Sleep and Performance

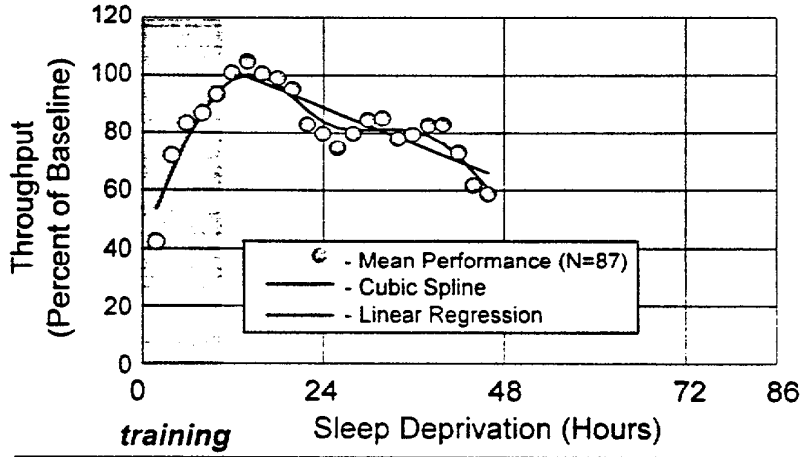
Gregory Belenky, M.D.
Colonel, Medical Corps, U.S. Army
Division of Neuropsychiatry
Walter Reed Army Institute of Research

Factors Affecting Performance

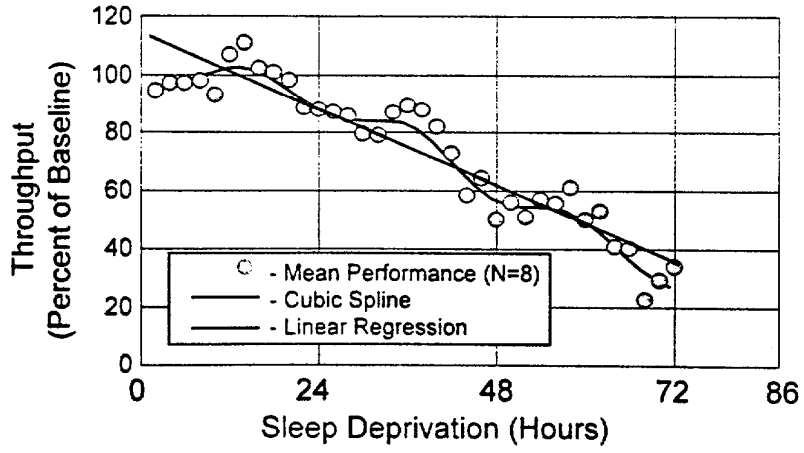
- Time Awake (sleep/wake history)
- Time of Day (circadian rhythm)
- Time on Task (~shift length)
- Task Complexity
- Individual Differences in Response to
  - Time Awake
  - Time of Day

Attachment 4

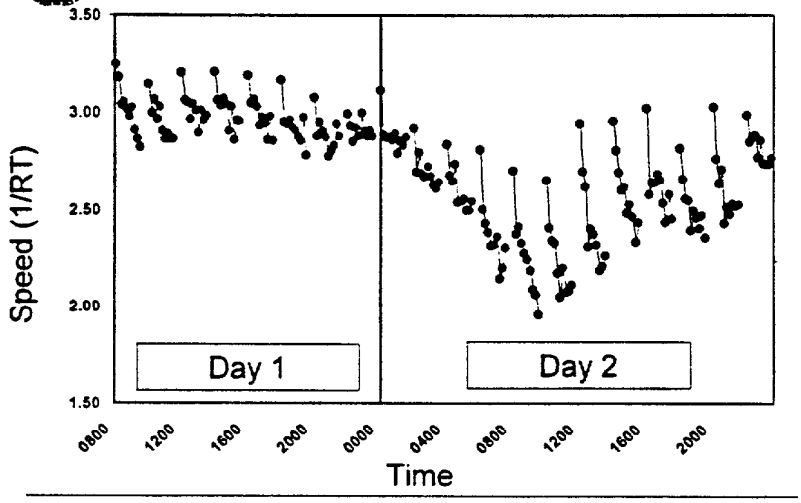
48 Hours of Total Sleep Deprivation: Effect on Complex Mental Operations



