# Shiftwork and Managing Fatigue

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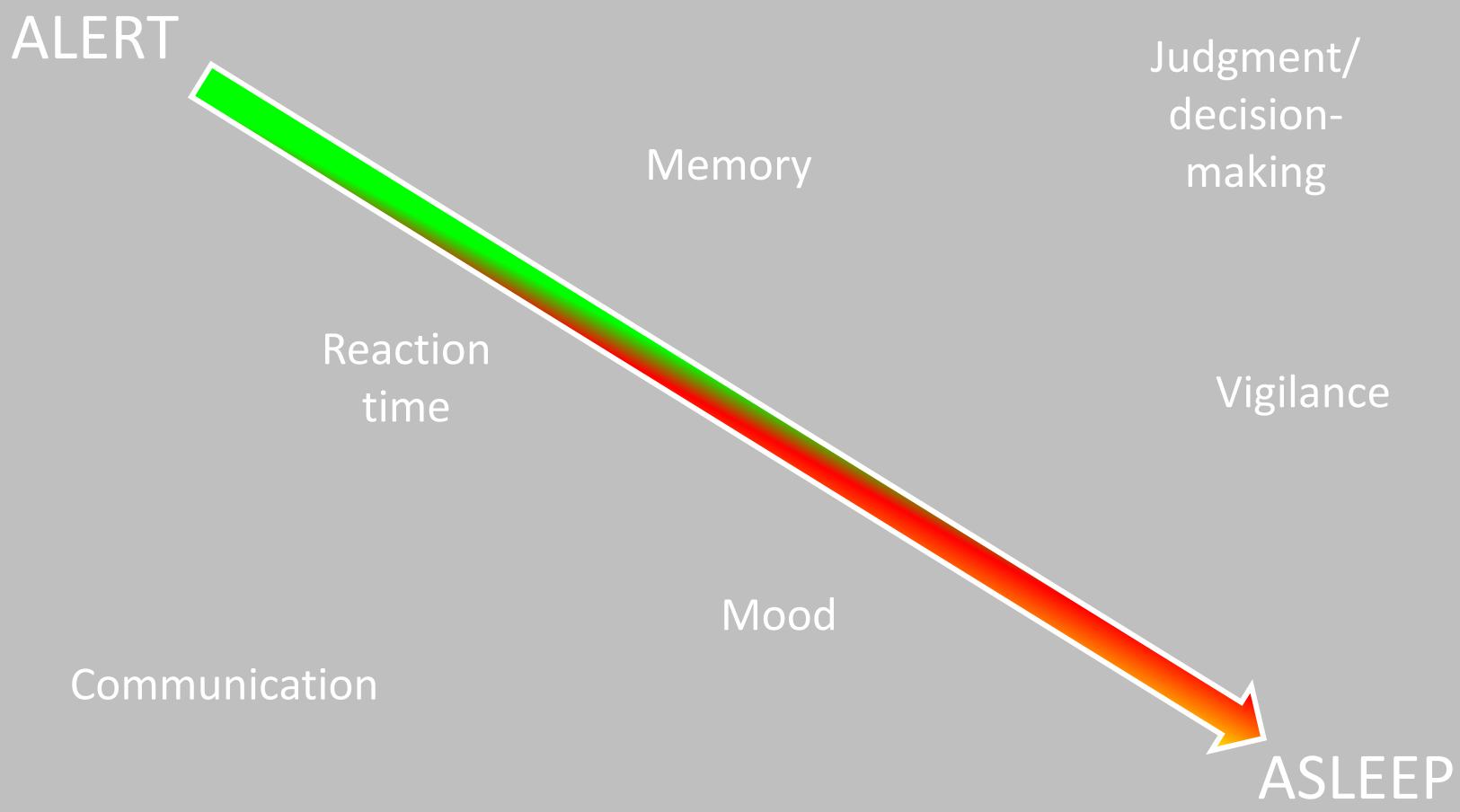
# Fatigue Defined

- "An unsafe condition that can occur relative to the timing and duration of work and sleep opportunities" (Institute of Medicine)

- "The potentially detrimental impacts of unusual shifts and prolonged work-times shall be…a high priority by all NASA centers…safe work practices that minimize human error factors, especially fatigue…" (NASA NPR 1800.1D)

# Fatigue: A Performance Issue



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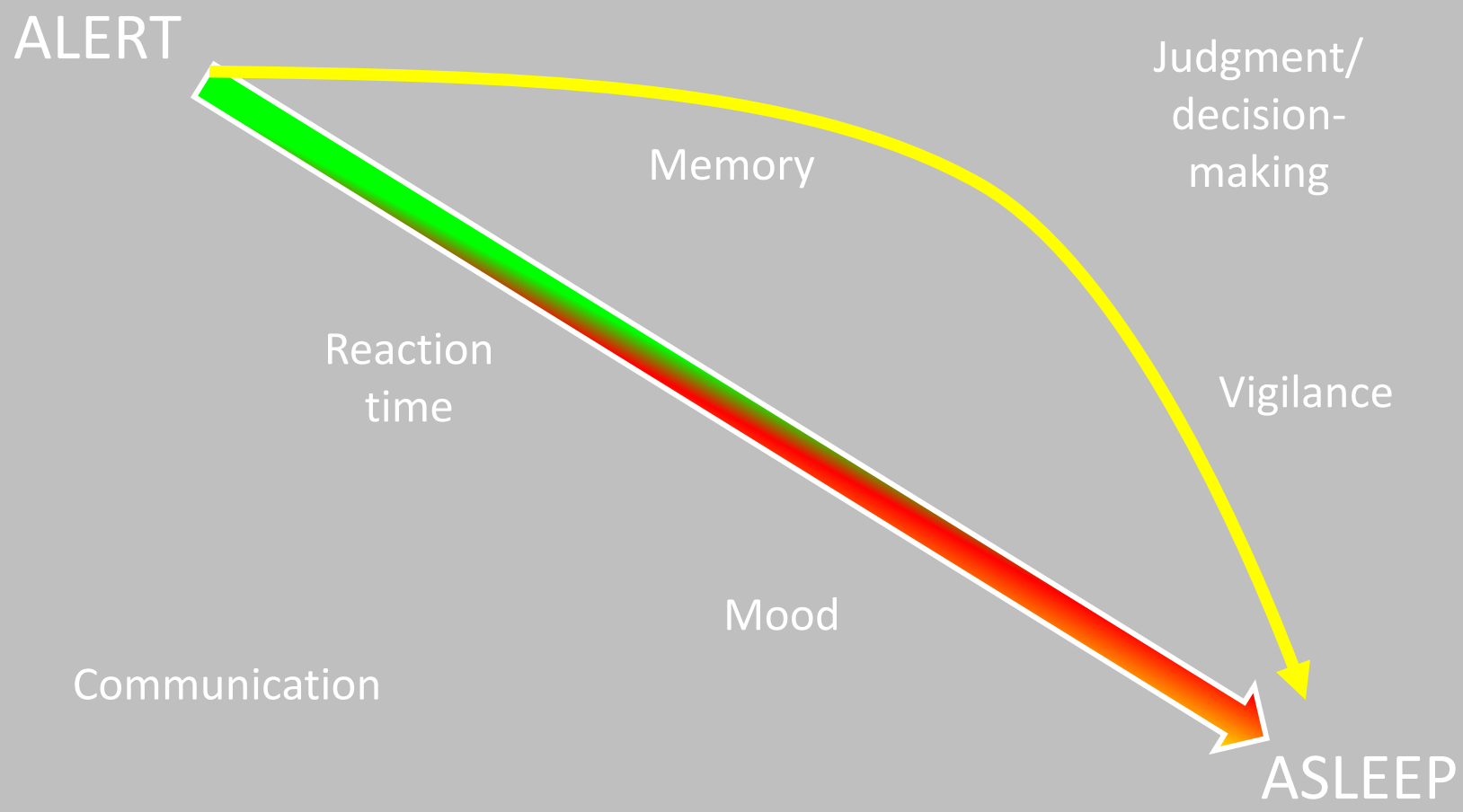

