

# Sleep and Dreams

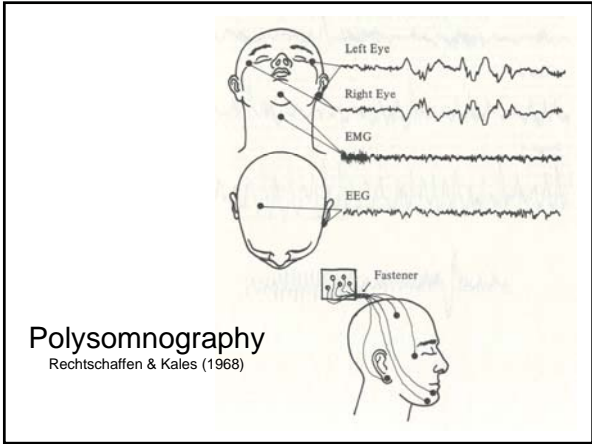
Fall 2014

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- ## Advertisements for Others
- Psychology of Sleep (Psych 133)
    - Prof. Allison Harvey
      - Sleep and Psychological Disorders Laboratory
    - Prof. Matt Walker
      - Sleep and Neuroimaging Laboratory
  - Psychology of Dreams (Psych 106)
    - Prof. Eleanor Rosch
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- ## Why Sleep is Interesting
- Puzzle of Function
  - Role in Learning, Memory
  - Insomnia, Other Sleep Disorders
  - Lapse in Consciousness
    - Consciousness as Wakefulness
    - Contrast with “Dreamless Sleep”
  - Conscious of Dreams?
  - Unconscious Processing
  - Mind-Body Problem
    - Physiological Correlates of Sleep/Dreams
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- ## Diagnosis of Sleep
- Overt Behavior
    - Relaxation
    - Prone Posture
    - Slow, Even Breathing
  - Subjective Experience
    - Interruption of Stream of Consciousness
    - Disorientation upon Awakening
    - Memory Failure
    - Dream Recall
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## The EEG Spectrum

Hugdahl (1995)

*Table 11.1. Description of EEG waveforms and corresponding scalp locations and psychological states.*

Type of wave or rhythm	Frequency per second (range)	Amplitude or voltage (V)	Percent of time present	Regional or diffuse	Region of prominence or maximum	Condition when present	Normal or abnormal
Alpha	8-12	1-100	1-100	Diffuse	Occipital and parietal	Awake, relaxed, eyes closed	Normal
Beta	18-30	2-20	5-100	Diffuse	Precentral and frontal	Awake, no movement	Normal
Gamma	30-100	2-10	5-100	Diffuse	Precentral and frontal	Awake	Normal, sleep deprived
Delta	0.5-4	20-100	Variable	Diffuse	Variable	Asleep	Normal
Theta	4.5-8	20-400	Variable	Bath	Ventricle	Awake	Abnormal
Theta	5-7	1-100	Variable	Regional	Frontal and temporal	Awake, reflective or stress stimuli	Normal (?)
Kappa	8-12	1-40	Variable	Regional	Anterior and temporal	Awake, problem solving	Normal
Lambda	Pos. or neg. spike or sharp wave	1-100	Variable	Regional	Parieto-occipital	Visual stimulus or eye opening	Normal (?)
K-complex	Pos. sharp wave and other slow pos. or neg. wave	20-50	Variable	Diffuse	Vertex	Awake, auditory stimuli	Normal (?)
K-complex		10-100	Variable	Diffuse	Vertex	Asleep, various stimuli	Normal
Sleep spindles	12-14	1-100	Variable	Regional	Precentral	Sleep onset	Normal

Source: From Lindley (1960), with permission from Academic Press and the author.

### Prominent EEG Bands

- EEG Bands
  - Delta (0.5-4 Hz)
  - Theta (5-7 Hz)
  - Alpha (8-12 Hz)
  - Beta (18-30 Hz)
  - Gamma (30-50 Hz)
  - High Gamma (>250 Hz)

Wikipedia: Ingo Garmisch/Dea 2008

### The Waking EEG

- Alpha Activity
  - Slow
  - High-Amplitude
  - Rhythmic
  - Arousal
    - Inverted-U
- Beta Activity
  - Fast
  - Low-Amplitude
  - Desynchronized
  - "Looking"

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### Drowsiness

- Eyes Closed
- Low Body Motility
- Decrease in Body Temperature
- EEG Alpha Activity
  - Initial Increase
  - Subsequent Decrease

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### Descending Stage 1

- EEG
  - Alpha Disappears
  - Desynchronized Activity
- EMG Muscle Relaxation
- EOG Slow Rolling Eye Movements
- Lack of Behavioral Response
- Denial of Sleep on Awakening?

