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VEHICLE AND TRAFFIC SAFETY CENTRE AT CHALMERS

Timing Matters: Visual Behavior and Crash Risk in the 100-car On-line Data

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Driver Distraction and Inattention 2011

VTTI NDS Glance Analysis

- Klauer et al (2006) and Olson et al (2009) show that accumulated eyes-off-road time (glance history) is associated with higher crash probability, but they **did not test independently the effect of single glance duration** or assess **how single glance duration combines with glance history** to influence crash risk.

Liang, Lee, and Yekhshatyan (2011)

- 100-Car study data
- 24 algorithms – varying glance duration, glance history, and glance location
- Instantaneous single off-road glance duration and not glance history, was the best crash predictor.
- Algorithms considering both glance history and glance location did not improve estimation above glance duration algorithms
- Using a small window led to better performance than those that used a large window.

- Present study picks up from there…

Timing & Unexpected Events

- Expectancy was an important simultaneous factor to inattention (Dingus et al, 2006).
  - unexpected or unanticipated maneuvers
  - expectancies about the flow of traffic are violated, such as sudden stops or lane changes.

→ Lack of forward roadway viewing
+ unexpected event = crash

→ **"…appropriate fixations typically lead manipulations by up to a second" (Land, 2007)**

Objectives

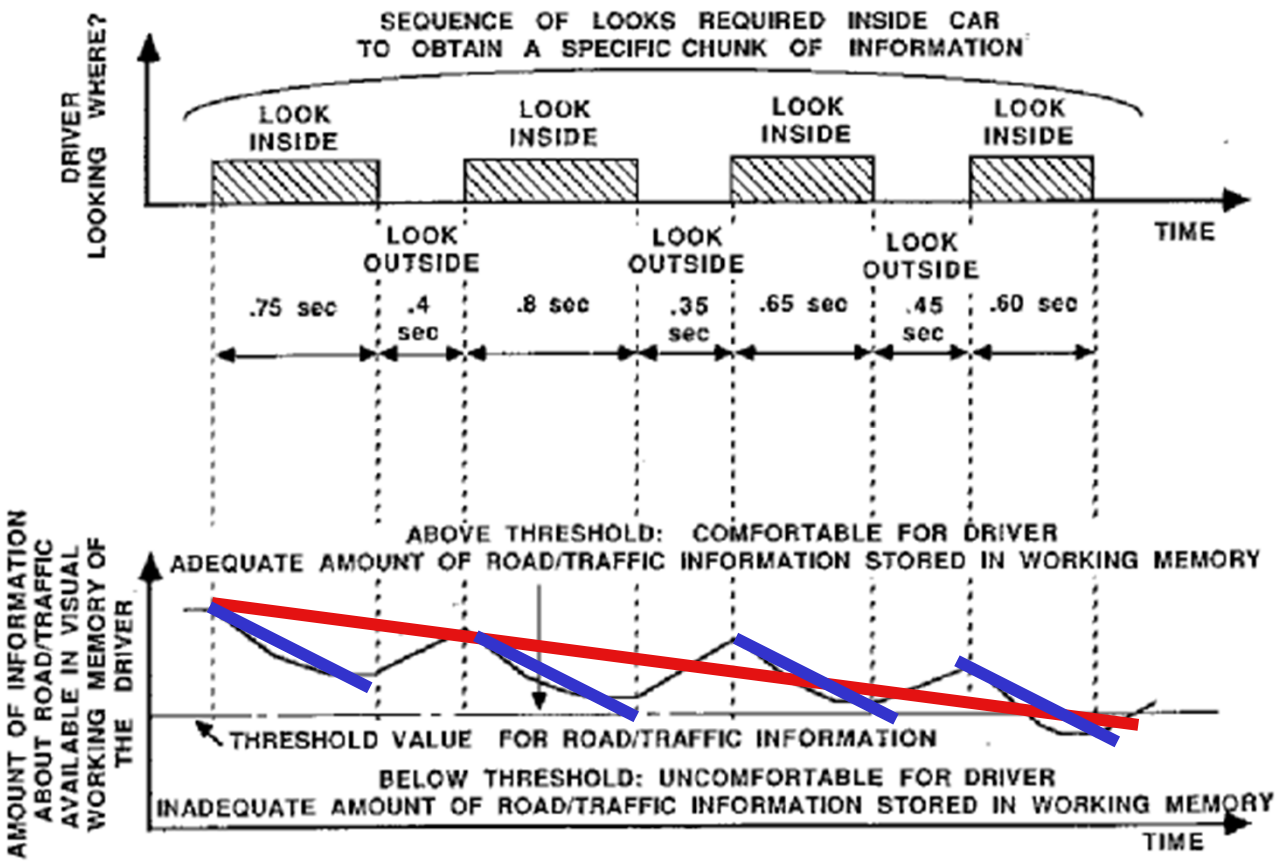
- Observable performance quantification of inattention must be a better way to go than the task classification approach → e.g. countermeasures

- **More detailed description of which glance patterns most significantly affect risk?**

