TECHNISCHE UNIVERSITÄT CHEMNITZ

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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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; Huisingh, 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

PRESENT STUDY

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?

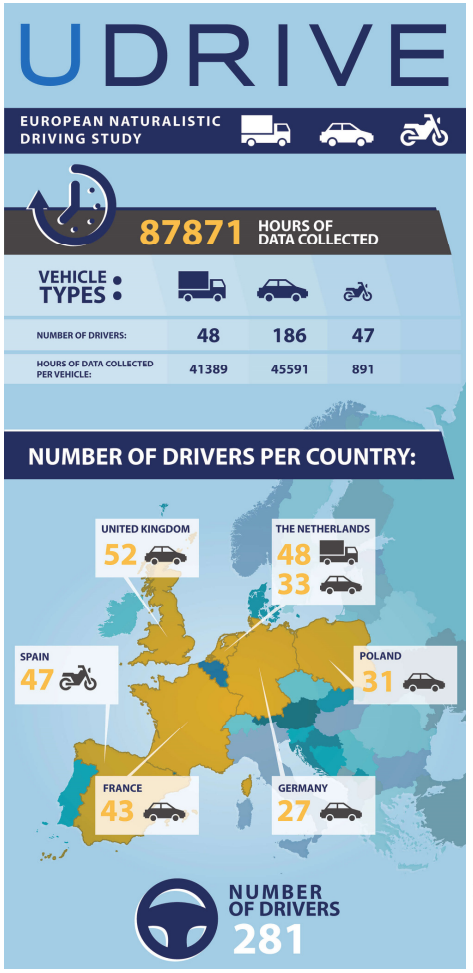
How do secondary task initiation and conclusion relate to the actual red light episode?

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 foward cameras, cabin camera, cockpit camera, face camera, feet camera)
  - **Smart cameras (MobileEye)**
    (to detect other road users)

Castermans (2017)



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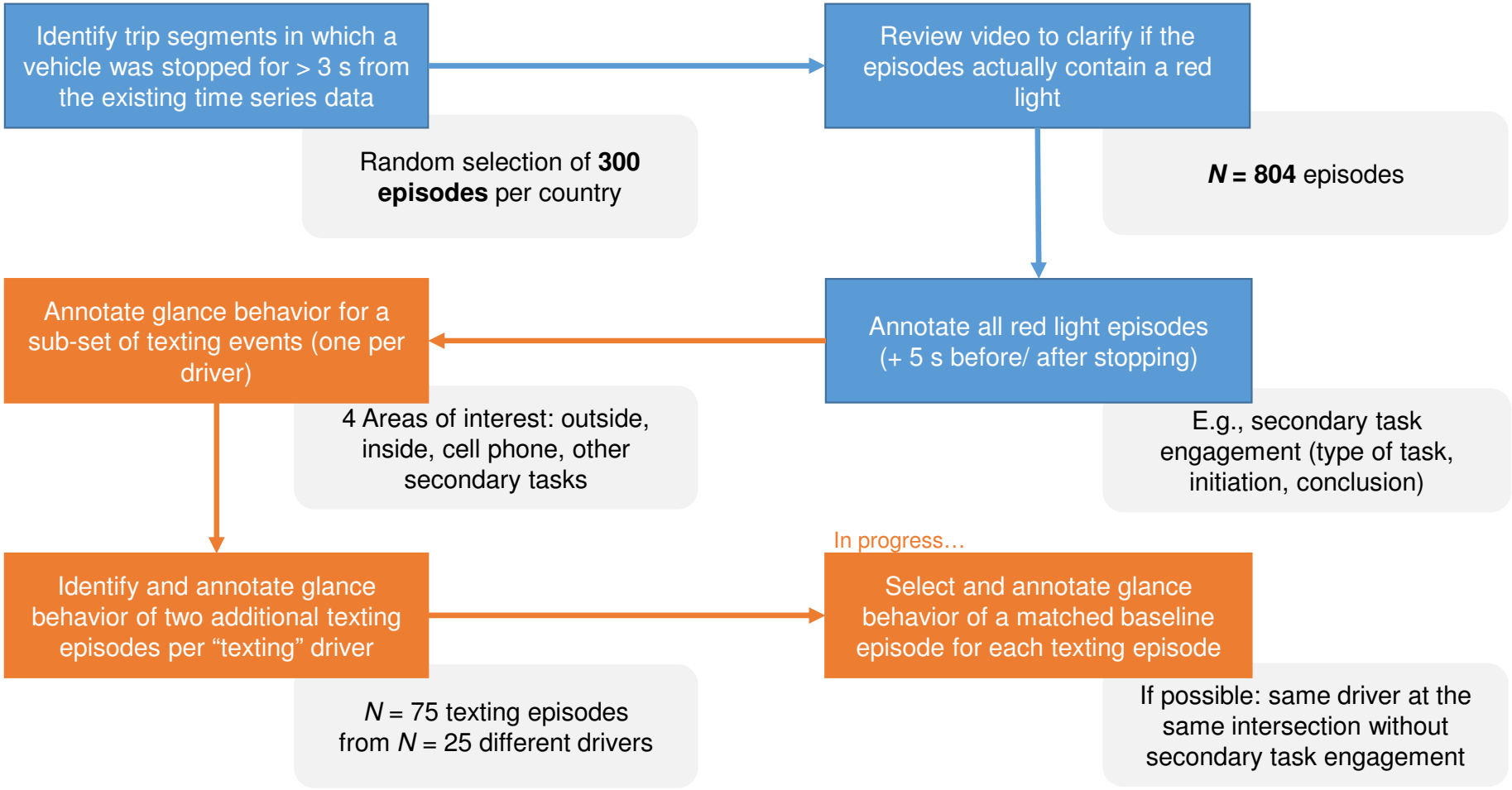
METHOD


