span Task**
  - Incoming message: “The train bought a newspaper.” Driver (correct response): “No” (not sensible)
  - Incoming message: “The boy brushed his teeth.” Driver (correct response): “Yes” (sensible)
  - After 5 sentences, recall the last word in each, in order

- **Cognitive Performance Assessment Batteries (PABs), e.g., Rosenbaum Battery**
  - Monologue: Incoming message: “Tell me as much as you can about the interior of your car”
  - Repeat sentence: Incoming message: “Undetected by the sleeping dog, the thief broke into Jane’s Apt.”
  - Mental puzzles: Incoming message: “John is darker than Jim. Who is the lighter of the two?”

- **Current Controversies or emotionally-laden topics**
  - Clinton scandal
  - Salt Lake City Olympic Scandal
  - Politics, current events
  - “Close Call” stories, describing a time when you almost died

- **Biographic questions**
  - Research Need: Content analysis of real-world cell-phone conversations while driving: When, where, how often, how long, listening vs. talking emphasis, etc.
Example: Decrease in Brain Activation Associated with Listening to Someone Speak
(Just et al., 2008; Brain Research)

- **Result**: fMRI study showed simple auditory comprehension task led to ‘deteriorated driving’ & 37% reduction in parietal lobe activation
- **Validity Threats:**
  - Video game, not a car or simulator
  - Difficult, ‘winding’ course selected
  - Drivers could not adjust speed; Apparent speed was fixed at 43 mph
  - ‘Steering’ was mouse or trackball, not steering wheel
  - Participants were told listening task and driving equally important
  - No realistic feedback on lanekeeping error:
    - “If the participant happened to steer the car into the side edge (berm) of the road, the program prevented the vehicle from leaving the road but recorded each time it made contact with the boundaries of the road as a road-maintenance error.” (p. 78)
- Participants not just listening/talking: Responses by button press
- **Interpretive Issues:**
  - The brain is highly non-linear: What does “37% reduction in parietal lobe activation” mean?
  - How dangerous is thinking about whether “Botany is the study of plants” is a true or false statement?

Why Would Cell Phone Lab and Simulator Results Not Extrapolate to the Real World?

- (1) The conversational content, length, duration, number of turns, etc. in real world cell phone calls may be substantially less demanding than the conversations used in controlled studies;
- (2) The reaction time increase arising from conversations in previous studies may be too small to give rise to a detectable increase in real-world crash rates;
- (3) Lab-based event detection does not account fully for similar types of event detection in real driving, let alone for crashes;
- (4) Conversation may at times mitigate risks such as fatigue;
- (5) Portable and embedded cell phones may have substantially different human factors properties; and
- (6) Drivers may tend to change behavior during calls in ways that reduce net risk: place calls in relatively benign driving conditions, reduce risky driving maneuvers, increase headway, glance longer to the forward roadway, increase glances to mirrors after an event.
Costs and Benefits of Cell Phone Ban

Harvard Center for Risk Analysis Studies

- Cohen and Graham (2003): “The annual value of the benefits gained by eliminating crashes caused by cell phone use would amount to $43 billion... The value of the eliminated calls would also amount to $43 billion... The central estimate result suggests that banning cell phone use while driving is virtually a break-even proposition...”

- Lissy, Cohen, Park and Graham (2000) listed cell phone benefits:
  - Cell phones help prevent unnecessary trips, provide parental and familial peace-of-mind, report criminal activity (e.g., drunk driving), convey emergency details and shorten response time, increase mental alertness during long, monotonous drives, enhance social connectedness, and improve productivity.
Conclusion

- Use of electronics while driving are increasing, expected to continue.

- Driver distraction is a real concern, though the nature and magnitude of the driver distraction problem is different than simulator studies and public opinion suggest.

- Real-world driving research indicates talking and listening on hand-held phones are not nearly so risky as visually distracting tasks.

- Policy actions to discourage activities that take a driver’s eyes off the road can reduce risks.

- Public outreach and education to inform drivers of distraction effects and remind them of their responsibility to drive safely are also appropriate.

- Research indicates there are benefits to hands-free voice interfaces over hand-held visual-manual devices.

End of Slides