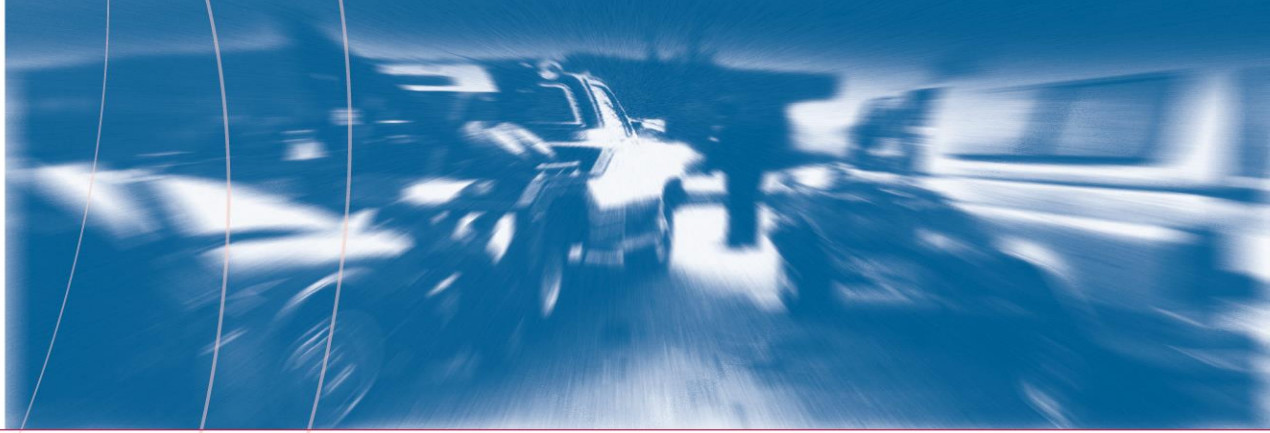

Sleep loss and change detection: a driving simulator study

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Sleep and Driving

- Driver sleepiness is estimated to contribute to 15-30% of crashes (Connor et al., 2002; Williamson et al., 2011)
- Run-off-road crashes.
- Research focus on lateral vehicle control and out-of-lane events.
- Less is known about driving impairment leading up to run-off-road.

Change detection

Change blindness: failure (or delay) in detecting an obvious change to a visual object or scene

- during eye movements
- during brief disruption to visual display

- Occurs for:
  - expected and unexpected changes
  - simple arrays – letters, digits
  - photographs
  - real-world interactions

(McConkie & Currie, 1996; Pashler, 1988; Rensink, O'Regan, & Clark, 1997; Simons & Levin, 1997, 1998)

Change detection

- Five steps involved in change detection:

  1. **attend** to location of target (i.e., object to change)
  2. **encode** info about **pre-change** target
  3. **encode** info about **post-change** target
  4. **compare** pre- and post-change target info
  5. **consciously recognise discrepancy** between pre- and post-change targets

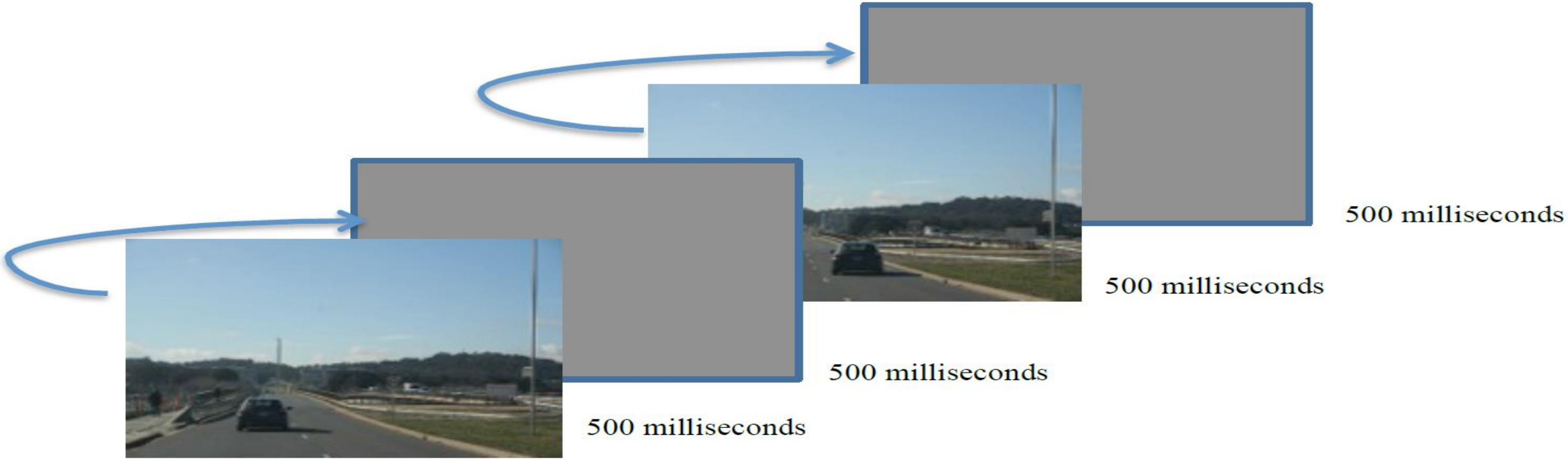
(Jensen, Yao, Street, & Simons, 2011)