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### Stage 2

- EMG Relaxation
- EOG SREMs
- EEG Changes
  - Spindles
  - K-complexes

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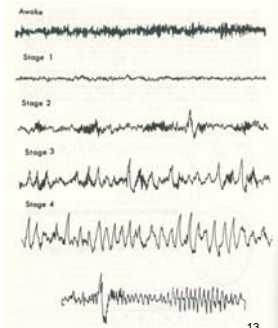
### Stage 3

- EMG Relaxation
- EOG SREMs
- EEG Delta Activity
- Awakening to Loud Noise, Name

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### Stage 4

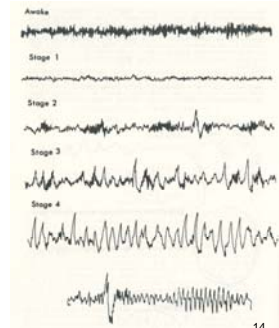
- EMG Relaxation
- EOG SREMs
- EEG Delta Activity
- Awaken Groggy (Sleep Inertia)



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### Stage REM

- EEG Resembles Stage 1
- EMG Relaxation
  - Sleep Paralysis
  - Narcolepsy
- EOG REMs
  - Conjugate
- ANS Arousal
  - High EKG
- Awaken Alert



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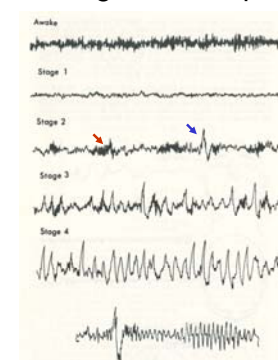
### Stages of Sleep

**Stage NREM (SWS)**  
"Descending" Stage 1  
Stages 2, 3, 4

- EMG Relaxed
- EOG SREMs
- EEG Slowing
- "Slow-Wave Sleep"
  - Stages 3, 4

**Stage REM**  
"Ascending" Stage 1

- EMG Relaxed
- EOG REMs
- EEG Fast



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### Sleep Architecture in Disorders of Consciousness

Cologan et al. (2009)

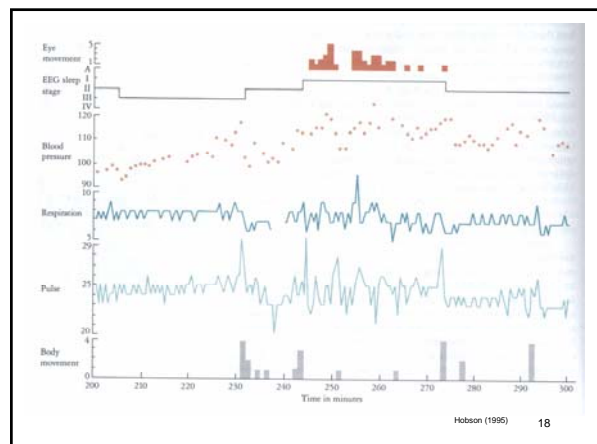
<p><b>Coma</b></p> <ul style="list-style-type: none"> <li>• EEG Slowing           <ul style="list-style-type: none"> <li>– Delta, Theta</li> </ul> </li> <li>• "Spindle Coma"           <ul style="list-style-type: none"> <li>– Better Prognosis?</li> </ul> </li> </ul>	<p><b>Vegetative State</b></p> <ul style="list-style-type: none"> <li>• Sleep Stages           <ul style="list-style-type: none"> <li>– Spindles, K-complexes</li> <li>– Alternating REM, SWS</li> </ul> </li> </ul>
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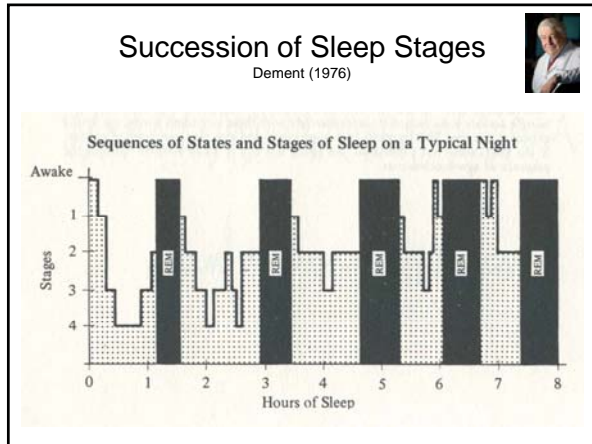
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### Nervous System Activity in Sleep

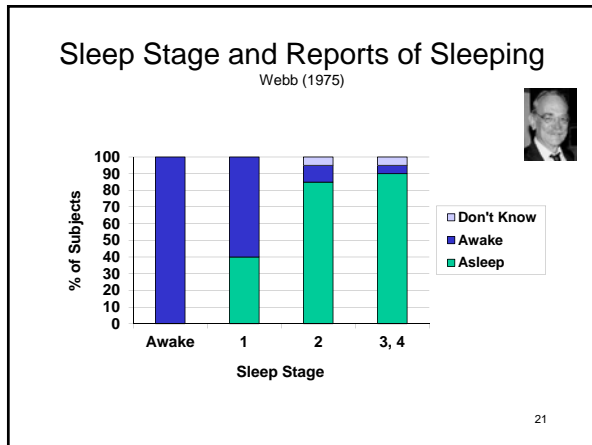
	SWS	REM
<b>Autonomic</b>		
Heart Rate	Slow Decline	Variable
Respiration	Slow Decline	Variable
Thermoregulation	Maintained	Impaired
Brain Temperature	Decreased	Increased
Cerebral Blood Flow	Reduced	High
<b>Somatic</b>		
Postural Tension	Slow Decline	Eliminated
Patellar Reflex	Normal	Suppressed
Phasic Twitches	Reduced	Increased
Eye Movements	Infrequent, Slow	Rapid, Conjugate