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
Review video to clarify if the episodes actually contain a red light
***N* = 804** episodes
Annotate all red light episodes (+ 5 s before/ after stopping)
E.g., secondary task engagement (type of task, initiation, conclusion)
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
In progress…
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

ANNOTATIONS

- No secondary task
- Passenger interaction
- Cell phone – conversation (hand-held) } merged
- Cell phone – conversation (hands-free) } merged
- Cell phone – texting, browsing, dialling
- Cell phone – reading (hand-held) } merged
- Cell phone – reading (hands-free) } merged
- Cell phone – holding } merged
- Cell phone – checking } merged
- Eating/ drinking } merged
- Smoking } merged
- Personal grooming
- Adjusting/ monitoring radio or climate control
- Object interaction
- External distraction
- Adjusting/ monitoring navigation system } merged
- Reading/ writing } merged
- Other } merged

ALL EVENTS

- Secondary task 1/ 2/ 3
  - Task initiation
  - Task conclusion
- Other variables
  - Other pas-sengers
  - Weather
  - Lighting

+ 5 s before/ after stopping

TEXTING & BASELINE EVENTS

- Glance behavior
  - Area of interest
  - Glance start
  - Glance end
- Other variables
  - Texting start
  - Texting end
  - Location of cell phone

+ 5 s before/ after stopping

A glance was defined according to the ISO 15007-1:2014.

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

	Episodes			Ø Age (SD)
All countries	**804**	**78**	**81**	**44 (13.16)***
Netherlands	162	15	16	45 (13.31)*
Germany	161	11	15	45 (17.15)*
Poland	161	11	18	38 (7.86)*
Great Britain	163	25	13	46 (13.63)*
France	157	16	19	44 (11.82)

