What is drowsy driving and what causes it?

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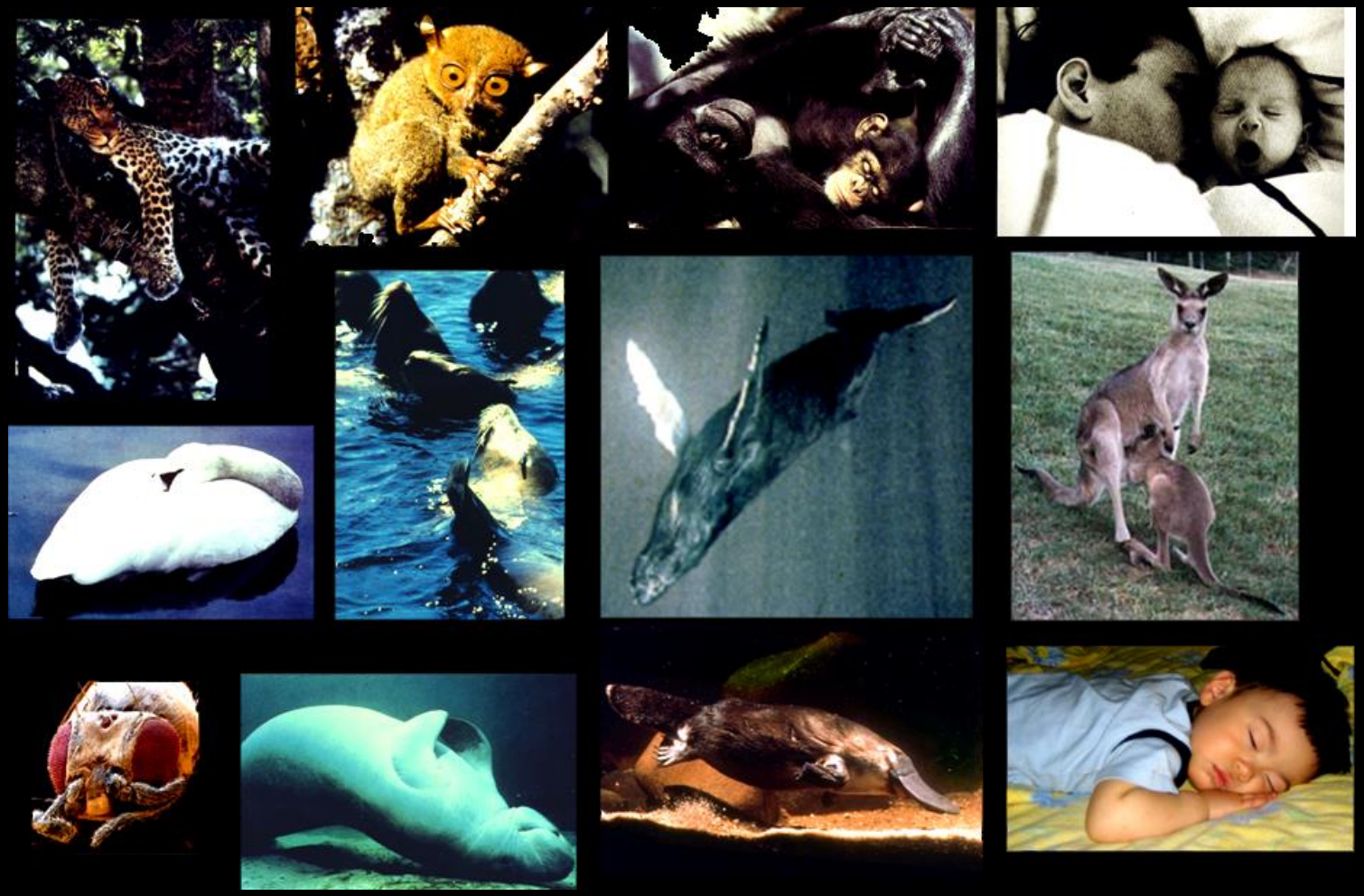
NTSB Forum
"Overcoming the Dangers of DROWSY DRIVING"

21 October 2014

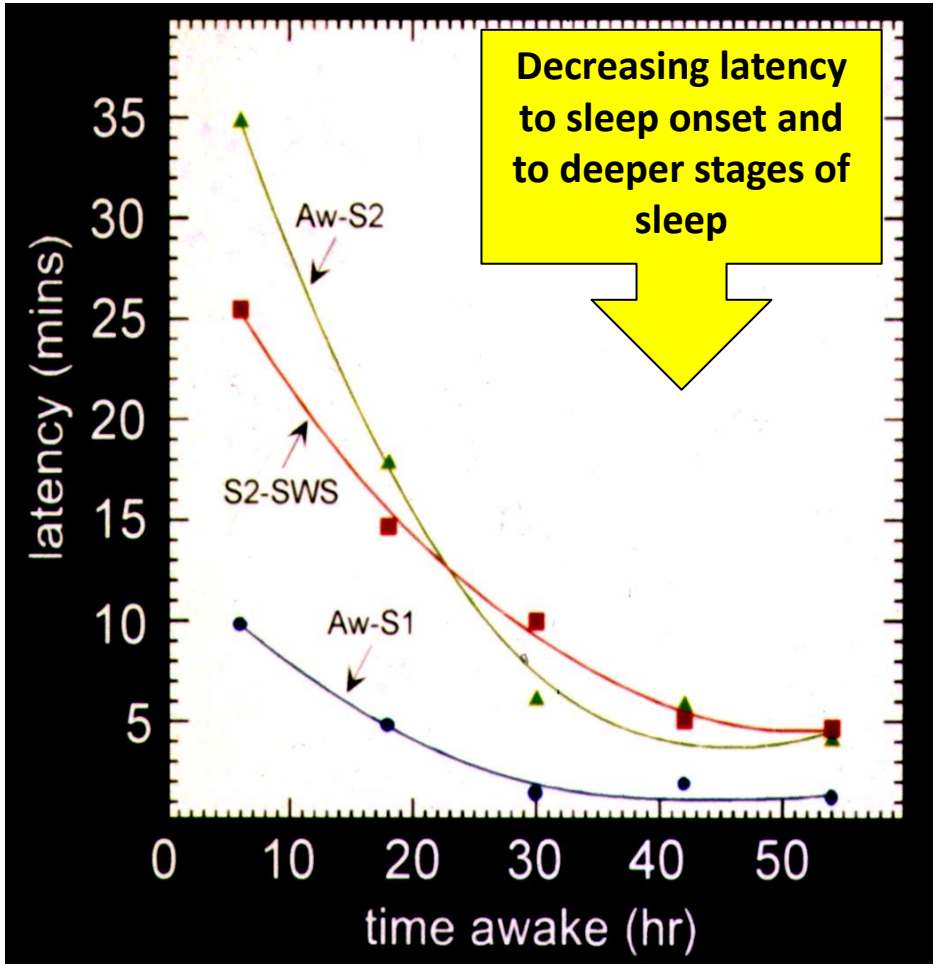
PANEL 1: INTRODUCTION AND SCOPE OF THE PROBLEM

