The AIM Theory of Dream Physiology

by

Henry B. Arantes, BA, RPSGT
Let’s Preview

• Brain States of WAKE, NREM, and REM
• Brief summary on reciprocal interaction of neurotransmitters in sleep
• A review of NREM vs REM Dreams
• The Activation-Synthesis Hypothesis
• The AIM Theory of Consciousness
• Future trends in dream research
• Conclusion
WAKE
WAKE (Eyes Closed)

Background EEG is Alpha (8-13 cps.)
Rolling eye movements or eye blinks present
High muscle tone activity
NREM Sleep
Light Sleep (N1 and N2)

Background EEG is Theta (3-7 cps.)
K-Complexes and Spindles present
Relatively high muscle tone but lower than wake muscle tone
Deep Sleep (N3 and N4)

Background EEG is Delta (0.5-2 cps.)
Greater than 20% of epoch is Delta activity
Generally lower muscle tone than light sleep
REM Sleep
REM Sleep

- Rapid eye movements are present
- Relatively low voltage and mixed frequency
- Lowest muscle tone
Reciprocal Interaction of Neurotransmitters in Sleep
Reciprocal Interaction Hypothesis

- Sleep is strongly influenced by fluctuations of neurotransmitters.
- Aminergic neurons consisting of neuropinephrine and serotonin are active during wake.
- In sleep, the aminergic system begins to slowly decrease in activity as person falls asleep but remains active.
- Cholinergic neurons are tonically suppressed during wake.
- The cholinergic system is relatively quiet during NREM but gradually increase in activity as NREM progresses to REM.
Reciprocal Interaction Hypothesis (cont)

- Aminergic system suppresses REM activity
- Cholinergic system releases aminergic suppression
- This fluctuation occurs regularly during the night
NREM vs REM Dreams
The Definition of Dreaming

- “Any mental activity occurring in sleep”
- “A series of images, ideas, emotions, and sensations occurring involuntarily in the mind during certain stages of sleep” American Heritage Dictionary (1992)
- “A succession of images, thoughts, or emotions passing through the mind during sleep” dictionary.reference.com
- “Mental activity occurring in sleep characterized by vivid sensorimotor imagery that is experienced as waking reality despite such distinctive cognitive features as impossibility or improbability of time, place, person and actions....” Sleep and Dreaming (2003)
NREM Dreams

- No difference in recall rate between the NREM stages of 1 - 4 (N1 - N3)
- More difficult to recall upon awakening
- Length of dream report considerably shorter
- Participants consistently report more “thought like” type of mental activity
- More representation of “current” events or general daily concerns
- Consistently less detailed dream reports
REM Dreams

- High recall rate when awakened during this state
- Length of dream reports considerably longer
- Participants consistently report more “bizarre” mental activity
- Reports are random and don't necessarily involve current events
- Consistently more detailed dream reports
- Reports contain hallucinatory perceptions
- Dream imagery changes or shifts rapidly
- Delusional style of dreams where people lack self awareness or believe they are awake
The Activation-Synthesis Hypothesis
The Original Activation-Synthesis Hypothesis

- Suggested that dreams were a source of neurobiological mechanisms.
- Aspects of dream mentation reflected the outcome of the sensorimotor and limbic structures to produce a coherent experience.
- These changes in the brain physiology would lead to specific features of dreams including:
  a) Hallucinatory visual imagery
  b) Frequent shifts in attention
  c) Loss of voluntary control
  d) Emotional intensification
  e) Memory loss
The Updated Activation-Synthesis Hypothesis

- The intense and vivid visual hallucinosis is governed by activity of the pontine activation processes (PGO waves).
- The intense emotional aspect of dreams including anxiety, fear, elation, and anger are due to the activation of the amygdala and other limbic structures.
- The delusional aspect of dreams, when we believe to be awake, is due to the deactivation of the dorsolateral prefrontal cortex.
- The overall bizarreness of dreams stems from the reciprocal interaction of the aminergic and cholinergic structures of the brain.
Activation-Synthesis
Updated

How It Explains Dreams

FOREBRAIN PROCESSES IN NORMAL DREAMING - INTEGRATED MODEL

1. Pontine and midbrain RAS and nuclei
   - Ascending arousal of multiple forebrain structures
   - Dream: Consciousness, eye movement and motor pattern information via PGO system
   - Neocortical and subcortical areas relatively activated during dreaming

2. Diencephalic structures (hypothalamus, basal forebrain)
   - Emotional and instinctual function, central arousal
   - Dream: Emotional, affective salience, movement