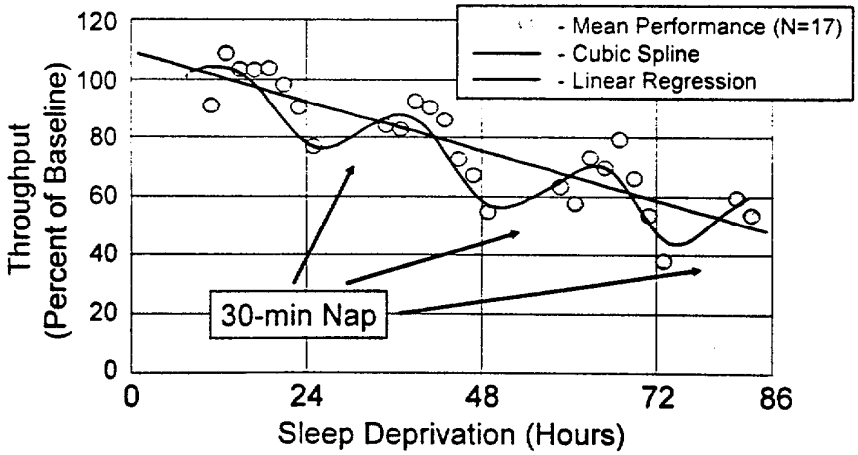
72 Hours of Total Sleep Deprivation: Effect on Complex Mental Operations ***Task***



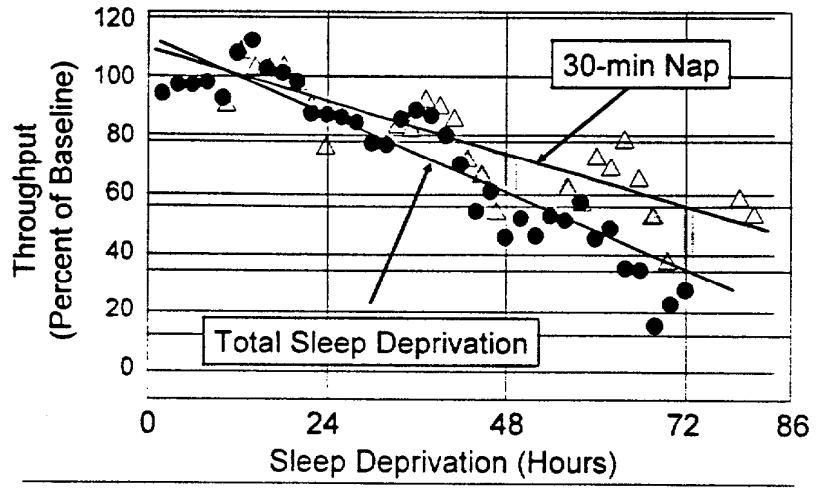
Time on Task Effects on PVT Speed over 38 Hours of Total Sleep Deprivation



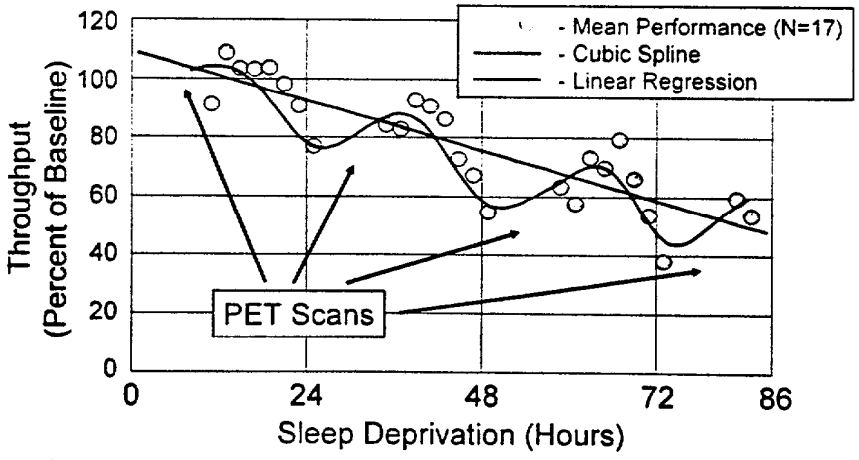
85 Hours of Sleep Deprivation: 30-min Daily Nap & Complex Mental Operations



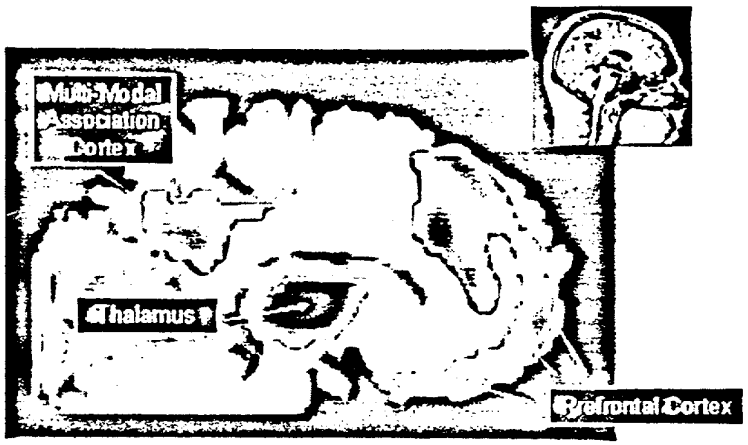
Total Sleep Deprivation vs.. Daily 30-min Nap: Effect on Complex Mental Operations