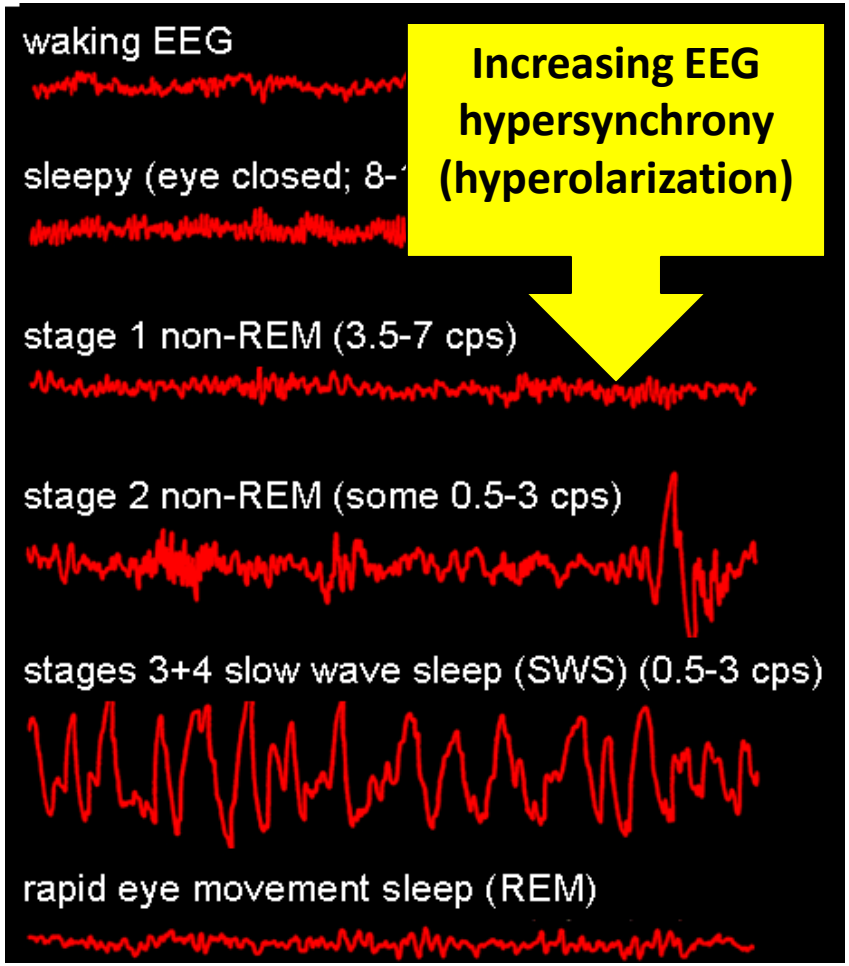
The need to sleep is pervasive among animals



When adequate sleep is denied, it bursts into wakefulness, even when we engage in a safety-sensitive task such as driving.

Elevated sleep pressure is associated with rapid transition from wake to sleep

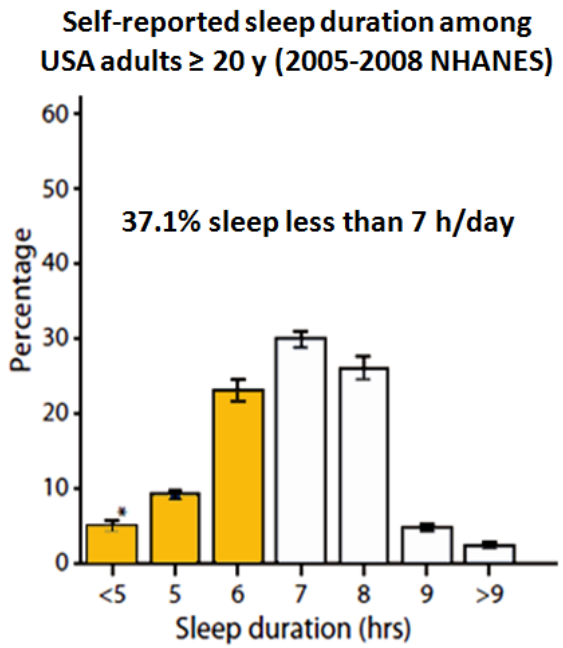




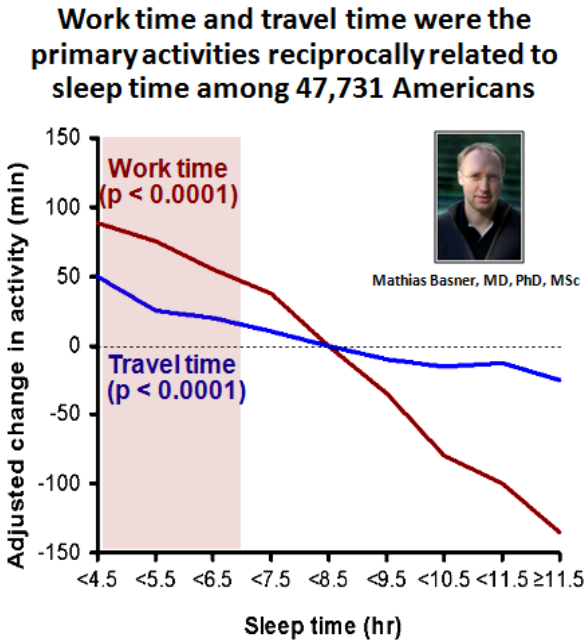
Sleep loss can come about through many factors. Lifestyle and sleep disorders are major contributors.

Sleep disorders (e.g., sleep apnea, insomnia) and sleep disturbances (e.g., pain,) involve chronic partial sleep loss (i.e., sleep restriction).

Modern lifestyles involve cycling through chronic sleep restriction (i.e., weekday sleep restriction; shift work).