Inattention Quantification

Single Glance
(local effect)
- Single Long Glance
- Inopportune Glance

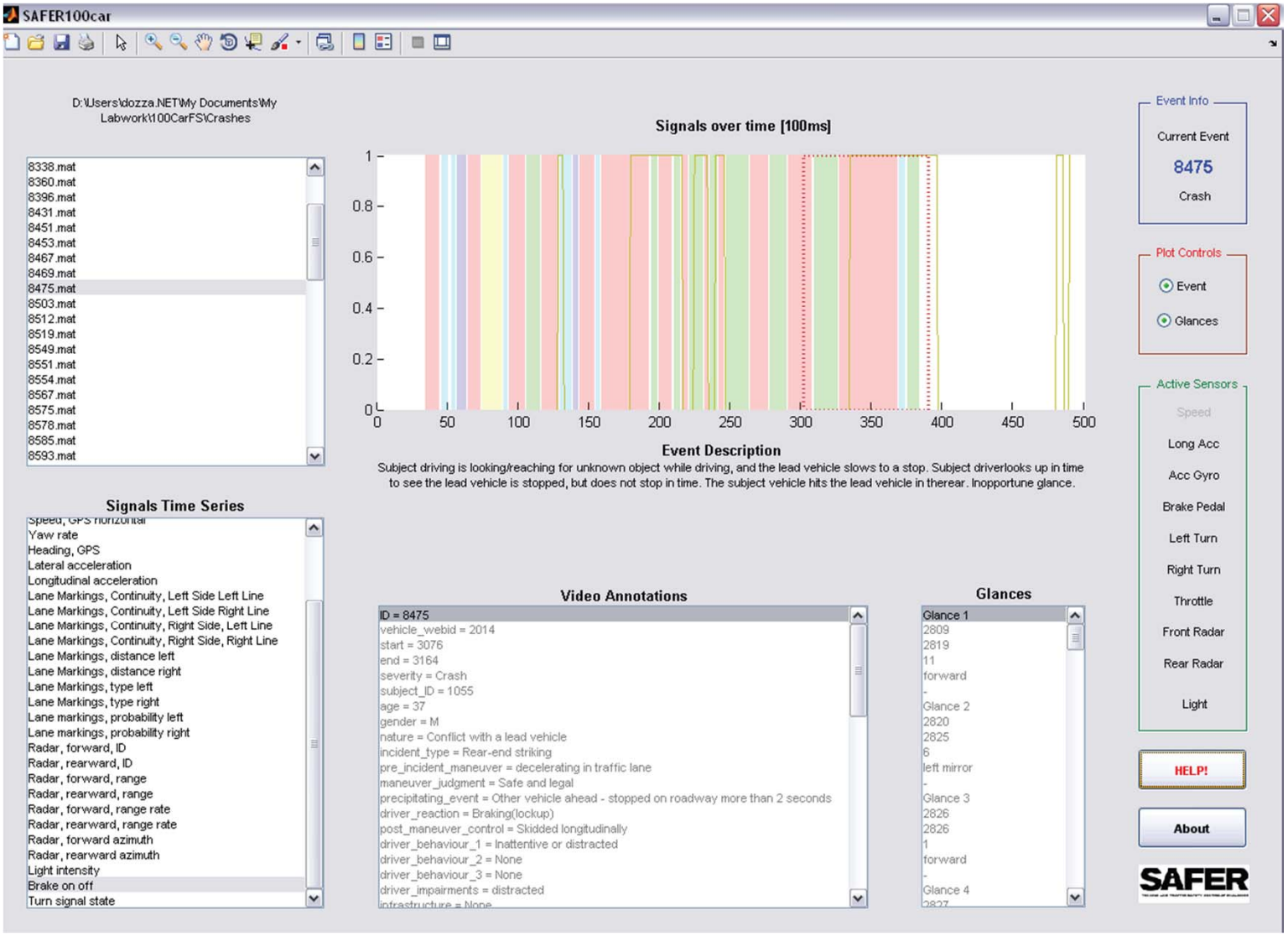
Glance History
(global effect)
- Intensity (%)
- Duration (s)