85 Hours of Sleep Deprivation: 30-min Daily Nap & Complex Mental Operations



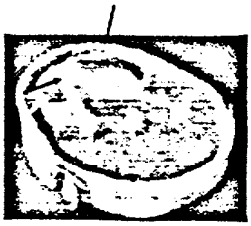
PET Study of Sleep Deprivation: Findings



Positron Emission Tomography (PET) Study of Sleep

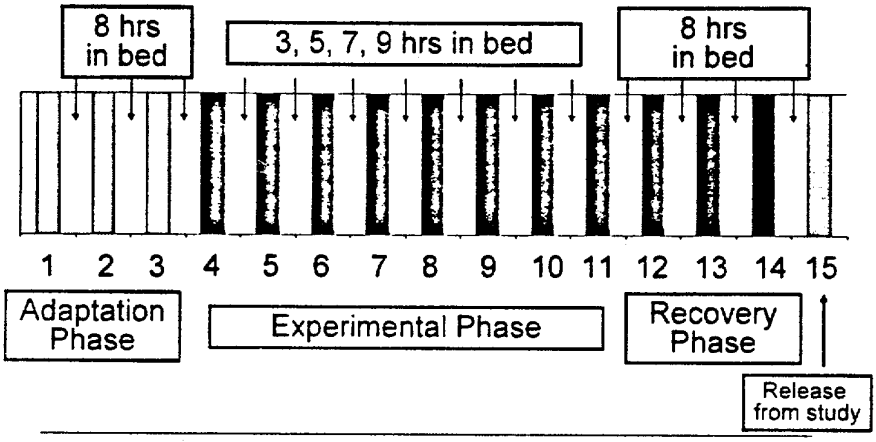
Frontal areas are deactivated during Slow Wave Sleep

Frontal areas remain deactivated during REM



Frontal areas are re-activated only after awakening

Sleep Dose-Response (SDR) Study: Design



Subjects, Number/Sleep Group, Time in Bed

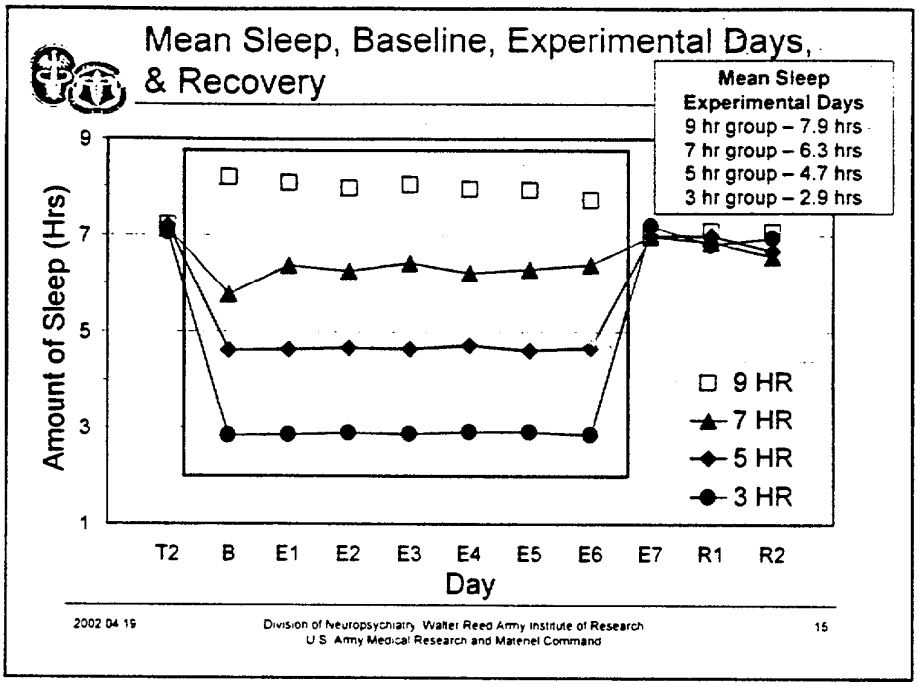
- 66 commercial drivers
  - in good general health
  - non smokers
  - light caffeine users (2-4 cups/day)
- 16 women
  - mean age 39 (range 24-55)
- 50 men
  - mean age 37 (range 24-62)