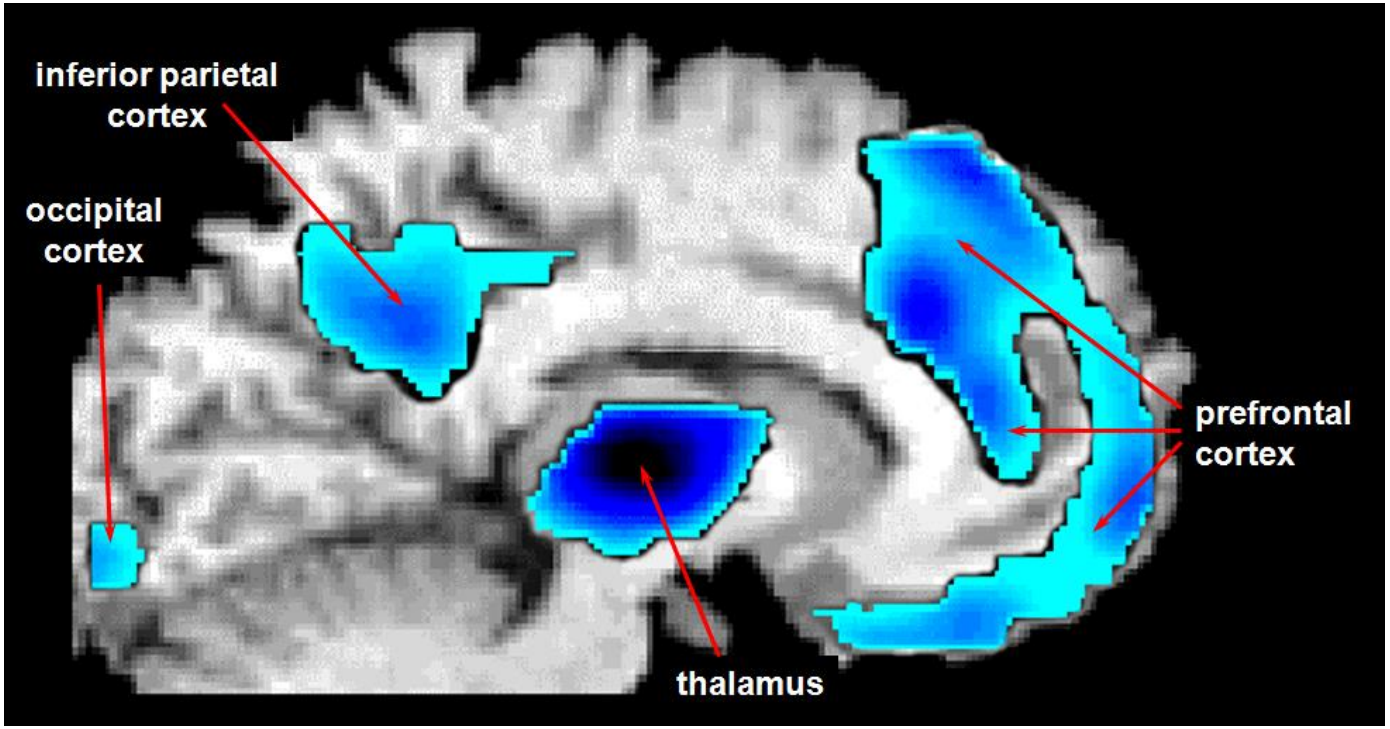


Center for Disease Control and Prevention MMWR (2011)



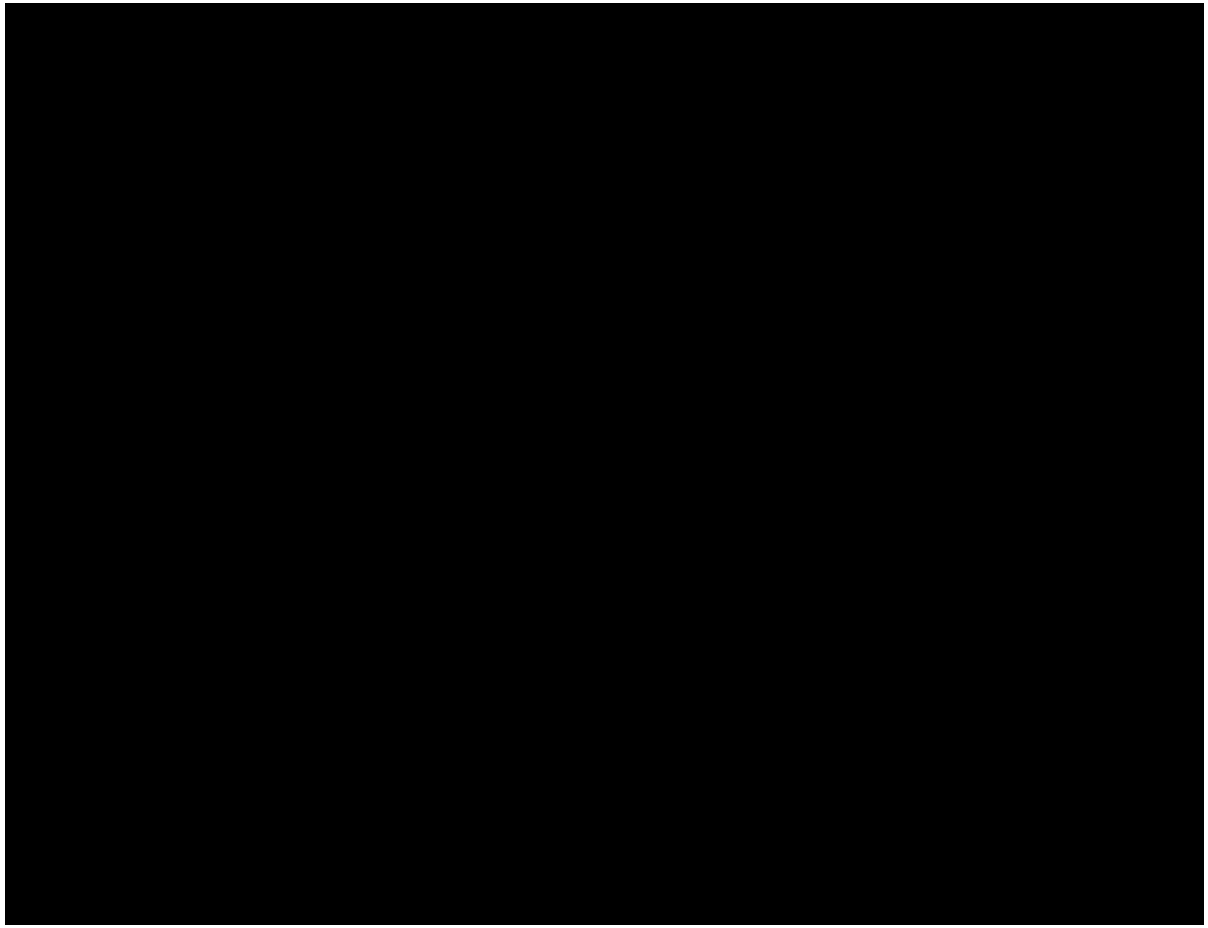
Basner et al. *SLEEP* (2007)

Brain imaging studies have consistently found that a night of sleep loss produces decreased activity in brain areas involved in alertness, attention and cognitive processes

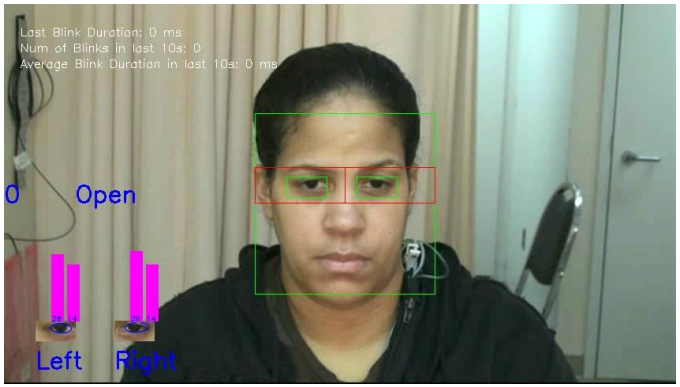


Thomas M et al. Neural basis of alertness and cognitive performance impairments during sleepiness. I. Effects of 24 h of sleep deprivation on waking human regional brain activity. *J Sleep Research*, 9(4);335-352, 2000

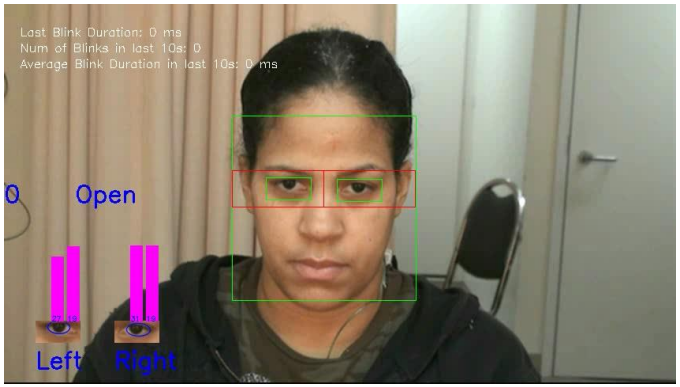
Falling asleep (even while driving) involves a loss of muscle tone throughout the body (eyelids, neck, arms, hands, etc.), as illustrated in this video of a sleepy driver in a driving simulator.