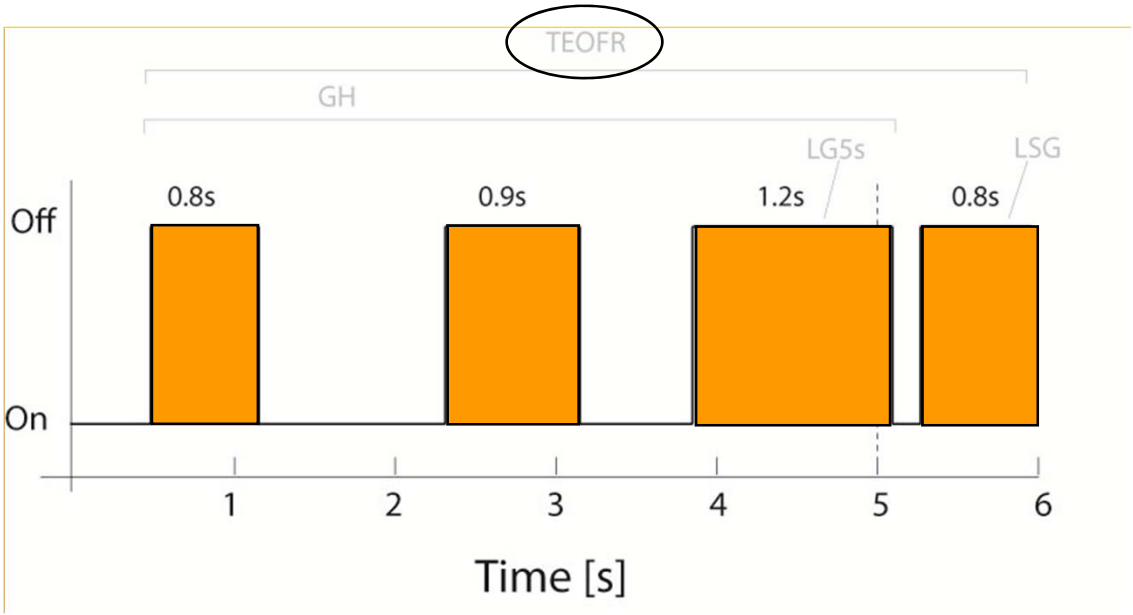


(Zwahlen, 1988)

Method

- Public 100-car data http://forums.vtti.vt.edu (Klauer, 2006)
  - Analyzed with SAFER100-Car toolkit (Dozza, 2010)
- Events (68 crashes and 760 near crashes) and Baseline (20000 epochs)
- A 6-s interval: 5s before the precipitating event and 1s after. Baselines also 6s.
- **Precipitating event: "**The action of a driver that begins the chain of events leading up to the crash, near-crash, or incident. For example, for a rear-end striking collision, the precipitating factor most likely would be lead vehicle begins braking (or lead vehicle brake lights illuminate)."
- 437 events and 4785 epochs satisfied inclusion criteria

