Naturalistic Driving Research Symposium 2018

USING EUROPEAN NATURALISTIC DRIVING DATA TO ASSESS SECONDARY TASK ENGAGEMENT WHEN STOPPED AT A RED LIGHT

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INTRODUCTION

SECONDARY TASK ENGAGEMENT

- The engagement in secondary tasks is common among drivers around the world (e.g., Dingus et al., 2016; Prat, Planes, Gras, & Sullman, 2014; Stutts et al., 2003; Thulin & Gustafsson, 2004)

- In addition to “traditional” secondary tasks (e.g., smoking, eating or drinking), drivers often engage in “technology based” secondary tasks (e.g., cell phone conversation or texting)

- Texting has increased in recent years, particularly among younger drivers (Nelson, Atchley, & Little, 2009; Young & Lenné, 2010)

→ Adverse effects on driving performance (e.g., Alm & Nilsson, 1994; Patten, Kircher, Östlund, & Nilsson, 2004; Strayer & Drews, 2004)
SELF-REGULATORY STRATEGIES

- Research indicates that drivers use various forms of self-regulatory strategies to accommodate secondary task engagement while driving, e.g. by …
  - … adjusting driving behavior
    - Slowing down
      (e.g., Haigney, Taylor, & Westermann, 2000; Rakauskas, Gugerty, & Ward, 2004; Patten, Kircher, Östlund, & Nilsson, 2004)
    - Increasing distance to the lead vehicle
      (e.g., Hosking et al., 2007; Ishida & Matsuura, 2001; Strayer & Drews, 2004)
    - Avoiding lane changes
      (Beede & Kass, 2006)
SELF-REGULATORY STRATEGIES

- Research indicates that drivers use various forms of self-regulatory strategies to accommodate secondary task engagement while driving, e.g. by …
  - … adjusting driving behavior
  - … selecting situations in which the driving task demand is low
    - When the car is moving slowly
      (e.g., Naujoks, Purucker, & Neukum, 2016)
    - When the car is stopped, e.g. at a red light
      (e.g., Stutts et al., 2005; Tivesten & Dozza, 2014)
      - Still - diversion of attention away from the roadway leads to a reduction of situation awareness
      - Risk for unsafe driving (in particular when the vehicle has to be set in motion again before the task has been completed)
      - Especially relevant for a secondary tasks like texting (due to long off-road glances)
SECONDARY TASK ENGAGEMENT AT RED LIGHTS

- So far, there are only a few studies that looked into secondary task engagement while waiting at a red light, mostly focusing on the prevalence of secondary task engagement (e.g., Huth, Sanchez, & Brusque, 2015; Huisingsh, Griffin, & McGwin Jr., 2015; Kidd, Tison, Chaudhary, McCartt, & Casanova-Powell, 2016).

- Most of these studies are roadway observational studies:
  - They only investigate *if* secondary tasks occur, but not *how* secondary tasks are performed (regarding secondary task initiation and conclusion, glance behavior, etc.), which is relevant for the assessment of self-regulatory strategies.
  - Naturalistic driving data can provide valuable insights.
GOAL OF THE PRESENT STUDY:
Investigation of drivers’ secondary task engagement while waiting at a red light using European naturalistic driving data

How often do drivers engage in which secondary tasks while waiting at a red light?

How do secondary task initiation and conclusion relate to the actual red light episode?

How can texting while waiting at a red light be characterized (especially with regard to glance behavior)?
UDRIVE – European naturalistic driving study

- First large-scale European naturalistic driving study
- Collection of naturalistic driving data for over two years for cars, trucks and powered two-wheelers
- Cars were equipped with:
  - **Data acquisition system**
    (to collect GPS position, speed, brake pressure, yaw rate, steering wheel angle, etc.)
  - **7 cameras**
    (3 forward cameras, cabin camera, cockpit camera, face camera, feet camera)
  - **Smart cameras (MobileEye)**
    (to detect other road users)
METHOD

Identify trip segments in which a vehicle was stopped for >3 s from the existing time series data

Random selection of 300 episodes per country

$N=804$ episodes

Review video to clarify if the episodes actually contain a red light

Annotate all red light episodes (+5 s before/after stopping)

E.g., secondary task engagement (type of task, initiation, conclusion)

In progress...