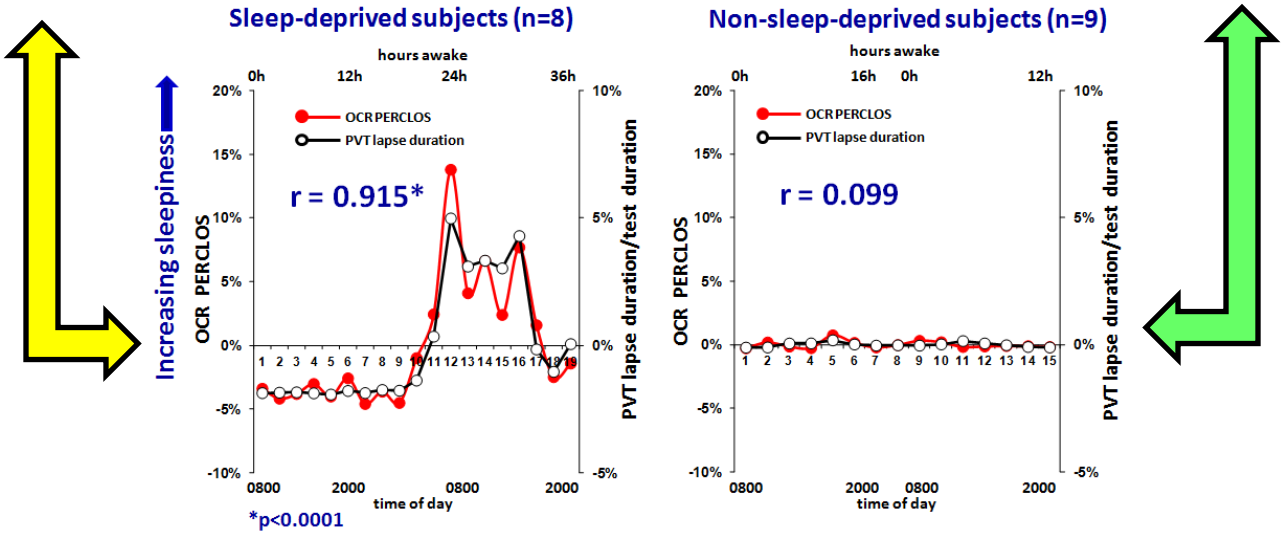
Sleep loss produces both increasingly slow eyelid closures and lapses of vigilant attention.
The brain is falling asleep while trying to remain awake.



SLEEP DEPRIVATION
PVT lapses = 4 in 1-min; 42 in 20-min.
Eyes closed epochs = 10.2 sec



NO SLEEP DEPRIVATION
PVT lapses = 0 in 1-min; 4 in 20 min.
Eyes closed epochs = 4.1 sec



But well before we have full sleep attacks while driving we experience decreases in alertness and attention

The earliest and most profound effects of sleep loss are on attention

Effect sizes (from sleep loss) were largest for lapses of attention and reaction times – two behaviors that are critical for safe driving.

Outcome variable	Combined effect size
Simple attention	
Lapses	−0.762**
Reaction time	−0.732**
Complex attention	
Accuracy	−0.479**
Reaction time	−0.312**
Processing speed	
Accuracy	−0.245
Reaction time	−0.302**
Working memory	
Accuracy	−0.555**
Reaction time	−0.515**
Short-term memory	
Recall	−0.383*
Recognition	−0.378*
Reasoning	
Accuracy	−0.125

**p<.001

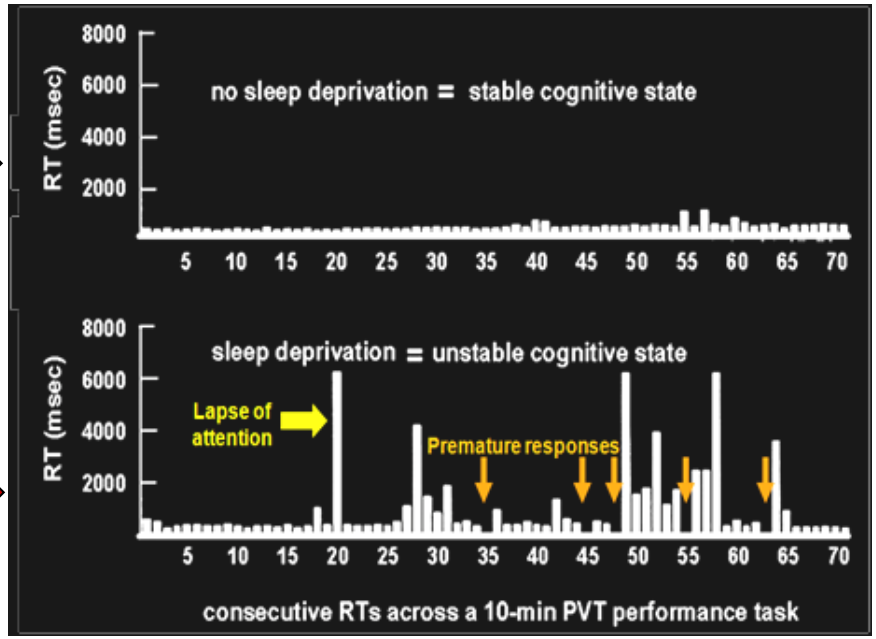
Lim & Dinges, *Psychological Bulletin* (2010)

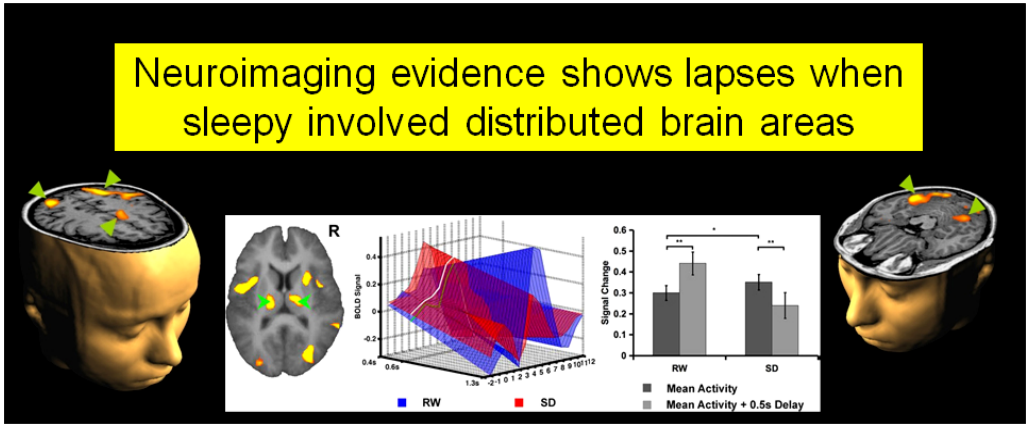
Data from a meta-analysis of the effects of sleep deprivation on speed and accuracy measures in six cognitive categories. A total of 70 articles (147 cognitive tests) met inclusion criteria.