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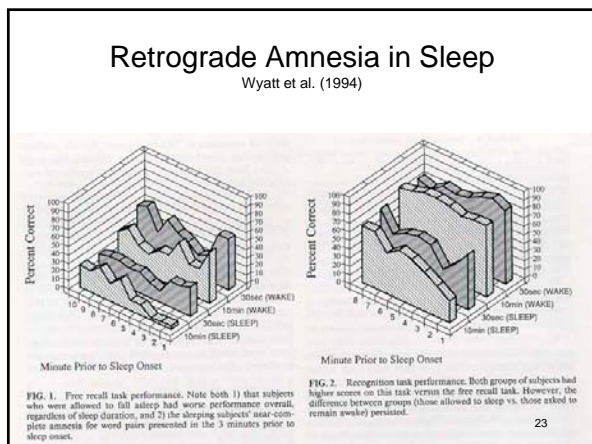




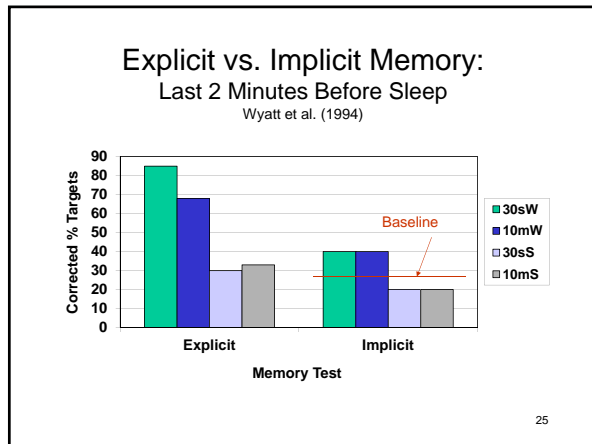
- ### Consciousness During Sleep
- Aspects of Information-Processing
    - Pickup Information from Environment
    - Integrate with Pre-Existing Knowledge
    - Respond Meaningfully while Asleep
    - Remember in Morning
  - Evidence (Largely Anecdotal)
    - Body Movements
    - Awakening to Meaningful Sounds
    - Awakening at Preselected Times
    - Dream-Incorporation
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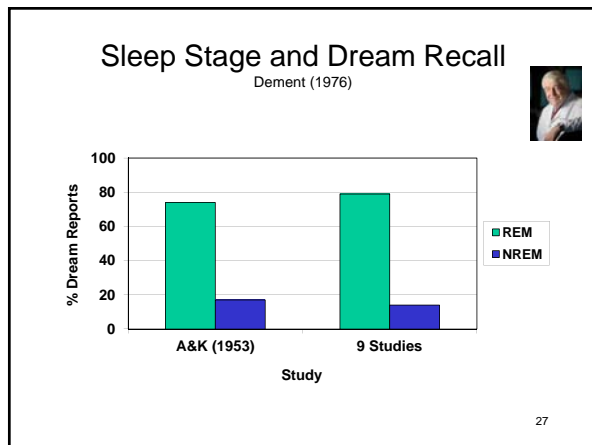
- ### Falling Asleep
- Wyatt et al. (1994)
- Paired Associates (*hot-cold*)
    - Lights out, 1/minute
    - Repeat word pair
  - Repetition failure
    - 15 secs of alpha-free Stage 1
    - further 30 secs or 10 min
  - Awakening
    - Recall and Recognition Tests
    - 10 Cycles
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- ### Explicit vs. Implicit Memory
- Explicit Test
    - Associate-Cued Recall
  - Implicit Test
    - Free Association
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- ### Dreaming and REM Sleep
- Aserinsky & Kleitman (1953)
- 
- Observed Cyclical Shift from SREM to REM
    - 10-20 Minute Bursts
    - c. Every 90 Minutes
  - Awakened Subjects in Various Sleep Stages
  - “Were You Dreaming?”
    - Awakened in REM, 74%
    - Awakened in NREM, 17%
  - Sleep Not a “Passive” Phenomenon
    - 2 Kinds of Sleep
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- ### Mental and Behavioral Activity During Sleep
- Descending Stage 1
    - Hypnagogic Reverie
  - Stage NREM
    - Reverie, Thoughts, Images
    - Sleepwalking, Sleep Talking, Night Terrors
  - Stage REM
    - Dreams, Nightmares
  - Ascending Stage 1
    - Hypnopompic Reverie
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- ### Hypnagogic Reverie
- Schacter (1976)
- 
- Imagery in Descending Stage 1
    - Visual
      - Patterns, Static Objects, Complex Scenes
    - Auditory
      - Images, Music, Own Name
  - “Myoclonic Jerk”
    - Accompanying imagery
    - Muscles-Tendons Antagonism
  - Hypnopompic Reverie (Ascending Stage 1)
    - Sleep Paralysis
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- ### Night Terrors
- (Pavor Nocturnus, Incubus)
- Gastaut & Broughton (1964)
- Behavioral
    - Inarticulate Scream, Cry for Help, Fear
    - Unable to account for distress
    - Return to (peaceful) sleep
    - No memory upon awakening
  - Physiological
    - Intense ANS Discharge
    - Arousal from Early Stages 3, 4
      - Not nightmare
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## Nightmares

Hartmann (1984)

- Frightening Dream
  - Awakens Sleeper
- Stage REM
  - Late in Night

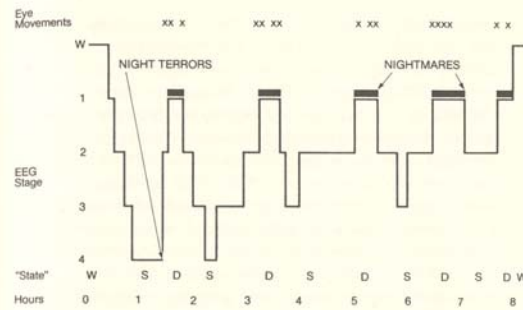


Fuseli, the Nightmare (1781)