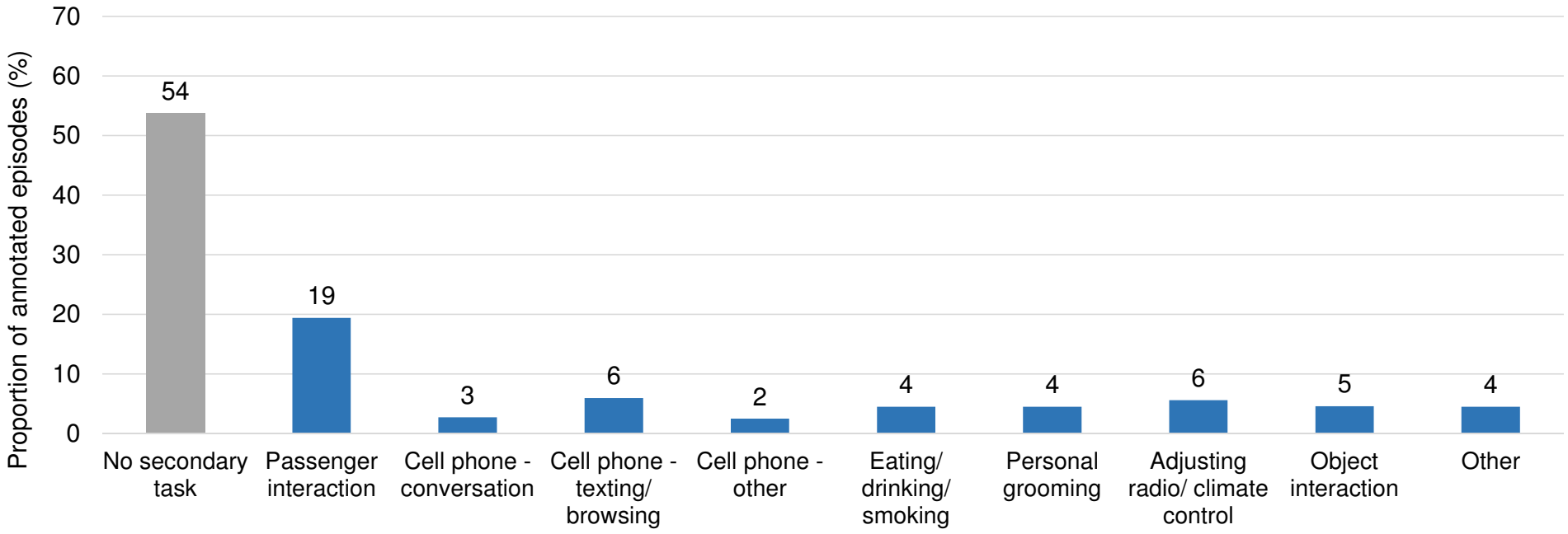
Traffic light time in seconds 

M	**27**
SD	21.10
Min	3
Max	137

* Missing values for age

FREQUENCY OF SECONDARY TASK ENGAGEMENT

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



RELATION TO THE RED LIGHT EPISODE

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

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

Note. Passenger interaction excluded.

