Effect of Driver Cell Phone Use on Queue Discharge Patterns at Signalized Intersections

Srinivas S. Pulugurtha, UNC Charlotte
Ryan Brumfield, FHWA

Presentation at
Midcontinent Transportation Research Symposium, Ames, IA

August 19, 2011
Outline

- Introduction
- Effects of Distracted Driving
- Study Background
- Methodology
- Results
- Conclusions
- Acknowledgements
Introduction

- 28% of all crashes are caused by drivers using cell phones (National Safety Council)
- 6 to 12% of drivers are talking on a cell phone at any given time
  - About 1% are texting
- Hand-held talking - illegal in 7 states, DC, and the Virgin Islands
- All cell phone use - illegal for novice drivers in 28 states and DC
- Texting - illegal in 30 states, DC, and Guam
Effect of Driver Distraction

- Visual, manual, and cognitive distractions
  - Eyes off the road
  - Hands off the wheel
  - Mind off the task

- Inattention Blindness (Strayer et al.)
  - Failure to see an object because attention is not focused on it (i.e., a pedestrian, motorcycle, bicycle, child playing, etc.)

- Multi-tasking is a myth
  - Faster to do two things separately than to do them simultaneously
  - Cell phone use while driving inevitably compromises the performance level for one or both tasks
Effects …

- Distracted drivers
  - Lack the ability to react to unexpected events
    - Car pulls out in front of you
    - Motorcycle, pedestrian, bicycle, a train
    - …

- When cognitive processing power suffers, performance suffers
  - Brookhuis et al. – reaction time, speed adaption, rear-view mirror checking
  - Mazzea et al. – reduced eye fixation on important roadway objects
  - Strayer et al. – stop sign compliance
Research Objectives

- Do cell phone users, those talking and texting, have an effect on queue discharge patterns at signalized intersections?
  - Saturation headway and saturation flow rate
  - Start-up lost time
Background ...

- Saturation Flow Rate = 3600/Saturation Headway
Methodology

- Data was collected at four intersections:
  - Albemarle Rd. @ Sharon Amity Road
  - Albemarle Rd. @ W.T. Harris Blvd.
  - South Tryon Street @ Arrowood Rd.
  - Providence Rd. @ Sharon Amity Rd.
- Sites were chosen based on the presence and placement of CDOT camera
- Data was collected in two formats:
  - In the field – cell phone distraction data
  - At the CDOT Traffic Management Center (TMC) – Video recordings of traffic
Methodology ...

- In the field, cell phone distraction data was collected
  - Place in the queue and presence of distraction was recorded for each vehicle/driver
<table>
<thead>
<tr>
<th>Cycle No.</th>
<th>Vehicle No.</th>
<th>Distracted?</th>
<th>Type of Distraction</th>
<th>Stationary at start of phase?</th>
<th>Approx. distance to next vehicle</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Y</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Y</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Y</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>√5</td>
<td>1</td>
<td>Y</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Y</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>√6</td>
<td>1</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>Y</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Date: 06/03
Location: Tryon & Ardwood

Notes:
- Red Ford Explorer
  - Stationary at start
  - 4 stations
- Bus
  - 1
  - 2
  - 3
- Black Car
  - 4 stations
- Cadillac
  - 1
  - 2

a: talking on phone = 1
texting = 2
b: <= 1 car length = 1
>1<2 = 2
>2<3 = 3
Methodology ...

- In the field, cell phone distraction data was collected
  - Place in the queue and presence of distraction was recorded for each vehicle/driver
- At CDOT’s TMC, video recordings captured the queue discharge activity of the lane in question
- Videos were later observed and processed to determine headways for each vehicle of each cycle in question
Methodology …

- Field data was correlated with video data based on vehicle descriptions (make and model of first car in queue)
- Saturation headways and start-up lost times per cycle were determined
- Queues with cell phone users were differentiated from those without cell users
Methodology...

- T-tests for difference in sample means* were used to look at statistical significance

**Hypotheses tested:**

1) Queues containing drivers talking on the phone have higher start-up lost times and saturation headways
2) Queues containing drivers who are texting have higher start-up lost times and saturation headways

**Secondary Analysis:** variance in headways

---

*T-test for difference in sample means:
-- Assume unequal variance of means
T-value = \( \frac{\text{difference between group means}}{\text{variability of the differences between means}} \)
P-value is found using critical value tables
Results

- 3741 observed
- 496 Talking (13.26%)
- 67 Texting (1.79%)

<table>
<thead>
<tr>
<th>Location</th>
<th>Sample Size</th>
<th>% Talking on Phone</th>
<th>% Texting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albemarle Rd. and Sharon Amity Rd.</td>
<td>746</td>
<td>11.93%</td>
<td>2.14%</td>
</tr>
<tr>
<td>Albemarle Rd. and WT Harris Blvd.</td>
<td>631</td>
<td>11.89%</td>
<td>1.11%</td>
</tr>
<tr>
<td>Providence Rd. and Sharon Amity Rd.</td>
<td>1829</td>
<td>14.16%</td>
<td>1.97%</td>
</tr>
<tr>
<td>Tryon St. and Arrowood Rd.</td>
<td>535</td>
<td>13.64%</td>
<td>1.50%</td>
</tr>
<tr>
<td>Overall</td>
<td>3741</td>
<td>13.26%</td>
<td>1.79%</td>
</tr>
</tbody>
</table>
Results …