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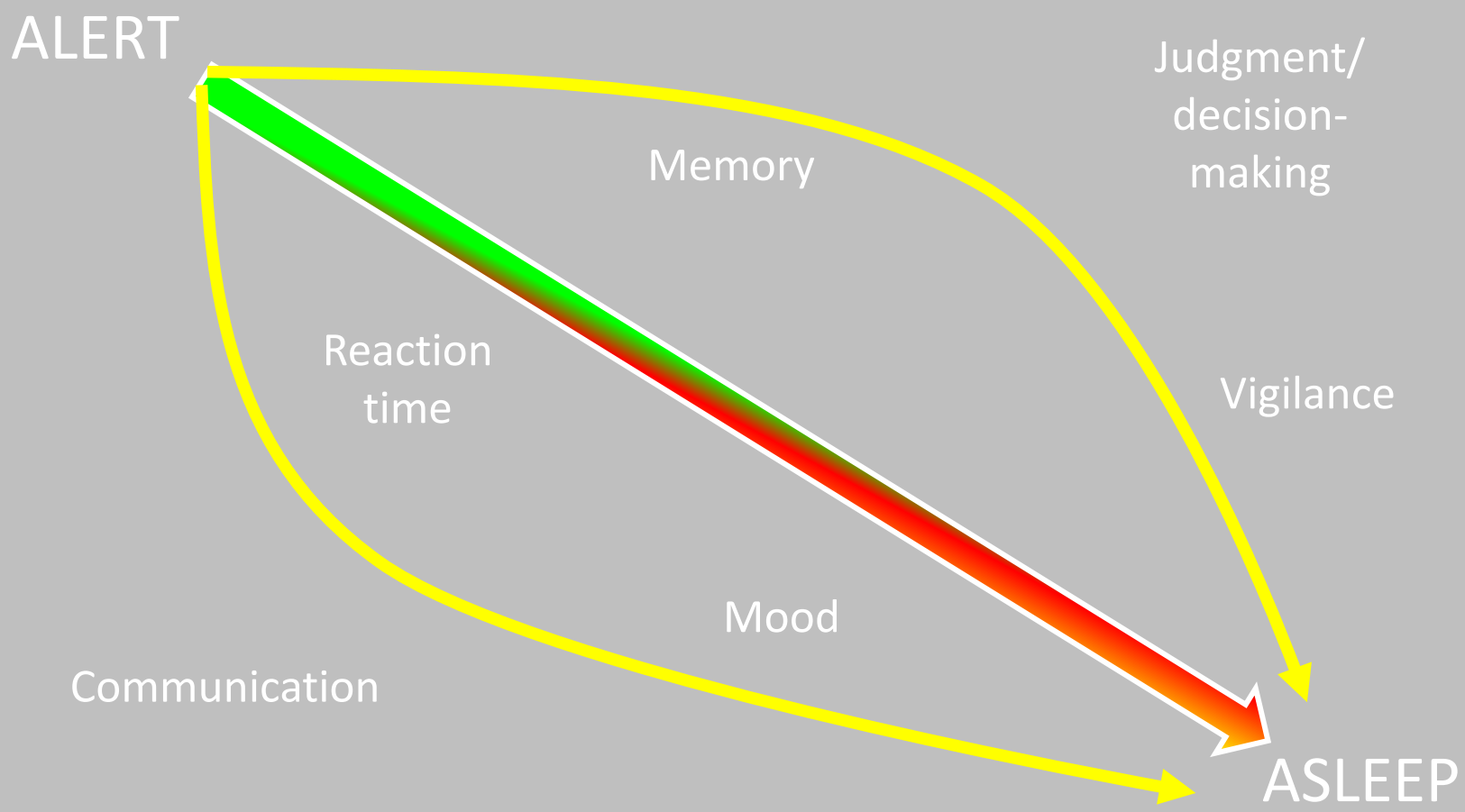
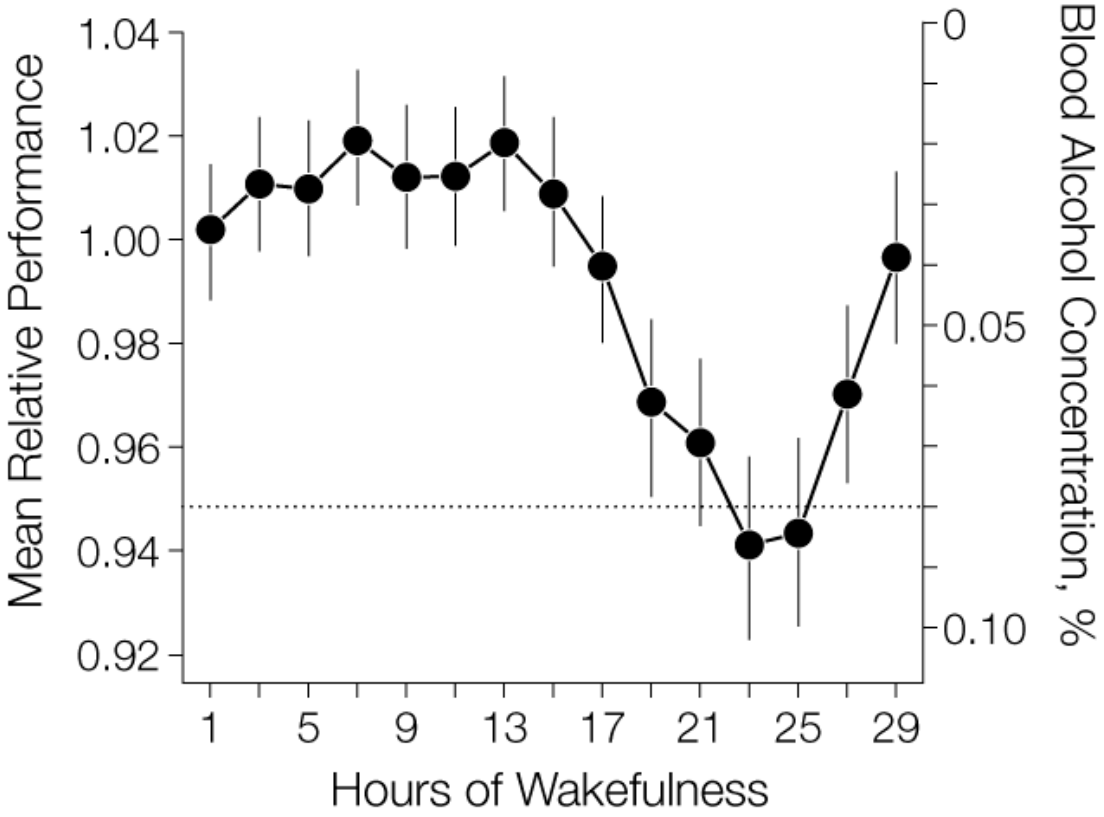


# Fatigue: A Performance Issue




*Lamond, Dawson; J Sleep Res, 1999*

*Photo by Adam Wilson on Unsplash*

# Causes of Fatigue

**Acute sleep loss**

(e.g., staying awake too long)

**Cumulative sleep loss**

(e.g., losing a little sleep several nights in a row)

**Circadian misalignment**

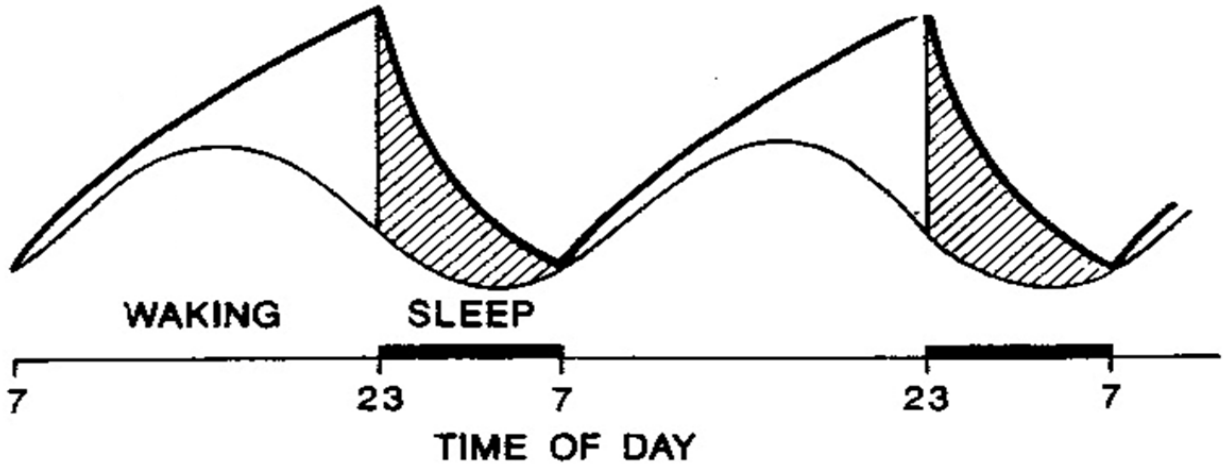
(e.g., trying to stay awake at night when your body is designed to sleep)

**Poor sleep quality**

(e.g., disrupted by noise, sleep disorders)

# Sleep and Circadian Rhythms

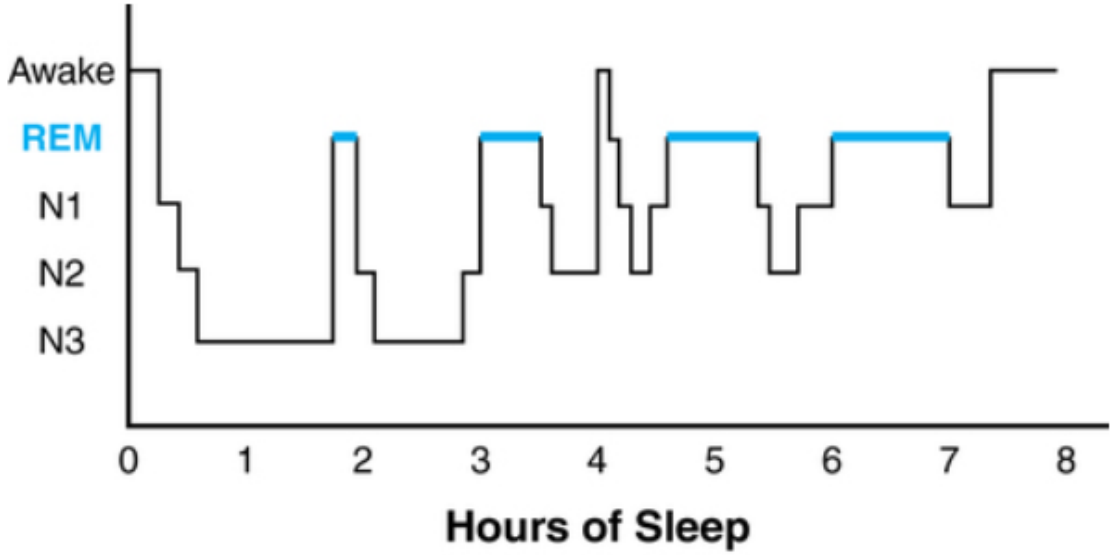
- Two process model
  - Process S: pressure for sleep increases with more hours awake
  - Process C: follows a daily rhythm




*Borbely & Achermann, 2000*

# What is Sleep?

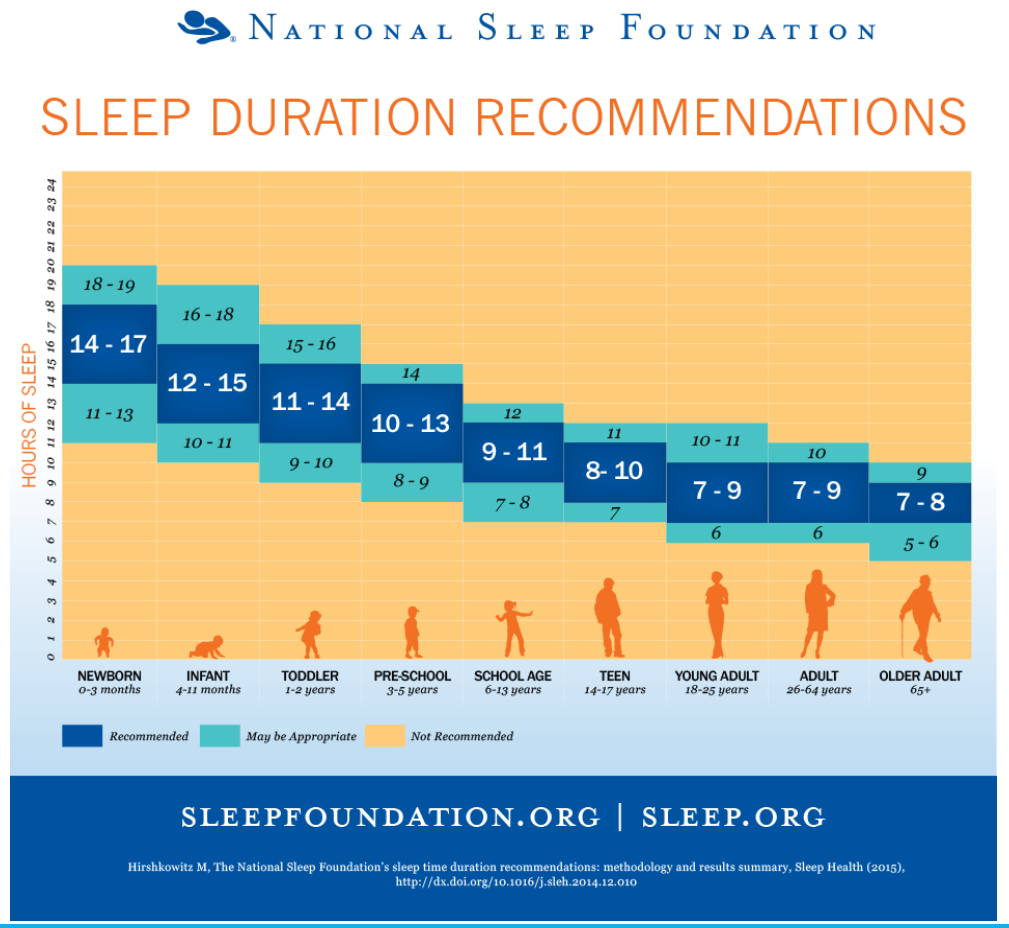
- Two kinds of sleep
  - Non-REM
    - Light and deep stages of sleep
    - Mental and physiological activity slow down
  - REM (rapid eye movement)
    - Active brain (dreaming) in paralyzed body




Normal adult hypnogram: Slow wave sleep (N3) is more prominent during the first portion of the night. REM episodes increase as the night progresses with the longest episode before awakening.

