Investigating Driver Distraction and Drowsiness using Naturalistic Driving Data

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April 15th, 2014

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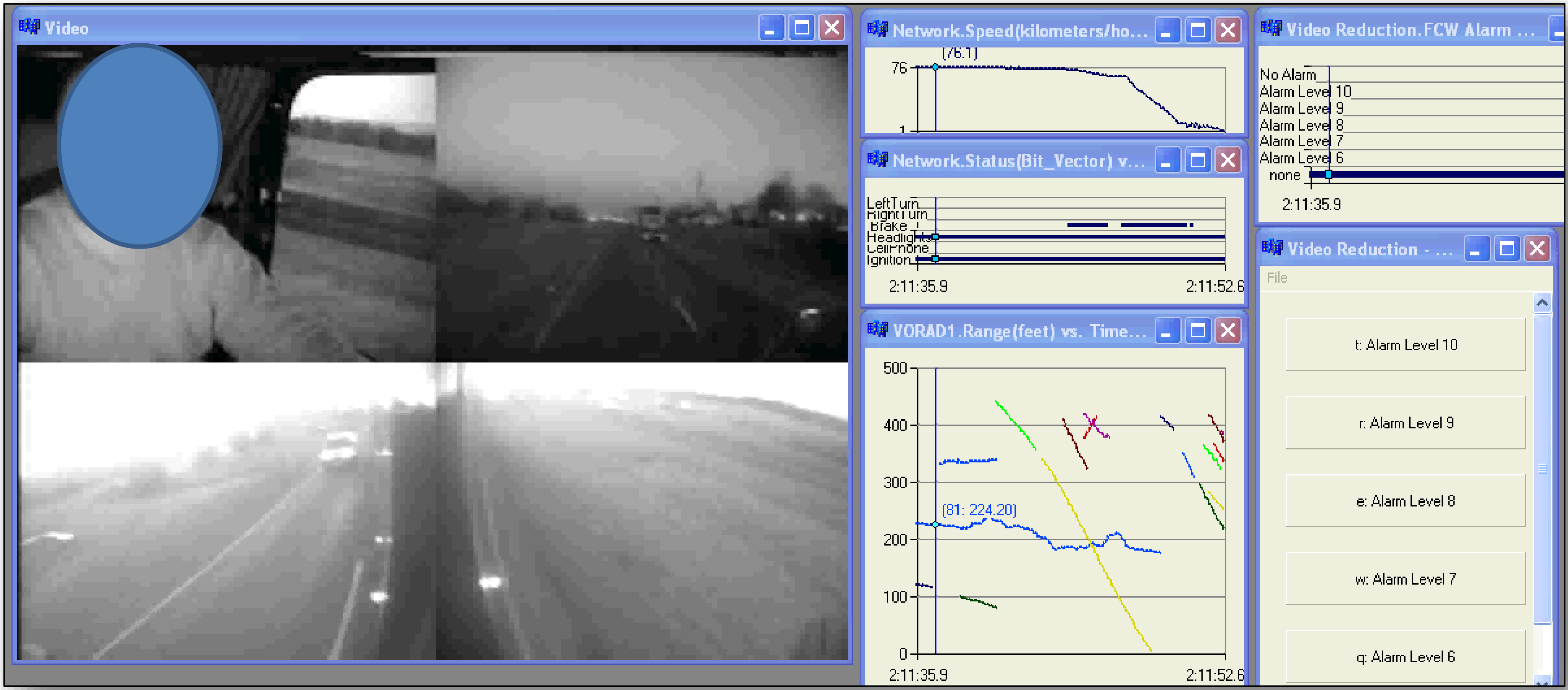
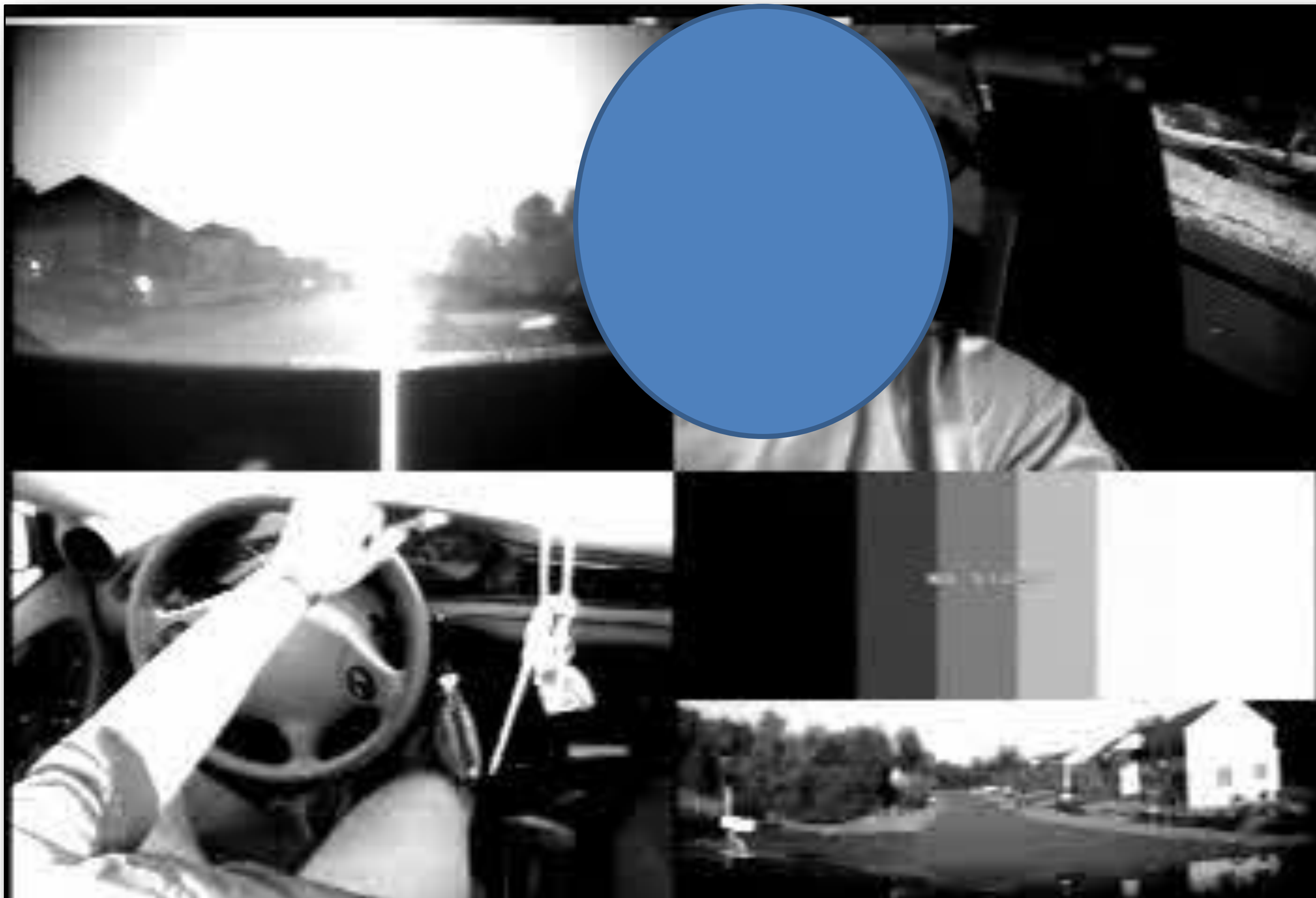
Naturalistic Driving Research