3. Anterior limbic structures (amygdala, anterior cingulate, parahippocampal corona, hippocampus, medial frontal areas)
   - Emotional labeling of stimuli, goal-directed behavior, movement
   - Dream: Emotional, affective salience, movement

4. Dorsolateral prefrontal cortex
   - Executive functions, logic planning
   - Dream: Loss of volition, logic, orientation, working memory

5. Basal ganglia
   - Initiation of motor actions
   - Dream: Initiation of fictive movement

6. Thalamic nuclei (e.g., LGN)
   - Relay of sensory and pseudo-sensory information to cortex
   - Dream: Transmits PGO information to cortex

7. Primary motor (7) and sensory (8, 10) cortices
   - Generation of sensory precepts and motor commands
   - Dream: Sensorimotor hallucinosis

8. Inferior parietal cortex (BA 40)
   - Spatial integration of processed heteromodal input
   - Dream: Spatial organization

9. Cerebellum
   - Fine tuning of movement
   - Dream: Fictive movement

Visual association cortex
   - Higher order integration of visual percepts and images
   - Dream: Visual hallucinosis
The AIM Theory of Consciousness
AIM Acronym

- **Activation** – The rate at which the brain-mind can process information.
- **Input Source** – The extent to which the brain-mind is processing external vs internal information.
- **Modulation** – Shift in balance between the cholinergic and aminergic system.

(Hobson et al, 2003)
Three Dimensional Space Model of AIM

Nature Reviews Neuroscience
The AIM Model 3D Cube

- Cortical Activation depicted on the “width” dimension
- Internal vs External inputs depicted on the “length” dimension
- Aminergic vs Cholinergic modulation depicted on the “height” dimension

NE = Norepinephrine
5-HT = Serotonin
Ach = Acetylcholine
AIM and Waking

- Cortical activity is high
- Internal vs External tends to be a midline
- Modulation of aminergic vs cholinergic activity is high on the aminergic system

(Hobson et. al, 2003)
AIM and NREM Dreams

- Cortical activity fluctuates from midline to relatively low levels
- Internal vs External tends to be at midline
- Modulation of aminergic vs cholinergic activity hovers around midline

(Hobson et al, 2003)
AIM and REM Dreams

- Cortical activity is at high levels similar to wake
- Internal vs External input is almost strictly internal
- Modulation is cholinergically dominated

(Hobson et al., 2003)
Hallucinations

- Cortical activity remains high
- External inputs dominate exclusively
- As opposed to waking activity, modulation is cholinergically dominated

(Hobson et. al, 2003)
Waking, Sleeping, and Hallucinations

- Waking is high on Activation, high on external input, and high on aminergic influence.
- Sleeping is low on activation, midline on internal vs external, and midline on aminergic vs cholinergic influence.
- Hallucinating is similar to waking activity on all aspects except for being cholinergically dominated.

NE = Norepinephrine
5-HT = Serotonin
Ach = Acetylcholine
AIM and Lucid Dreaming

- Activation remains high as it does in wake
- Input information remains internal as found in REM sleep but is also influenced by external information (i.e. awareness)
- Cholinergic and aminergic system fluctuates between one another

NE = Norepinephrine
5-HT = Serotonin
Ach = Acetylcholine
Future Trends in Dream Research and Consciousness
Future Neurobiological Trends

- PET and MRI studies quantitatively mapping the changes in the modulation of the aminergic and cholinergic system
- Improvements on the sensitivity of EEG acquisition systems for more accurate cortical activity information
- A focus on the activity of the limbic system and its effect on the AIM model of consciousness
Dream Research

- Using dream reports to detail and support or refute various aspects of the AIM model
- Utilizing aspects of the AIM model to compare vivid REM dreams and disorders that involve hallucination, such as schizophrenia
- Can the AIM model be put to practice in order to help psychiatry and the consciousness field?
Conclusion

- Reciprocal Interaction Theory gives rise to further research in the physiology of dreams.
- Activation Synthesis Hypothesis presents a neurobiological model of dream physiology.
- Activation Synthesis Hypothesis is updated to reflect detailed brain areas associated with dreams.
- AIM Model of Consciousness presents a new outlook on brain states including dreams.
- Future research and alternate theories also attempt to explain the purpose of dreams.
Acknowledgements

Valerie Brown – Clinical Services Manager - SleepMed

Dan Martin – Regional Vice President - SleepMed

Chad Ratsamy – Sleep Lab Manager – UIC Sleep Science Center

Dr. Mary Carskadon – Professor of Psychiatry - Brown University

Dr. J. Allan Hobson – Professor of Psychiatry - Harvard University
I know you have questions!