Instability of wakefulness when sleep is inadequate is the reason lapses of attention are common during drowsy driving

Stable responses without sleep loss

Unstable responses after sleep loss

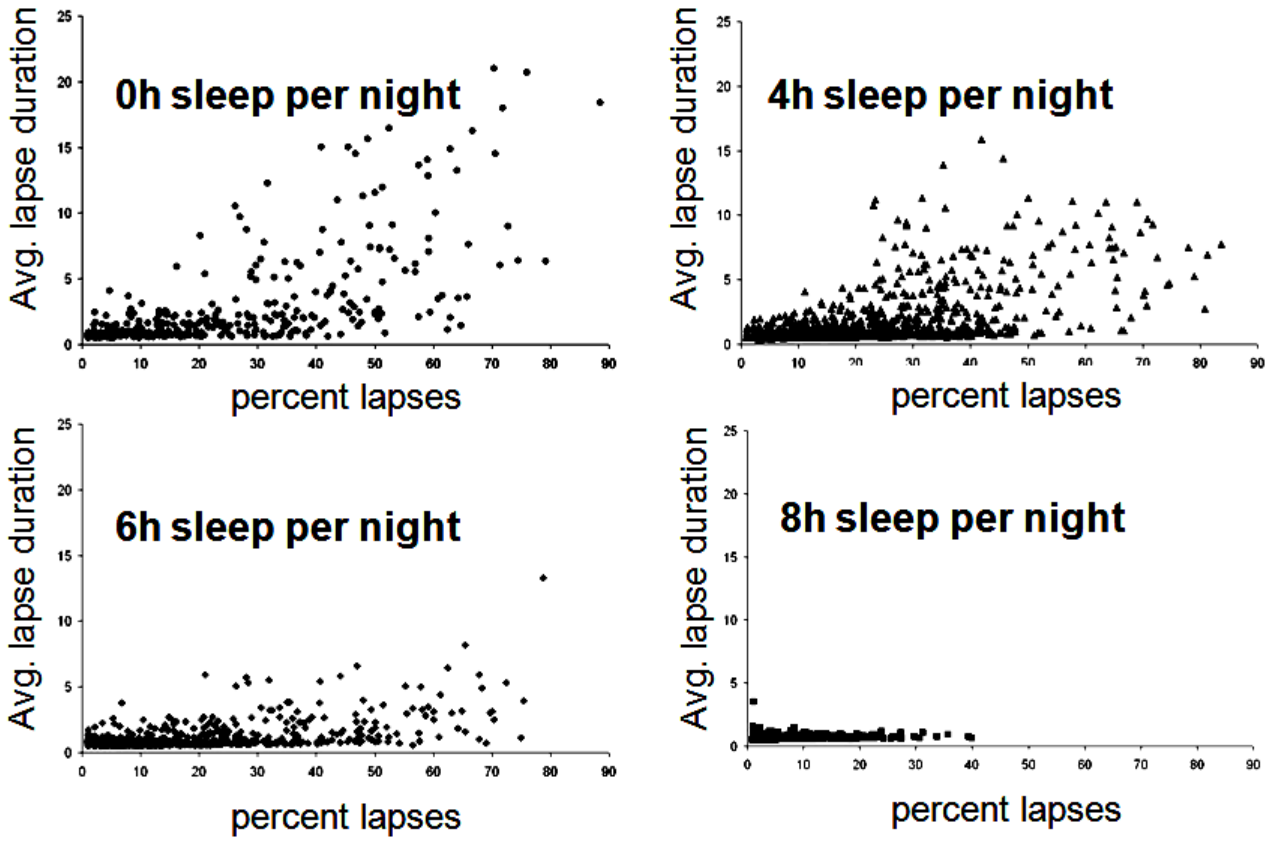




Drummond et al. SLEEP (2005)

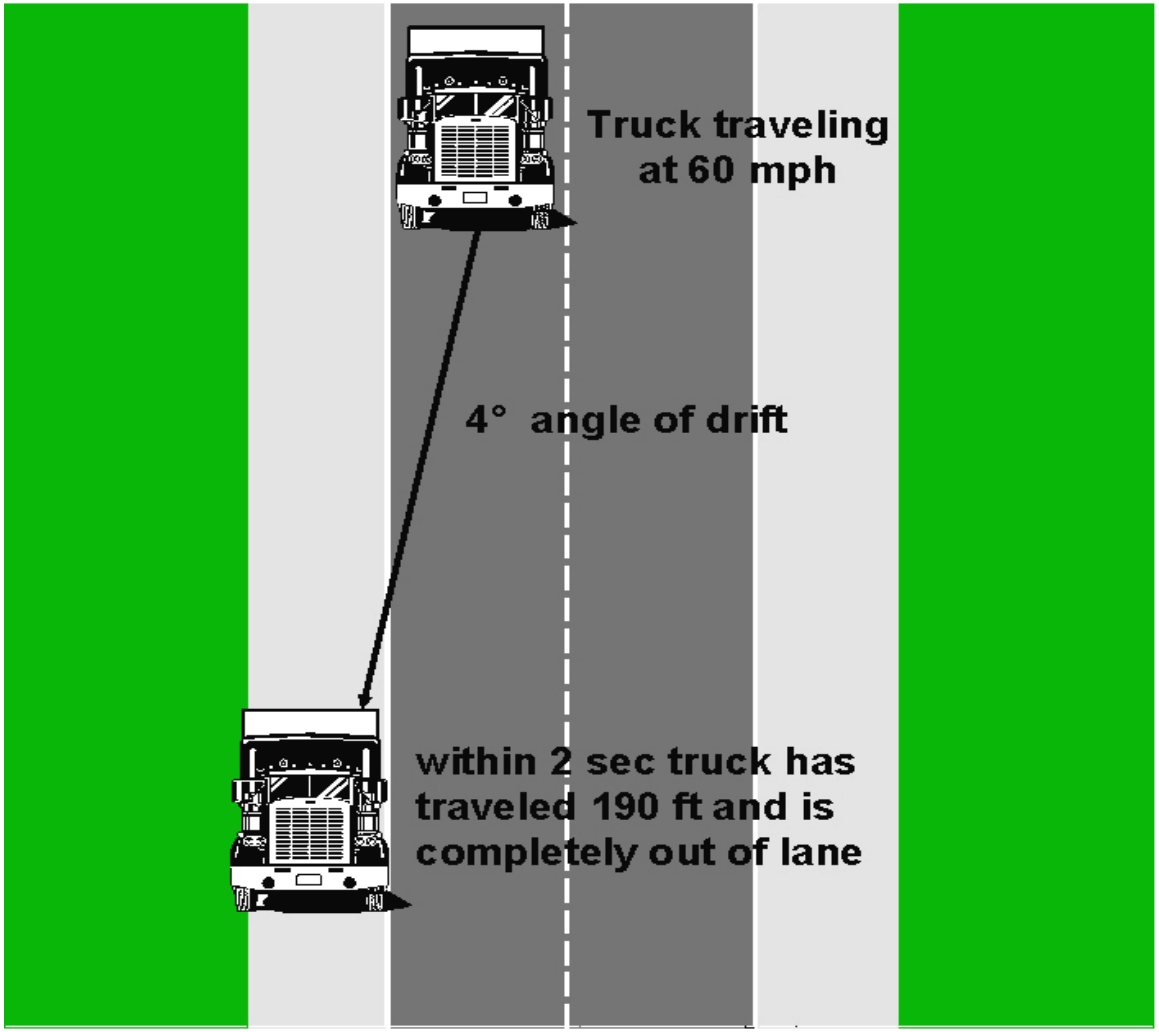
Chee et al. J Neuroscience (2008)

Average PVT lapse duration correlated with the number of lapses per test (r=0.75, p<0.001), which means that the more you lapse when driving drowsy, the longer the lapses become, and the greater the risk of a drowsy driving crash.