- *In Situ* investigation of driver performance
  - Use an instrumented vehicle
  - No experimenter or instructions
  - Data continuously collected for extended period
  - Real world data generated
  - Driver, Vehicle, and Environment

Naturalistic Driving Research



Naturalistic Driving Research



Driver Distraction

Investigating Driver Distraction

- Two large scale heavy-vehicle naturalistic driving studies were performed by VTTI (Funded by FMCSA)
- 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

Investigating Driver Distraction

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

Investigating Driver Distraction

- FMCSA-funded study using DriveCam data was conducted
  - 13,305 vehicles (trucks and buses)
  - 1,085 crashes; 39,036 near-crashes and events
  - 211,171 baselines

Investigating Driver Distraction

Task	Odds Ratio	LCL	UCL	Frequency of Safety-Critical Events	Frequency of Baselines
Text message on cell phone	**163.59**	51.77	516.73	90	3
Reaching for cell phone	**3.74**	2.97	4.71	128	178
Reaching for headset/earpiece	**3.38**	2.64	4.31	104	168
Dialing cell phone	**3.51**	2.89	4.27	165	256
Any cell phone use	**1.14**	1.06	1.23	895	4,262
Consuming food or drink	1.11	0.97	1.26	268	1,320
Talk or listen to hand-held phone	0.89	0.80	1.00	372	2,266
Talk or listen to hands-free phone	**0.65**	0.56	0.76	194	1,626

Investigating Driver Distraction

- Analysis of 100-Car light vehicle naturalistic driving study
  - 109 cars
  - 12 to 13 months per car
  - 42 crashes, 476 near-crashes
  - 16,614 baselines