Annotate glance behavior for a sub-set of texting events (one per driver)

4 Areas of interest: outside, inside, cell phone, other secondary tasks

Identify and annotate glance behavior of two additional texting episodes per “texting” driver

$N=75$ texting episodes from $N=25$ different drivers

Select and annotate glance behavior of a matched baseline episode for each texting episode

If possible: same driver at the same intersection without secondary task engagement
A glance was defined according to the ISO 15007-1:2014.

- **Outside:**
  Glances to the outside (e.g., through windshield, side windows, side mirrors, rear mirror)

- **Inside:**
  Glances to the inside of the vehicle (associated with the driving task, e.g., looking at speedometer)

- **Cell phone:**
  Glances to the cell phone

- **Other secondary tasks:**
  Glances to other secondary tasks (e.g., radio or climate control)
### OVERVIEW OF THE DATASET

<table>
<thead>
<tr>
<th>Country</th>
<th>Episodes</th>
<th>Female</th>
<th>Male</th>
<th>Ø Age (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All countries</td>
<td>804</td>
<td>78</td>
<td>81</td>
<td>44 (13.16)*</td>
</tr>
<tr>
<td>Netherlands</td>
<td>162</td>
<td>15</td>
<td>16</td>
<td>45 (13.31)*</td>
</tr>
<tr>
<td>Germany</td>
<td>161</td>
<td>11</td>
<td>15</td>
<td>45 (17.15)*</td>
</tr>
<tr>
<td>Poland</td>
<td>161</td>
<td>11</td>
<td>18</td>
<td>38 (7.86)*</td>
</tr>
<tr>
<td>Great Britain</td>
<td>163</td>
<td>25</td>
<td>13</td>
<td>46 (13.63)*</td>
</tr>
<tr>
<td>France</td>
<td>157</td>
<td>16</td>
<td>19</td>
<td>44 (11.82)</td>
</tr>
</tbody>
</table>

* Missing values for age

<table>
<thead>
<tr>
<th>Traffic light time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
</tr>
<tr>
<td>SD</td>
</tr>
<tr>
<td>Min</td>
</tr>
<tr>
<td>Max</td>
</tr>
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</table>
FREQUENCY OF SECONDARY TASK ENGAGEMENT

- Engagement in secondary tasks while waiting at the red light ($N = 804$)
### RESULTS

#### RELATION TO THE RED LIGHT EPISODE

- Proportion (in %) of secondary tasks initiated/ concluded while waiting at the red light ($N = 270$)

<table>
<thead>
<tr>
<th>Type of secondary task</th>
<th>Initiation and conclusion while standing</th>
<th>Only initiation while standing</th>
<th>Only conclusion while standing</th>
<th>Neither initiation nor conclusion while standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>All secondary tasks</td>
<td>51</td>
<td>11</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Cell phone conversation</td>
<td>9</td>
<td>5</td>
<td>9</td>
<td>77</td>
</tr>
<tr>
<td>Cell phone texting, browsing, dialing</td>
<td>40</td>
<td>10</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>Cell phone other</td>
<td>70</td>
<td>10</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Eating, drinking, smoking</td>
<td>8</td>
<td>22</td>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>Personal grooming</td>
<td>47</td>
<td>22</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>Adjusting radio or climate control</td>
<td>82</td>
<td>0</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Object interaction</td>
<td>76</td>
<td>3</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>65</td>
<td>15</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

*Note.* Passenger interaction excluded.
## RESULTS

### RELATION TO THE RED LIGHT EPISODE

- Proportion (in %) of secondary tasks initiated/ concluded while waiting at the red light ($N = 270$)

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Texting, browsing, dialing was significantly more frequently **initiated** ($\chi^2 (1) = 8.419$, $p = .004$, $\phi = .347$) as well as **concluded** ($\chi^2 (1) = 14.197$, $p < .001$, $\phi = .450$) while waiting at the red light compared to cell phone conversations.