*Neubauer, 1999*

# Sleep Need?


NATIONAL SLEEP FOUNDATION
SLEEP DURATION RECOMMENDATIONS
HOURS OF SLEEP
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
NEWBORN 0-3 months: 18 - 19 | 14 - 17 | 11 - 13
INFANT 4-11 months: 16 - 18 | 12 - 15 | 10 - 11
TODDLER 1-2 years: 15 - 16 | 11 - 14 | 9 - 10
PRE-SCHOOL 3-5 years: 14 | 10 - 13 | 8 - 9
SCHOOL AGE 6-13 years: 12 | 9 - 11 | 7 - 8
TEEN 14-17 years: 11 | 8- 10 | 7
YOUNG ADULT 18-25 years: 10 - 11 | 7 - 9 | 6
ADULT 26-64 years: 10 | 7 - 9 | 6
OLDER ADULT 65+: 9 | 7 - 8 | 5 - 6
Recommended
May be Appropriate
Not Recommended
SLEEPFOUNDATION.ORG | SLEEP.ORG
Hirshkowitz M, The National Sleep Foundation's sleep time duration recommendations: methodology and results summary, Sleep Health (2015), http://dx.doi.org/10.1016/j.sleh.2014.12.010

# Factors that affect Sleep

- Age
- Alcohol
- Sleep disorders
  - Insomnia, sleep apnea, restless legs
- Environment
  - Noise, light, temperature
- Stress
- Caffeine, nicotine

# Sleep and Aging

**Comparison of Sleep Cycles in Young Adults and the Elderly**

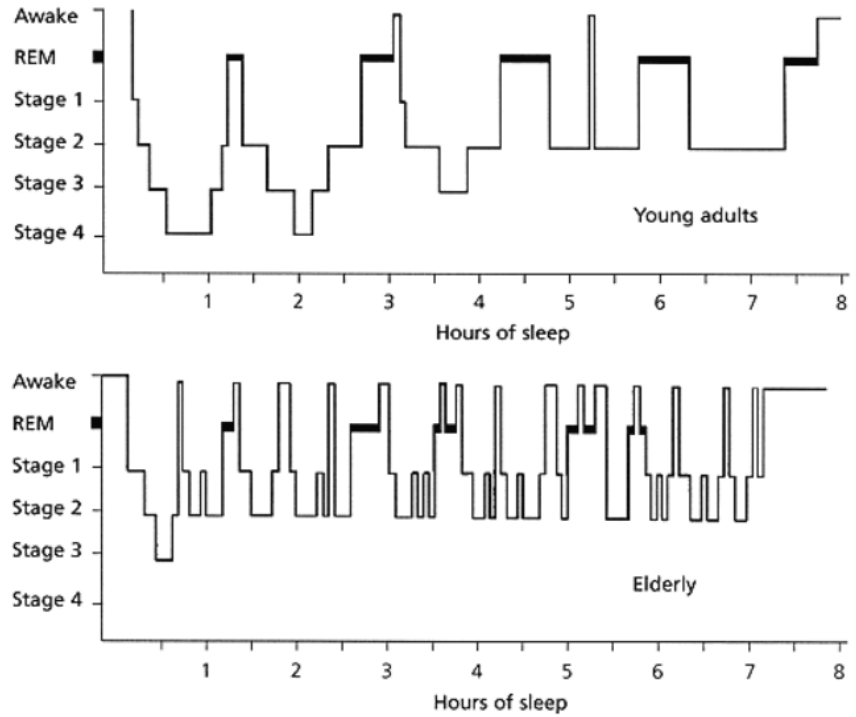
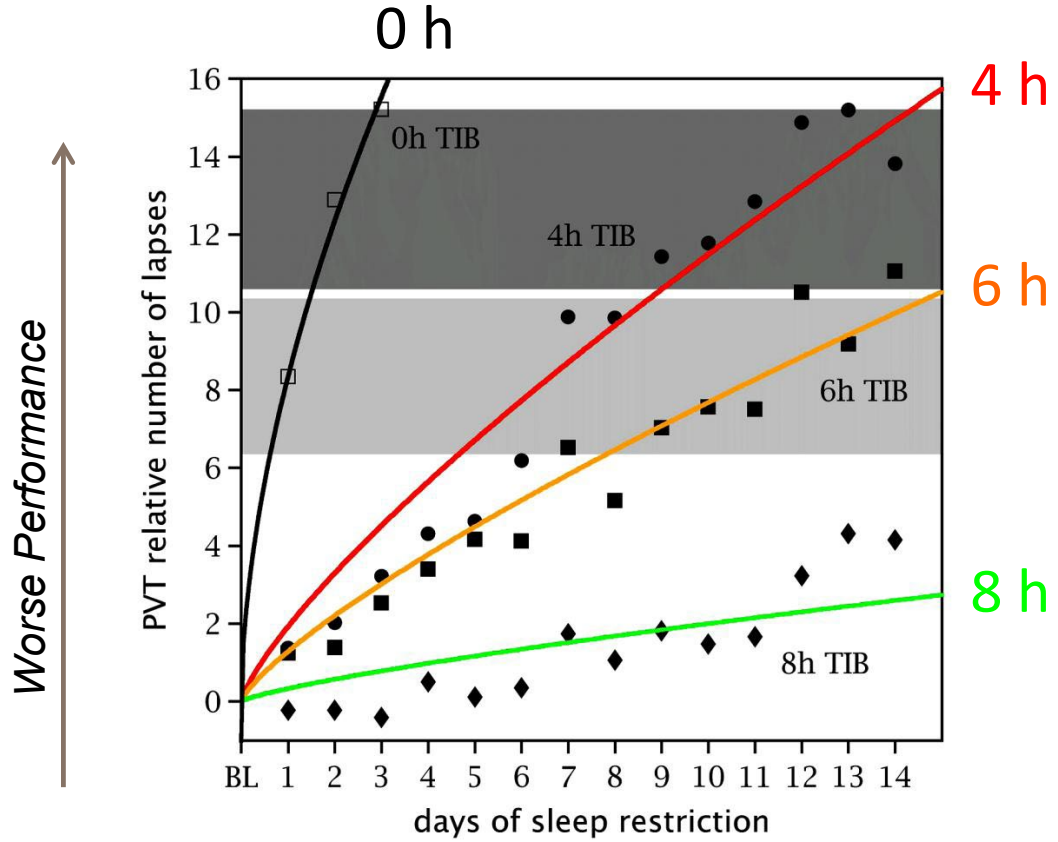



**FIGURE 1.**

Hypnograms demonstrating typical sleep characteristics in young adults and elderly persons. Compared with young adults, the elderly tend to have delayed sleep onset, fragmented sleep, early-morning awakening and decreased time in sleep stages 3 and 4. (REM = rapid eye movement)

