

Round 16

Attention:

Confusional States, Neglect, & ADHD

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# What is Attention?

- There is a limit
  - to the number of stimuli that can be acted on
    - due to physical constraints of effectors
  - to what can be consciously processed at a given moment in time
    - consciousness is slow, emergent and requires involvement from disparate brain regions
  - some stimuli need to be chosen at the expense of others.
- Where is the selector?
  - At first it was believed to at very low levels in the brainstem
    - Cocktail party effect
  - Selection/relevance depends on many factors
    - Network including neocortex, thalamus, brainstem
- Attentional modulation is inferred when identical events elicit different responses within different contexts
  - Reflected in alterations in selectivity, intensity, and duration of neuronal responses

# Aspects of Attention

- Arousal
  - Level of responsiveness
- Orientation
  - Alignment of sensory organs
- Selective attention
  - Preference for some stimuli over others
  - Determines the contents of consciousness
- Sustained attention
  - Vigilance, concentration
- Divided attention
  - Heeding of several events simultaneously
- Exploration
  - Searching a scene for specific stimuli

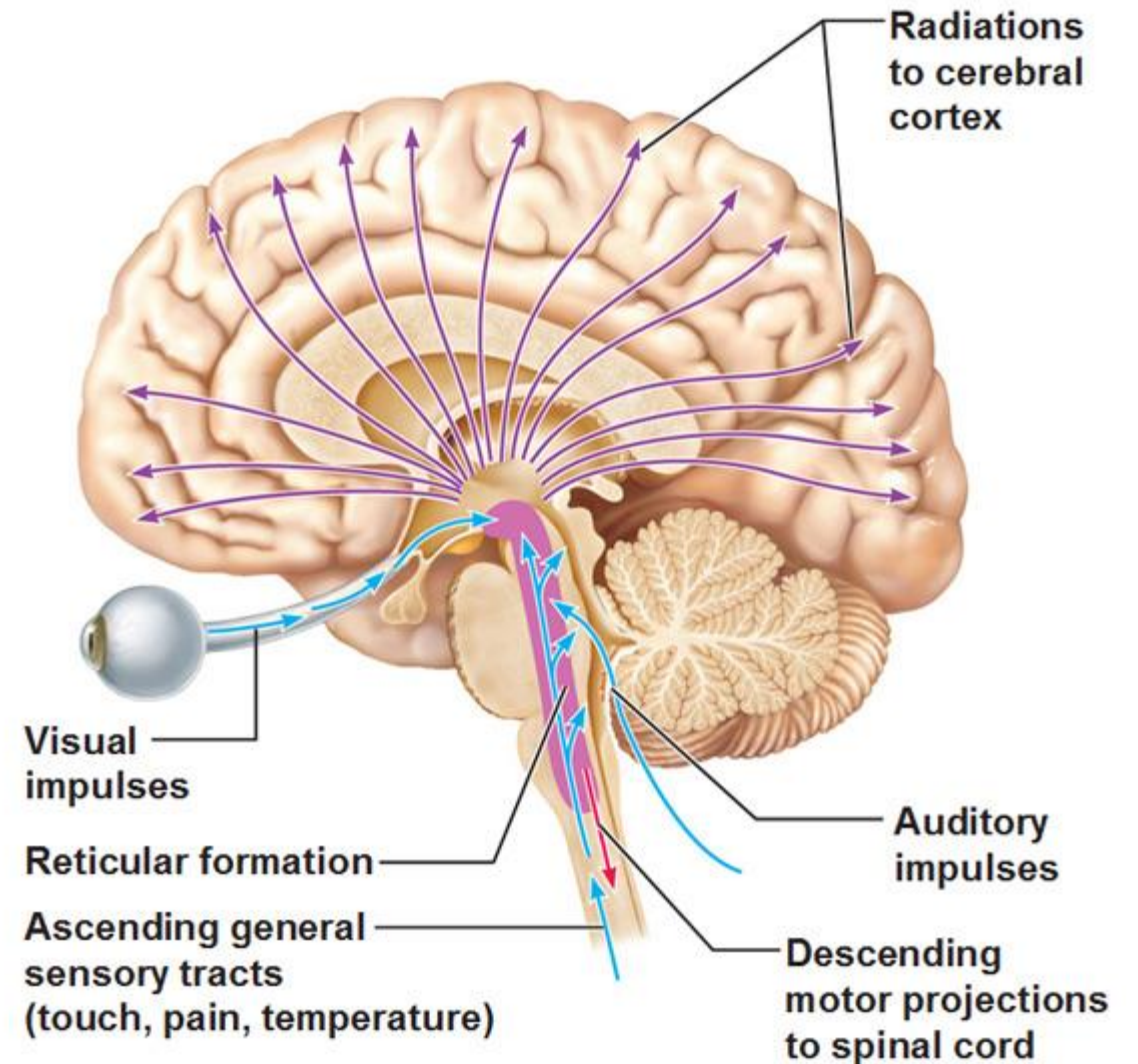
# Problems Attention Solves

- Cognitive processes
  - Detecting motivational salience
  - Compiling mental representations
  - Planning search strategies
  - Volitional shifting of attention from one target to another
  - Rapid detection of deviance from uniformity
    - E.g., Something comes into the roadway unexpectedly
  - Anticipation
    - E.g., Searching or orienting for missing or expected items
- Coordinate transformation
  - Visuospatial attention must translate retinocentric information to body-centered spatial frames of reference so they can be targeted for action

# Attentional Matrix

- Bottom-up
  - Stimulus driven
  - Mediated by Ascending Reticular Activating System (ARAS)
- Top-down
  - Goal driven
  - Mediated by cerebral cortex, frontal lobes