Investigating Driver Distraction

Type of Secondary Task	Odds Ratio	Lower CL	Upper CL
Using cell phone			
Texting or using internet	NA		
Dialing	**2.49**	1.38	4.54
Talking	0.76	0.51	1.13
Reaching for phone	1.37	0.31	6.14
Reaching for object other than cell phone	1.19	0.61	2.31
Looking at roadside object	0.67	0.37	1.22
Adjusting controls for radio or HVAC	**0.53**	0.30	0.94
Adjusting controls other than those for radio or HVAC	0.64	0.15	2.65
Eating	1.26	0.74	2.15
Drinking nonalcoholic beverage	0.44	0.16	1.22

Latest Research

Teen Drivers

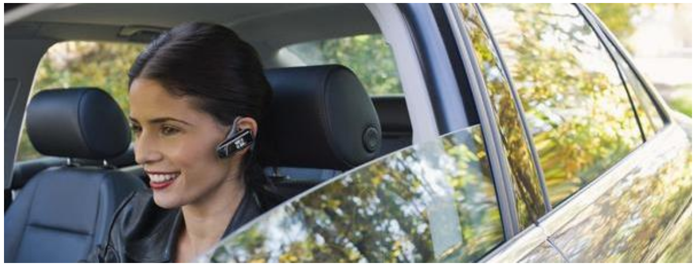
- Analysis of teen driver naturalistic driving study
  - 42 newly licensed teen drivers
  - 18 months each
  - 31 crashes, 136 near-crashes
  - 5,238 baselines

Teen Drivers

Type of Secondary Task	Odds Ratio	Lower CL	Upper CL
Using cell phone			
Texting or using internet	**3.87**	1.62	9.25
Dialing	**8.32**	2.83	24.42
Talking	0.61	0.24	1.57
Reaching for phone	**7.05**	2.64	18.83
Reaching for object other than cell phone	**8.00**	3.67	17.50
Looking at roadside object	**3.90**	1.72	8.81
Adjusting controls for radio or HVAC	1.37	0.72	2.61
Adjusting controls other than those for radio or HVAC	2.60	0.89	7.65
Eating	**2.99**	1.30	6.91
Drinking nonalcoholic beverage	1.36	0.31	5.88

Hands-Free Devices

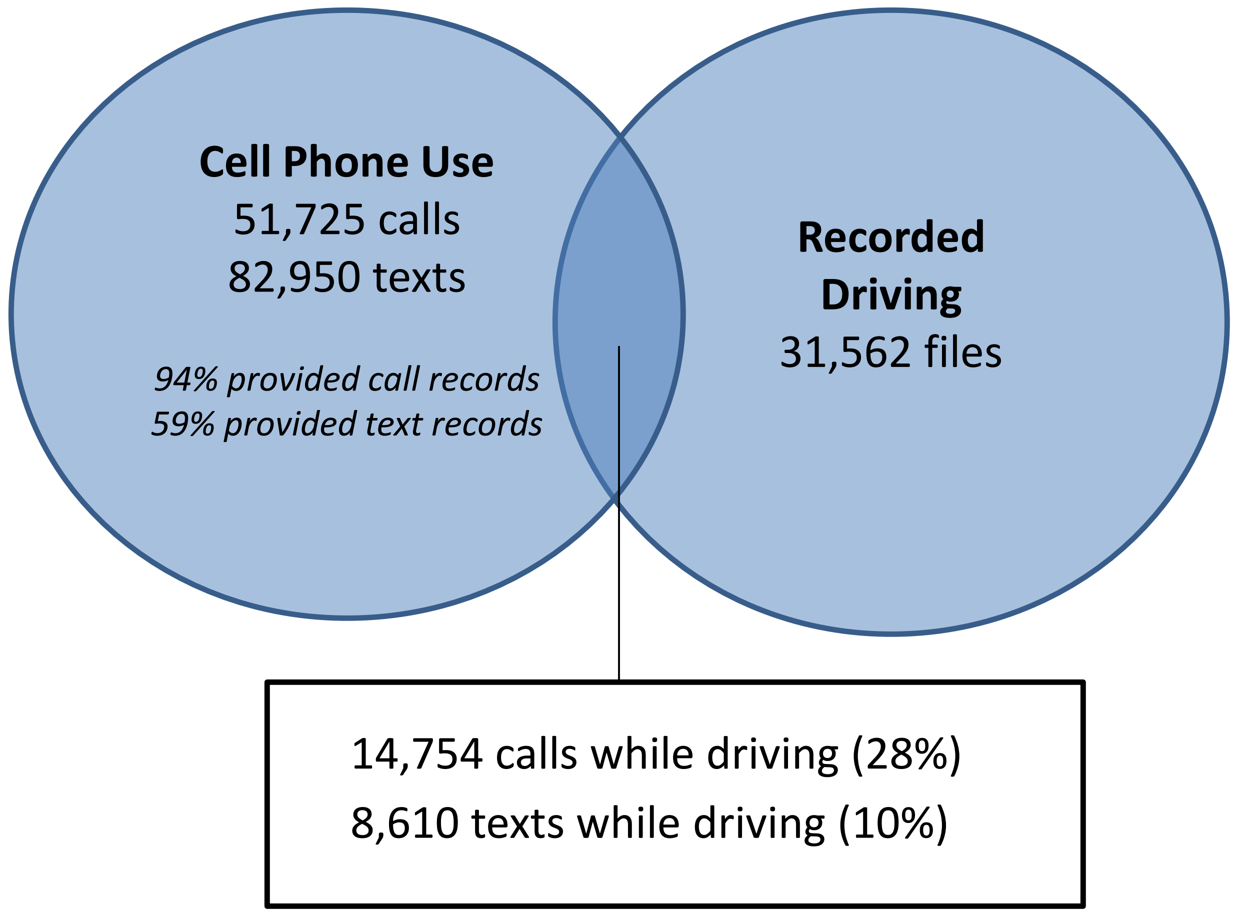
- Investigate SCE risk and performance when using 3 phone types
  - Hand-held (HH)
  - Portable hands-free (PHF)
  - Integrated hands-free (IHF)



