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

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
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
**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)

**The Waking EEG**

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

**Drowsiness**

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

Stage 2

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

Stage 3

- EMG Relaxation
- EOG SREMs
- EEG Delta Activity
- Awakening to Loud Noise, Name
Stage 4

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

Stage REM

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

Stage NREM (SWS)

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

Stage REM

- EMG Relaxed
- EOG REMs
- EEG Fast

Stages of Sleep
Sleep Architecture in Disorders of Consciousness
Cologan et al. (2009)

Coma
• EEG Slowing
  – Delta, Theta
• *Spindle Coma*
  – Better Prognosis?

Vegetative State
• Sleep Stages
  – Spindles, K-complexes
  – Alternating REM, SWS

Nervous System Activity in Sleep

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

Hobson (1995)
Succession of Sleep Stages
Dement (1976)

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

Sleep Stage and Reports of Sleeping
Webb (1975)
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

Retrograde Amnesia in Sleep
Wyatt et al. (1994)

Explicit vs. Implicit Memory

- Explicit Test
  - Associate-Cued Recall
- Implicit Test
  - Free Association
Explicit vs. Implicit Memory: Last 2 Minutes Before Sleep
Wyatt et al. (1994)

Dreaming and REM Sleep
Aserinsky & Kleitman (1953)
- Observed Cyclical Shift from SREM to REM
  - 10-20 Minute Bursts
  - c. Every 90 Minutes
- Awaken 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

Sleep Stage and Dream Recall
Dement (1976)
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

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

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
Nightmares
Hartmann (1984)

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

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Nightmares and Night Terrors
Hartmann (1984)

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Sleepwalking (Somnambulism)
Kales et al. (1966)

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

Parasomnias

In REM
- REM Sleep Behavior Disorder
- Recurrent Isolated Sleep Paralysis

In NREM
- Sleepwalking
- Night Terrors
- Bruxism
- Restless Leg Syndrome

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
Sleep and Waking Learning
Fox & Robins (1952)

Analysis of Sleep Learning
Simon & Emmons (1955)

Alpha Activity in Memory
Simon & Emmons (1956)
“Sleep learning is possible, to the extent that the subject remains awake”
Simon & Emmons (1955)

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, SREM

Homophone Priming
Wood et al. (1992)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Targets</th>
<th>Lures</th>
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<tbody>
<tr>
<td>Sleeping</td>
<td></td>
<td></td>
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<tr>
<td>Waking</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
“Sleep learning is possible, to the extent that the subject remains awake”

Simon & Emmons (1955)

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
Factors Affecting “Consolidation”

- Low Arousal During Sleep
- REM Awakenings
  - Abrupt vs. Gradual Arousal
  - Distraction
- Salience

Sleep Stage and Dream Recall

Asarinsky & Kleitman (1953); Dement (1976)

<table>
<thead>
<tr>
<th>Study</th>
<th>REM</th>
<th>NREM</th>
</tr>
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<tbody>
<tr>
<td>A&amp;K (1953)</td>
<td>100</td>
<td>0</td>
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<tr>
<td>9 Studies</td>
<td>90</td>
<td>10</td>
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</table>

Sleep Stage and Mentation

Foulkes (1962); Foulkes & Schmidt (1983)

<table>
<thead>
<tr>
<th>Study</th>
<th>REM</th>
<th>NREM</th>
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</thead>
<tbody>
<tr>
<td>1962</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>1983</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>
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

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?)

Analysis of Sleep Mentation
Foulkes & Schmitt (1983)

<table>
<thead>
<tr>
<th>Quality</th>
<th>REM</th>
<th>NREM</th>
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<tbody>
<tr>
<td>Mental Content</td>
<td>93%</td>
<td>67%</td>
</tr>
<tr>
<td>% &quot;Dreams&quot;</td>
<td>80%</td>
<td>40%</td>
</tr>
<tr>
<td>Dreams</td>
<td>74%</td>
<td>27%</td>
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<tr>
<td>Length</td>
<td>5.5</td>
<td>1.3</td>
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</table>
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

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….”

Dreams as Wish Fulfillments
Freud (1900)

- The Dream of Irma
  - Injection of Trimethylamine
- Anna’s Dream (a Paraphrase)
  - Stwabewwies!
Vocabulary of the Dream Theory
Freud (1900)

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

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

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
“Dreaming Begins with “PGO Waves”
Brooks & Bazil (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)

“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

“AIM Model of Consciousness
“An Integrative Theory of Mind-Brain States”

**Psychological Level**
• Alertness
• Input Source
  – Internal vs. External
• Information Processing
  – Attentiveness

**Physiological Level**
• Cortical Activation
  – RAS
  – Neural Firing Rate in Brainstem
• Sensory/Motor Channels
  – Input-Output Gating
• Neuromodulatory Balance
  – Aminergic Neurons
    • Norepinephrine (NE)
    • Serotonin (5-HT)
  – Cholinergic Neurons
    • Acetylcholine (Ach)
Brainstem Neuromodulatory Systems

- Acetylcholine
- Noradrenergic
- Serotonergic
- (Dopaminergic)

Noradrenergic Neuromodulatory System

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

Serotonergic Neuromodulatory System

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

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

**Dopaminergic Neuromodulatory System**

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

**The AIM State-Space**

- **Activation**
- **Modulation**
- **Input Source**
Waking Consciousness in the AIM State-Space

Input Source
Internal
External

Activation
Low
High

Modulation
High Cholinergic
High Aminergic

NREM in the AIM State-Space

Input Source
Internal
External

Activation
Low
High

Modulation
High Cholinergic
High Aminergic

REM in the AIM State-Space

Input Source
Internal
External

Activation
Low
High

Modulation
High Cholinergic
High Aminergic
### Sleep Cycle in the AIM State-Space

- **Activation**
  - Low
  - High

- **Modulation**
  - High Aminergic
  - High Cholinergic

- **Input Source**
  - Internal
  - External

#### 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

#### 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
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

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?

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
Are Dreams and REM Dissociable?

Solms (2000)

- Dreams Occur in NREM as well as REM
  - 5-10% of NREMAwakenings → 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

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
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

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

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
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

The Meaning of Dreams
Foulkes (1985)

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

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 Bizarreness
  - Little Emotion
  - Thinking Generally Coherent
- Laboratory vs. Home Environments
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