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## Nightmares and Night Terrors

Hartmann (1984)



## Sleepwalking (Somnambulism)

Kales et al. (1966)



- Stage NREM (SWS)
- Random, Purposelessness
- Dexterity
- Episodic
- Affect
- Development
  - Children
  - Adults

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## Sleeptalking (Somniloquy)

Arkin et al. (1978)

- Speech, Other Meaningful Sounds
  - No Awareness on Awakening
- Children vs. Adults
- REM, Concordant with Dream Contents
  - Syntax, Semantics
  - Monologue, One-Sided Conversation
- NREM, Discordant with Dream Contents
  - Aphasic?

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## Parasomnias

### In REM

- REM Sleep Behavior Disorder
- Recurrent Isolated Sleep Paralysis

### In NREM

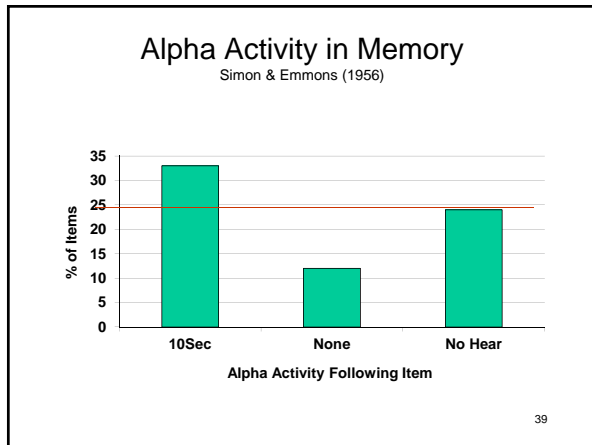
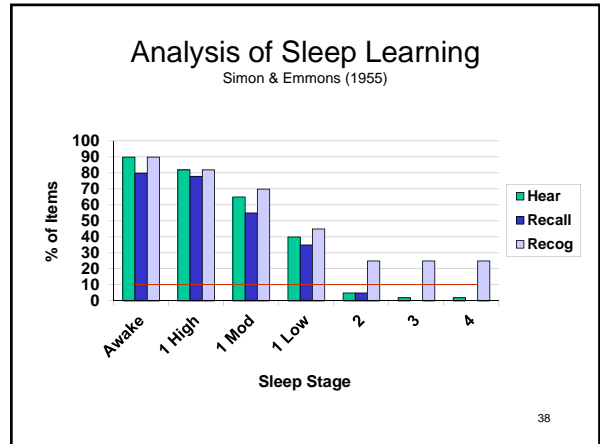
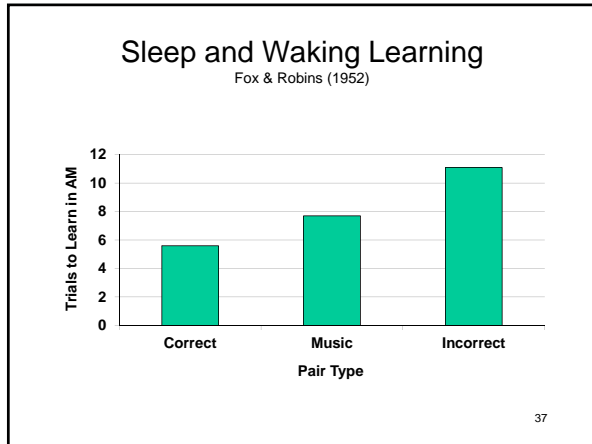
- Sleepwalking
- Night Terrors
- Bruxism
- Restless Leg Syndrome

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## Early Studies of Sleep-Learning

- Thorndike (1916), Morse Code
  - Learning
  - Fatigue
  - Surreptitious Practice
- Fox & Robins (1952)
  - Chinese-English Paired-Associates
    - Correct Pairs, Incorrect Pairs
    - Music as Control
  - Savings in Relearning


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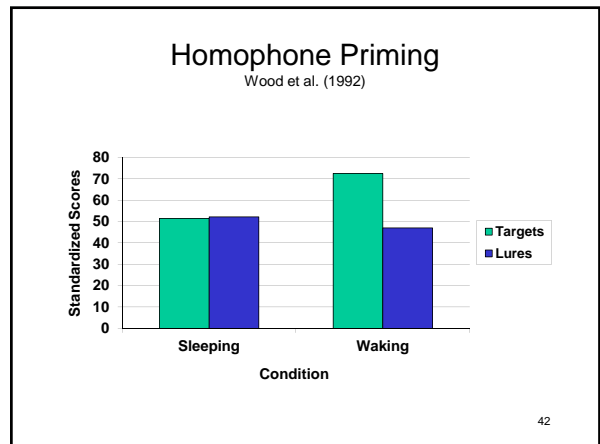


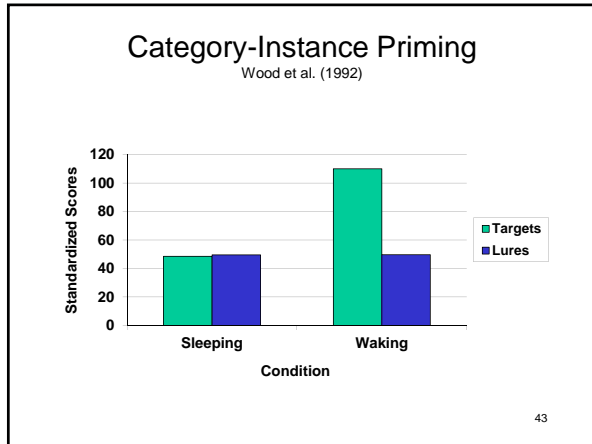
“Sleep learning is possible, to the extent that the subject remains awake”