RELATION TO THE RED LIGHT EPISODE

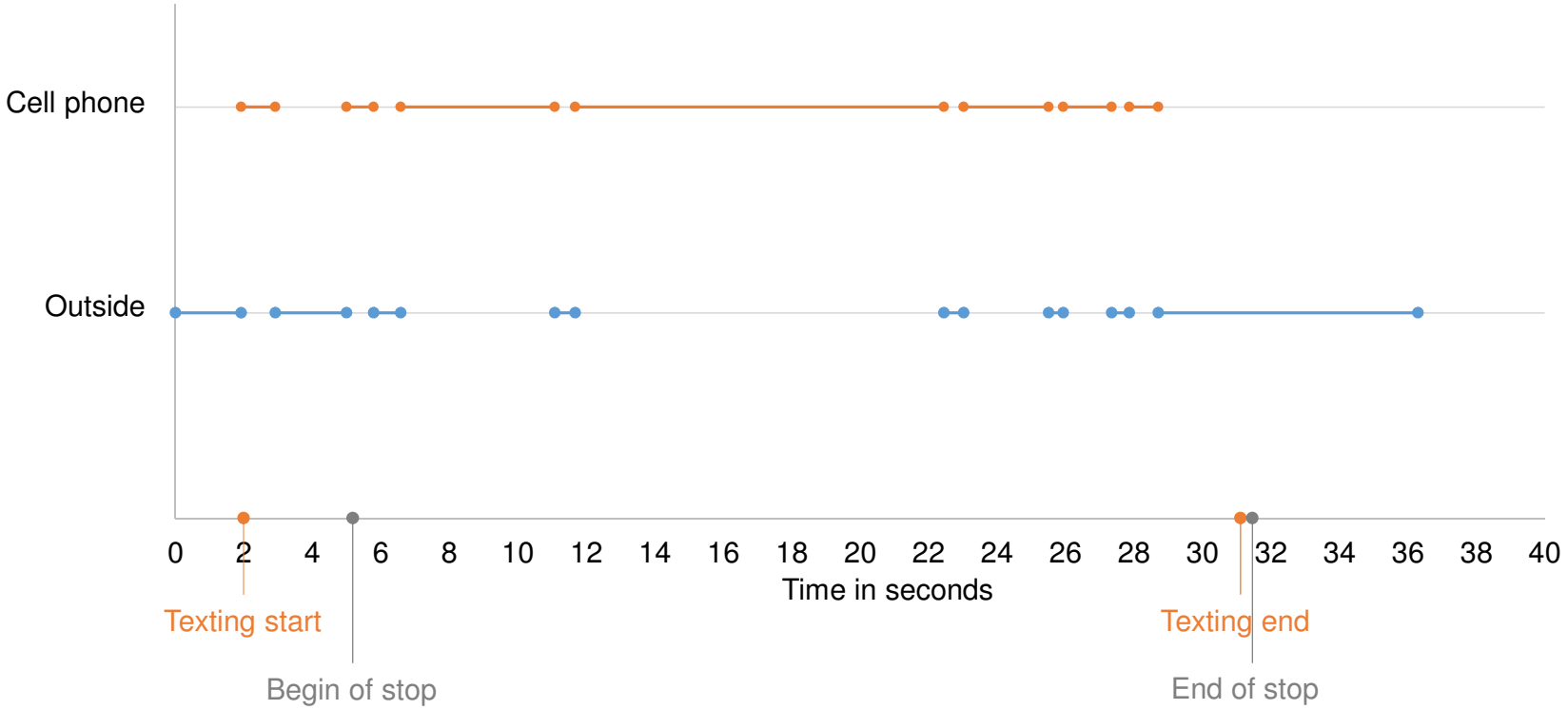
- Proportion (in %) of secondary tasks initiated/ concluded while waiting at the red light ($N = 270$)

Type of secondary task	Initiation and conclusion while standing	Only initiation while standing	Only conclusion while standing	Neither initiation nor conclusion while standing
All secondary tasks	**51**	11	17	21
Cell phone conversation	9	5	9	**77**
Cell phone texting, browsing, dialing	**40**	10	27	23
Texting, browsing, dialing was significantly more frequently **initiated** (χ^2 (1) = 8.419, p = .004, ϕ = .347) as well as **concluded** (χ^2 (1) = 14.197, p < .001, ϕ = .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.