| Object interaction | 76 | 3 | 22 | 0 |
| Other             | 65 | 15 | 12 | 8 |

*Note. Passenger interaction excluded.*
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- Glance pattern while texting for one prototypical texting episode (from begin to end of waiting period)
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- Mean glance ratios for the four AOIs for texting episodes when analyzing the complete red light period and when analyzing the engagement period only ($N = 75$), contrasted with glance ratios in the baseline episodes ($N = 25$)
### CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- Maximum glance duration to each of the four AOIs for texting episodes when analyzing the engagement period only ($N = 75$)

![Graph showing maximum glance duration in seconds (95th CI) for different locations: Outside, Inside, Cell phone, Other secondary task.]

<table>
<thead>
<tr>
<th></th>
<th>Outside</th>
<th>Inside</th>
<th>Cell phone</th>
<th>Other secondary task</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M$</td>
<td>3.08</td>
<td>0.32</td>
<td>10.33</td>
<td>0.20</td>
</tr>
<tr>
<td>$Min$</td>
<td>0.00</td>
<td>0.00</td>
<td>2.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$Max$</td>
<td>19.70</td>
<td>6.48</td>
<td>35.61</td>
<td>7.80</td>
</tr>
</tbody>
</table>
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- Continuation of texting after the traffic light turned green
  - In 57% of all texting events, texting was continued after the traffic light turned green
  - For these events: texting was finished on average 35 s after the vehicle started moving again (SD = 91.04, Mdn = 4 s, Min = 1 s, Max = 448 s)
  - Most of the texting events were finished within 5 s after the vehicle started moving again; but: there were some events in which texting was continued for more than 1 minute

**RESULTS**

![Distribution of texting duration after the traffic light turned green](image)
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- Continuation of texting after the traffic light turned green
  - Comparison of the outside glances of those drivers who concluded texting while stopped ($N = 32$) and those drivers who continued texting ($N = 43$) in the 5 s after the vehicle started moving again showed a statistically significant difference regarding outside glance ratios ($t(63.610) = -6.559, p < .001, d = -1.53$)
  - Drivers who continued to text after the car was set in motion again spent 27% less time glancing to the outside than drivers who concluded texting while stopped

![Graph showing outside glance ratios for drivers who concluded texting while stopped and drivers who continued texting after stopping.](Image)
DISCUSSION & CONCLUSION

- Drivers engaged in secondary tasks in almost half of the analyzed red light segments
- This prevalence is much higher than reported in observational studies from different European countries that are not restricted to red light contexts (Sullman, 2012; Prat, Planes, Gras, & Sullman, 2014; however, for prevalence in the US see Dingus et al., 2016)

➔ Drivers seem to prefer this low-demand situation for secondary task engagement

- In-depth analyses of texting episodes showed that drivers who texted while waiting at a red light spent most of the time looking at their cell phone with a mean maximum glance duration of more than 10 s

➔ Potentially unexpected events remain unobserved

➔ Risk when driving is resumed

- A considerable portion of texting events were concluded far outside the red light episode

➔ Adverse effects on glance behavior - drivers who continued to text showed lowered percentages of outside glances after the traffic light turned green

➔ Implications for traffic safety
THANK YOU FOR YOUR ATTENTION!

Tina Morgenstern\textsuperscript{1}, Tibor Petzoldt\textsuperscript{2}, Josef F. Krems\textsuperscript{1}, Frederik Naujoks\textsuperscript{3} & Andreas Keinath\textsuperscript{3}

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**DESCRIPTION OF THE TEXTING SAMPLE**

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<td>Netherlands</td>
<td>21</td>
<td>5</td>
<td>2</td>
<td>45 (14.44)</td>
</tr>
<tr>
<td>Germany</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>51 (0.00)*</td>
</tr>
<tr>
<td>Poland</td>
<td>15</td>
<td>2</td>
<td>3</td>
<td>37 (8.83)*</td>
</tr>
<tr>
<td>Great Britain</td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>38 (12.37)*</td>
</tr>
<tr>
<td>France</td>
<td>18</td>
<td>4</td>
<td>2</td>
<td>45 (13.51)</td>
</tr>
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