Simon & Emmons (1955)

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- ### Explicit and Implicit Memory for Sleep Learning
- Wood et al. (1992)
- 
- Night 1, Homophone Pairs
    - *War-Peace, Tortoise-Hare*
    - Homophone Spelling
  - Night 2, Category-Instance Pairs
    - *Metal-Gold, Animal-Horse*
    - Category Instance Generation
  - Signs of Arousal
    - Body Movement
    - EEG Alpha, SREMs
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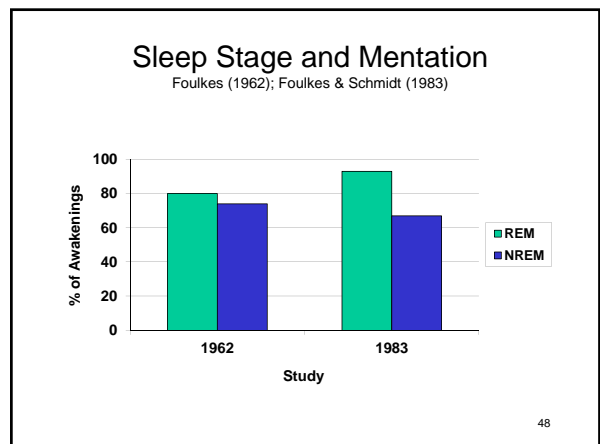
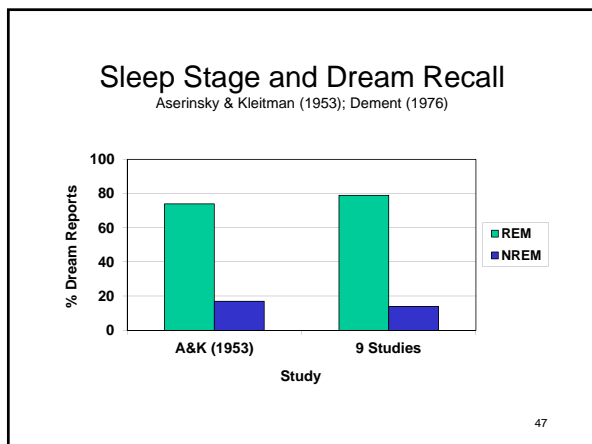
“Sleep learning is possible, to the extent that the subject remains awake”

Simon & Emmons (1955)

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- ### Memory for Dreams
- Problem
    - High Frequency of Dreams in Stage REM
    - 4-5 Epochs of REM in Night’s Sleep
    - Why Remember Only 1 Dream (At Most)?
  - Dream Occurs in Primary/Working Memory
    - REM Awakening Permits Immediate Readout
    - Consolidation
    - Retrieval
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- ### Factors Affecting “Consolidation”
- Low Arousal During Sleep
  - REM Awakenings
    - Abrupt vs. Gradual Arousal
    - Distraction
  - Salience
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## Normative Characteristics of Dreams

Snyder (1970)



- Vivid, Complex Imagery
- Temporal Progression
- Primarily Visual
- Familiar Setting
- Dreamer as Central Character
- Moderate to High Credibility
- Fairly Coherent
- Flat Affect
  - Nightmares

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## Characteristics of NREM Mentation

- Stage 1 (NREM)
  - Reverie, Daydreaming
- Stage 2
  - Imageless Thoughts, Reverie
- Stage 3
  - Imageless Thoughts, Floating Images
- Stage 4
  - Incoherent Reports (Sleep Inertia?)

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## Analysis of Sleep Mentation

Foulkes & Schmitt (1983)

<u>Quality</u>	<u>REM</u>	<u>NREM</u>
Mental Content	93%	67%
% "Dreams"	80%	40%
Dreams	74%	27%
Length	5.5	1.3

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## Dream Content

Hall & Van de Castle (1966)

- Dreams Constant Despite Cultural Change
- No Changes in Content Across Adulthood
- Stable Patterns of Differences Across Cultures
  - Characters: Women, M=F; Men, M>>F
  - Aggression>Friendliness
  - Misfortune>Good Fortune
  - Emotion: Negative>Positive
- Individual Differences Consistent with Waking Personality

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## The Interpretation of Dreams

Freud (1900)



“I shall demonstrate that there is a psychological technique which makes it possible to interpret dreams, and that on the application of this technique, every dream will reveal itself as a psychological structure, full of significance....”

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## Dreams as Wish Fulfillments

Freud (1900)



- The Dream of Irma
  - Injection of Trimethylamine
- Anna's Dream (a Paraphrase)
  - Stwabewwies!

