



NOTES

BRAIN FUNCTIONS

WHAT ARE BRAIN FUNCTIONS?

- **Normal brain functions:** continuous neuronal electrical activity
- Measured by electroencephalogram (EEG) for research, diagnostics
 - Electrodes on scalp record brain activity (measure voltage differences between cortical regions)

BRAIN WAVES

- Brain wave activity altered by mental state
 - **Slower brain waves:** prominent during relaxation
 - **Higher brain waves:** prominent during wakefulness/alertness
 - **Extreme \uparrow/\downarrow frequencies:** suggest damaged cerebral cortex
- Spontaneous brain waves controlled by autonomic nervous system, continue to appear during unconsciousness, coma (if some brain, body functions continue)
 - Lack of spontaneous brain waves (i.e. "flat EEG" without peaks/troughs) suggests brain death
- **Four characteristic EEG brain wave patterns:** different consciousness/sleep stages
 - **Appearance:** continuous peaks/troughs
 - **Wave frequency:** number of peaks/second (hertz (Hz))
 - **Wave amplitude/intensity:** indicates synchronicity of many neurons

Alpha waves (8–13Hz)

- Low amplitude, rhythmic, regular, synchronous waves
- Appear during **relaxed consciousness** states

Beta waves (14–30Hz)

- Rhythmic, but \uparrow frequency, \downarrow regularity compared to alpha waves
- Appear during **alert consciousness** states

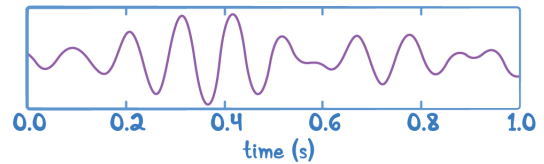
Theta waves (4–7Hz)

- Irregular waves
- Often appear in children, may appear in conscious, alert-stage adults

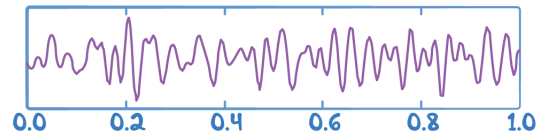
Delta waves (<4Hz)

- \uparrow amplitude waves
- Often appear during **deep sleep stages**, anesthesia
- In awake adults, may indicate brain damage

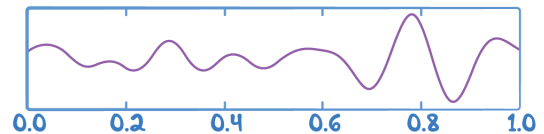
ALPHA WAVES



BETA WAVES



THETA WAVES



DELTA WAVES

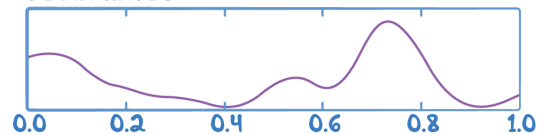


Figure 53.1 Four types of brain waves. From top to bottom: alpha waves (awake but relaxed), beta waves (awake and alert), theta waves (common in children), delta waves (deep sleep).

SLEEP

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WHAT IS SLEEP?

- Naturally recurring partially-unconscious state (inhibited response to external stimuli)
 - Coma: unconscious state (no response to external stimuli)
- Depressed cortical, continued brain stem activity → continued autonomic nervous system functions (e.g. controlling heart rate, respiration, blood pressure)
- Alternating stages based on EEG patterns

SLEEP STAGES

Non-rapid eye movement (NREM) sleep

- Little/no eye movement, thought-like brain activity, less voluntary muscle inhibition
- Stage 1
 - Immediately after falling asleep
 - EEG: irregular waveforms: slow frequencies, ↑ amplitudes
- Stage 2
 - First 30–45 minutes of sleep; occurs with deeper sleep
 - EEG: theta waves present
- Stages 3/4
 - Slow-wave sleep (SWS)
 - 90 minutes into sleep
 - EEG: activity slows down progressively
 - Decreased heart rate, blood pressure
 - Important for restorative functions