Hands-Free Devices

- 204 drivers
- 31 days each
- 342 SCEs
  - 6 crashes
  - 72 near-crashes
  - 264 crash-relevant conflicts

NDS Data + Cell Phone Records



Cell Phone Use

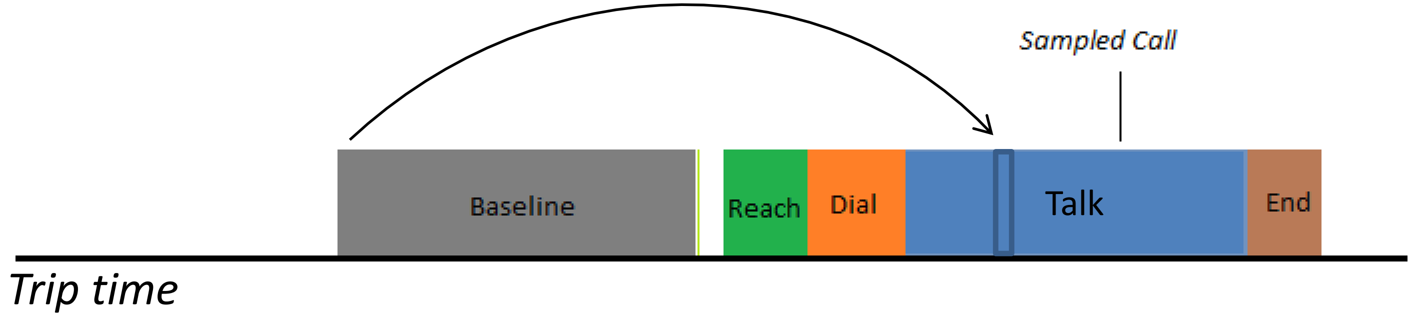
- Drivers conversed on cell phone 12% of time
- Mean call length was 2.36 minutes
- Dialing averaged 12 s
- Push to begin averaged 3 s on PHF and 5 s on IHF
- Texting averaged 35 s

SCE Risk

Subtask	Rate Ratio	LCL	UCL	p-value
Cell Phone Use – Collapsed	1.32	0.96	1.81	.0917
Visual-Manual	**2.93**	1.90	4.51	< .0001
Call-related Visual-Manual	**3.34**	1.76	6.35	.0003
Text-related Visual-Manual	**2.12**	1.14	3.96	.0184
Talking/Listening	0.84	0.55	1.29	.4217
Talking/Listening HH	0.84	0.47	1.53	.5764
Talking/Listening PHF	1.19	0.55	2.57	.6581
Talking/Listening IHF	0.61	0.27	1.41	.2447
HH Cell Phone Use (Collapsed)	**1.73**	1.20	2.49	.0034
PHF Cell Phone Use (Collapsed)	1.06	0.49	2.30	.8780
IHF Cell Phone Use (Collapsed)	0.57	0.25	1.31	.1859