Lim, J., Dinges, DF. *Annals NY Acad. Sciences* (2008)

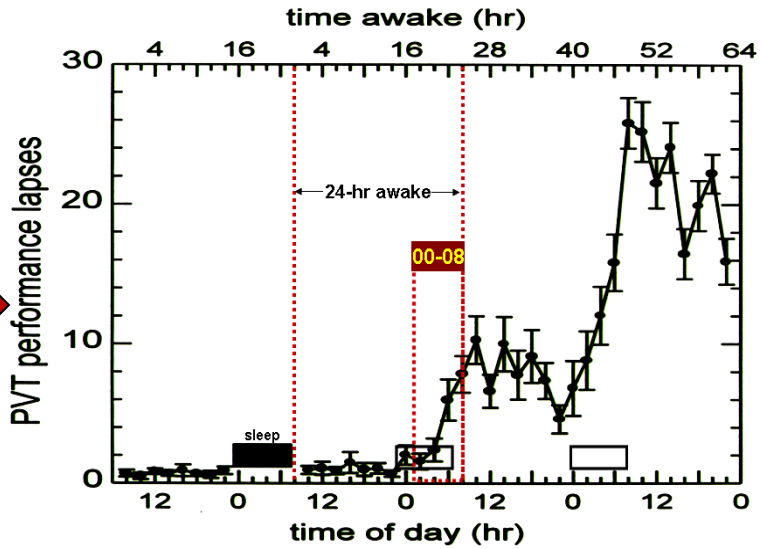
A drowsy driving crash requires a lapse of only a few seconds to result in a crash



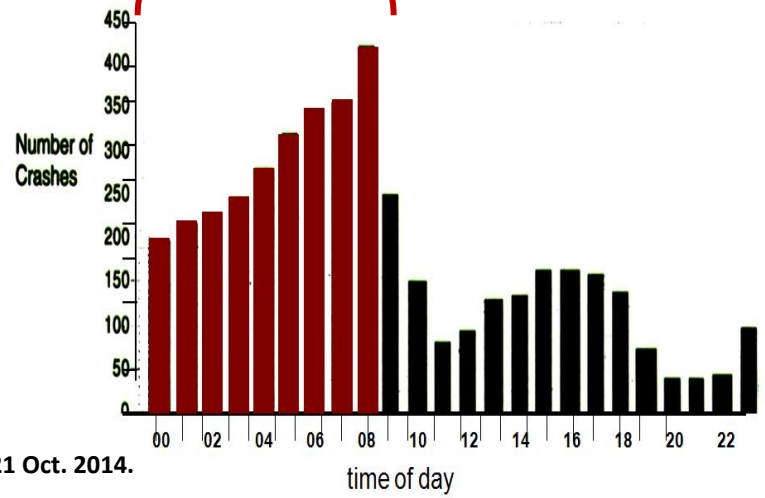
David F Dinges—NTSB Forum "Overcoming the Dangers of DROWSY DRIVING" 21 Oct. 2014.

Both lapses of attention (lab data) and fall asleep crashes (field data) increase over a night without sleep (from midnight to 8 am), reflecting the brain's programmed dynamics

Laboratory data showing psychomotor vigilance task (PVT) lapses increasing across a night without sleep. Data from Doran et al. *Archives of Italian Biology* (2001)



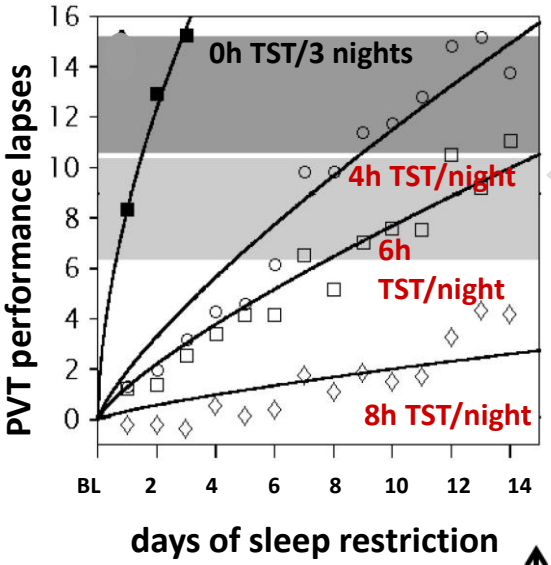
Field data showing fall asleep motor vehicle crashes increasing across the night. Data from Pack et al. *Accident Analysis and Prevention* (1995)



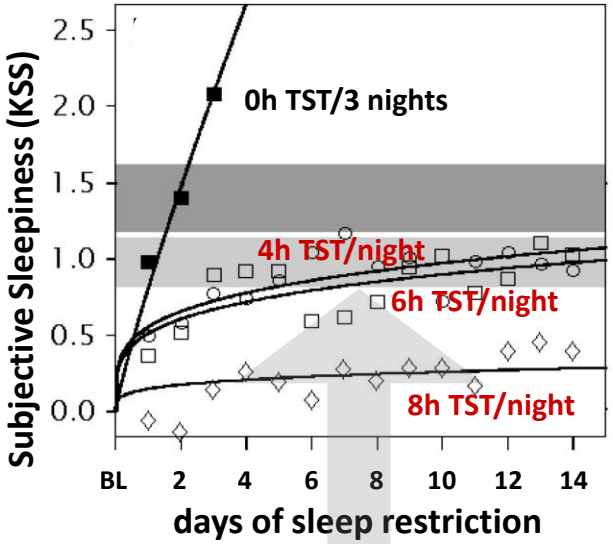
When sleep is chronically restricted below 7-8h/night, lapses of attention increase, but awareness of sleepiness does not.

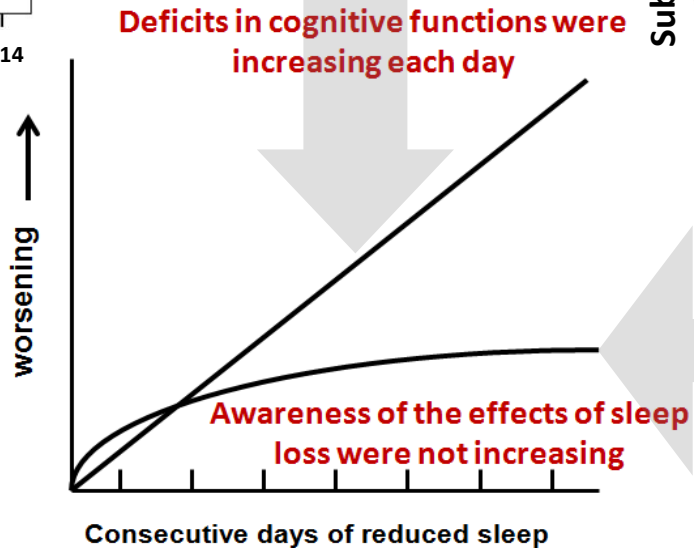
This may explain why people think they can drive when they are sleep deprived.