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## Vocabulary of the Dream Theory

Freud (1900)



- Day Residues
- Manifest vs. Latent Content
- Dreamwork
  - Displacement
  - Condensation
  - Visual Representation
  - Secondary Revision

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## Common Dream Symbols

Freud (1900), Chapter 6

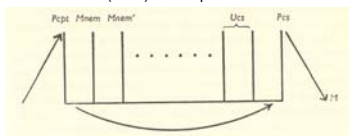


- A Hat as a Symbol of a Man (or of Male Genitals)
- A "Little One" as the Genital Organ
  - "A Little One Being Run Over" as a Symbol of Sexual Intercourse
- The Genitals Represented by Buildings, Stairs and Shafts
- The Male Organ Represented by Persons
- The Female Organ by a Landscape
- Dreams of Castration in Children
- Urinary Symbolism

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## Topographical Theory of the Mind

Freud (1900)'s "Compound Instrument"



- Perceptual, Mnemic Systems
- Motor Activity
- Systems Ucs, Pcs, Cs
- Cathexis and Anticathexis
- Replaced by Functional Theory (1923)
  - Id, Ego, Superego

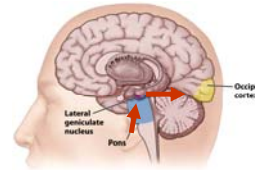


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## Dreaming Begins with "PGO Waves"

Brooks & Bizzi (1963), after Jouvet, Michel, & Courjon (1959)

- Implanted Microelectrodes
  - Cats, Rodents
- Activity During REM Sleep
  - Not during SWS, Waking
- Sequential Activation
  1. Pons
  2. Lateral Geniculate Nucleus
  3. Occipital Cortex



Types of Neuron  
 Executive  
 Trigger, Transfer  
 Modulatory  
 Aminergic (NE, 5-HT)  
 Cholinergic (Ach)

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## Activation-Synthesis Theory of Dreams

Hobson & McCarley (1977)



- Cyclic Activation of Cortex
  - Controlled by Biological Clock
  - Consequences of Activation
    - Feedback of Eye Movements
    - Motor Commands
    - Vestibular Activity
    - ANS Activity
- Automatic Synthesis of Imagery
  - Corresponding to Sensory Activity
- Dreams are Essentially Meaningless

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## AIM Model of Consciousness

"An Integrative Theory of Mind-Brain States"

Hobson et al. (1990, 1992, 1995, 1999, 2000, 2001, 2014)



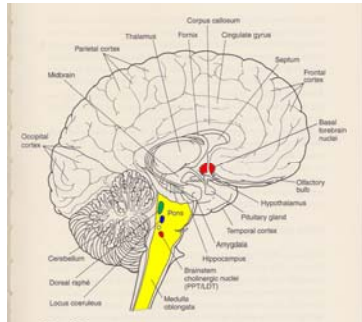
- | <u>Psychological Level</u>  | <u>Physiological Level</u>  |
|---|---|
| • <b>Alertness</b>  | • <b>Cortical Activation</b> <ul style="list-style-type: none"> <li>– RAS</li> <li>– Neural Firing Rate in Brainstem</li> </ul>   |
| • <b>Input Source</b> <ul style="list-style-type: none"> <li>– Internal vs. External</li> </ul>   | • <b>Sensory/Motor Channels</b> <ul style="list-style-type: none"> <li>– Input-Output Gating</li> </ul>   |
| • <b>Information Processing</b> <ul style="list-style-type: none"> <li>– Attentiveness</li> </ul> | • <b>Neuromodulatory Balance</b> <ul style="list-style-type: none"> <li>– Aminergic Neurons                             <ul style="list-style-type: none"> <li>• Norepinephrine (NE)</li> <li>• Serotonin (5-HT)</li> </ul> </li> <li>– Cholinergic Neurons                             <ul style="list-style-type: none"> <li>• Acetylcholine (Ach)</li> </ul> </li> </ul> |

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## Brainstem Neuromodulatory Systems

Hobson (2001)

- Acetylcholine
- Noradrenergic
- Serotonergic
- (Dopaminergic)
  - Not Visible
  - Not Yet in AIM Model

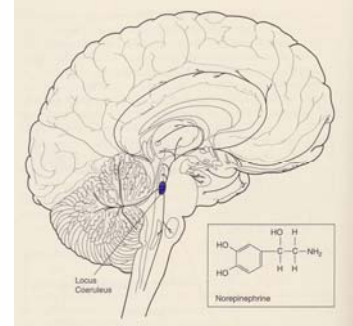


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## Noradrenergic Neuromodulatory System

Hobson (2001)

- Locus Coeruleus
  - Spinal Cord
  - Brainstem
  - Cerebellum
  - Thalamus
  - Subthalamus
  - Limbic System
  - Neocortex

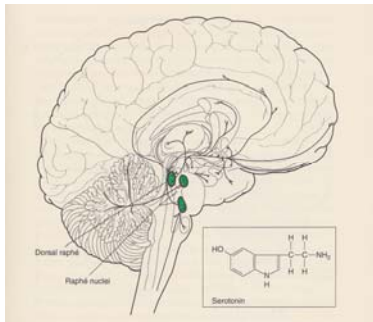


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## Serotonergic Neuromodulatory System

Hobson (2001)

- Raphe Nuclei
  - Spinal Cord
  - Brainstem
  - Cerebellum
  - Thalamus
  - Subthalamus
  - Limbic System
  - Neocortex

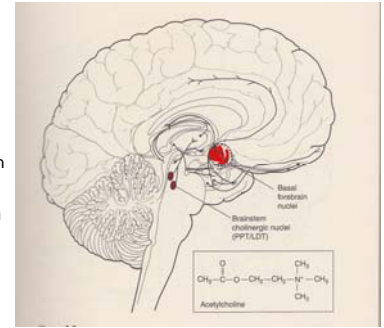


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## Acetylcholine Neuromodulatory System