- 3 hr sleep group
  - Time in bed: 0400-0700
  - n = 18
- 5 hr sleep group
  - Time in bed: 0200-0700
  - n = 16
- 7 hr sleep group
  - Time in bed: 2400-0700
  - n = 16
- 9 hr sleep group
  - Time in bed: 2200-0700
  - n = 16

Instrumented Volunteers

Measures

- 24 hr. Polysomnography (EEG, EOG, EMG) (Oxford Medilog)
  - Sleep scoring
  - Sleep latency testing
- 24 hr. Actigraphy (Precision Control Design, Inc.)
- Psychomotor Vigilance Task (PVT)
- Driving Simulator (STI, Inc)
- Oculomotor Responses - Fitness Impairment Tester (FIT) (PMI, Inc.)
- WRAIR Performance Assessment Battery (PAB)
- Synthetic Work Task
- Stanford Sleepiness Scale
- Profile of Mood States


Mean Sleep, Baseline, Experimental Days, & Recovery
Mean Sleep
Experimental Days
9 hr group – 7.9 hrs
7 hr group – 6.3 hrs
5 hr group – 4.7 hrs
3 hr group – 2.9 hrs
Amount of Sleep (Hrs)
9
7
5
3
1
9 HR
7 HR
5 HR
3 HR
T2 B E1 E2 E3 E4 E5 E6 E7 R1 R2
Day
2002 04 19
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U S Army Medical Research and Materiel Command
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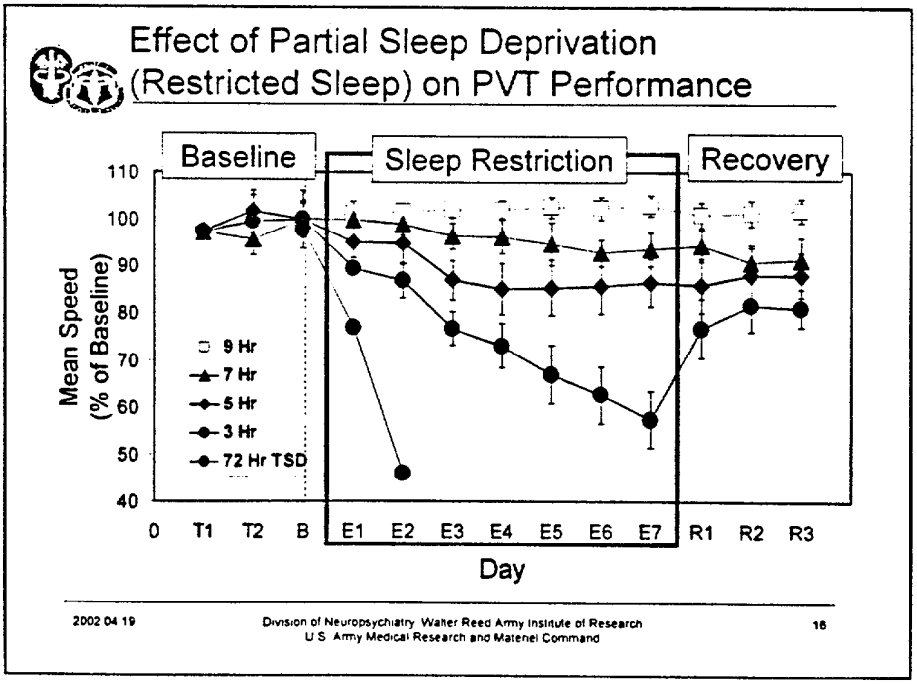
Effect of Partial Sleep Deprivation (Restricted Sleep) on PVT Performance
Baseline
Sleep Restriction
Recovery
Mean Speed (% of Baseline)
110
100
90
80
70
60
50
40
9 Hr
7 Hr
5 Hr
3 Hr
72 Hr TSD
0 T1 T2 B E1 E2 E3 E4 E5 E6 E7 R1 R2 R3
Day
2002 04 19
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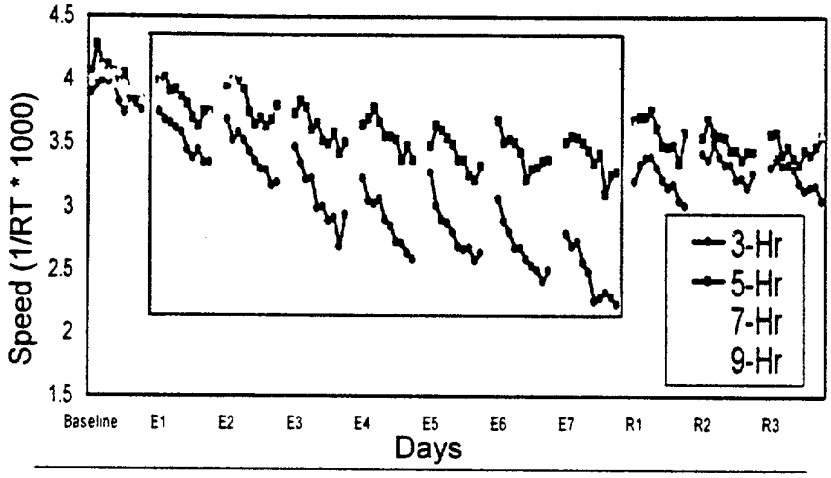
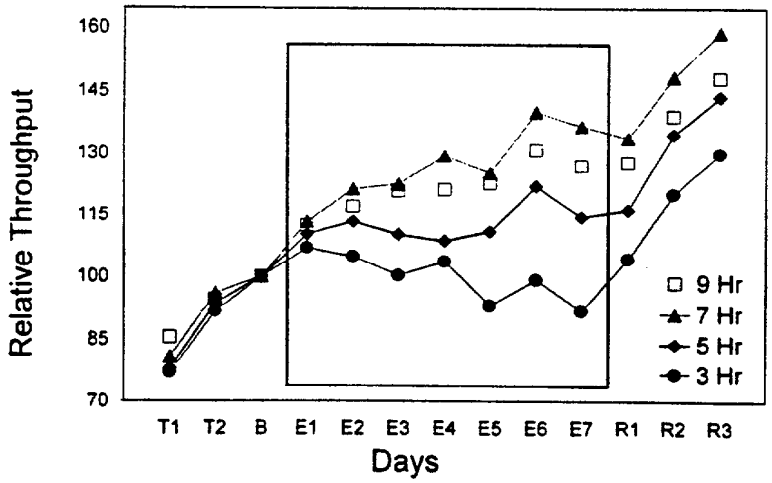
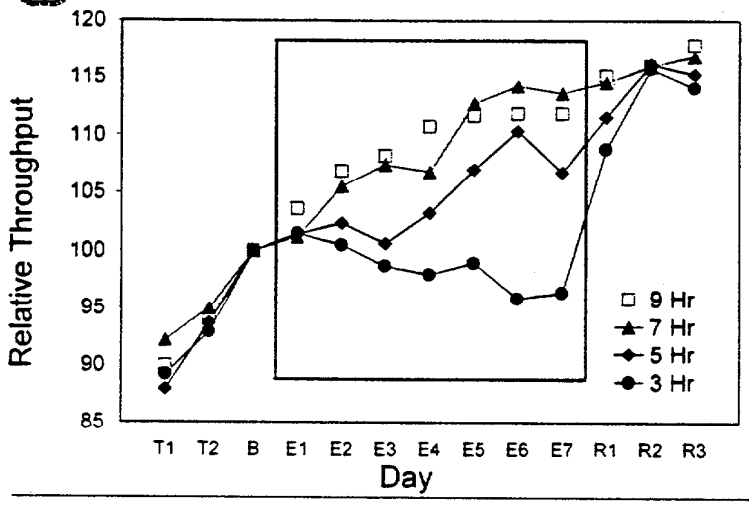
Psychomotor Vigilance Task (PVT)
Time on Task Effects @ 1200