Driver Adaptation

- Analyzed data 30 s prior to the start of the call
- Compared driving performance during call
- Method also applied to truck dataset



Driver Adaptation

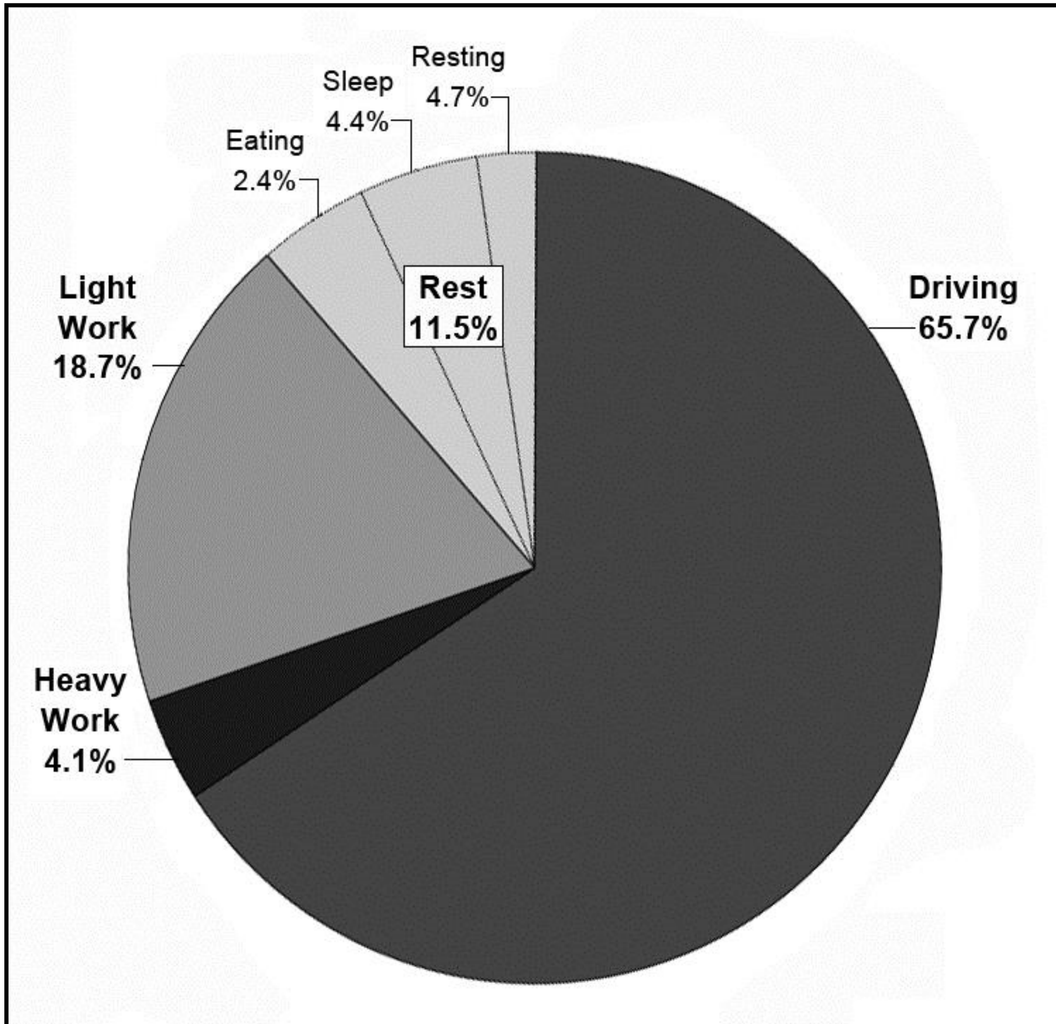
- Drivers did not increase longitudinal safety margins
  - Headway did not change
  - 4 km/h speed increase a practical effect?
- CMV drivers changed lanes less often
  - Reduced complexity of managing large blind spots
- Light vehicle drivers stayed in lane more often
  - Showed improved lateral vehicle control

Discussion

- Known that drivers look forward more often when conversing on cell phone
  - LV drivers look forward 5.1% more on average
  - CMV drivers look forward 3.3% more on average
- Could be ultimate reason why
  - It has not been found to increase SCE risk for LV drivers
  - It was found to be associated with a decreased SCE risk for CMV drivers
    - Less unintentional lane departures
    - Less external distraction
    - More opportunity to detect unfolding conflicts in pathway