Hobson (2001)

- Sources
  - Pons
    - Thalamus
    - Subthalamus
    - Basal Forebrain
    - Limbic System
  - Basal Forebrain
    - Neocortex
    - Limbic System

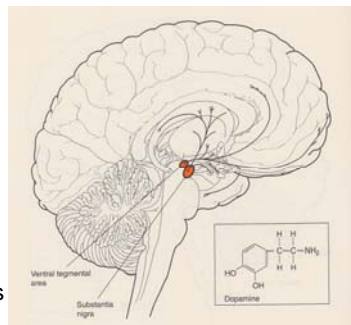


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## Dopaminergic Neuromodulatory System

Hobson (2001)

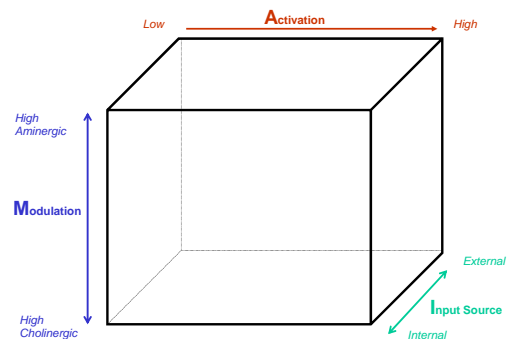
- Midbrain
  - Limbic System
  - Neocortex
  - Extrapyramidal Motor System
- Not Involved in Sleep and Dreams
- Relevant to Psychedelic States
  - LSD



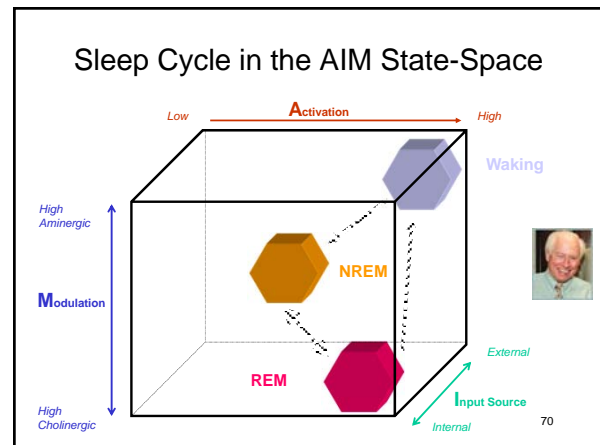
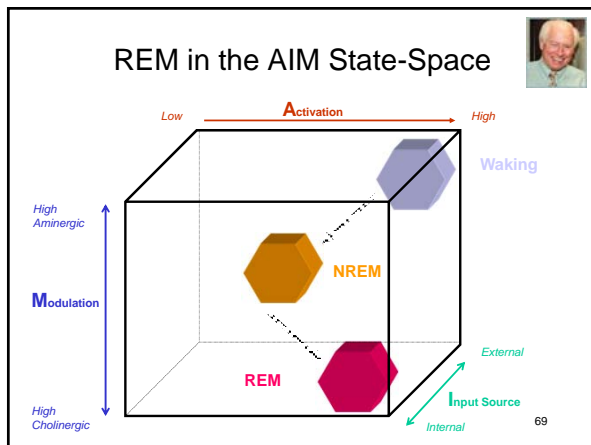
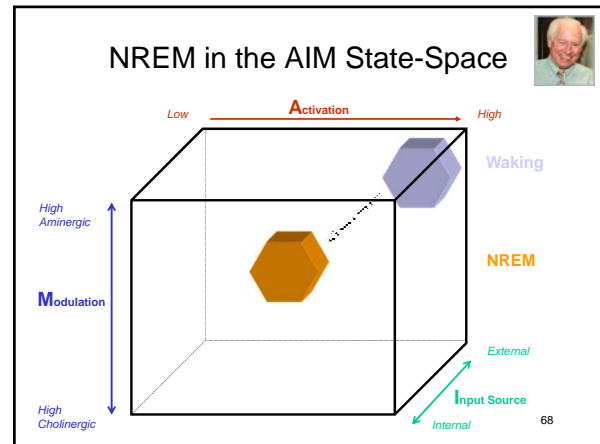
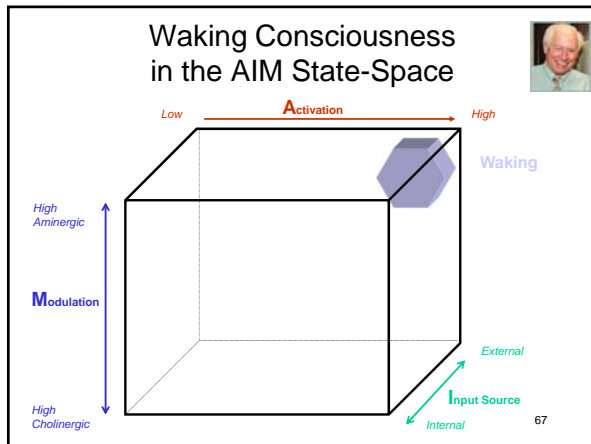
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## The AIM State-Space

Hobson (1990)