*Neubauer, 1999*

# Chronic Sleep Loss

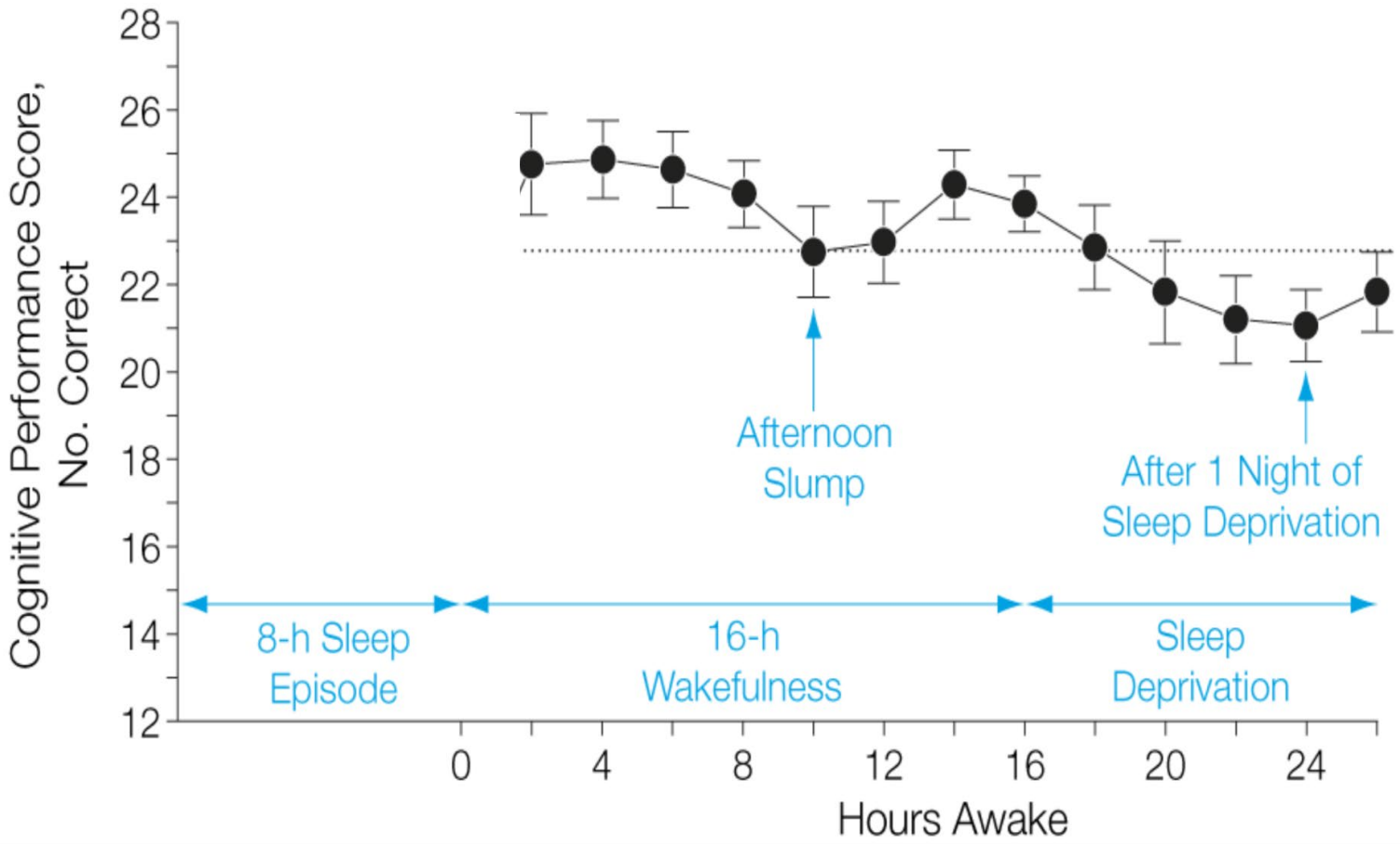



*Van Dongen et al., 2003*

# Recovery from Sleep Loss

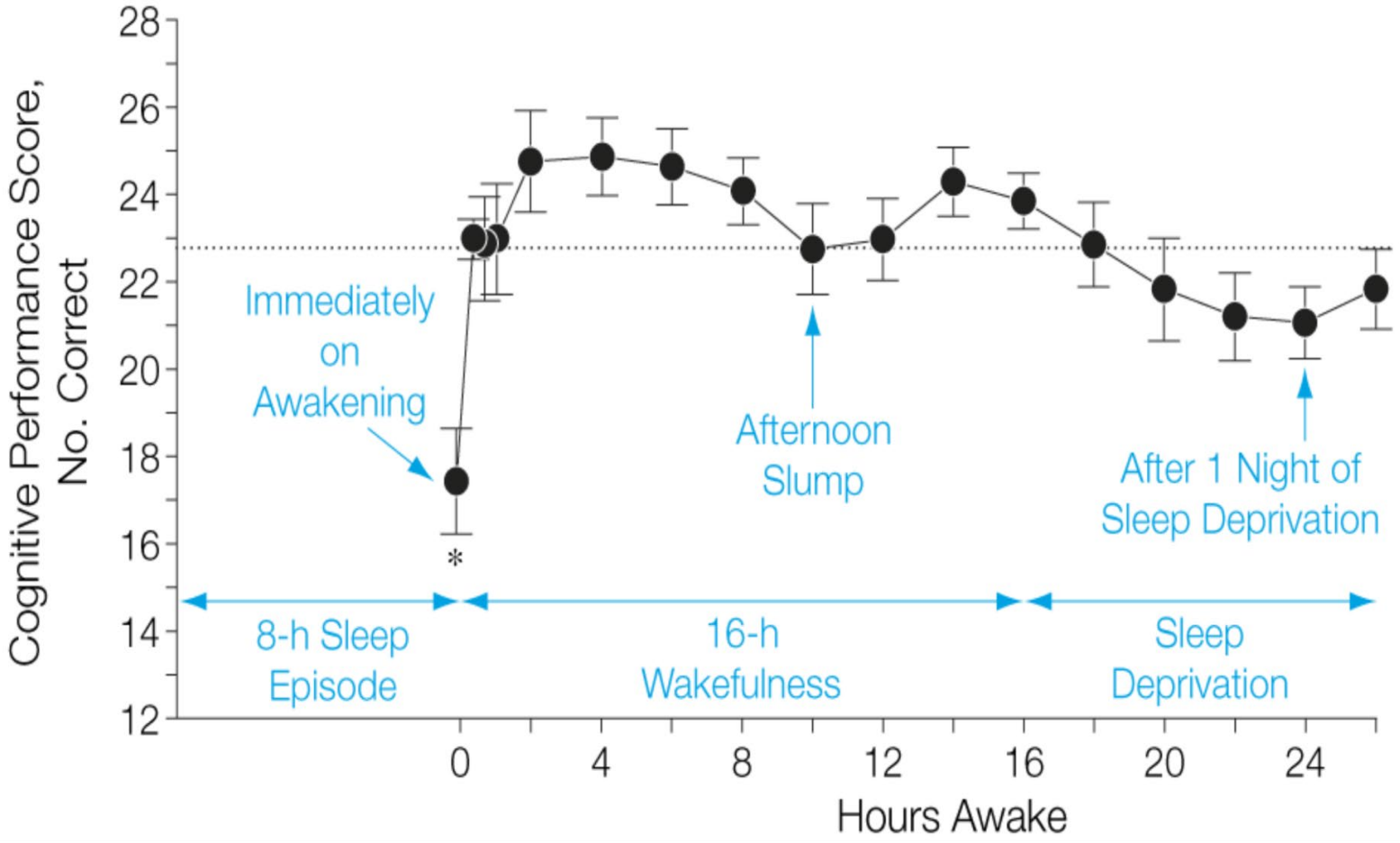
- Increased duration
- More deep sleep
- For short term sleep loss
  - two nighttime sleep periods
- For longer term sleep debt
  - May require several night sleeps to return to normal functioning levels
  - Circadian misalignment a factor

# Sleep Inertia




*Wertz et al., 2006*

# Sleep Inertia




*Wertz et al., 2006*

# Circadian Rhythms

- *Circa* = about; *dies* = day
- All living creatures show circadian rhythms
- Normal environmental stimuli (light/dark cycle) can entrain rhythm to 24 hrs
- There are many different systems that follow this rhythm
  - sleep/wake
  - body temperature
  - mental performance
  - hormones
  - digestion

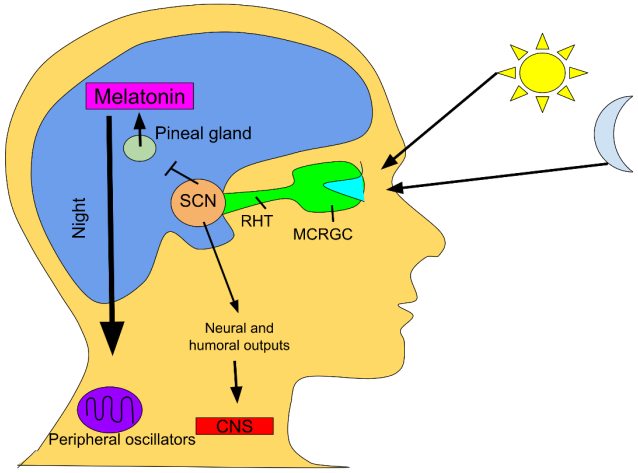



*Image from* https://upload.wikimedia.org/wikipedia/commons/e/e6/Circadian_rhythm.svg

# Circadian Rhythms: the Daily Clock

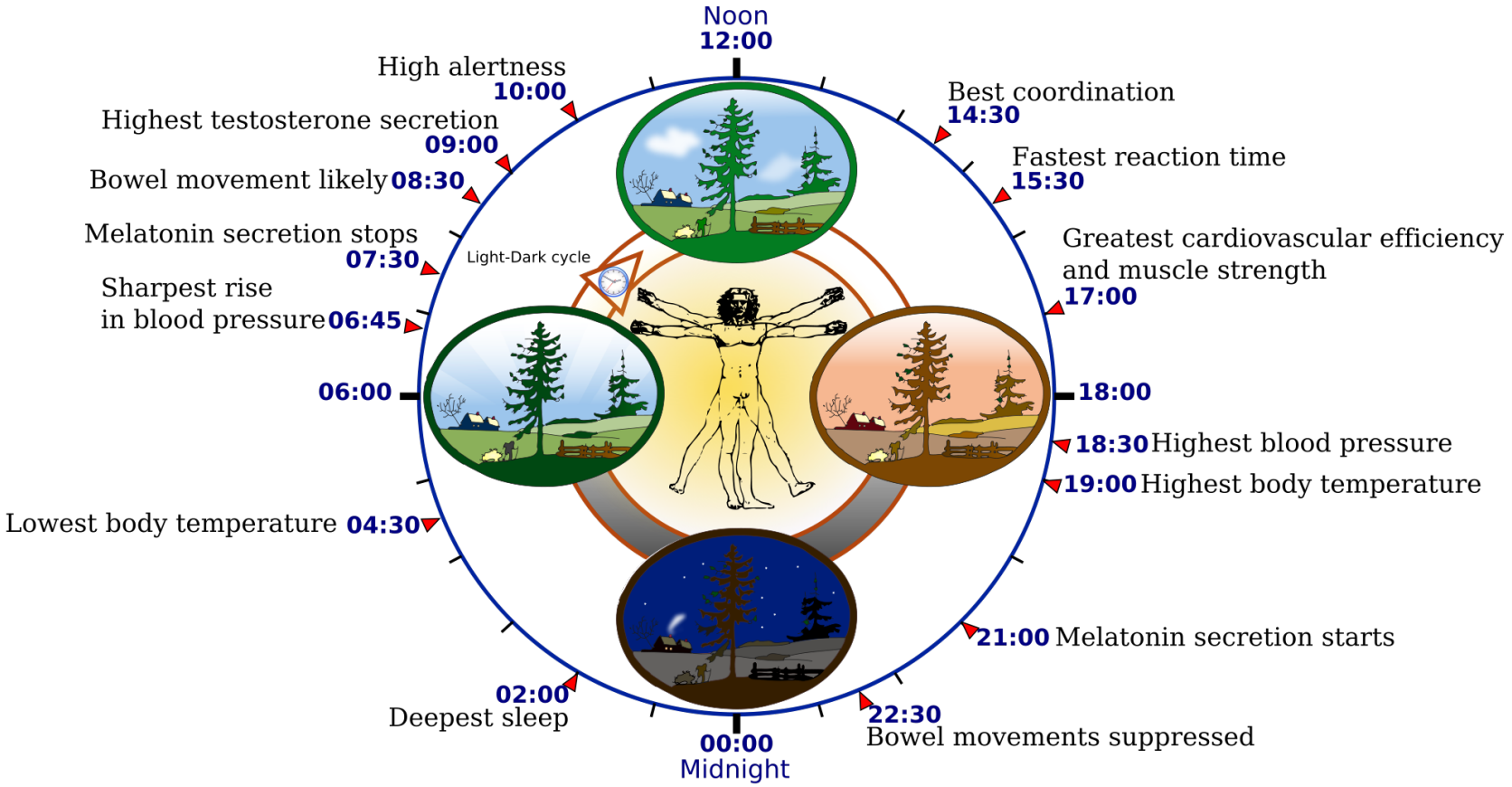
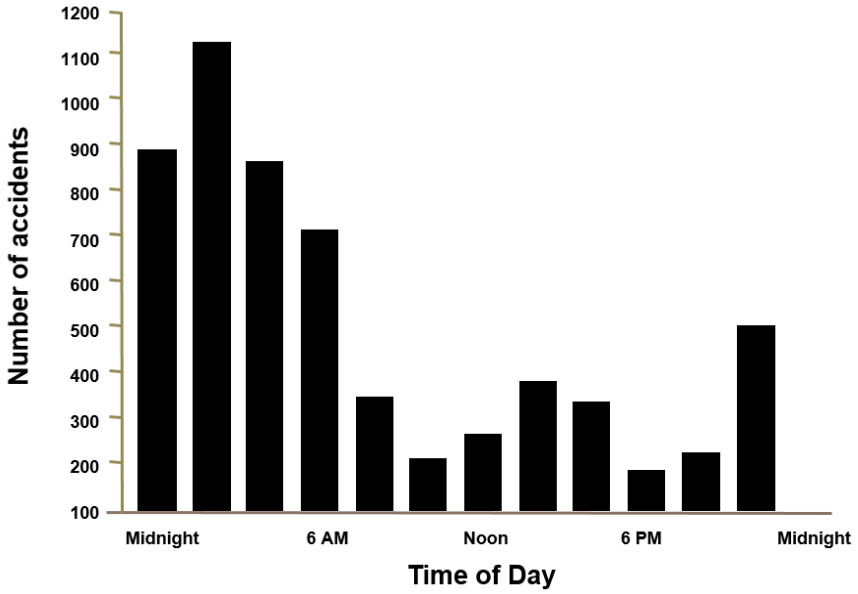
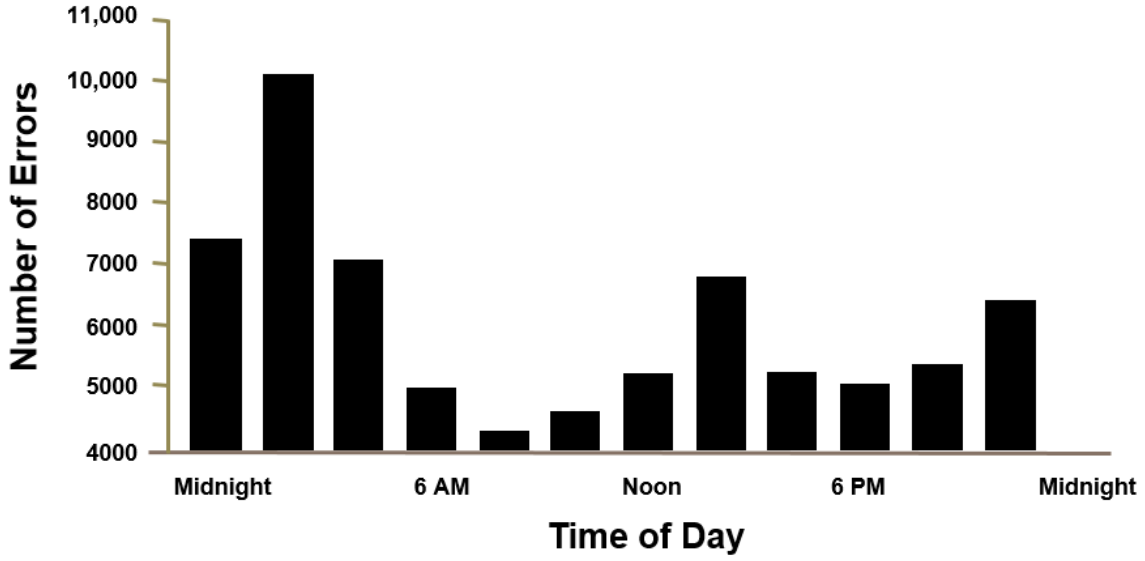