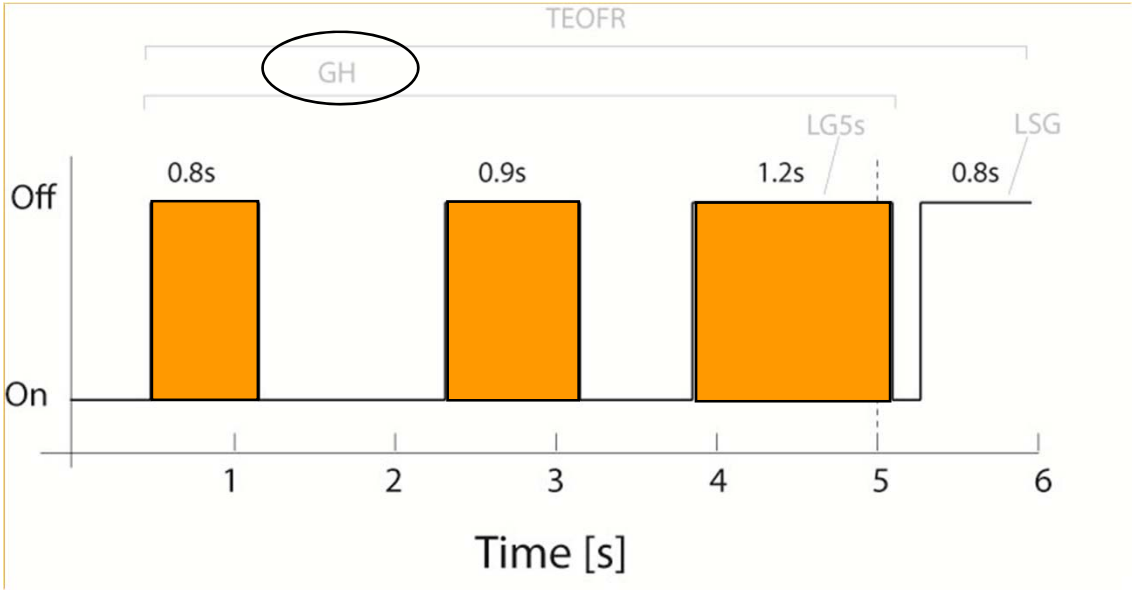

SAFER100car
D:\Users\dozza.NET\My Documents\My Labwork\100CarFS\Crashes
8338.mat
8360.mat
8396.mat
8431.mat
8451.mat
8453.mat
8467.mat
8469.mat
8475.mat
8503.mat
8512.mat
8519.mat
8549.mat
8551.mat
8554.mat
8567.mat
8575.mat
8578.mat
8585.mat
8593.mat
Signals over time [100ms]
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
450
500
Event Description
Subject driving is looking/reaching for unknown object while driving, and the lead vehicle slows to a stop. Subject driverlooks up in time to see the lead vehicle is stopped, but does not stop in time. The subject vehicle hits the lead vehicle in therear. Inopportune glance.
Signals Time Series
Speed, GPS horizontal
Yaw rate
Heading, GPS
Lateral acceleration
Longitudinal acceleration
Lane Markings, Continuity, Left Side Left Line
Lane Markings, Continuity, Left Side Right Line
Lane Markings, Continuity, Right Side, Left Line
Lane Markings, Continuity, Right Side, Right Line
Lane Markings, distance left
Lane Markings, distance right
Lane Markings, type left
Lane Markings, type right
Lane markings, probability left
Lane markings, probability right
Radar, forward, ID
Radar, rearward, ID
Radar, forward, range
Radar, rearward, range
Radar, forward, range rate
Radar, rearward, range rate
Radar, forward azimuth
Radar, rearward azimuth
Light intensity
Brake on off
Turn signal state
Video Annotations
ID = 8475
vehicle_webid = 2014
start = 3076
end = 3164
severity = Crash
subject_ID = 1055
age = 37
gender = M
nature = Conflict with a lead vehicle
incident_type = Rear-end striking
pre_incident_maneuver = decelerating in traffic lane
maneuver_judgment = Safe and legal
precipitating_event = Other vehicle ahead - stopped on roadway more than 2 seconds
driver_reaction = Braking(lockup)
post_maneuver_control = Skidded longitudinally
driver_behaviour_1 = Inattentive or distracted
driver_behaviour_2 = None
driver_behaviour_3 = None
driver_impairments = distracted
Glances
Glance 1
2809
2819
11
forward
-
Glance 2
2820
2825
6
left mirror
-
Glance 3
2826
2826
1
forward
-
Glance 4
Event Info
Current Event
8475
Crash
Plot Controls
Event
Glances
Active Sensors
Speed
Long Acc
Acc Gyro
Brake Pedal
Left Turn
Right Turn
Throttle
Front Radar
Rear Radar
Light
HELP!
About
SAFER



Glance Metrics

Total time eyes off forward roadway (TEOFR)

0.8 + 0.9 + 1.2 + 0.8 = 3.7s

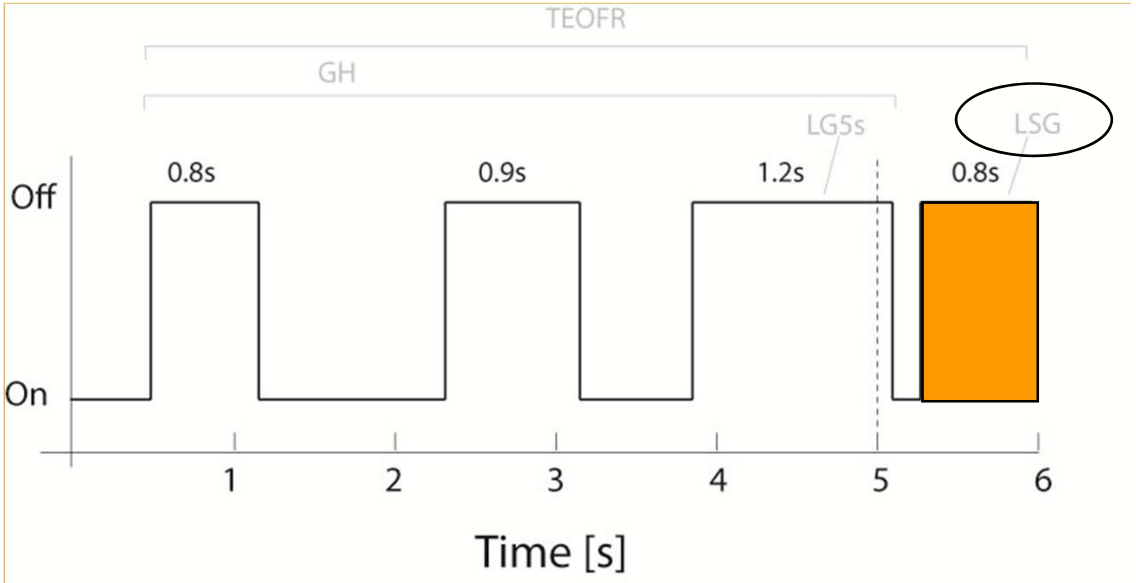


Glance Metrics

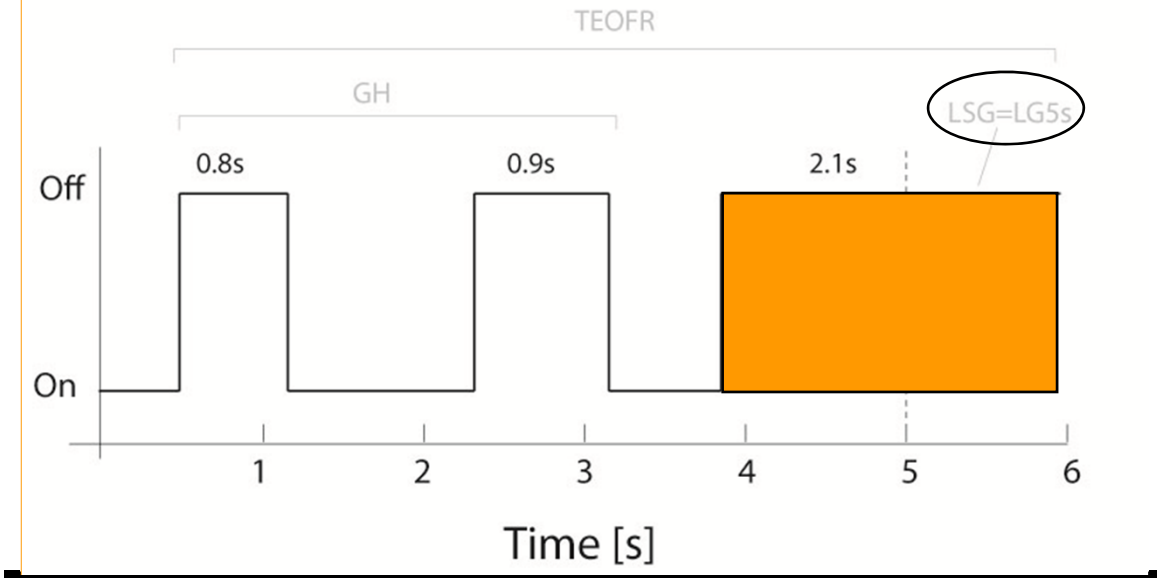
- Glance history (GH; TEOFR minus LSG)