- Reflected in
  - Detection efficacy
  - Focusing power
  - Concentration span
  - On-line processing capacity
  - Signal-to-noise ratio

## The Reticular Formation



# Bottom-Up Components

- Ascending Reticular Activating System (ARAS)
  - Exerts domain-independent global influence on attentional modulation
    - Arousal level
  - Pacemaker for EEG rhythms in brainstem reticular formation, thalamus, and nucleus basalis
  - Activation is necessary but not sufficient for wakefulness & attentiveness
  - Fine tuning of attentional tone during wakefulness
- Reticular nucleus -> attentional valve regulates thalamocortical transmission via integrated influence of the cortex & brainstem

# Bottom-Up Components: Neurotransmitters

- Projection from brainstem to thalamus is mainly cholinergic
  - Activation promotes transfer of information from the thalamus to the cerebral cortex
  - Modulates signal-to-noise ratios during attentional focusing and sensory discrimination
- Serotonin agonist reduce distractibility
  - May modulate sensory gating of behaviorally relevant cues in the environment
- Dopaminergic of substantia nigra-ventral tegmental areas
  - Selectively responsive to motivationally relevant stimuli & to cues that signal their existence

# Top-Down Components

- Parietal, limbic, prefrontal cortices mediate top-down modulation of attentional responses
  - Sensitive to context, motivation, acquired significance, & conscious volition
- Prefrontal & posterior parietal cortices exert top-down influence on all types of domain-specific attentional modulation -> mediates the volitional regulation of attentional focus
- Working memory
  - On-line maintenance of information
    - Prefrontal cortex & posterior parietal cortex
  - Active manipulation of that information “central executive”
    - Prefrontal dorsolateral cortex
  - Prefrontal neurons
    - Play a critical role in protecting the contents of working memory from distraction
      - Become active when A is presented in an ABCDA paradigm and stays active until the reappearance of the cue