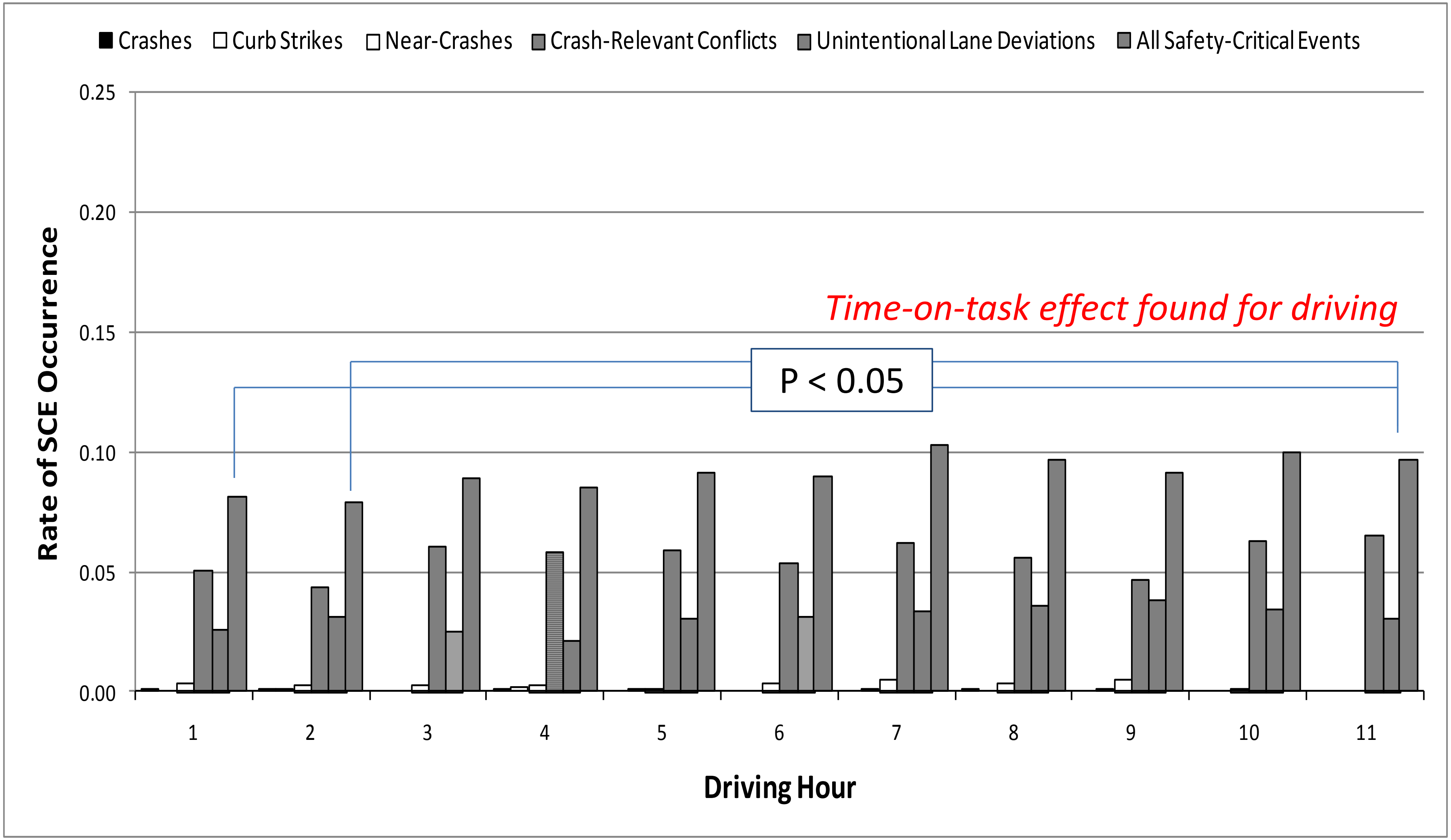
Driver Drowsiness

What Do Truck Drivers Do?