Performance lapses



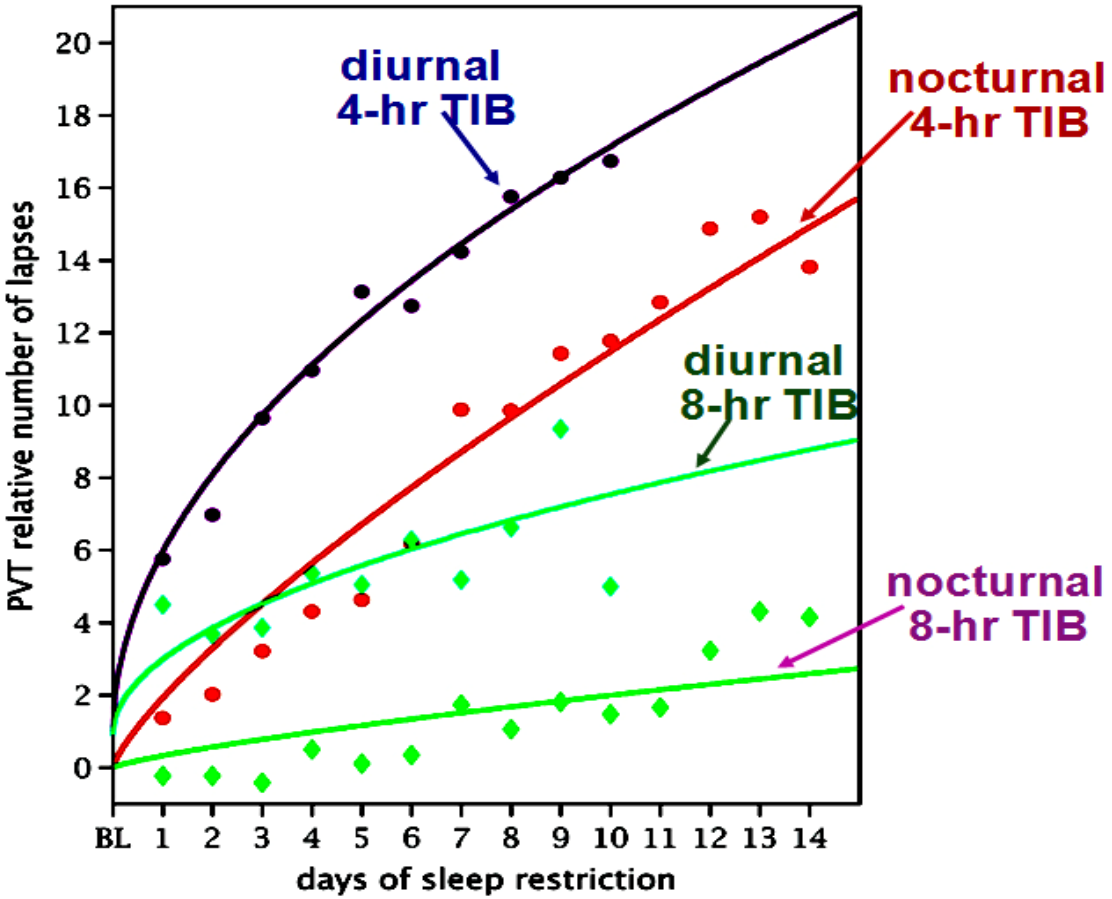
Subjective sleepiness





Data from Van Dongen et al. *SLEEP* (2003)

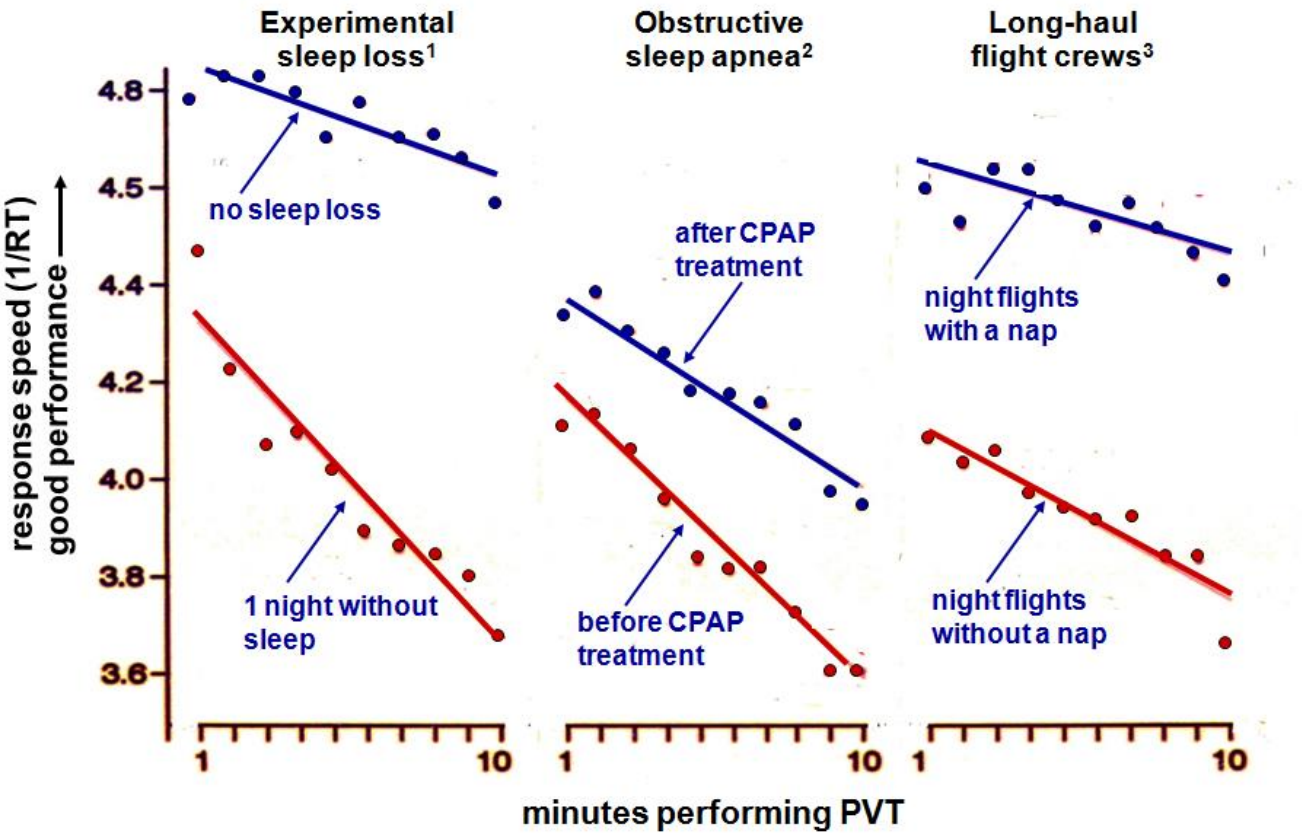
Restriction of daytime sleep (wakefulness at night) also yielded cumulative increases in PVT lapses



Performance getting worse (i.e., increasingly slower reaction times)

Data from Dinges et al. (2006)

PVT vigilance decrement functions from experimental, medical and operational fatigue