0.8 + 0.9 + 1.2 = 2.9s

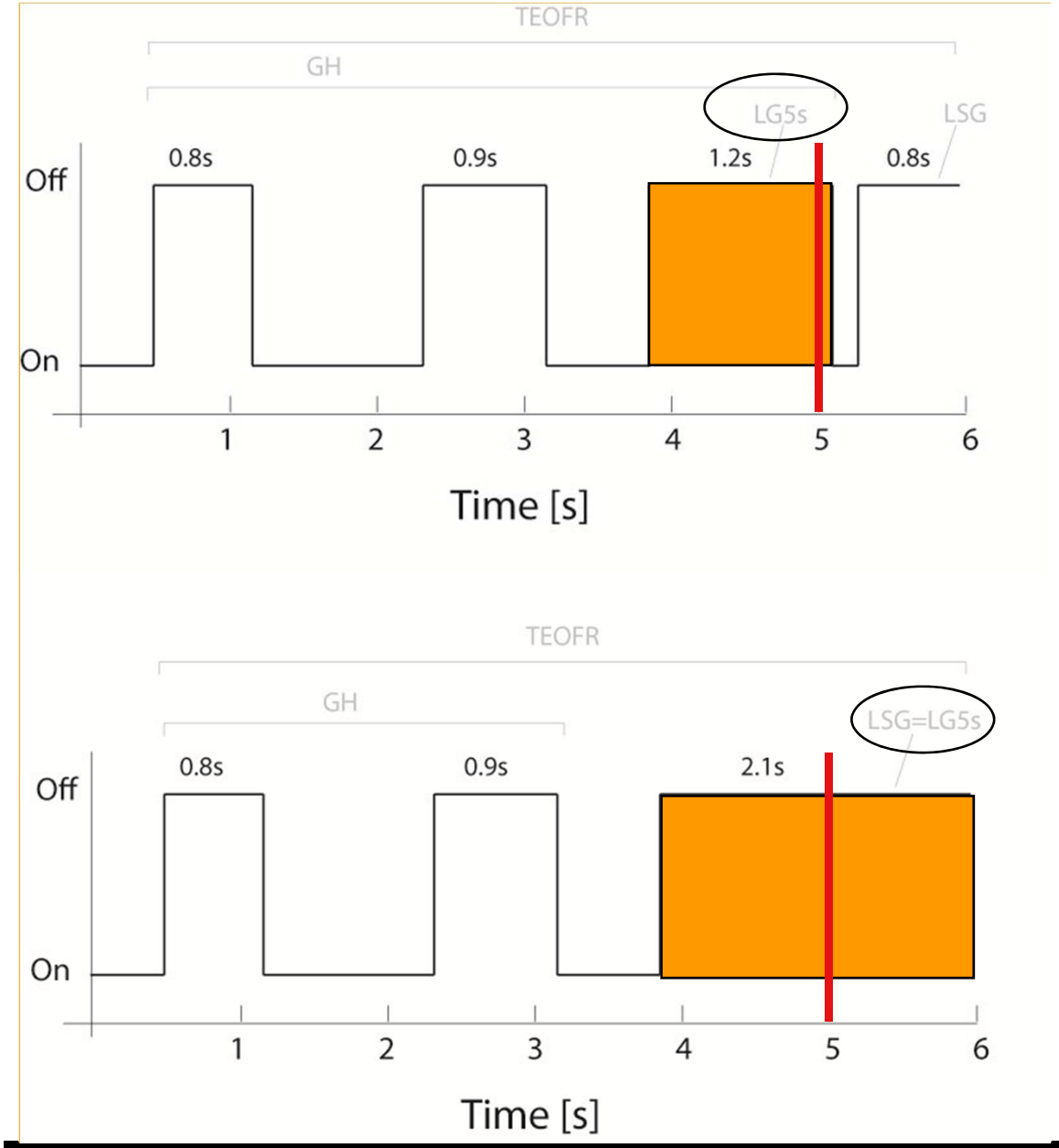
Glance Metrics



Last Single Glance (LSG)