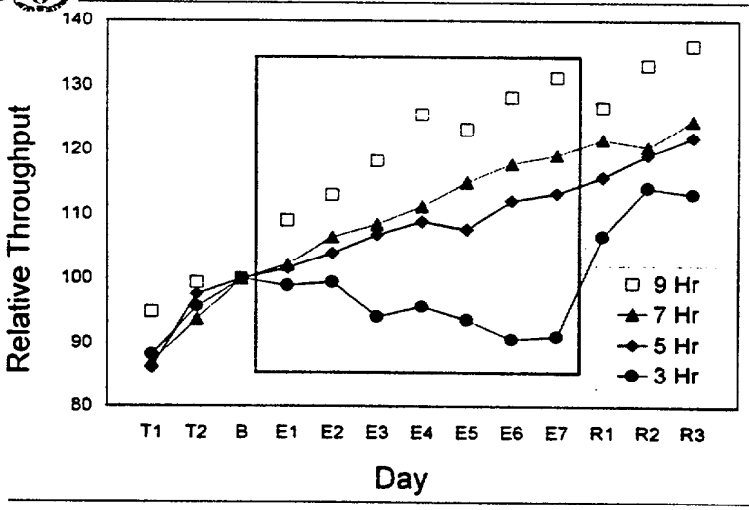
Serial Addition Subtraction



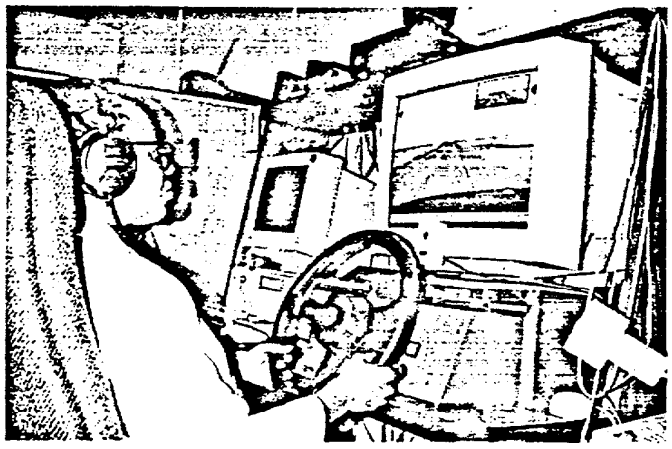
10 Choice Reaction Time



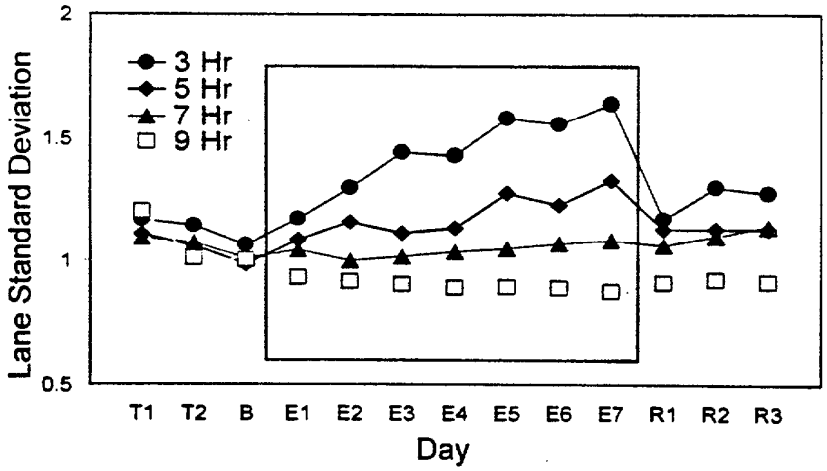
Wilkinson 4-Choice Reaction Time



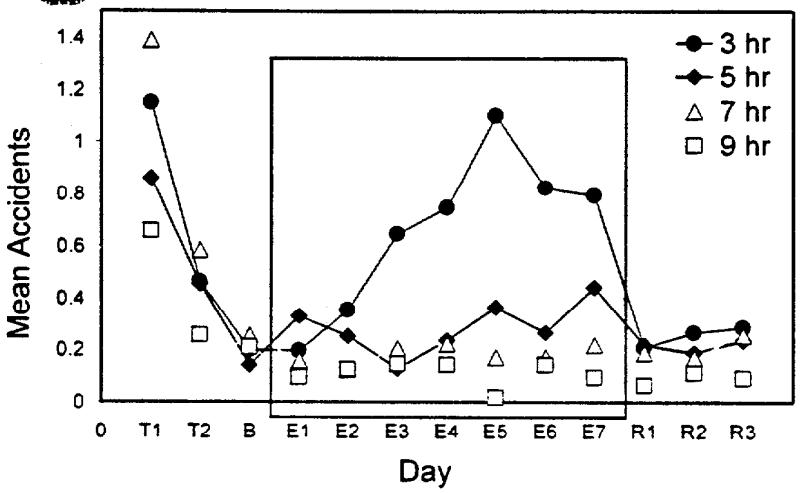
Driving Simulator



Driving Simulator: Lane Tracking



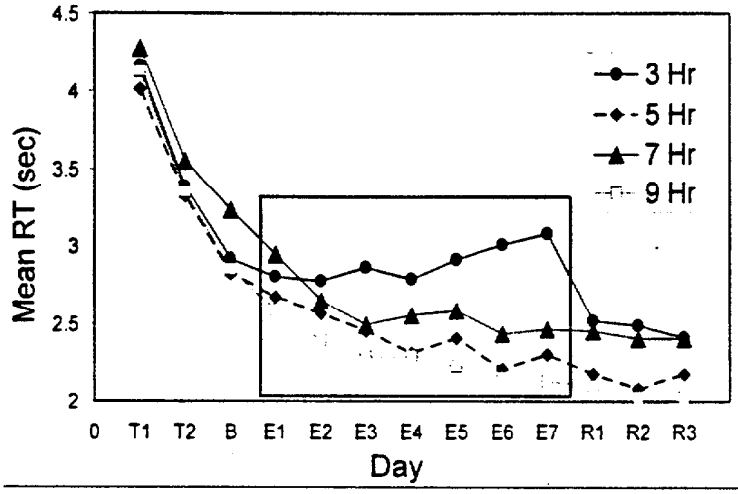
Driving Simulator: Accidents



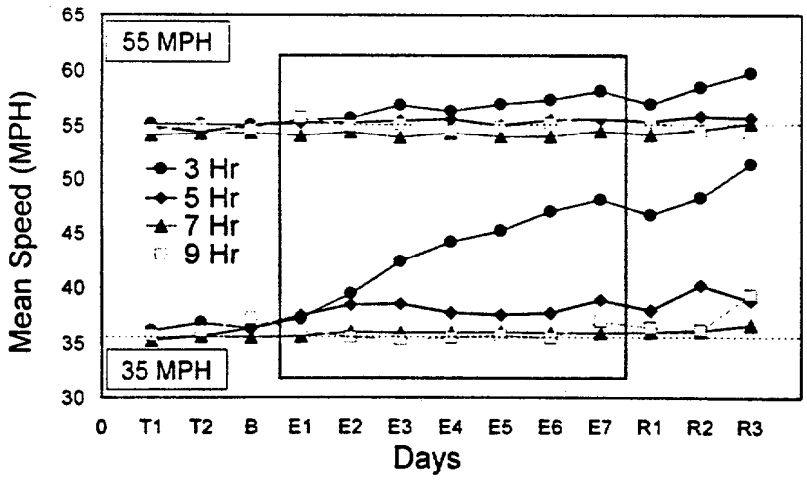
Microsleeps and Accidents