Rapid eye movement (REM) sleep

- Characterized by irregular brain waves → alpha waves (typically seen when awake)
- ↑ heart rate, blood pressure, respiratory rate; ↓ gastrointestinal function
 - Paradoxical sleep: although most body function activity increases/mimics wakefulness, individual is asleep
- Brain oxygen use: REM sleep > awake
- Spinal cord interneurons inhibit motor neurons → temporary skeletal muscle paralysis
- Most dreaming occurs
- Associated with memory consolidation;

important for learning, cognitive performance

SLEEP PATTERNS

- Hypothalamus controls sleep cycle timing
 - Retina directly connected to hypothalamus, controls pineal gland (produces melatonin)
 - Decreasing light → melatonin release → sleepiness
- Alternating sleep/wake cycles = body's natural circadian rhythm
- Young/middle-aged adults: sleep starts in 4-stage NREM sleep → alternating REM, NREM cycles
- REM occurs approximately every 90 minutes; each cycle ↑ time
 - First REM: 5–10 minutes
 - Last REM: 20–50 minutes
 - Early in the night: deep sleep → awake periods (SWS sleep dominant)
 - Later in the night: REM sleep dominant
- Sleep patterns change over lifetime; ↑ age = ↓ sleep needs
 - Infants: 16 hours
 - Adults: 7.5–8.5 hours
 - ↑ age = ↑ length of each sleep cycle
 - Children spend more time in SWS than adults

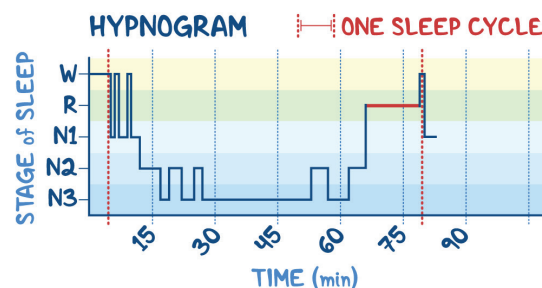


Figure 53.2 Hypnogram illustrating progression through one sleep cycle. W = wakefulness, R = REM sleep, N1 = stage 1 NREM, N2 = stage 2 NREM, N3 = stage 3 NREM.

CONSCIOUSNESS

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WHAT IS CONSCIOUSNESS?

- Awake, responsive state; simultaneous cerebral cortex electrical activity
- Associated with stimuli perception, voluntary movement control, high mental processing levels
- Superimposed by different neuron activities
 - E.g. same neurons involved in cognition, motor control
- Holistic, interconnected (e.g. memories can be triggered by smells, locations, people, etc.)
- Clinically, consciousness used to assess response (range: conscious → coma)
- Commonly assessed based on response to stimuli (movements, sounds, touch, etc.)

CONSCIOUSNESS STAGES

- **Alertness:** information processing, physical arousal
- **Sleep:** partially unconscious state (reduced sensory activity)
- **Dreaming:** mental experiences during sleep
- **Altered:** hypnosis, meditation, drug-induced, brain diseases, age → brain wave activity changes

LEARNING

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WHAT IS LEARNING?

- Respond to stimulus → acquire new/adjust existing knowledge/skills/information/behaviors
- Influenced by single/repeated events
- Active process
 - Absorb knowledge by experiencing, exploring, interacting with world
- Begins at birth, ends at death
- Can occur in different forms
- Affected by internal, external factors
 - **External:** genetics, environment
 - **Internal:** attention, attitude, goals, values, behavior, emotions

ATTENTION

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WHAT IS ATTENTION?

- Behavioral, cognitive process
 - Selective concentration on information
- Attention placed on subset of all perceived stimuli (e.g. one person in a crowd)
- Limited by capacity, duration
- Involves allocating processing resources (e.g. while multitasking)
- Integral component of cognitive system for environmental responses

MEMORY

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WHAT IS ATTENTION?