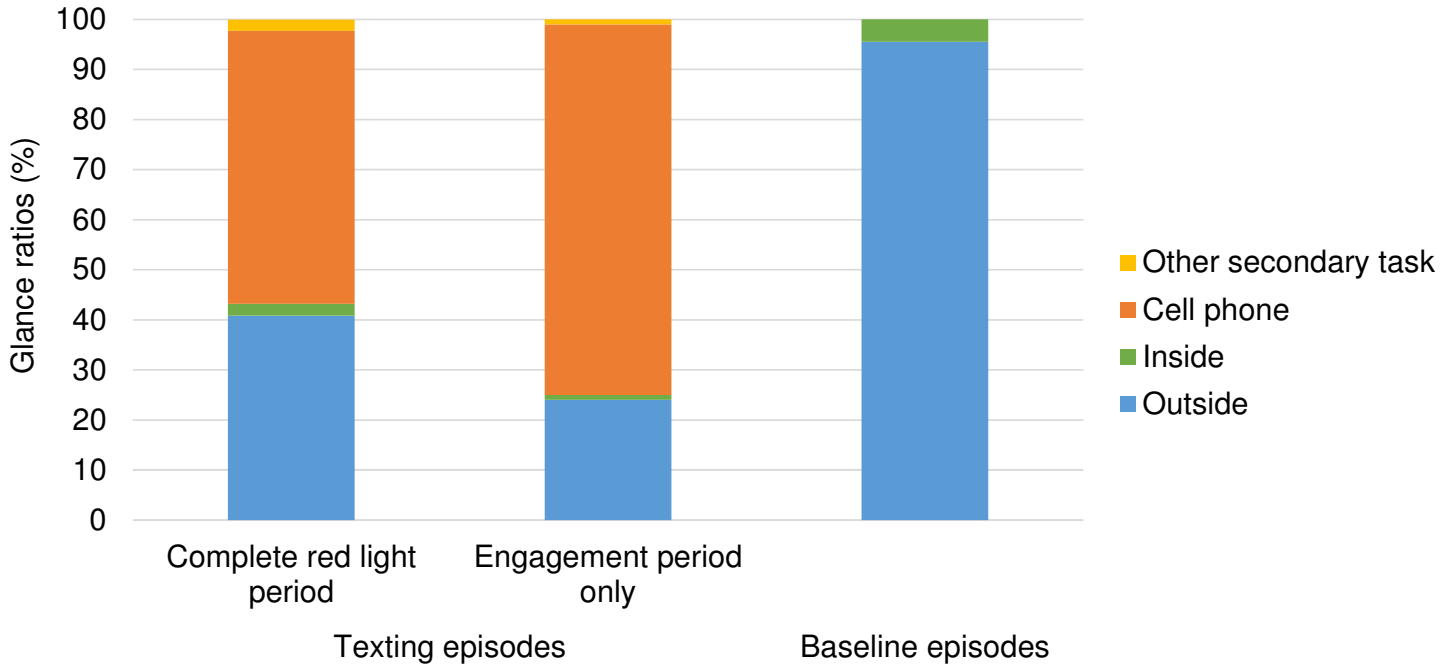
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- Glance pattern while texting for one prototypical texting episode (from begin to end of waiting period)



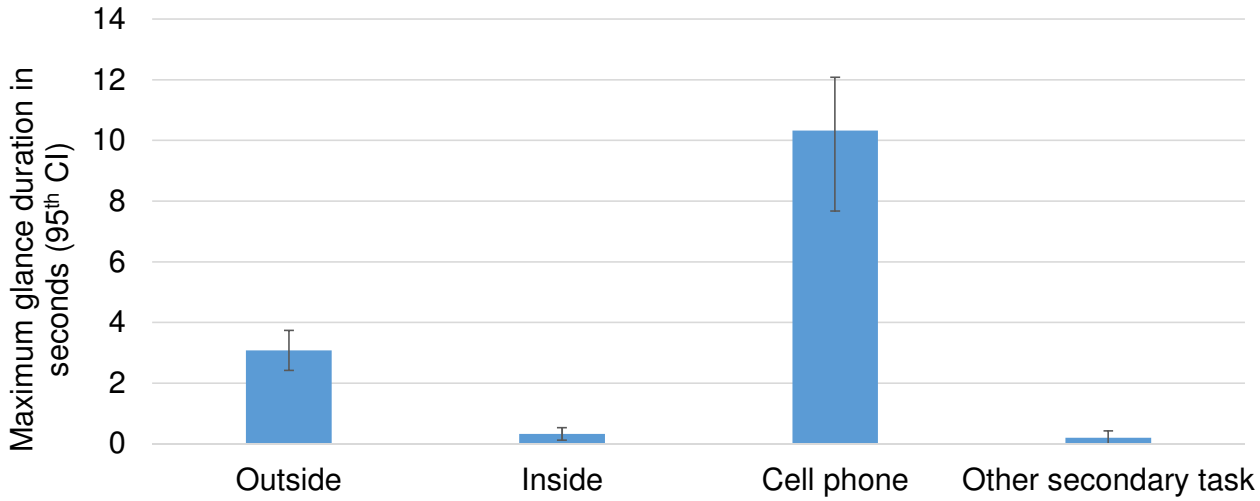
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- 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