Change blindness

- In the person change paradigm, observers are more likely to notice the change if the person is an “in-group” vs. “out-group” member

(Simons & Levin, 1998)

Change blindness paradigm

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Previous findings

- Faster and more accurate change detection in rural vs urban scenes.
- Faster and more accurate change detection with greater safety relevance.
- Change detection accuracy is maintained when sleepy.
- When sleepy, drivers detected changes more slowly in urban images, but faster in rural images.

Beanland, Filtness, Jeans (2017) Change detection in urban and rural driving scenes: Effects of change target and safety relevance on change blindness. Accident Analysis and Prevention, 100, 111-122.

Cox, Beanland, Filtness (In press) Risk Safety perception on urban and rural roads: Effects of environmental features, driver age and risk sensitivity. Traffic Injury Prevention.

Filtness, Beanland (under review) Sleep loss and change detection in driving scenes. Transportation Research Part F.

Limitations of photo paradigm

Validity for driving.

- Distracting environment.
- Often one opportunity to detect change.
- Movement through environment (travel speed).
- Unexpected changes.

Method – Driving simulator

Aim: Does sleep loss affect change detection when driving in urban and rural environments?

Participants:

- 21 experienced drivers (12 female),
- Aged 18-33 years,
- Regular 7-8h sleepers
- Regular drivers (at least weekly)

Method

Design:

Two 1h experimental sessions (counterbalanced)

- a normal night's sleep,
- one night of sleep restriction to 5 hours

10.30am (8 participants), 12.00 noon (4 participants), 1.30pm (6 participants) or 3.00pm (6 participants). At least 3 days apart.

Prior sleep recorded by sleep diary and actigraphy.

Familiarisation drive (2 laps)

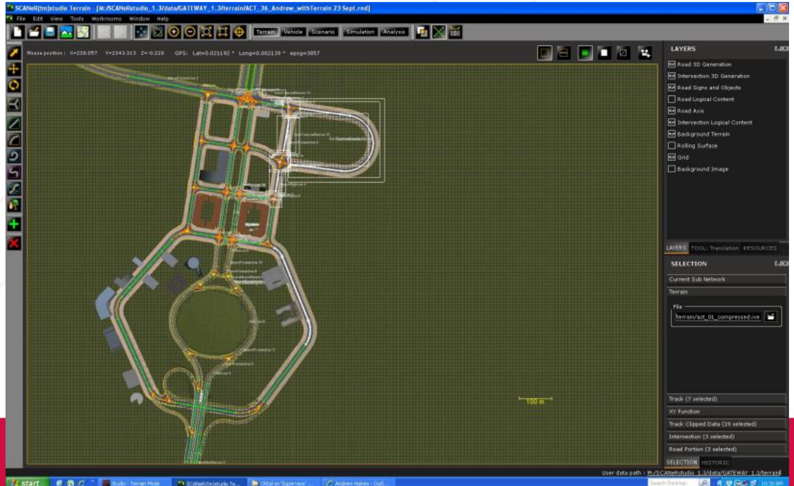
Driving simulator

- SCANeR™ studio software version 1.4
- 180° forward field of view from 3 projector screens
- Six degree of freedom (6DOF) motion platform

Photo by Sonja de Sterke

Road description

- 2 matched driving scenarios (order and timing of changes differed)
- 5 laps of a 11.3km circuit (45min driving)
- 50% urban Canberra 60km/h, 50% rural 100km/h



Sleep measures

- KSS before and after driving
- How much effort to stay awake? (7point scale)
- Sleep related eye symptoms[1]

1: Filtness A.J., Anund A., Fors C., Ahlström C., Åkerstedt T., Kecklund G. (2014). Sleep related eye symptoms and their potential for identifying driver sleepiness. Journal of Sleep Research, 23(5), 568-575.