<table>
<thead>
<tr>
<th>Description of Result</th>
<th>Albemarle Rd. and Sharon Amity Rd.</th>
<th>Albemarle Rd. and WT Harris Blvd.</th>
<th>Providence Rd. and Sharon Amity Rd.</th>
<th>Tryon St. and Arrowood Rd.</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average saturation headway overall (sec.)</td>
<td>2.03</td>
<td>1.92</td>
<td>1.94</td>
<td>2.00</td>
<td>1.96 sec. 1837 veh/hr</td>
</tr>
<tr>
<td>Average saturation headway for queues without cell talkers present (sec.)</td>
<td>2.00</td>
<td>1.90</td>
<td>1.84</td>
<td>2.03</td>
<td>1.95 sec. 1848 veh/hr</td>
</tr>
<tr>
<td>Average saturation headway with cell phone users present (sec.)</td>
<td>1.99</td>
<td>1.97</td>
<td>1.96</td>
<td>1.93</td>
<td>1.97 sec. 1827 veh/hr</td>
</tr>
<tr>
<td>Average saturation headway with texters present (sec.)</td>
<td>2.01</td>
<td>2.00</td>
<td>2.04</td>
<td>2.00</td>
<td>2.02 sec. 1782 veh/hr</td>
</tr>
</tbody>
</table>

- Queues containing drivers talking on the phone had 1.5% higher saturation headways (not significant)

- Queues containing texting drivers had 3.6% higher saturation headways (statistically significant)
## Results …

<table>
<thead>
<tr>
<th>Description of Result</th>
<th>Albemarle Rd. and Sharon Amity Rd.</th>
<th>Albemarle Rd. and WT Harris Blvd.</th>
<th>Providence Rd. and Sharon Amity Rd.</th>
<th>Tryon St. and Arrowood Rd.</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average start-up lost time overall (sec.)</td>
<td>1.91</td>
<td>2.92</td>
<td>1.95</td>
<td>1.77</td>
<td>2.21 sec.</td>
</tr>
<tr>
<td>Average start-up lost time without cell phone talkers present (sec.)</td>
<td>2.20</td>
<td>2.95</td>
<td>1.85</td>
<td>1.80</td>
<td>1.94 sec.</td>
</tr>
<tr>
<td>Average start-up lost time with cell phone talkers present (sec.)</td>
<td>1.80</td>
<td>2.73</td>
<td>2.08</td>
<td>1.95</td>
<td>1.97 sec.</td>
</tr>
<tr>
<td>Average start up lost time with texters present (sec.)</td>
<td>4.06</td>
<td>-</td>
<td>2.91</td>
<td>2.52</td>
<td>3.26 sec.</td>
</tr>
</tbody>
</table>

- Queues containing drivers talking on the phone had 1.5% higher start-up lost times (not significant)

- Queues containing texting drivers had 54% higher start-up lost times (statistically significant)
Variance in Headways

- Theoretically, cell phone talkers have a smaller variance and texters have a larger variance.
- Overall, the variance among non-users was 0.40 compared to 0.27 for drivers talking on the phone and 0.92 for drivers that were texting.
- Findings were observed to be statistically significant (F-test for difference in variance* was used).

<table>
<thead>
<tr>
<th>Results</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Cell Phone Users</td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>1177</td>
</tr>
<tr>
<td>Average headway (sec.)</td>
<td>2.17</td>
</tr>
<tr>
<td>Variance in headways</td>
<td>0.40</td>
</tr>
<tr>
<td>Drivers talking on cell phone</td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>181</td>
</tr>
<tr>
<td>Average headway (sec.)</td>
<td>2.17</td>
</tr>
<tr>
<td>Variance in headways</td>
<td>0.27</td>
</tr>
<tr>
<td>Drivers texting</td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>34</td>
</tr>
<tr>
<td>Average headway (sec.)</td>
<td>2.67</td>
</tr>
<tr>
<td>Variance in headways</td>
<td>0.92</td>
</tr>
</tbody>
</table>
Summary

- Why does talking on a cell phone have an insignificant effect on reaction time and queue discharge patterns at signalized intersections?
  - Cell phone talkers have a stabilizing effect
    - Perform worse than attentive drivers
    - … better than drivers who are visually distracted
- Drivers who are texting are visually distracted so they tend to have a more adverse effect on traffic flow
Conclusions

- ~13% of drivers were talking on their phone
- ~1.8% were texting
- Drivers talking on the phone hurt operational performance in some cases, but likely helped it in others
- Drivers who were texting had a negative effect on queue discharge patterns in most cases
- Numerous driver distractions are present, all with a varying level of influence on performance.
Acknowledgments

- Brian Fowler, Beth Boswell, and Dan Murphy of the Charlotte Department of Transportation
- Nathan Conard, former UNC Charlotte Graduate Student