*Image from* https://upload.wikimedia.org/wikipedia/commons/3/30/Biological_clock_human.svg

# Circadian Rhythms and Safety



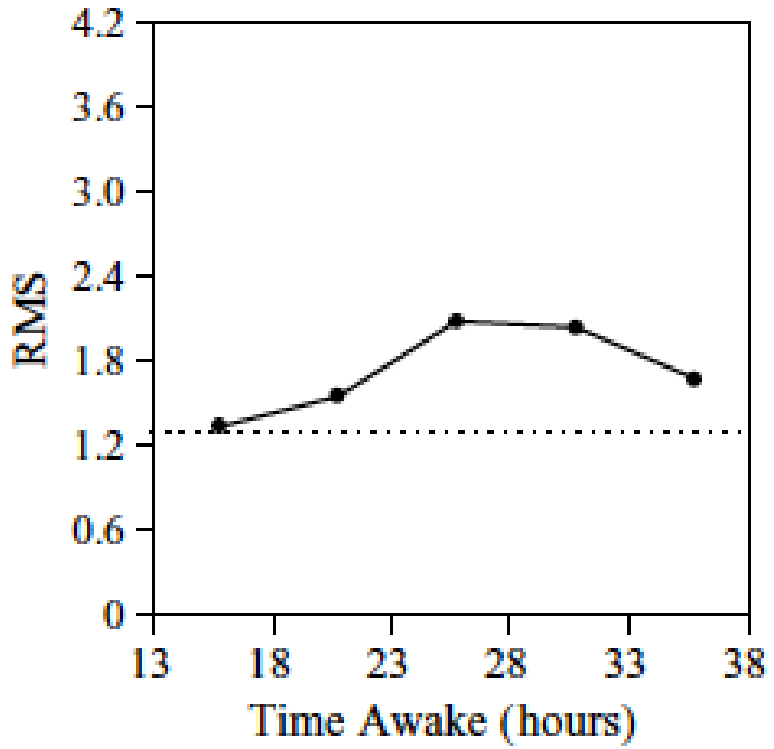




*Mitler et al., Sleep, 1988*

# Circadian Misalignment

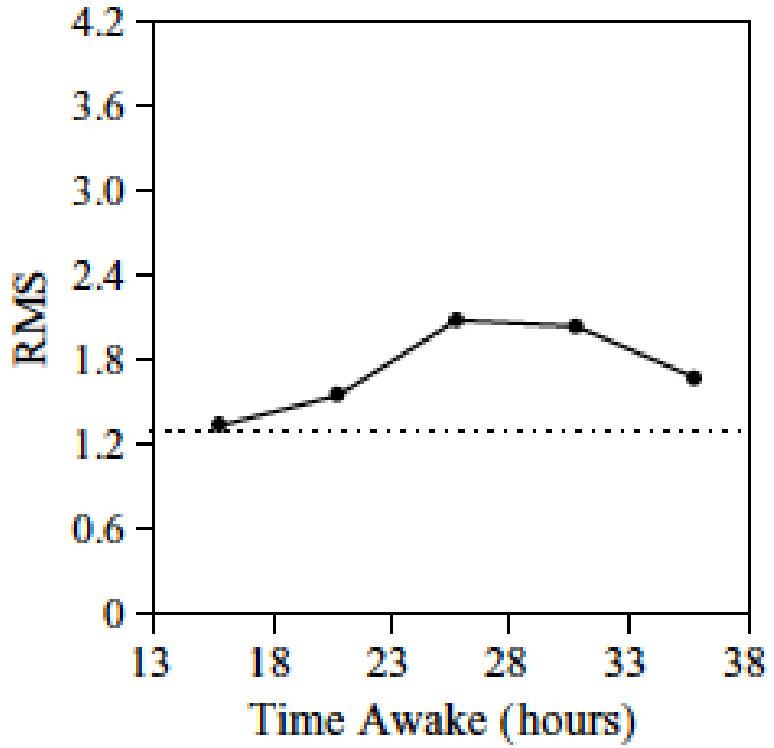
- Circadian clock can not adapt immediately to work/rest schedule changes
- Misalignment between sleep/wake cycle and timing of clock
- Some individual variation in programming of the clock (chronotype)
  - Morning types= “larks”
  - Evening types= “owls”
  - Clock cycle for “owl” up to 5 hr later than “lark”