- Microsleep –
  - the occurrence of theta in the absence of artifact
  - with a duration up to 15 s
  - Anything longer scored as R&K Stage 1 sleep
- Occurrence during the minute preceding the accident
- During the sleep restriction phase
  - No R&K Stage 1 Sleep
  - all groups - 33% preceded by microsleep
  - 3 hr sleep group - 49%
  - 9 hr sleep group - 29%

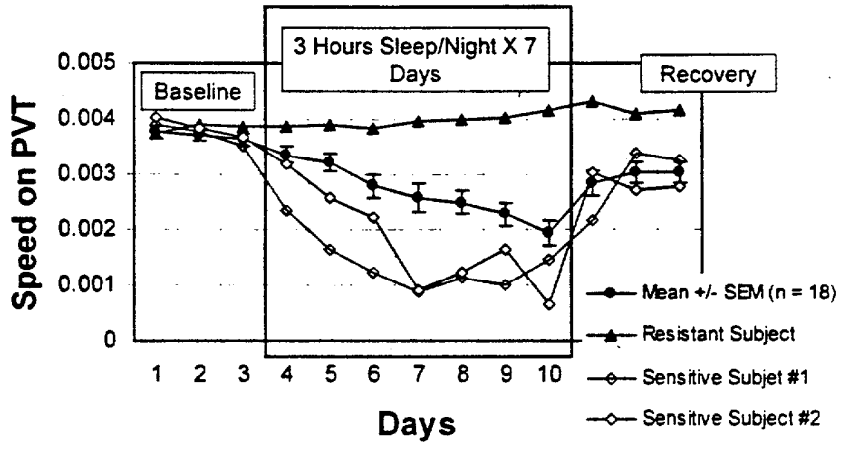
Driving Simulator: Peripheral Attention Task



