How to Study and Measure Sleep

Sleep: Absence of overt behavior accompanied by an absence of consciousness

- All the measures we have about sleep are indirect
- We have to infer what is happening during sleep

Methods to measure sleep characteristics

1. ElectroMyoGram (EMG): Measures muscle activity (typically in face and legs)
2. ElectroEncephaloGram (EEG): Brain activity
   a. Wearing electrodes on the skull
3. ElectroOculoGram (EOG): Measures eye movement
   a. Typically used on sleep
4. (Physiology) Airflow measurements: Breathing
5. (Physiology) Heart rate...sweating

EEG Measurements of Sleep

- Sleep has different stages characterized by different EEG waveforms
- Stages of sleep can be detected by the waves produced

Awake...

1. Stage 1 sleep - more low frequency
   a. Drowsiness, heavy eyes
   b. Lasts - 10 minutes
2. Stage 2 sleep
   a. K. Complex and sleep spindles
   b. Sensory disconnection - disconnection from the world - still aware of the environment
   c. Theta sleep
   d. Lasts - 15 minutes
3. Stage 3 sleep/Stage 4 sleep - Very slow and big oscillations
   a. Loss of consciousness
   b. Dominated by delta(low) frequency
   c. Lasts - 60 minutes
   d. Slow wave sleep
4. REM sleep - High frequencies
   a. Dreaming, loss of muscle tonus, rapid eye movements
   b. Activity in sexual organs
   c. Theta and Beta frequency - active thinking (same as in the active awake state)
   d. Lasts - 25 minutes
   e. Paradoxical sleep
      i. Paradoxical = weird

EEG and Single Neurons
During Slow Wave Sleep, neurons undergo

**Up and down states:** Periods of activity/silence
  - Down States: No action potential
    - Rest
  - Up state: Neurons are firing
    - Memory consolidation - what should be memorized versus discarded

**Sleep is a Cycle:** Free Running Sleep/Wake Cycle
- Experiment: Room/cave without windows, free food, entertainment, no clocks
- Measure: The amount of time awake/sleeping
- Result: The cycle between sleep/wake is not the same as the day/night cycle
- Every 23 days

**Michel Siffre Video:** We are always deprived of sleep by about 1 hour

**Sleep Has Cycles:**
- Sleep is a cycle
  - Never sleep at the same stage constantly
- Free running awake/sleep cycle - 25 hours
- REM/nonREM cycles every 90 minutes
  - Controlled by the internal clock
  - You get more and more REM as it gets later
- REM sleep has a refractory period of - 1 hour - Cannot go in and out of REM sleep
  - Increase of metabolic activity in CNS - Neurons are active
  - Decrease in activity in PNS
  - Sex organs are active
  - Dynamic dreams

**Why Do We Sleep?**
1. Sleep is a behavior (adaptive response to something, something we do because of the environment):
   - All animals have SWS but only mammals and birds have REM sleep
   - Sleep is a protective behavior - It can be dangerous to move at night
     - As animals we like sounds, vision inputs to function in the world - lack of these = danger (night)
   - Dolphins: They sleep one hemisphere at a time (left is asleep, right is awake and then opposite)
     - If both hemispheres are asleep, they can no longer swim
     - Behavior has evolved to help protect the dolphin from these potential dangers
2. Sleep as a restorative process (resting of the brain)
   - Evidence:
i. Cortex: Measure the metabolic activity and blood flow, there is a decrease of 25% during SWS

ii. Highest activity - Available during delta + lowest activity
   1. During slow sleep

iii. Sleep needs vary with development
   1. May differ by age, sleep is different when you are younger

**Sleep is a Need:** Genetic basis
- Different species have different sleep needs
- Humans can be divided into different stages of sleep needs
- Bats sleep the most
- Giraffes sleep the least - almost never sleeps

**Sleep Duration In Humans:**
- Sleep needs vary among humans (4-10 hours)
  - Bell curve at about 7-8 hours
- Sleep starts in utero - womb
- Sleep needs vary along the life span
  - We need less and less sleep as we get older

**Sleep Deprivation:**
- 25 hours sleep deprivation: no rebound in sleep duration
  - If you do not sleep for an entire day, you will still sleep normally the next night
- Record: 264 hours (11 days) by a 17 year old high school student
  - With 2 days of rebound only!