- Information storage, retrieval
 - Important for learning, behavior, consciousness

MEMORY STAGES

- Sensory memory
 - Visual, auditory memory
 - Generally lasts 1 second without rehearsal, but recalled information very detailed
- Short-term memory (STM) (AKA working memory)
 - Generally fades over 30 seconds without rehearsal
 - Limited capacity
- Working memory
 - Information kept in consciousness for manipulation, integration
- Long-term memory (LTM)
 - Vast information amounts stored, recalled on demand
 - Short-term → long-term memory transfer influenced by emotional states; repetition; new, old information association; automatic memory

MEMORY TYPES

- Declarative (explicit/fact) memory
 - Explicit information learned, requires conscious recall
- Non-declarative memory
 - Procedural (skills) memory; motor memory; emotional memory; conditioned responses from repetition, experience

LANGUAGE

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WHAT IS LANGUAGE?

- System that communicates ideas, feelings through words

COMPONENTS OF LANGUAGE

- **Phonology:** language's auditory sound
- **Morphology:** word structure
- **Semantics:** word meaning
- **Syntax:** words combined into sentences
- **Pragmatics:** language depends on context, pre-existing knowledge, audience

BRAIN'S LANGUAGE PROCESSING

- Processed in dominant left hemisphere, especially Broca's area, Wernicke's area (connected by arcuate fasciculus)
 - **Broca's area:** controls speech's motor functions
 - **Wernicke's area:** language comprehension
- **Non-dominant right hemisphere:** body language (language's nonverbal component)
- **Aphasia:** inability to produce/comprehend language

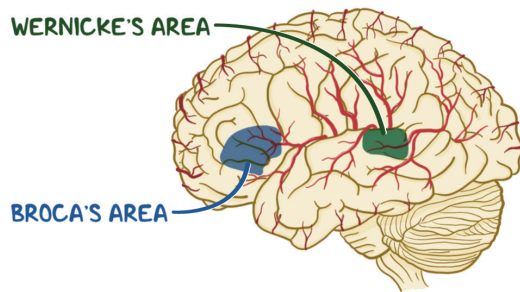


Figure 53.3 Lateral view of the left side of the brain showing the locations of Wernicke and Broca's areas. These areas are responsible for language comprehension and production, respectively.

EMOTION

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WHAT IS EMOTION?

- Conscious experience involving mental activity, pleasure/displeasure levels
- Associated with mood, motivation, behavior
- Involves experience, processing, behavior, psychological changes, behavioral changes

EMOTIONAL RESPONSE

- *Physiological response*: arousal → heart rate, body temperature, blood pressure changes
- *Behavioral response*: facial expressions, body language
- *Cognitive response*: interpretation depends on past experience

STRESS

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WHAT IS STRESS?

- Body's physical, mental, emotional response to change requiring adaptation
- *Positive stress (eustress)*: motivation, alertness
- *Negative stress (distress)*: decreased performance, anxiety
- *Stress level severity*: dependent on individual's skills, abilities, coping mechanisms

STRESSORS

- Biological elements, external stimuli, causal events
 - *Environment*: uncomfortable temperature, loud noises
 - *Daily events*: losing keys, forgetting items
 - *Work/academic events*: assignments, time management
 - *Social events*: family-, friend-, society-related demands

- **Chemical/biological:** diet, alcohol, drugs
- **Psychological:** pressure, lack of control, unpredictability, frustration, conflict

STRESS RESPONSES

- Physiological
 - **Alarm stage:** initial reaction activates sympathetic nervous system (to maintain body functions enabling response)
 - **Resistance stage:** continuous hormone release (e.g. cortisol to maintain blood sugar levels; epinephrine to stimulate sympathetic nervous system) to continue engaging body
 - **Exhaustion stage:** body unable to maintain increased sympathetic nervous system activity
- Emotional
 - Individual may feel irritable, tense, helpless
 - May affect concentration, memory
- Behavioral
 - Individual may withdraw, abuse substances, become aggressive, suicidal
 - Chronic stress may lead to mental health disorders