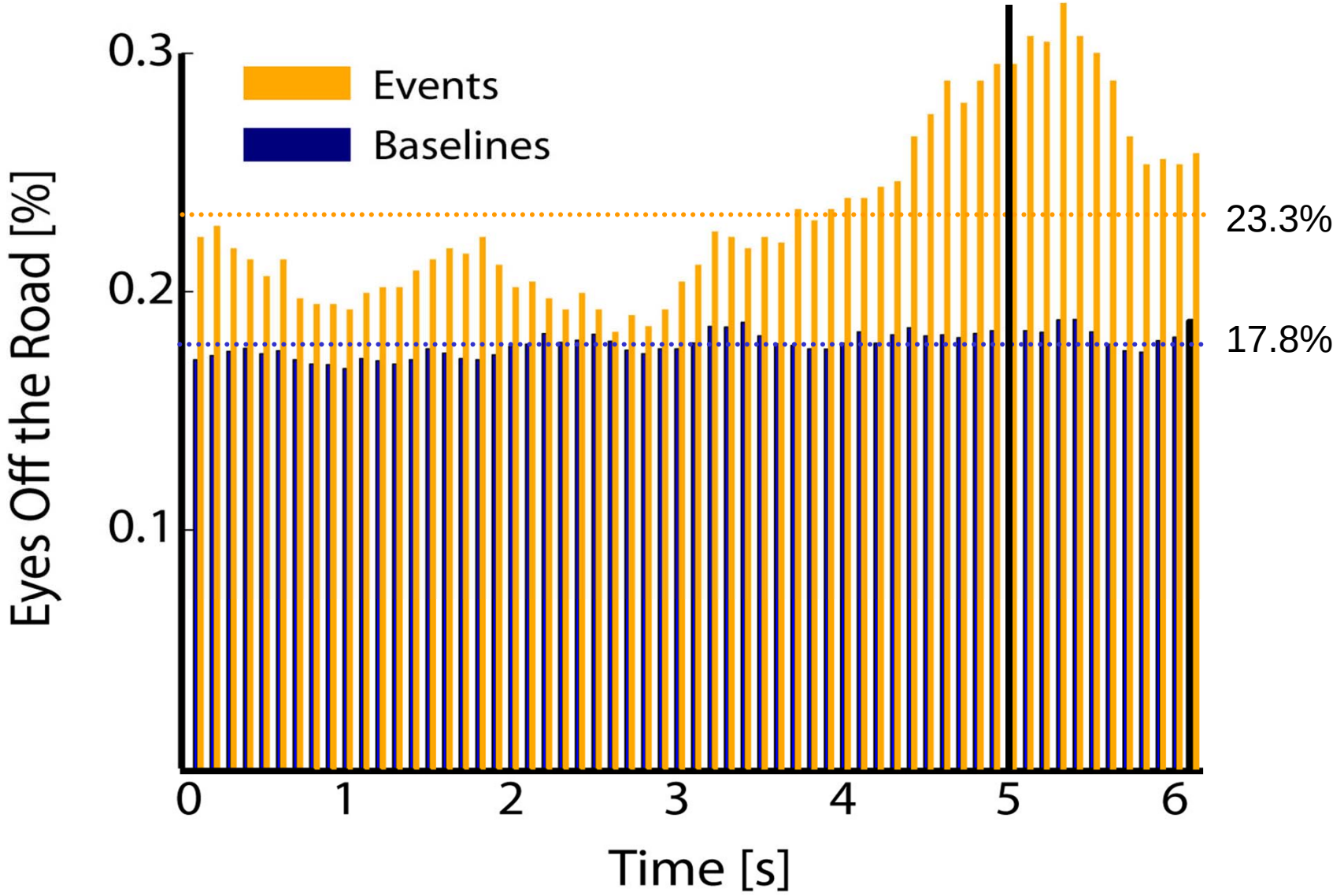
Glance Metrics

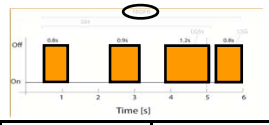
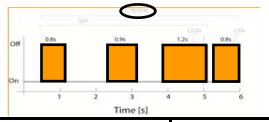
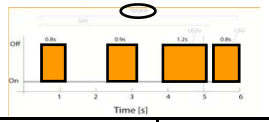
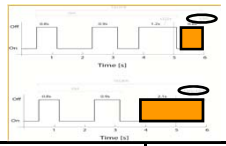
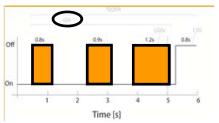
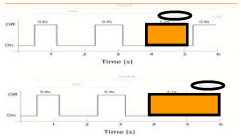


Last glance off-road at the instant in which time was 5s (LG5s)
i.e. intersects with precipitating event

