Advertisements for Others

- Psychology of Sleep (Psych 133)
  - Prof. Allison Harvey
  - Sleep and Psychological Disorders 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

Polysomnography
Rechtschaffen & Kales (1968)
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)

- "Descending" Stage 1
  - Stages 2, 3, 4
- EMG Relaxed
- EOG SREMs
- EEG Slowing
- "Slow-Wave Sleep" – Stages 3, 4

Stage REM

- "Awakening" Stage 1
- EMG Relaxed
- EOG REMs
- EEG Fast

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>
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<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>
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<tr>
<td>Somatic</td>
<td></td>
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<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>
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

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)

- 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

Dreaming and REM Sleep
Aserinsky & Kleitman (1953)

- Observed Cyclical Shift from SREM to REM
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Sleep Stage and Dream Recall
Dement (1976)

- Descending Stage 1
  - Hypnagogic Reverie
- Stage NREM
  - Reverie, Thoughts, Images
  - Sleepwalking, Sleep Talking, Night Terrors
- Stage REM
  - Dreams, Nightmares
- Ascending Stage 1
  - Hypnopompic Reverie

Mental and Behavioral Activity During Sleep

- 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

Hypnagogic Reverie
Schacter (1976)

- Inarticulate Scream, Cry for Help, Fear
- Unable to account for distress
- Return to (peaceful) sleep
- No memory upon awakening

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

Nightmares and Night Terrors
Hartmann (1984)

Sleepwalking (Somnambulism)
Kales et al. (1966)

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

Sleptalking (Somniloquy)
Adkin et al. (1976)

- 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)

- Trials to learn in AM
- Correct, Music, Incorrect Pair Type

Analysis of Sleep Learning
Simon & Emmons (1955)

- % of items
- Sleep Stage
- Awake, 1-High, 1-Mid, 1-Low, 2, 3, 4

Alpha Activity in Memory
Simon & Emmons (1956)

- % of items
- Alpha Activity Following Item
- 10Sec, None, No Hear

“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, SREMs

Homophone Priming
Wood et al. (1992)

- Standardized Scores
- Conditions
- Sleeping, Waking

- Targets, Lures
“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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Sleep Stage and Dream Recall

Aserinsky & Kleitman (1953); Dement (1976)

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Sleep Stage and Mentation

Foukes (1962); Foukes & Schmidt (1983)
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>
</tr>
<tr>
<td>Length</td>
<td>5.5</td>
<td>1.3</td>
</tr>
</tbody>
</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
- Cathectic and Anticathetic
- Replaced by Functional Theory (1923)
  - Id, Ego, Superego

### 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

### 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


#### Psychological Level

- Alertness

#### 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

- Low
- High
- Internal
- External

Hobson (2001)
Hobson (2001)
Hobson (2001)
Hobson (2001)
Hobson (1990)
Waking Consciousness in the AIM State-Space

NREM in the AIM State-Space

REM in the AIM State-Space

Sleep Cycle in the AIM State-Space

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
  – Dosolateral 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 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

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 Bizarrenesses
  - 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