Change detection task

- Black simulator screen for 500ms
  - identical (change-absent)
  - changed (change-present)

- 8 change-absent trials per drive (4 urban, 4 rural)
- 12 change-present trials per drive (6 urban, 6 rural)

- Change targets regularly present

- Familiarisation drive included 8 blackouts (3 change-absent)

Changes

	Low Safety Relevance	High Safety Relevance
Urban	- Parked cars change colour - Advisory road sign changes - Cyclist moves from the hard shoulder to the road (opposite side of road).	- Car travelling towards participant (head on-collision) - Cyclist moves from hard shoulder to driving lane (rear-end collision) - Speed limit sign decreases by 10 km/h
Rural	- Parked cars change colour. - Advisory road sign changes - Tractor moves from the hard shoulder to the road (opposite side of road).	- Car travelling towards participant (head on-collision) - Tractor moves from hard shoulder to driving lane (rear-end collision) - Speed limit sign decreases by 10 km/h

Unexpected changes

- Lead vehicle change colour (rural)
- Text signs change to German

Sleep duration

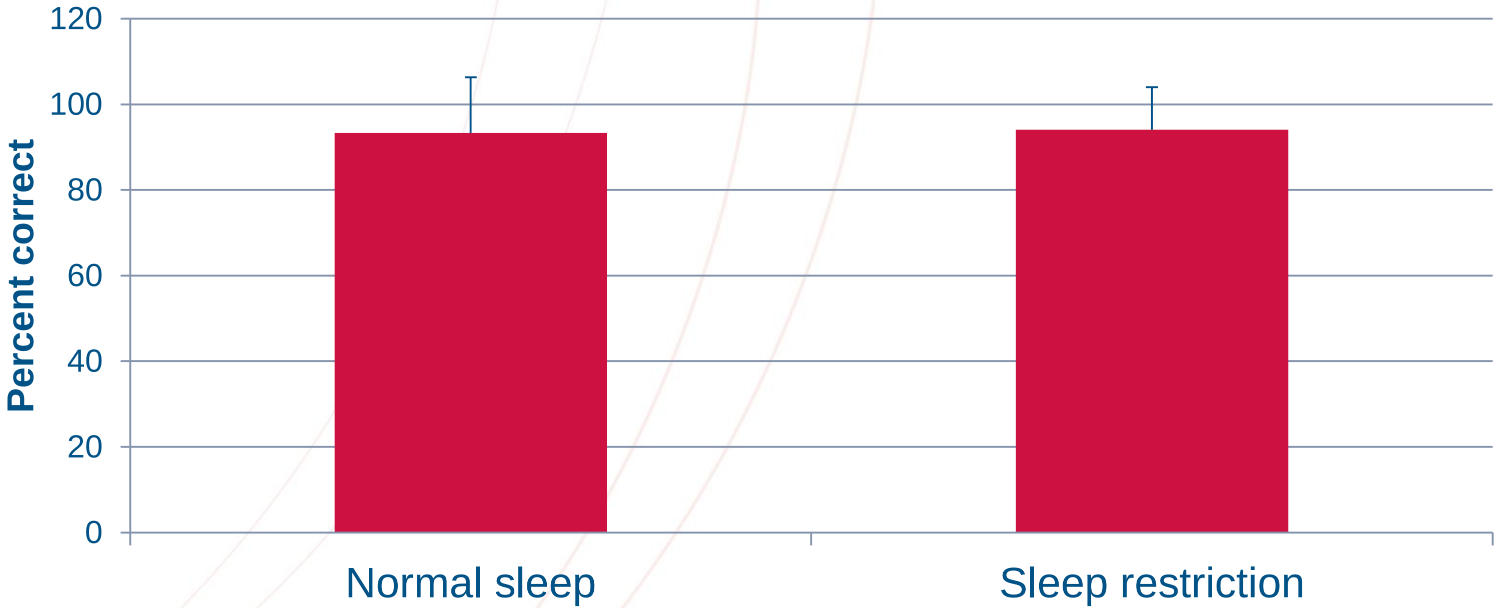
	Normal night's sleep (SD)	Sleep restriction (SD)	t test
Mean sleep duration (min)	473 (57)	300 (19)	$t(23) = 14.38$ $p<.001$

Subjective sleepiness

Measure	NS M (SEM)	SR M (SEM)	t statistic	df.	Significance p (r)
Heavy eyelids	2.00 (0.21)	3.33 (0.27)	5.10	18	< .001 (.77)***
Difficulty keeping eyes open	1.48 (0.16)	2.57 (0.24)	4.11	20	.001 (.68)**
Difficulty focusing	1.86 (0.24)	2.95 (0.23)	3.75	20	.001 (.64)**
Eye strain	2.00 (0.23)	2.95 (0.29)	2.50	19	.022 (.50)*
Effort to stay awake	2.21 (0.29)	4.32 (0.34)	5.21	18	< .001 (.78)***
KSS	3.73 (0.27)	5.75 (0.27)	7.18	20	< .001 (.85)***