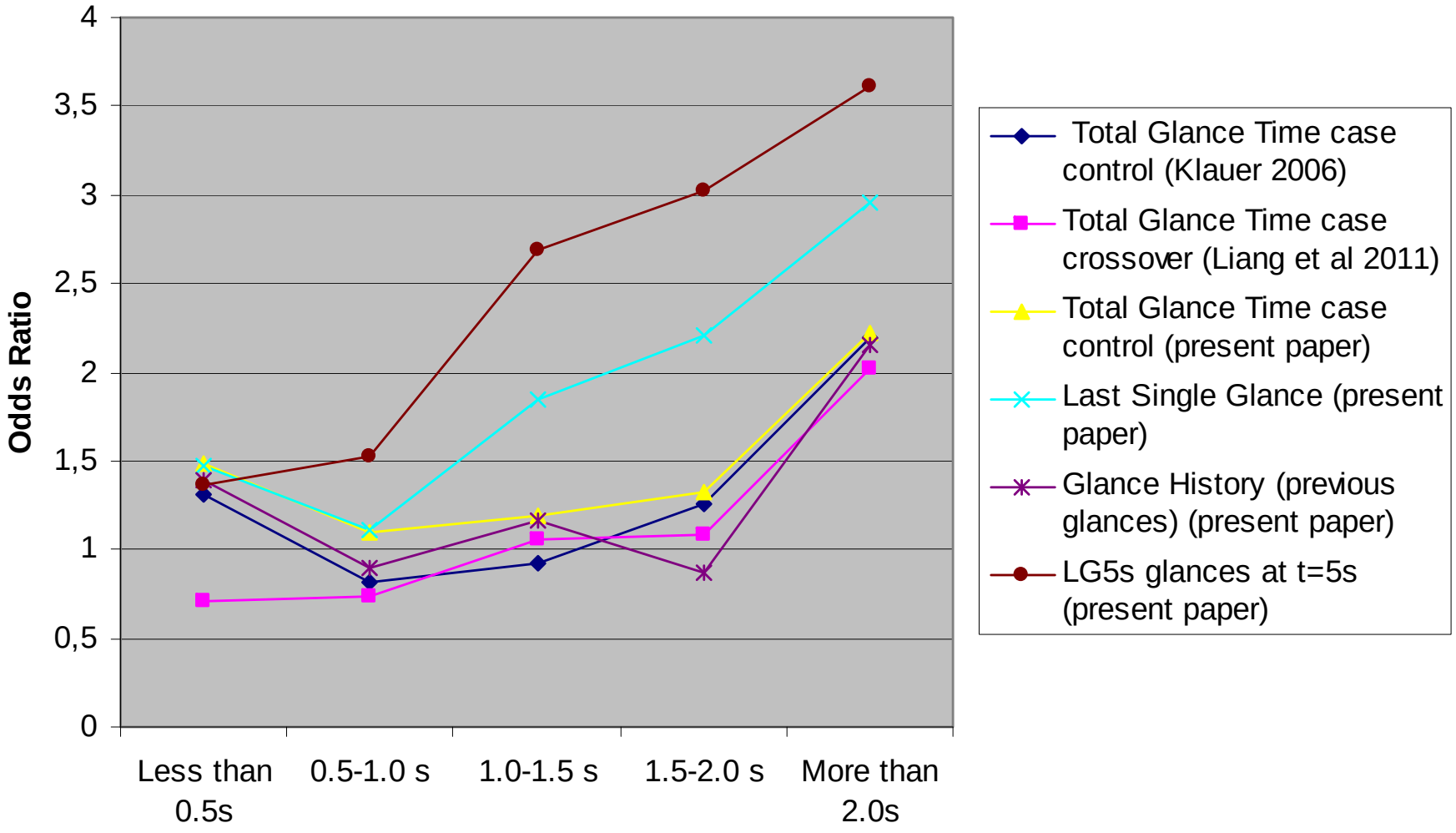
Results

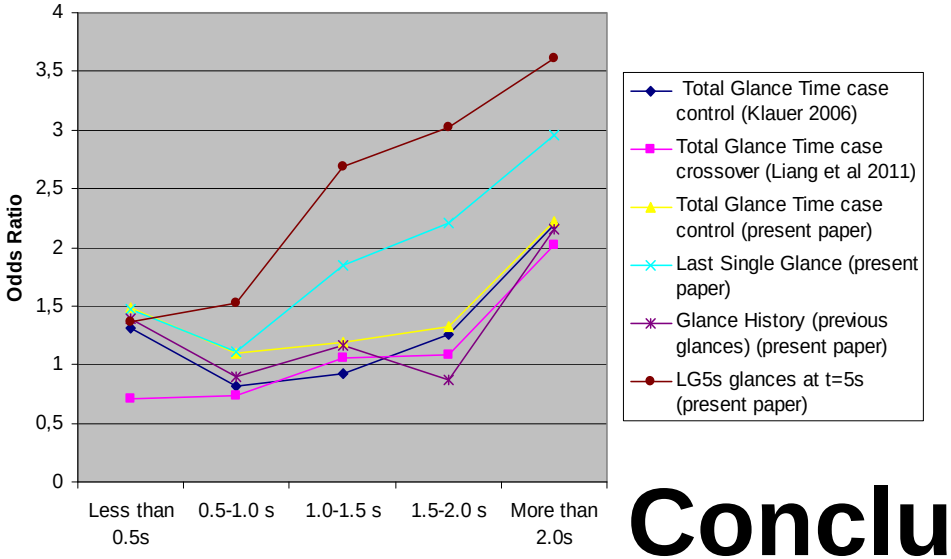
Eyes Off Road Over Time (100ms bins)