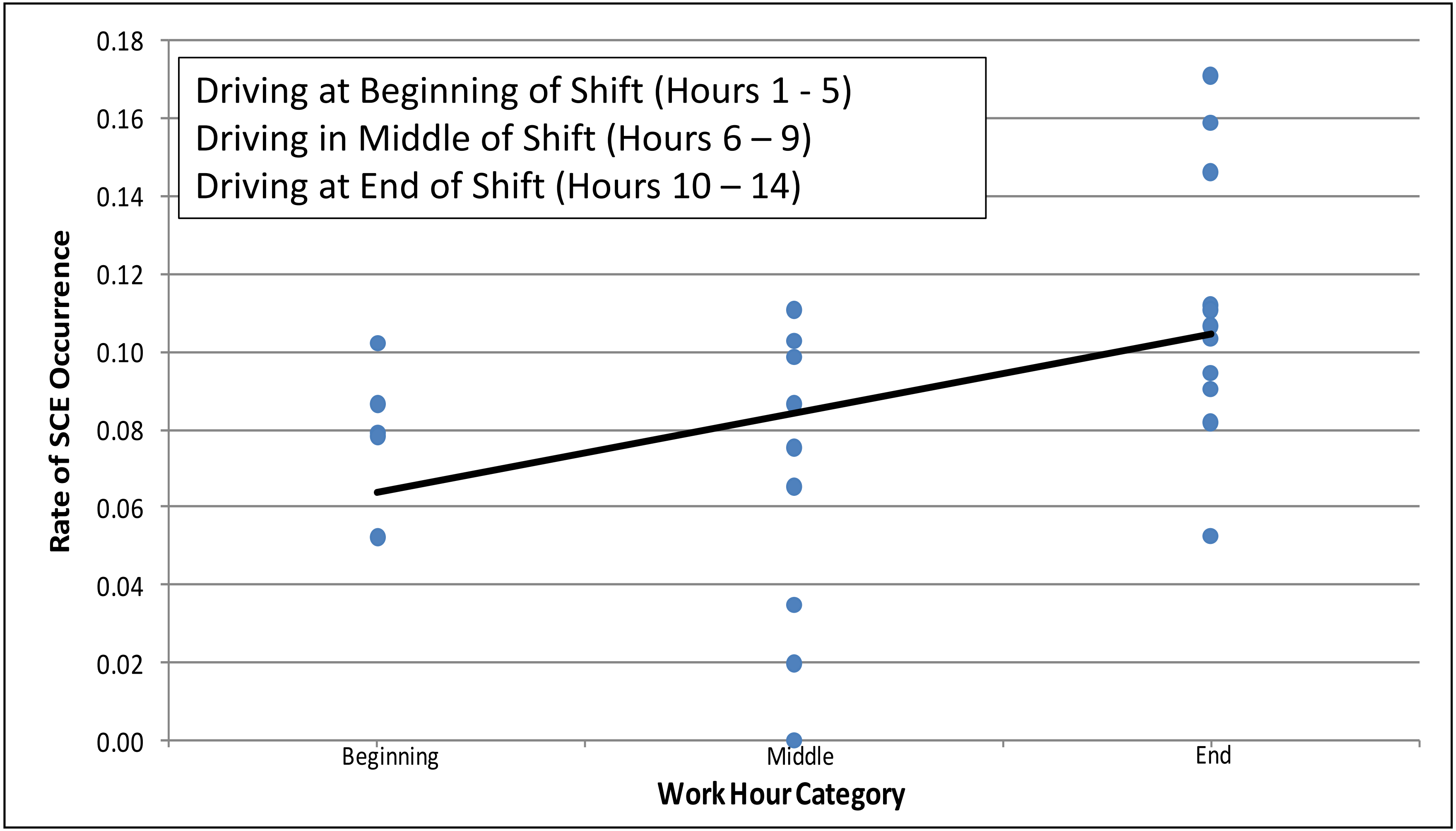


Truck drivers only drive 2/3 of their workday

SCE Rate by Driving Hours

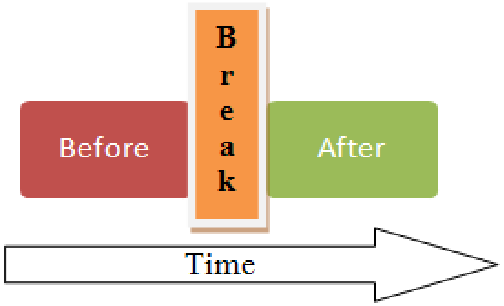


SCE Rate by Working Hour for Shifts with 14 Working Hours



What is the safety impact of a 14 hour workday?

Do Breaks Help?