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- ### AIM and Sleep
- Hobson (1990)
- Waking
    - High Activation, External Information
    - Aminergic > Cholinergic
  - NREM Sleep
    - Low Activation, Internal Information
    - Aminergic = Cholinergic
  - REM Sleep
    - High Activation, Internal Information
    - Cholinergic > Aminergic
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- ### Consequences of REM Modulation
- High Levels of Cortical Activation
    - Lots of Mental Activity
  - Shift from External to Internal Inputs
    - Mental Activity Dominated by Memory
    - No Behavioral Outputs
  - Low Aminergic Activity
    - Poor Memory on Waking
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## The AIM Model Beyond Sleep and Dreams

Hobson et al. (2000)



- Activation
  - Normal Consciousness (High)
  - Quiet Waking (Low)
- Input
  - Daydreams, Fantasies
- Modulation
  - Psychedelic Drugs
  - Depression

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## Implications of AIM Model



- Brainstem Critical for Dreams
  - Reticular Activating System
- Dreams Meaningless
  - Contents a Product of Random Activation
- Focus on Formal Properties of Thought
  - Similar to Waking Thought

**But Are Dreams Really Devoid of Meaning?**

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## Brain Damage and Dreaming

Solms (1997)



- 200/332 Patients with No Changes
  - Dorsolateral Prefrontal Cortex
  - Sensorimotor Cortex
  - Primary Visual Cortex
- 121/132 Patients Lost All Dreaming
  - Parietal Lobes (Spatial Representation)
  - Frontal-Limbic Region (Executive Functions)
- 2 Patients Lost Visual Imagery
  - Damage in Visual Association Cortex

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## Are Dreams and REM Dissociable?

Solms (2000)



- Dreams Occur in NREM as well as REM
  - 5-10% of NREM Awakenings → Dream Report
    - Indistinguishable from REM Dream Reports
  - 5-30% of REM Awakenings → No Dream
- Forebrain Mechanisms Critical for Dreaming
  - Cholinergic Systems Control REM
  - Frontal/Dopaminergic Systems Control Dreaming
- A Double Dissociation?
  - Pontine Damage Suppresses REM, not Dreams
  - Frontal Damage Suppresses Dreams, not REM

## A New Dream Theory

Solms (2000)



- Evidence for a Dopaminergic Hypothesis
  - Forebrain Transection Eliminates Dreaming
    - Interrupts Mesocortical/Mesolimbic Dopamine System
    - No Effect on REM Sleep
  - L-dopa Stimulates Vivid Dreams, Nightmares
  - Haldol Inhibits Frequent/Vivid Dreams
- Dream-Generation Process
  - Cerebral Activation During Sleep
    - Many Different Origins, Not Just Pontine Activity

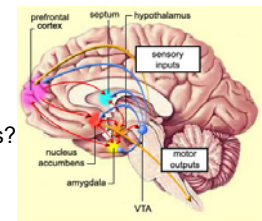
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## A “Dream-On” Mechanism?

Solms (2000)



- Mesocortical/Mesolimbic Dopamine System
  - Ventral Tegmental Area (VTA)
  - Amygdala
  - Prefrontal Cortex
- Dreams as Wish-Fulfillments?
  - Goal-Directed Behavior
    - A “Seeking System”
  - Reward/Pleasure
- Neuro-Psychoanalysis



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## Hobson and Solms Compared and Contrasted

Domhoff (2005)



- Differences
  - Role of PGO Waves
  - Association of Dreaming with REM
  - Role of Neurotransmitters
    - Cholinergic/Adrenergic vs. Dopamine
- Similarities
  - Dreaming as Psychosis
  - Dream Content Insignificant
  - Need to Polarize Debate

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## A Cognitive Theory of Dreams

Foulkes (1985)

- Development of Dreaming
  - Dream Recall Minimal Before Age 9
  - Low Levels of Negative Content in Children
- Dreaming Instigation
  - Random Activation of Memory Structures
    - Episodic, Semantic
- Dream-Production system
  - Organizes Random Elements
    - Coherent Dream Experience

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## Sources of Mnemonic Activation in Sleep

Foulkes (1985)

- External or Internal Stimuli
  - Spontaneous Brain Activity
- Associations with Activated Memories
  - Looser in Sleep
- Voluntary Retrieval
  - Absent

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## Dream-Production System

Foulkes (1985)

- Dreaming as Thinking
  - Visual-Spatial Thinking Skills
    - Right Hemisphere?
  - Syntactical Rules, Script Knowledge
    - Left Hemisphere?
- One Dream-Production at All Stages
  - Cortical Excitation Greater in REM
- Developmental Trends (“Piagetian”)
  - No Dreams During Sensory-Motor Period
- Amnesia as Encoding Failure

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## The Meaning of Dreams

Foulkes (1985)

- Indicative Meaning
  - Reflect Mind of Dreamer
    - Random Sampling
- Personality
- Life Situation

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## Dream Content Revisited

Domhoff (2001, 2005)



- Uncertain Relationship b/ Dreams, Physiology
  - REM and Dreaming (REM Deprivation)
  - Unusual Eye Movements and Bizarreness
- Faithfulness to Everyday Waking Life
  - Commonplace, Familiar Settings
  - Low Degree of Drama
  - Low Degree of Bizarrenes
  - Little Emotion
  - Thinking Generally Coherent
- Laboratory vs. Home Environments

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# Neurocognitive Theory of Dreams

Domhoff (2001, 2005)



- Neural Network for Dreaming
  - Forebrain
    - Limbic System
    - Inferior Parietal Cortex
- Dreaming as Cognitive Achievement
  - Develops Over First 9 Years of Life
- Dreams Continuous with Waking Life
  - Continuity Principle
  - Repetition Principle

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