Driving Simulator: Average Speed Across Zones

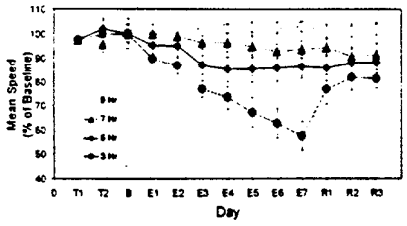


Variation between Individuals in Resistance and Sensitivity to Sleep Restriction



Conclusion: Restructuring the Sleep Debt

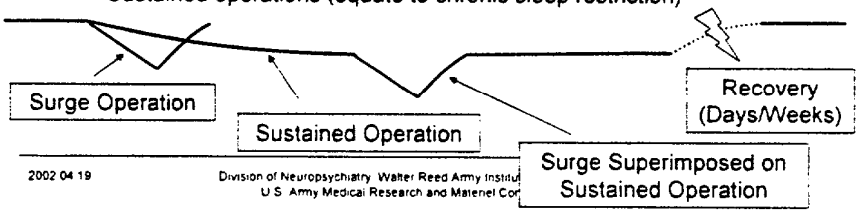
Sleep Restriction & Performance



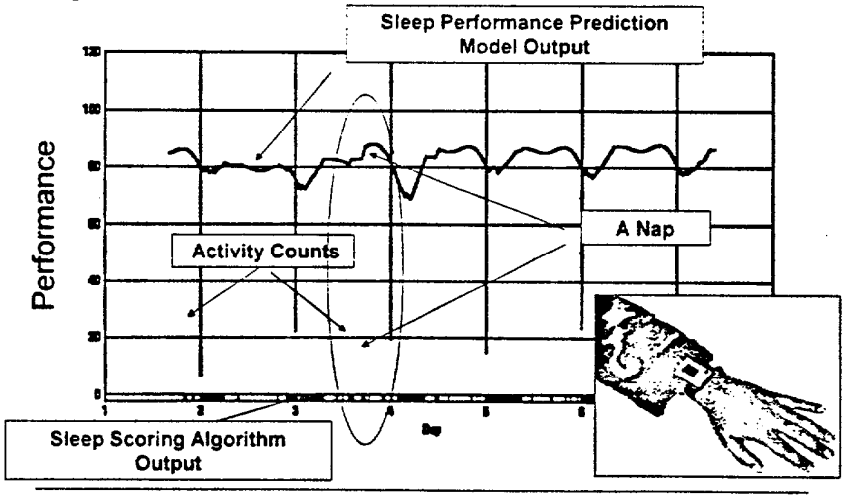
- Sleep Debt – Traditional view
  - Sleep debt accumulates continuously, linearly
  - Sleep debt takes days, weeks, or months to pay off
- Sleep Debt - Restructured
  - As long as performance is degrading sleep debt is accumulating
  - Once performance stabilizes sleep debt no longer accrues
  - Sleep debt is paid off rapidly
- The brain adapts to sleep restriction by capping operational capacity
- This adaptation persists into recovery, restricting performance

Issues in Modeling

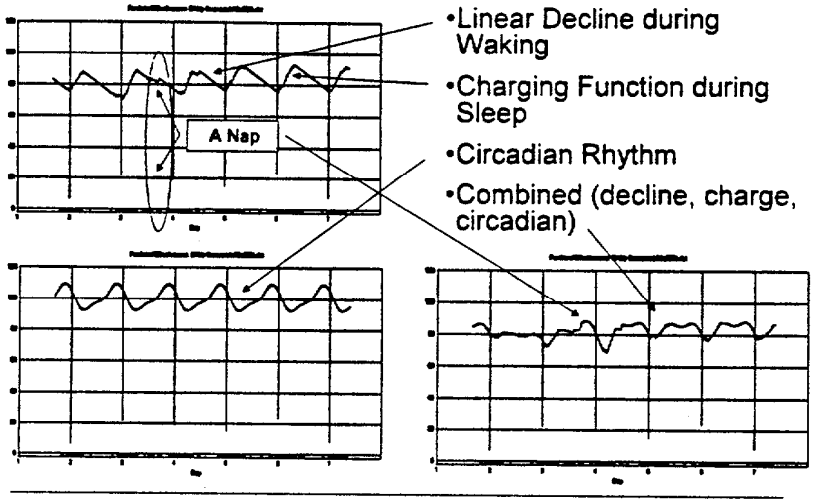
- Current models are simple one-quantity reservoir models
  - A single quantity depleting
  - The same quantity replenishing
  - Typically different functions govern depletion and replenishment
- Simple reservoir models cannot account for the effects of sleep deprivation and sleep restriction on performance
- The performance effects and neurobiology are distinct for surge vs. sustained operations
  - Surge operations (equate to acute, severe/total sleep deprivation)
  - Sustained operations (equate to chronic sleep restriction)



Sensors, Circuits, and Software Models in Real-World Application: The Sleep Watch



Sleep Performance Model Based on Leading Facts from Sleep Research



- Linear Decline during Waking
- Charging Function during Sleep
- Circadian Rhythm
- Combined (decline, charge, circadian)

Point of Contact

Gregory Belenky, MD
COL, MC, USA
Director
Division of Neuropsychiatry
Walter Reed Army Institute of Research
503 Robert Grant Avenue
Silver Spring, MD 20910-7500

Phone: (301) 319-9085
FAX: (301) 319-9255
DSN: 285-9085
Email: gregory.belenky@na.amedd.army.mil