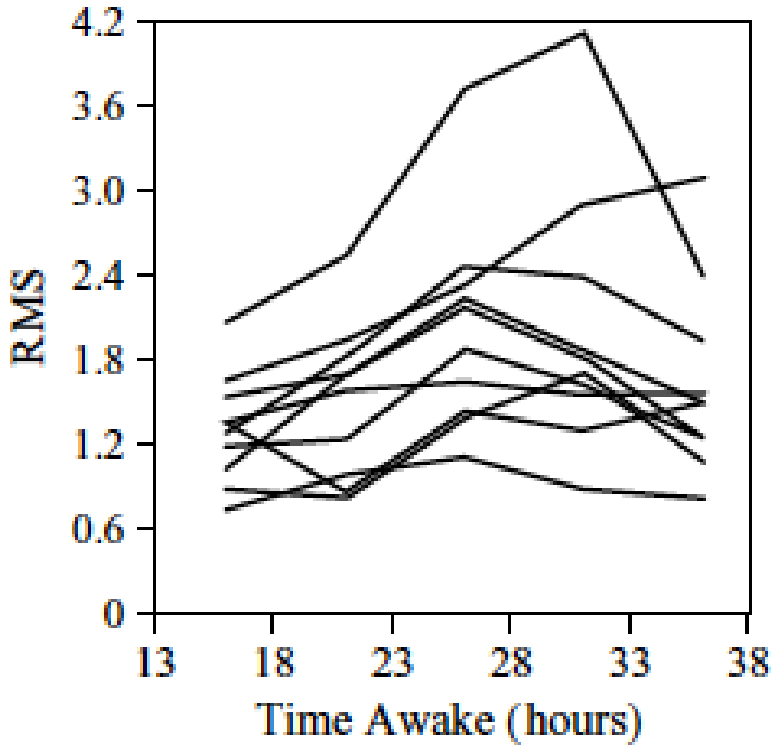
# Individual Differences




*Van Dongen et al., Sleep, 2006*

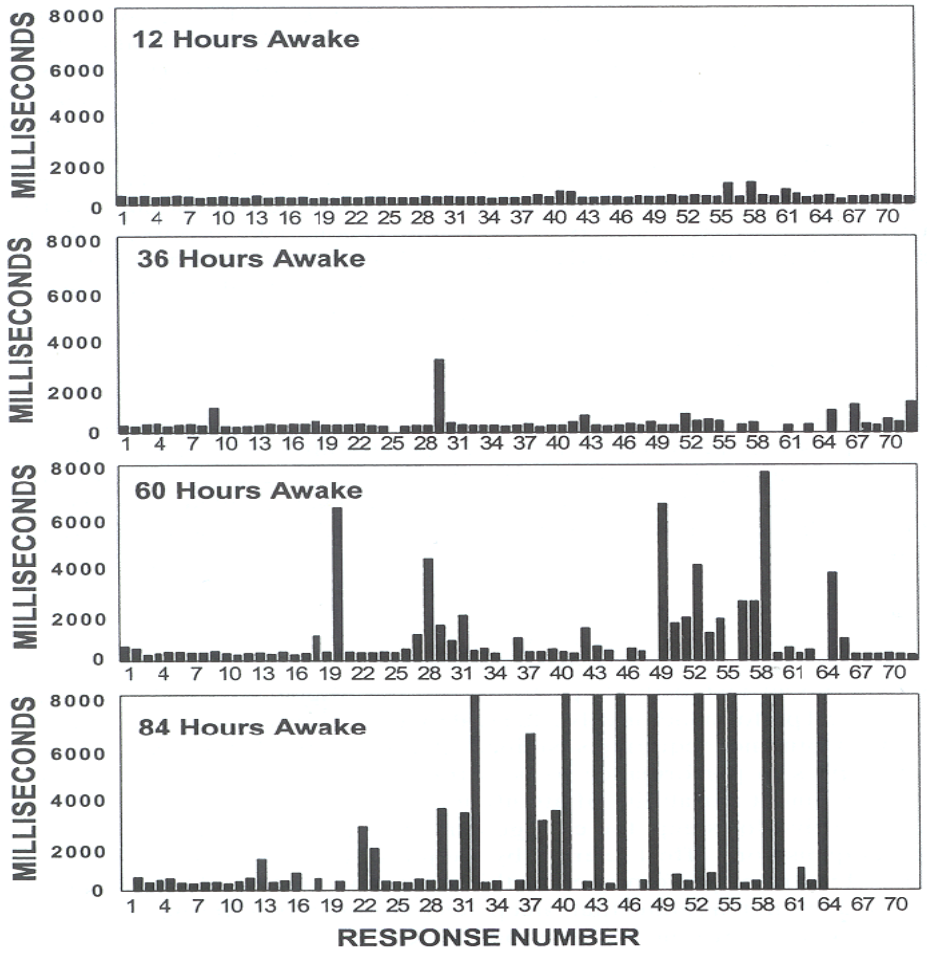
# Individual Differences




*Van Dongen et al., Sleep, 2006*

# State Instability




*Doran et al., 2001*

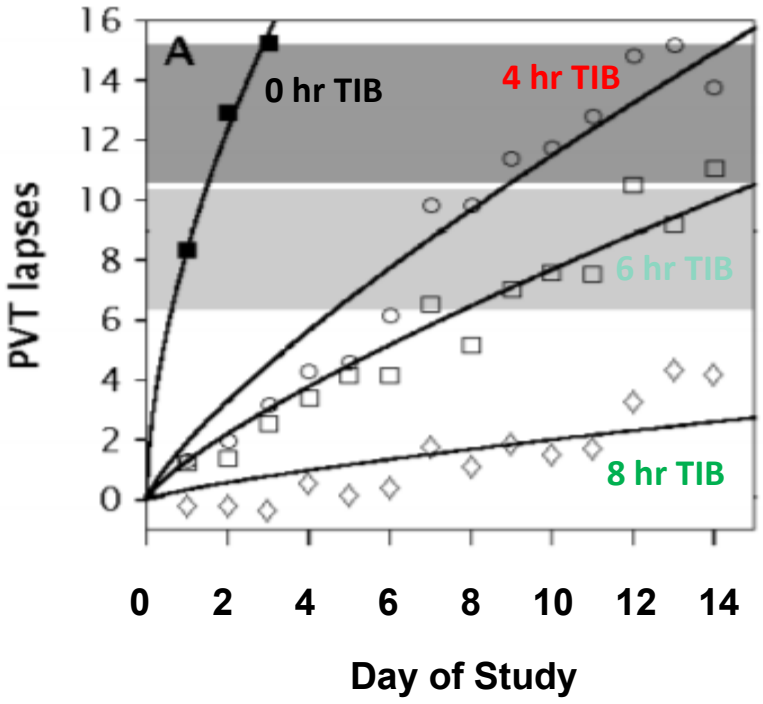
# Common Misperceptions

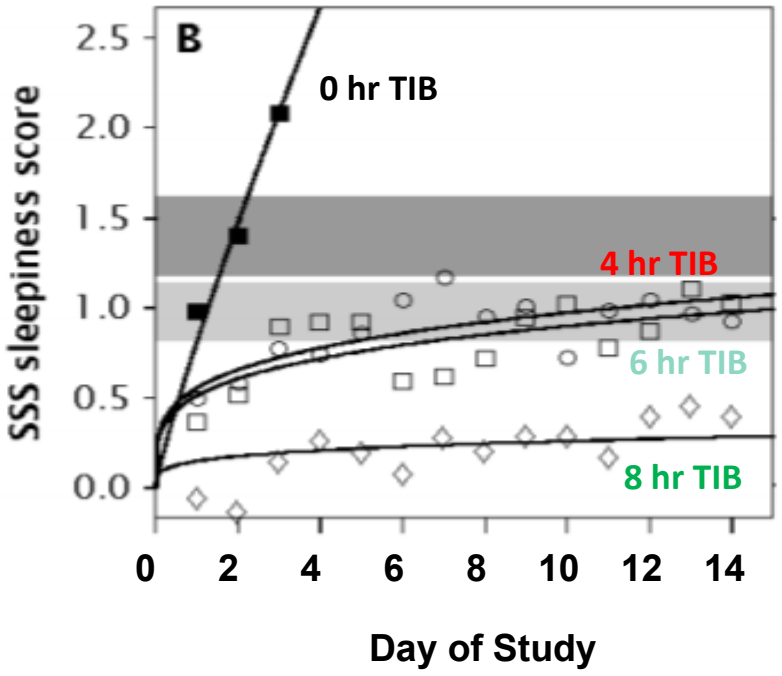
*I know how tired I am.*

*I have lost sleep before and did just fine.*

*Motivation and stimulation will get me through.*

# Self-assessments

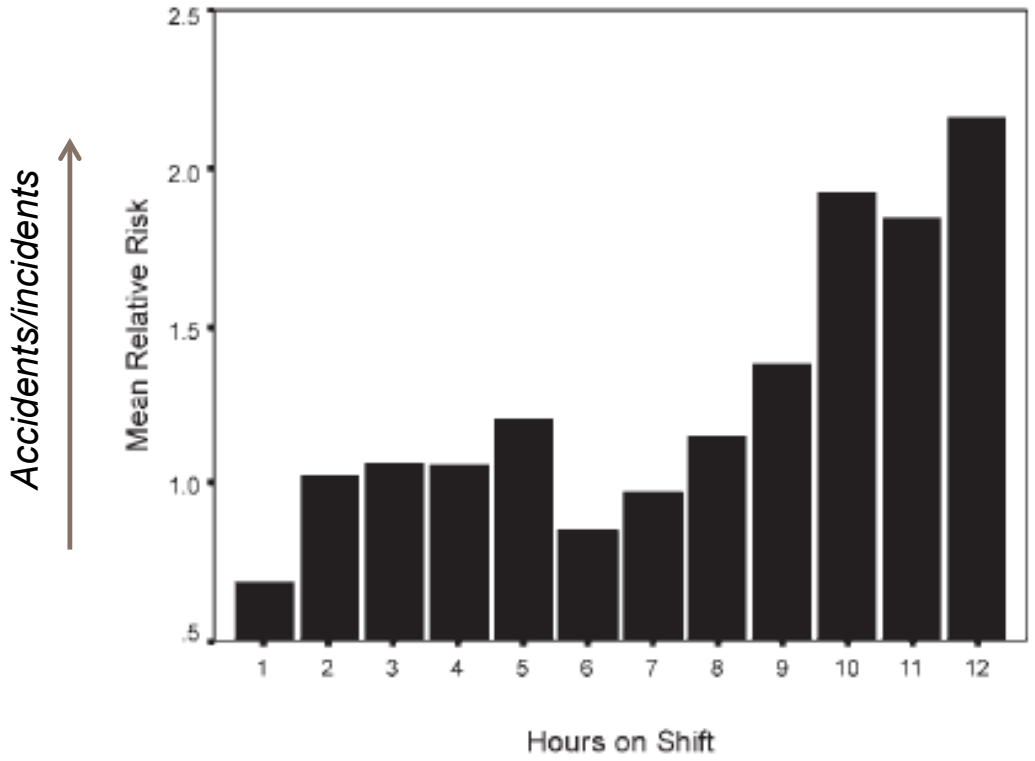



Van Dongen *et al*. 2003

# Work Schedules

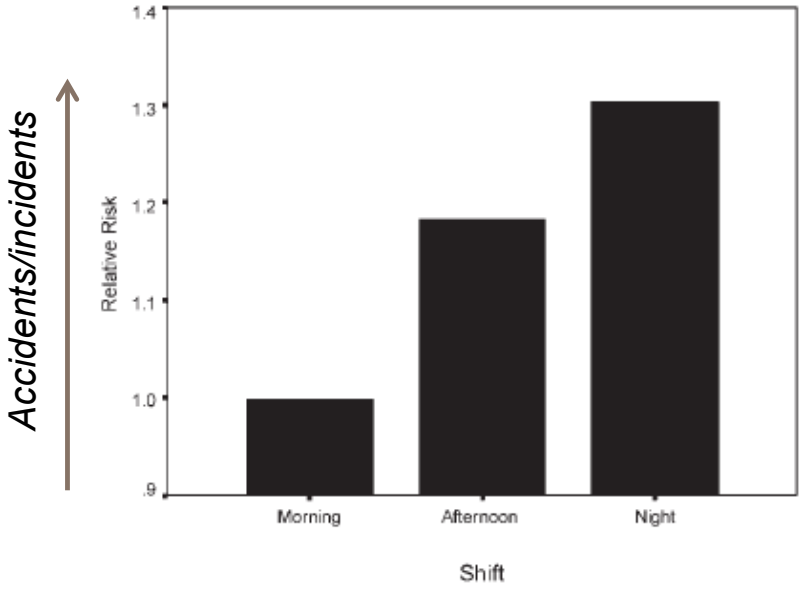
- Length of work periods
  - Hours awake
  - Time on task




*Folkard & Tucker, 2003*

# Work Schedules

- Timing of work periods
  - Circadian nadir (night)
  - Early morning starts
  - Plan for critical tasks
  - Task rotation



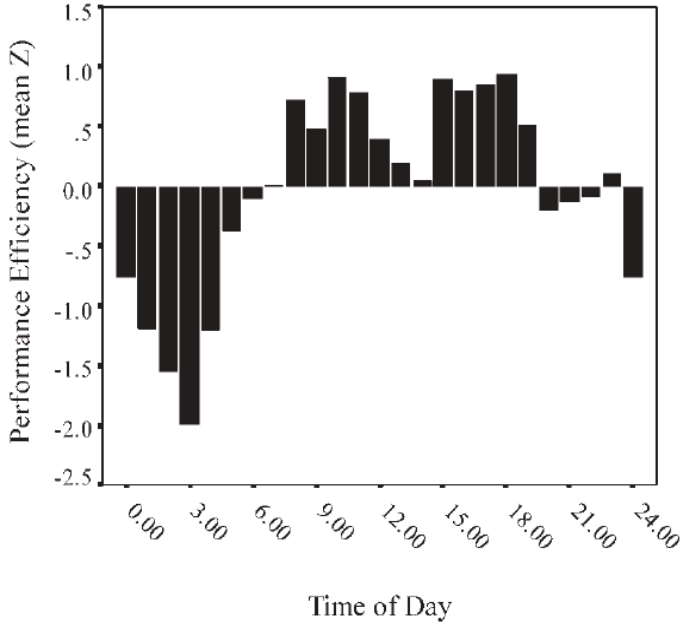
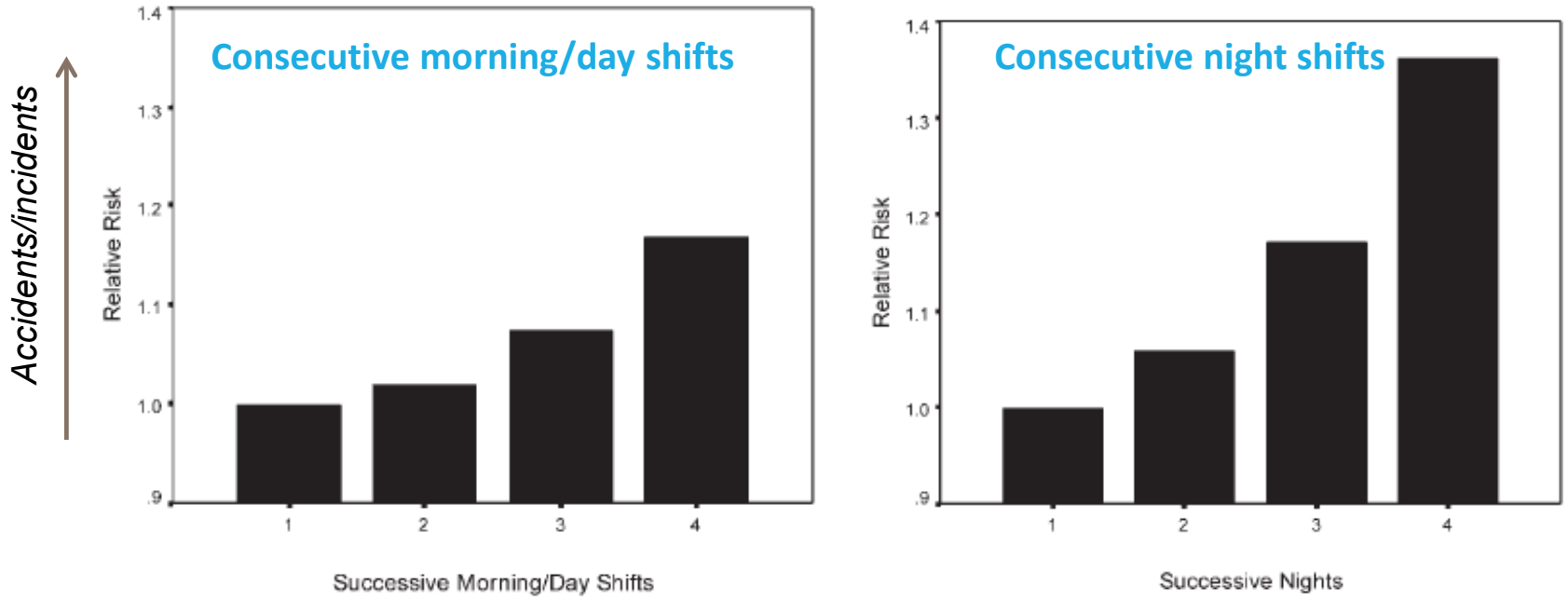