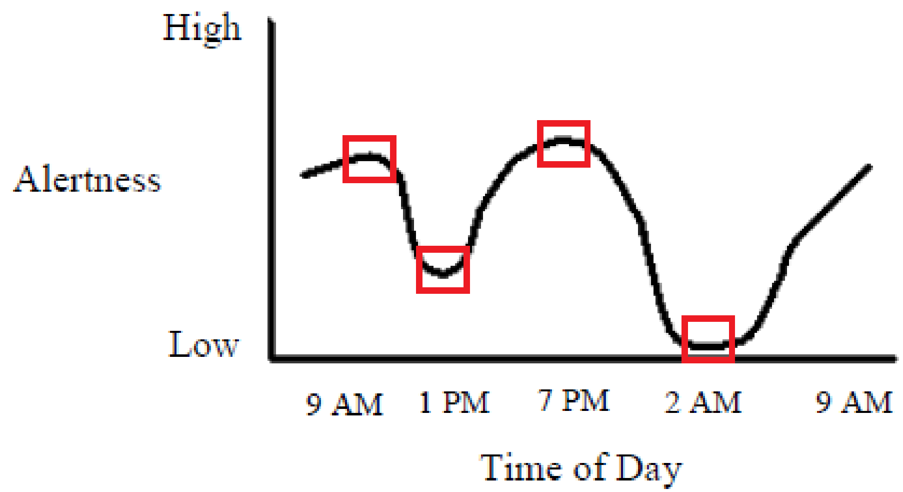
- Analyzed the one-hour window before and after each 30-minute, or longer, break from driving
- Found breaks counteract the negative effects of time-on-task

Break Type	Before Break	After Break	SCE Ratio (Before/After)	Magnitude of Reduction
All Breaks Types	0.135	0.096	1.406	**29%**
Type 1: Rest During Duty Period	0.150	0.108	1.389	**28%**
Type 2: Work During Duty Period	0.135	0.094	1.436	**30%**
Type 3: Rest During Duty/Off-duty	0.200	0.133	1.504	**34%**
Type 4: Off-Duty	0.166	0.081	2.049	**51%**

- Any break is better than no break, but a true rest break (Off-Duty) provides the most benefit

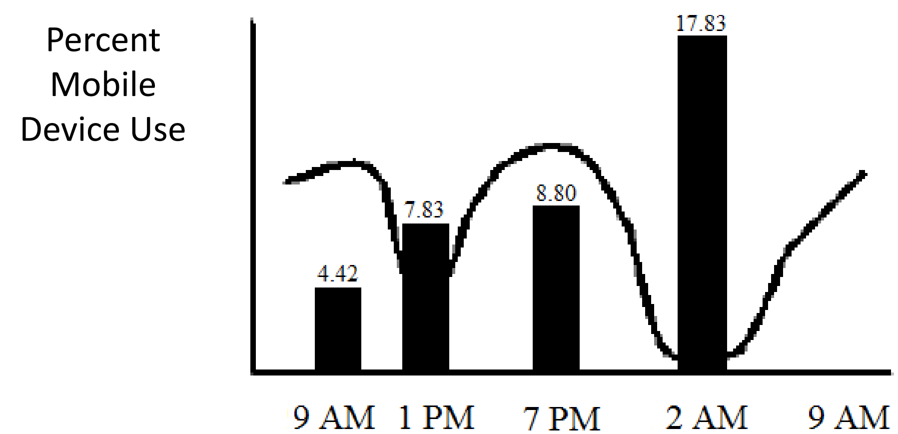
Relationship between Mobile Device Use and Drowsiness

Bin	Time of Day
Low Morning Bin	2:00AM – 3:59AM
High Morning Bin	9:00AM – 10:59AM
Low Afternoon Bin	1:00PM – 2:59 PM
High Evening Bin	7:00PM – 8:59PM



Percent Mobile Device Use:

$$\frac{\text{Number of samples with mobile device use}}{\text{Total number of samples}}$$



Percent Mobile Device Use Greatest during Circadian Low

Key Points

- Distraction
  - Drivers use cell phones despite laws and education
  - Visual-manual distraction increases risk
  - Ban hand-held cell phones and use eyes-free interfaces
- Drowsiness
  - Truck drivers do much more than drive
  - Time-on-task effect for 14 hour workday
  - Breaks counteract the negative effects of time-on-task
  - Drivers may use mobile devices to break monotony and stave off drowsiness

Questions

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Analysis Opportunities

- Kinematic naturalistic data from light vehicle (100-Car) and heavy vehicle (8-Truck) studies available on-line: http://forums.vtti.vt.edu/
- Open to all researchers to use the data
- Open forum to add algorithms, etc (e.g., SAFER)

New Naturalistic Studies

- SHRP 2 Safety Program (TRB)
  - ~ 2,000 cars
  - Canadian cohort in development
- 270 Truck Study (FMCSA)
- Both studies will have analysis opportunities for outside researchers
  - $$$ Funding available (SHRP 2)
- Goal of both efforts is for the data to be open access
- Video would have protection (IRB)

Take Away Message

Look Forward!