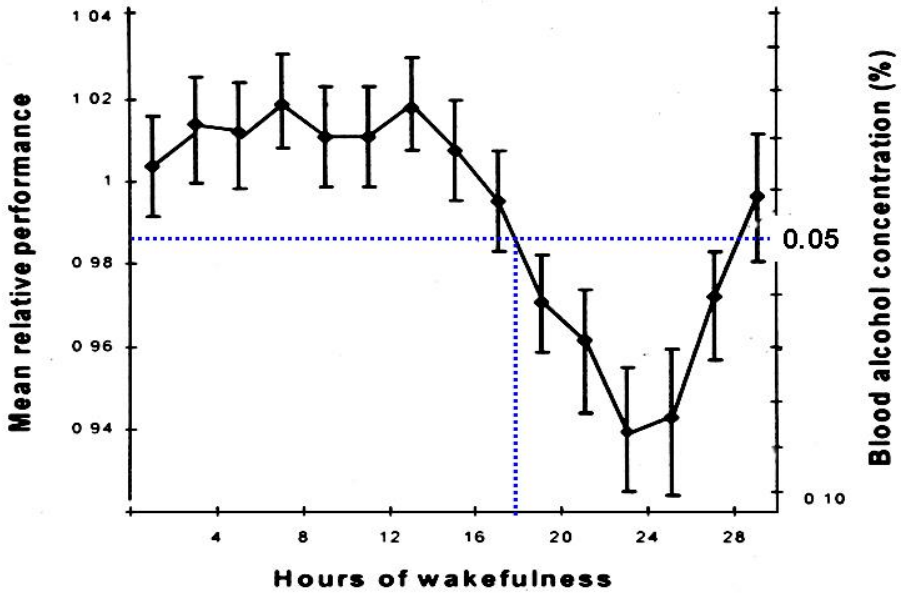


Performance getting worse (i.e., increasingly slower reaction times)

Dinges et al. (1994); Kribbs et al. (1993); Rosekind et al. (1994)

Scientific studies have equated the performance deficits induced by sleep loss to those induced by alcohol.

Studies equating the effects of alcohol on performance to those of time awake on psychomotor performance tasks found
18h awake ≈ 0.05 g%
(8 other studies also equate prolonged wakefulness with BAC >0.04 g%)

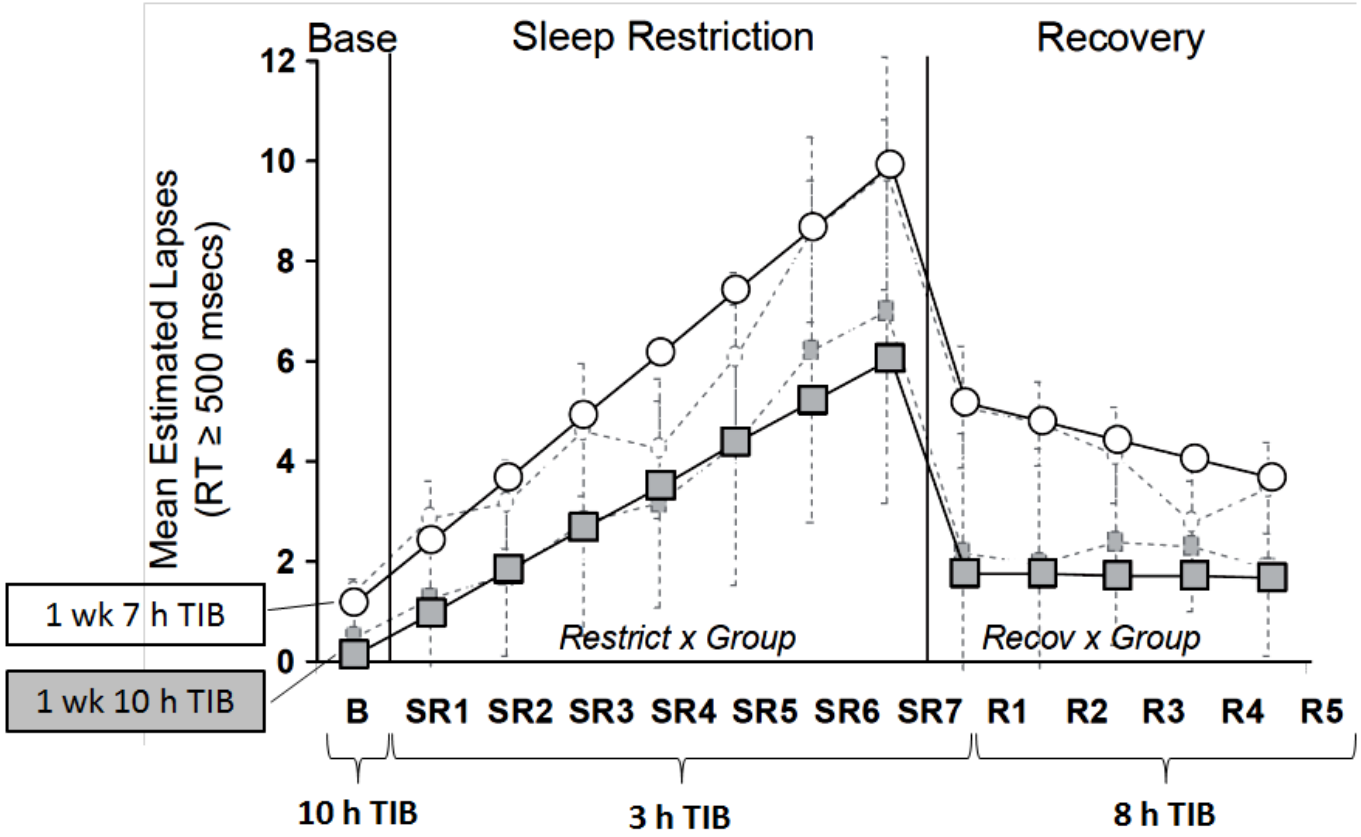


Data from Dawson D, Reid K. *Nature* (1997).

Sleep related crashes have a fatality rate near that of alcohol-related crashes. This is due to their often involving roadway departures at relatively high speeds, with not conscious effort to avoid other objects.

Pack et al. *Accident Analysis & Prevention* (1995)

Sleep in advance of sleep loss (i.e., “prophylactic naps” or “banking” sleep) attenuates the effects of sleep restriction



Data from Rupp et al. *SLEEP* (2009).

7 Messages

- The brain is the organ of behavior and the brain needs healthy sleep of adequate daily duration to prevent drowsy driving.
- When sleep is inadequate the brain has a slower response and it unpredictably lapses into microsleeps that result in waxing and waning of attention and slowed reactions—these pose a very serious crash risk.
- As sleepiness increases, lapses get more frequent and longer in duration, and there is increasing loss of muscle tone (e.g., eyelids, arms, hands) that contributes to an even greater driving risk.
- A sleepiness-related lapse of attention of only 2 seconds with loss of steering input from muscle relaxation can result in a drift out-of-lane crash.
- Such crashes often involve serious bodily injury and are fatal due to the drowsy driver failing to take corrective action in a timely manner.
- The slowed reaction times (even without frequent lapses of attention) when driving sleepy can cause sleepiness-related crashes in traffic.
- Since people are frequently unable to judge their vulnerability to drowsy driving, even when they are lapsing repeatedly, it is essential that people not drive when they have not slept sufficiently to maintain alertness effortlessly.