**Figure 1.** Industrial performance efficiency over the 24 h day.

*Folkard & Tucker, 2003*

# Work Schedules

- Consecutive work periods
  - Chronic sleep restriction
  - Cumulative workload




*Folkard & Tucker, 2003*

# Work Schedules

- Rotation of work periods
  - Forward rotation in sync with clock
  - Circadian adaptation is gradual

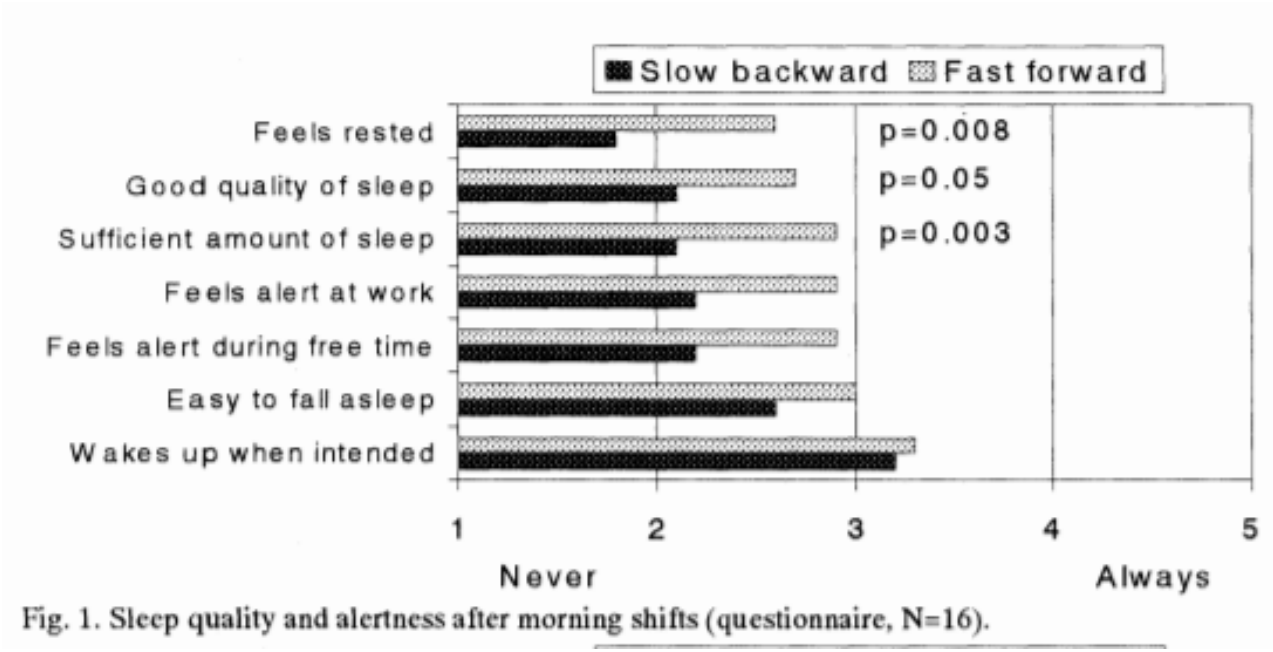


Fig. 1. Sleep quality and alertness after morning shifts (questionnaire, N=16).

*Hakola & Härmä, 2001*

# Work Schedules

- Overtime/work extensions
  - Extended hours awake
  - Extended time on task
  - Chronic sleep restriction
  - Cumulative workload

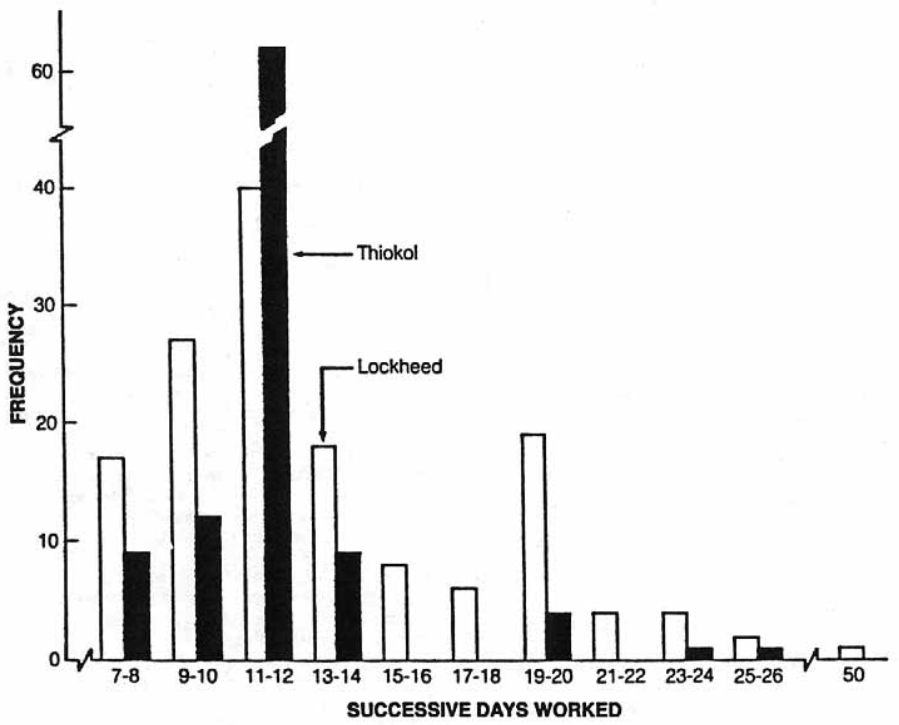
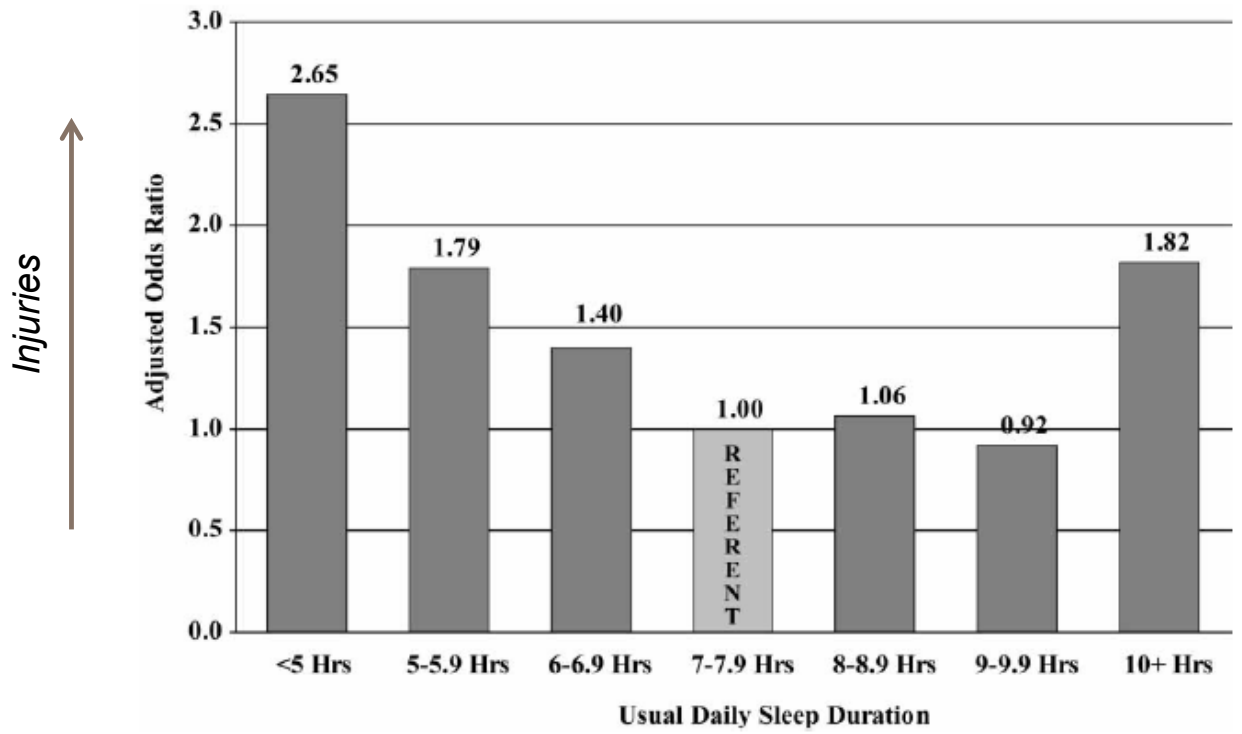



*Figure 1*—Incidence of more than six consecutive workdays among a group of Lockheed (N = 93) and Thiokol (N = 48) shiftworkers at Kennedy Space Center. Time period of sample varies from seven to ten weeks extending from October 26, 1985 to January 24, 1986.