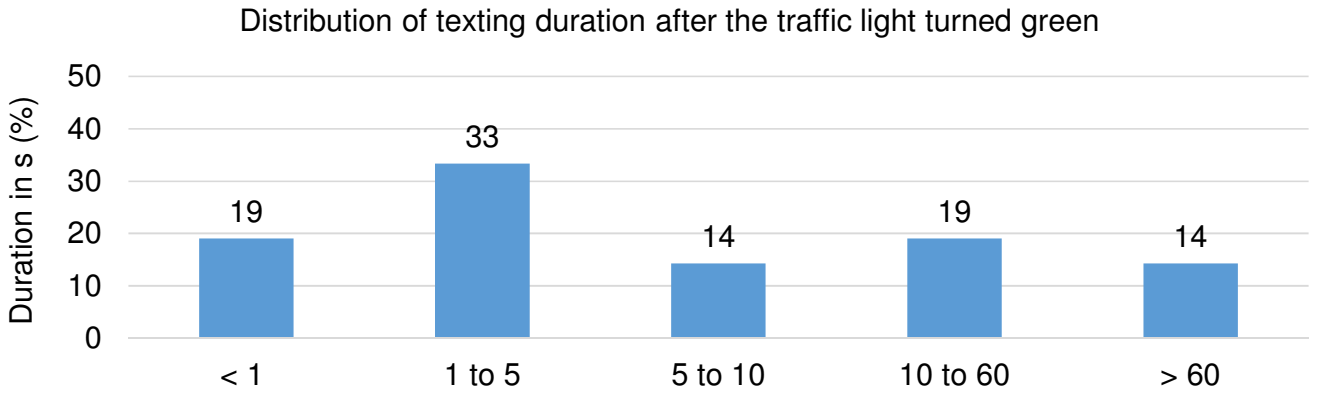
- Maximum glance duration to each of the four AOIs for texting episodes when analyzing the engagement period only ($N = 75$)



M	3.08	0.32	10.33	0.20
Min	0.00	0.00	2.00	0.00
Max	19.70	6.48	35.61	7.80

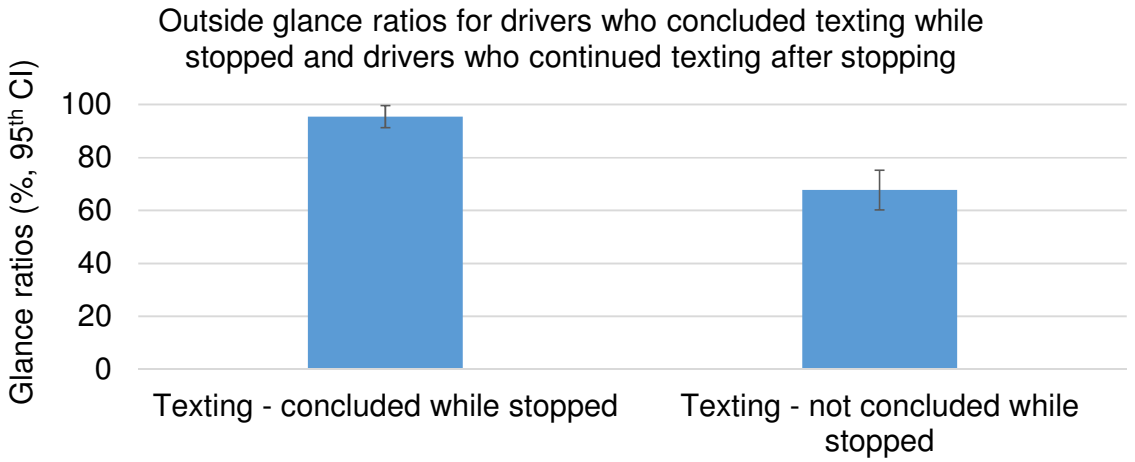
CHARACTERIZATION OF TEXTING WHILE WAITING AT A RED LIGHT

- 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



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



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 YOU ATTENTION!

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DESCRIPTION OF THE TEXTING SAMPLE

	Episodes			Ø Age (SD)
All countries	**75**	**16**	**9**	**43 (12.35)***
Netherlands	21	5	2	45 (14.44)
Germany	6	2	2	51 (0.00)*
Poland	15	2	3	37 (8.83)*
Great Britain	15	4	1	38 (12.37)*
France	18	4	2	45 (13.51)

* Missing values for age