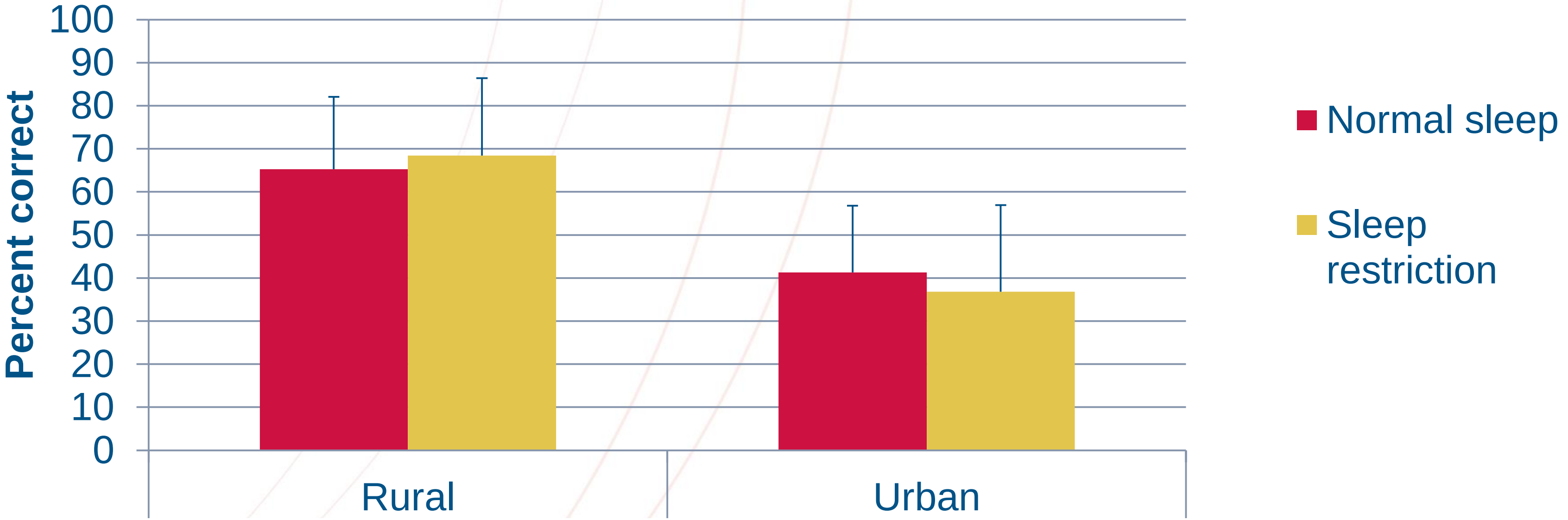
Note. NS = Normal Sleep; SR = Sleep Restriction; M = mean; SEM = standard error of mean; df = degrees of freedom. *$p < .05$, **$p < .01$, ***$p < .001$.

Accuracy Change-Absent



Accuracy did not differ between sleep conditions $t(23) = 1.15$, $p = .262$

Accuracy Change-Present



Greater accuracy in rural than urban environments $F(1,23) = 121.85$, $p < .001$.
Interaction between sleep and environment not significant, $F(1,23) = 1.38$, $p = 2.52$.
No main effect of sleep $F(1,23) = 0.05$, $p = 0.833$.

Unexpected changes

Unexpected Change	NS	SR	McNemar's test significance
Lead vehicle change colour	33%	24%	$p = .500$ (1-tailed) $n = 20$
Text signs change to German	76%	67%	$p = .500$ (1-tailed) $n = 20$

Conclusion

- Manipulation worked
  - Shorter sleep duration
  - Participants felt sleepier following sleep restriction, had sleep related eye symptoms.
- Accuracy is lower for change-present than change-absent trials

Conclusion

- Sleep restriction does not affect change detection accuracy.
- Change detection has greater accuracy in rural than urban environments.

Conclusion

- Accuracy results mirrored those of static images.
- Rural changes (less visual clutter) were easier to detect even with faster movement through the environment.

Note on the method

- Smaller number of changes possible than photo paradigm.
- Difficult to measure reaction time.
- Difficulties with scripting and consistency of events. Demanding programming and processing speed.
- Resource intensive.

Next steps

- Implications for safety relevance.
- Eye movements.
- Driving response (vehicle metrics).

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Questions?

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