*Report of the Presidential Commission on the Space Shuttle Challenger Accident – Volume 2: Appendix G*

# Work Schedules

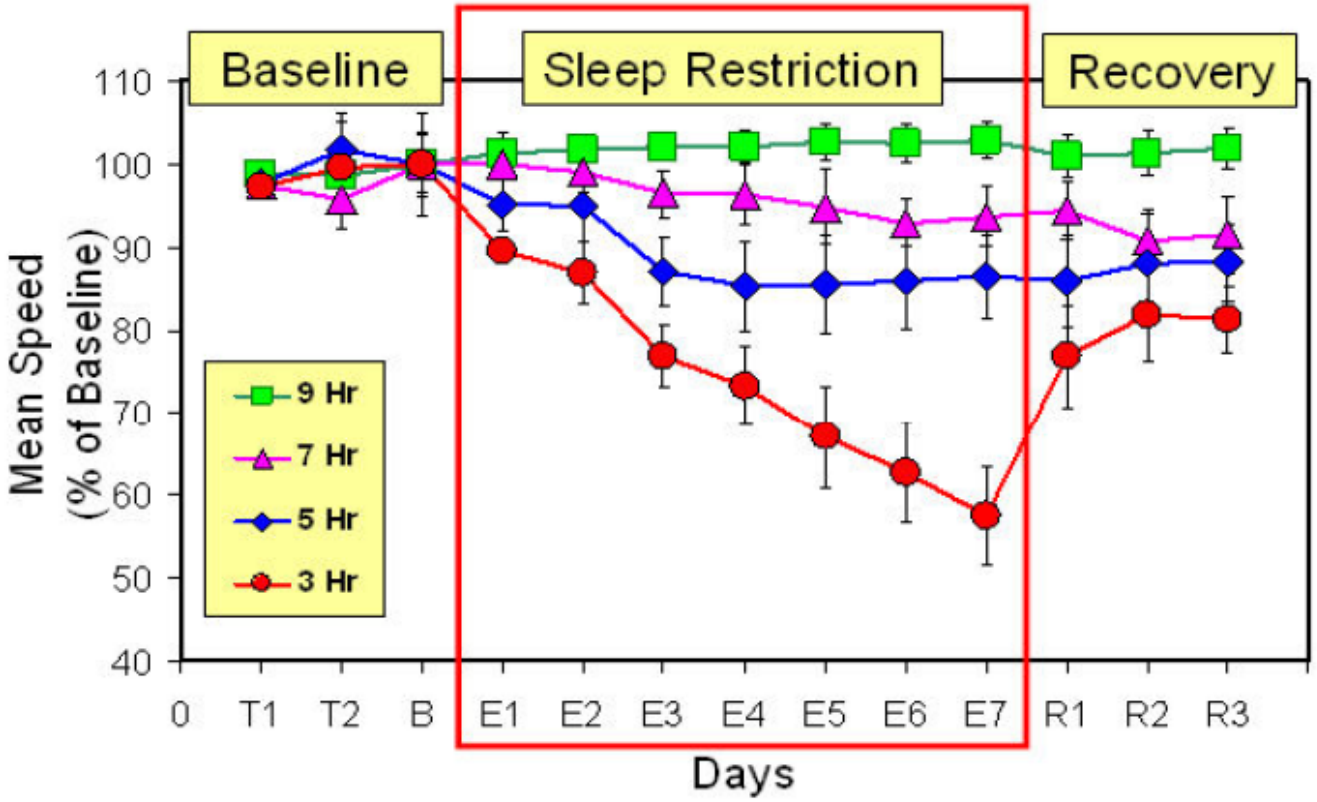
- Length and timing of off-duty periods
  - Prioritize sleep opportunities
  - Manage acute sleep loss
  - Nighttime sleep quality/quantity better




*Lombardi, et al 2010*

# Work Schedules

- Recovery off-duty periods
  - Prioritize sleep opportunities
  - Manage chronic sleep loss




*Adapted from Belenky, et al 2003*

# Work Schedules

- Regular breaks
  - Shorter, more often may provide benefit
  - Manage time on task/workload

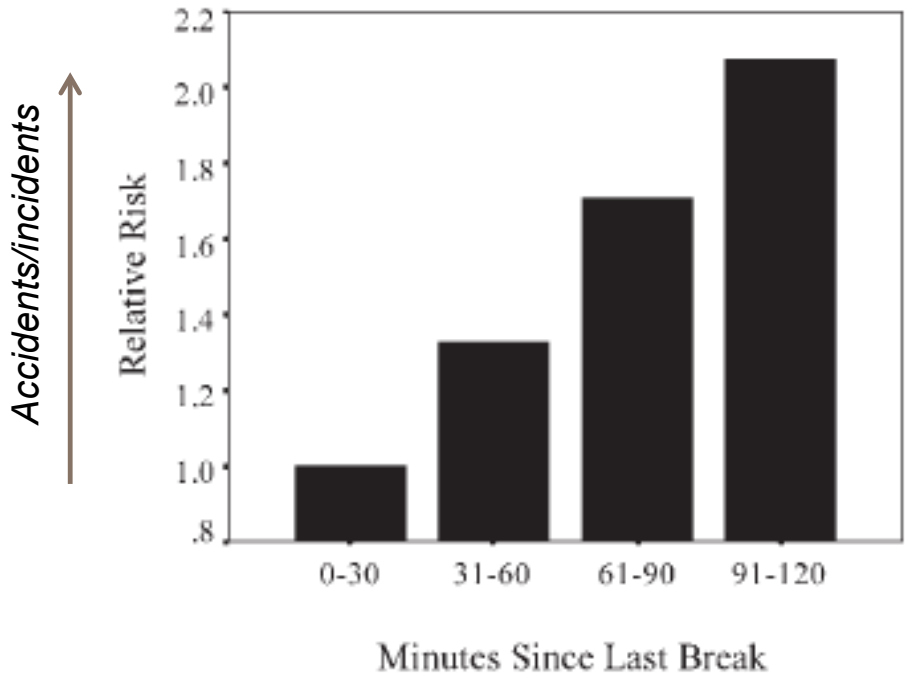



**Figure 7.** The trend in relative risk between breaks (from [30]).

*Folkard & Tucker, 2003*

# Drowsy Driving: Risk Factors

- Night shifts or non-standard work schedules
- Less or poorer quality sleep
- Untreated sleep disorders
- Longer hours awake
- Medication use
- Young men
- Distraction
- Road conditions/type


*Photo from* http://safetytoolboxtopics.com/Fatigue/driver-fatigue.html

# Fatigue Management: Personal Strategies

- Sleep and naps
- Caffeine
- Light
- Exercise/physical activity
- Diet
- Family life

# Fatigue Management: Good Sleep Habits

- Protect sleep time
- Keep regular bed/wake times (when possible!)
- Use a regular pre-sleep routine
- Limit caffeine, nicotine, exercise, alcohol
- Light snack or drink if needed
- Don’t toss and turn for >30 minutes

# Fatigue Management: Good Sleep Habits

- Pre-sleep routine
  - Control the environment
    - Dark, cool, quiet
  - Keep work/stress out of the bedroom
  - Avoid bright/blue light before bed
  - Avoid caffeine/alcohol/nicotine
  - Tell household your schedule

*Photo by Victoria Heath on Unsplash*

# Fatigue Management: Napping

- Naps are best countermeasure to fatigue/sleep loss
- Longer naps provide longer benefits
- Short naps can be beneficial
- Benefits of nap depend on:
  - Duration and quality of the sleep
  - Timing
  - Prior sleep/wake history

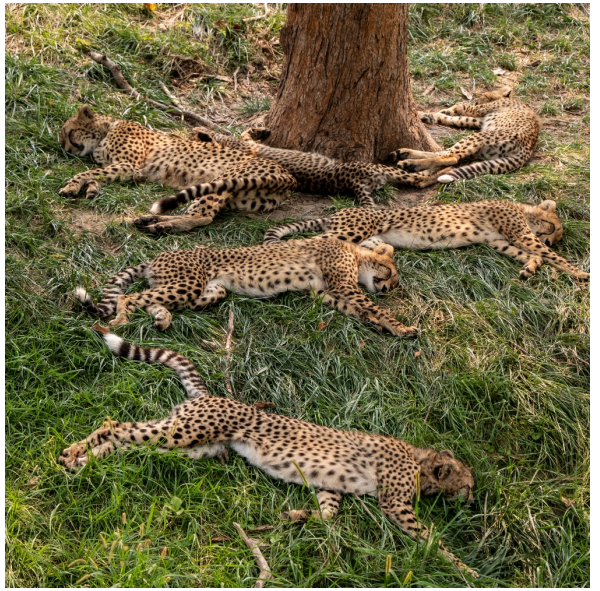
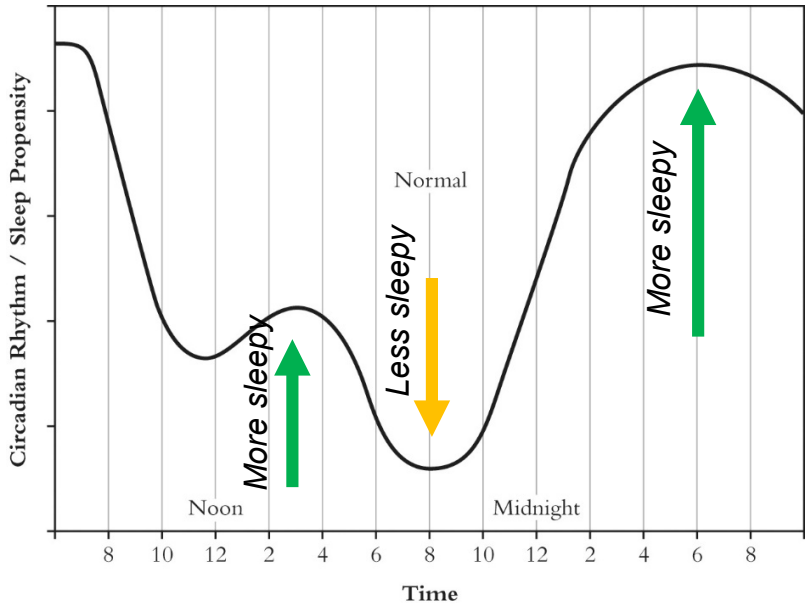


*Photo by Andrew Seaman on Unsplash*

# Fatigue Management: Napping

- Timing of naps
  - Use afternoon ‘dip’ prior to night shift
  - In morning when coming off night shift
- Consider use of eye masks, white noise, ear plugs, alarm
- Allow wake up time, minimize sleep inertia




*Broughton, 1994*

# Fatigue Management: Caffeine

- Plan timing: use strategically
- Can be effective short-term
- Improves alertness, performance
- Downsides:
  - Tolerance levels/effectiveness vary
  - Half-life up to ~5 hr
  - Ineffective for extreme circumstances
  - Disturb sleep if too close

*Photo by Estela Shaddix on Unsplash*

# Fatigue Management: Planning

- Try different strategies to determine what works best for you
- Effectiveness of strategies will vary by individual
- Plan according to:
  - Type of shift worked
  - Consecutive days/nights worked
  - Working extended hours
  - Quality of last sleep period

*Photo by Glenn Carstens-Peters on Unsplash*

# Fatigue Management: Summary

- Fatigue can arise due to multiple factors
  - Acute sleep loss
  - Chronic sleep loss
  - Circadian misalignment
  - Hours awake
- Fatigue can lead to impaired performance and increased safety risks

# Fatigue Management: Summary

- Fatigue management in the workplace requires awareness and responsibility from all participants

- Prioritize sleep during off-duty periods

  - Practice good sleep habits

- Utilize fatigue countermeasures strategies that work best for you and for the work time at which it is applied

- Evaluate and change strategies as needed

“Although neither man was really tired after the first half of the picture-snapping, Conrad considered closing the hatch and resting until the next night pass. He asked the Hawaii CapCom if there was enough oxygen. The answer was yes. But the skies were clear over the United States, and they might want to take more pictures there. In that case, said Conrad, the hatch would stay open. Soon the crew marveled at the view of their home area-Houston. They passed quietly across Florida and out over the Atlantic with nothing to do. Suddenly, Gordon broke the silence to announce that they had just taken a catnap. ‘There we were. . . , he was asleep hanging out the hatch on his tether and I was asleep sitting inside the spacecraft,’ Conrad reported. ‘That's a first,’ John Young answered, ‘first time sleeping in a vacuum.’”

p://www.nasa.gov/sites/default/files/styles/1x1_cardfeed/public/images/139573main_image_feature_470_ys_full.jpg


# Thank you!

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