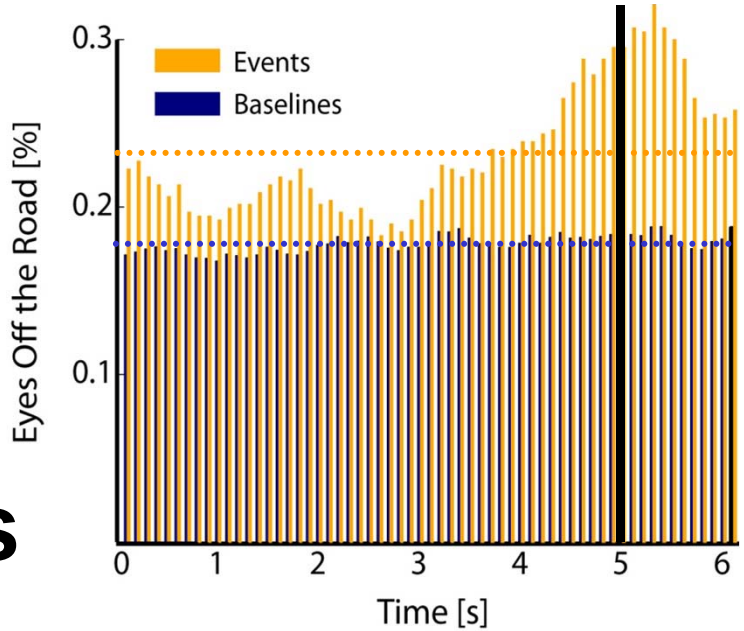







	Odds Ratio from **Total Glance Time** case control (Klauer 2006)	CI	Odds Ratio from **Total Glance Time** case crossover (Liang et al 2011)	CI	Odds Ratio from **Total Glance Time** case control (present paper)	CI	Odds Ratio from **Last Single Glance** (present paper)	CI	Odds Ratio from **Glance History** (previous glances) (present paper)	CI	Odds Ratio for **LG5s glances at t=5s** (present paper)	CI
Less than 0.5s	1.31	0.91-1.89	0.71	0.58-0.86	1.48	0.94-2.33	**1.47**	**1.05-2.06**	1.39	0.83-2.33	1.37	0.55-3.42
0.5-1.0 s	0.82	0.60-1.31	0.74	0.55-1.00	1.10	0.73-1.64	1.11	0.78-1.56	0.90	0.58-1.39	1.52	0.94-2.48
1.0-1.5 s	0.92	0.65-1.31	1.06	0.78-1.44	1.19	0.75-1.87	**1.85**	**1.22-2.81**	1.17	0.75-1.84	**2.69**	**1.77-2.69**
1.5-2.0 s	1.26	0.89-1.79	1.08	0.75-1.56	1.32	0.83-3.02	**2.21**	**1.28-3.81**	0.87	0.46-3.12	**3.02**	**1.76-5.20**
More than 2.0s	**2.19**	**1.72-2.78**	**2.02**	**1.60-2.55**	**2.22**	**1.63-3.02**	**2.95**	**1.93-4.49**	**2.16**	**1.49-3.12**	**3.61**	**2.44-5.35**


Odds Ratio
4
3,5
3
2,5
2
1,5
1
0,5
0
Less than 0.5s
0.5-1.0 s
1.0-1.5 s
1.5-2.0 s
More than 2.0s
Total Glance Time case control (Klauer 2006)
Total Glance Time case crossover (Liang et al 2011)
Total Glance Time case control (present paper)
Last Single Glance (present paper)
Glance History (previous glances) (present paper)
LG5s glances at t=5s (present paper)



Conclusions



- **The glance at event onset gives the highest OR across the board.**
- Last Single Glance and LG5s glance at t=5s give significant results for shorter glances and highest ORs → They captured the ”Hump”
- Glance History same as Total Glance Time
- By combining GH with LSG you *lose* the effects from LSG
- Because the >2s bin is so strongly significant it shows up in the TGT and GH also. → Looking away from road more than 2s at anytime is so important
- The 0.5s bin becomes more reasonable.

Implications

- The 100-car data is really saying that single glances from 1s and up at the wrong time (at precipitating event) are significantly risky, not necessarily accumulated glance history.

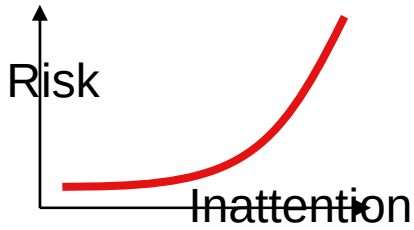
→ Keep glances short (<1s) and well-timed

→ Previous glances don't necessarily contribute.

→ If glances don't match up with precipitating event then they may be ok

→ HMI Design implications, Safety systems, policy…

Limitations & Further Work



- External event not clear (precipitating event) → SHRP2 SAFER project
- Risk estimates not conclusive because of small 100car sample size and because there is not a matched baseline → SHRP2 SAFER project
- Extra conditions comparisons not possible because of small sample size
  - Should check effects of: Incident types, Precipitating event type, Age (teens<20), Driver reaction type
- Find the optimized interval → SHRP2 SAFER Project