**Sleep: Slow Wave Sleep**
- Deprivation studies:
  - No significant physical consequences in humans
    - Won't feel any more exhausted when you wake up
  - Loss of weight and death in rats
    - If it is done often/consistently enough
  - SWS need is not related to physical exercise
    - If you exercise one day, you will not get better sleep that night
  - Brain metabolic activity decreases by 25%
    - Delta (slow) oscillations occur in the regions that were the most active in the awake state
  - Related to mental activity and declarative memory consolidation
    - Declarative learning task: Improvement was extreme when students were allowed to nap
    - Being able to nap after learning improved the conservation of learning
  - Related to body temperature: Even though it is not necessarily related with physical exercise
- Aspirin/Ibuprofen - to reduce temperature...Temp -- prevents slow wave sleep
- Cytokines - to stimulate the immune system...Raise temperature -- increases slow wave sleep
  - Dreams: REM sleep holds these complex dreams
  - Dreams in slow sleep are static images

**Sleep: REM Sleep**

**Deprivation Studies:**
- Significant consequences on cognitive performance
- REM sleep shows rebound phenomenon after deprivation
  - You need a certain amount, your body makes up for this if you do not get it

**Metabolic activity**
- An increase in REM sleep
- In infants - REM=70% of sleep
  - Developmental role? Something is happening to build up the neurons
- Adults - REM=15% of sleep
  - Nondeclarative is affected
    - Learning to do something motor
    - If you allow yourself a nap, you will do much better!
  - Sleep, learning, memory, consolidation? Forgetting…
- Dynamic: Dreams

**Sleep Disorders:**

**General sleep disorders**
- Insomnia: Problem falling asleep
  - May be due to stress, psychological factors, drug rebounds

- Sleep needs are variable (about 4-8 hours needed)
  - Depends on genetic and environmental factors (health, day activity, mood)
  - Insomnia criteria depends on the natural needs of the individual

- Quantity of sleep versus quality of sleep (sleep apnea)
  - 4 hours of great quality = 6 hours decent quality

**REM sleep disorders**
- Narcolepsy (4 different kinds)
  - Sleep attack (low arousal, last few minutes (from awake to fast asleep) and then person wakes up)
  - Cataplexy (high arousal, no loss of consciousness)
    - Not REM sleep, but also not entirely awake - looking at EEG, looks like REM sleep
    - Genes are responsible for this
    - Can be found in certain animal species (dogs)
  - Sleep paralysis (awake atonia): Just before/after sleep
Subject is not really awake or asleep
Muscles are atonic (can drop the arm down)
  ○ Hypnagogic Hallucinations: State of awakenss where there is dreaming (nightmares)
    ■ Person is to a large extent, awake
  ○ REM without atonia: REM sleep behavior disorder
    ■ EEG will say it is REM sleep but muscles are not paralyzed
    ■ May act out dreams
  ○ Narcolepsy: Genetic and hormonal (orexin) bases

**Slow Sleep Disorders:**

Sleep walking: More of a phase than a disorder
  ● Affects about 15% of children between 5-12
  ● Eyes open, no arms stretched, state of half consciousness
  ● Usually there is no walking, some exceptions
  ● Sleep-related eating disorder: Not fully aware
    ○ Much more elaborate
    ○ Technically asleep but have enough consciousness to eat

Sleep talking: Can be induced by hypnosis or truth serums
  ● Also may not be a disorder until it is at a certain extent

Night terror: Fear of losing consciousness - state of terror
  ● Very strong and emotional reaction to something that is not precise (may be a dream, may not be)
  ● The action of falling asleep is when this can be seen
  ● No memory for the event

Fatal Familial Insomnia: Damage to the thalamus
  ● Produces general insomnia (issues falling asleep)
  ● Progressive: Hallucinations, dementia, death
  ● Related to mad cow disease (has an understandable basis for physiology)
  ● No cure
  ● Genetic

Bed-Wetting: Primarily in children
  ● More of a phase than a disorder
  ● Partly genetic and partly environmental
  ● Overcoming this: Devices to wake-them up, etc

**Practice Quiz:**

T/F: Our natural sleep/wake cycle is always exactly 24 hours
  ● False, about 25

T/F: The brain is much less active in REM sleep than in SWS
  ● False, it is the opposite
  ● Much more active in REM
You dream full dynamic stories during REM sleep. Sleep attacks may occur during REM sleep. Research shows that REM sleep is involved in…Patients suffering from cataplexy