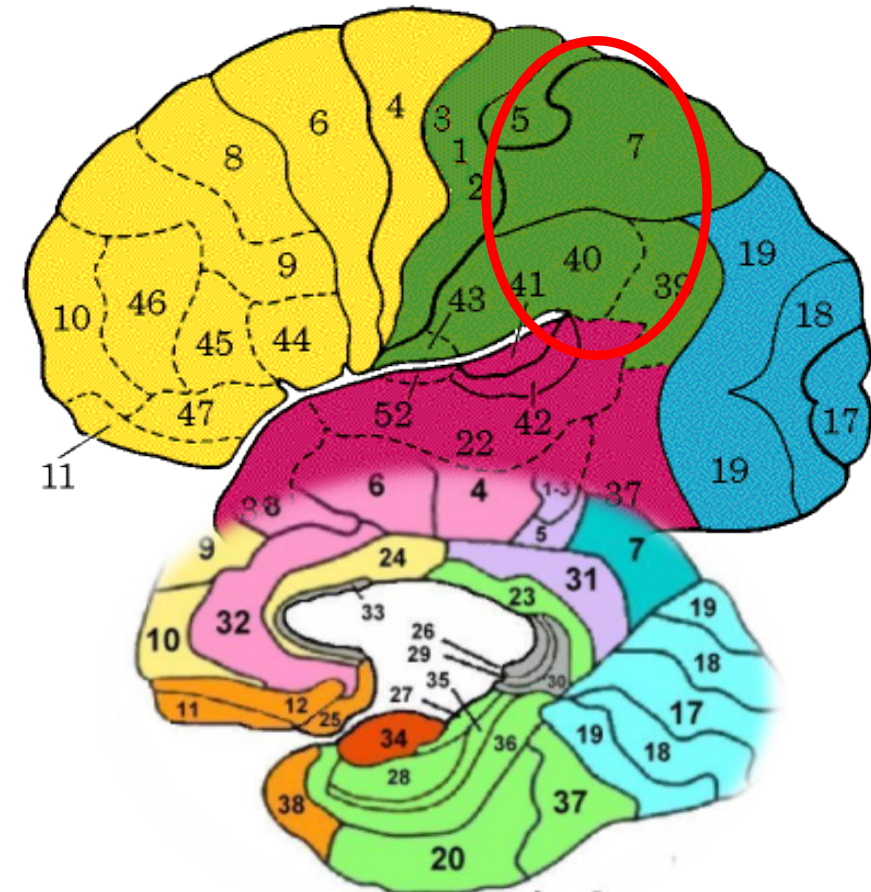
# Motivation

- Limbic system induces widespread attentional modulations that modify the impact of sensory events according to their emotional and motivational salience
  - Mood & motivation strongly influence the allocation of attentional resources
  - Degree of hunger enhances the response of orbitofrontal taste area to food items
- Prefrontal & Parietal regions mediate effect of motivation
  - Identical sensory stimuli elicit different responses from lateral prefrontal neurons when their relationships to reward are altered
  - Dorsolateral prefrontal activity greater when viewing a preferred food item relative to less preferred
  - Posterior parietal region increases firing when look at food when hungry and liquid when thirsty

# Attentional Network

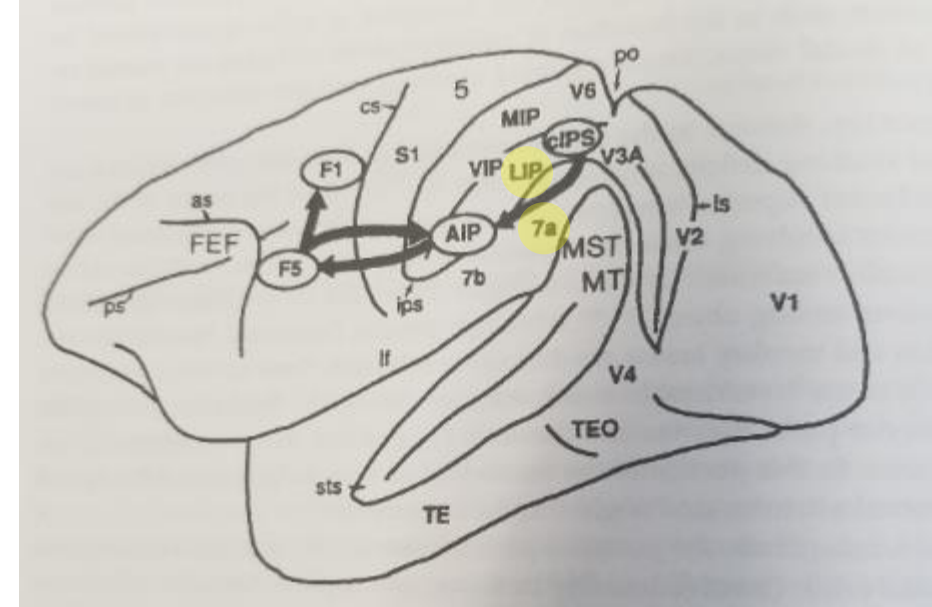
- Parietal Component

- Posterior parietal cortex situated at the confluence of visual, auditory, somatosensory, and vestibular unimodal areas
- Well positioned to mediate sensory-motor & cognitive integration necessary for spatial attention
- Four components:
  - Superior Parietal Lobule
    - Somatosensory association cortex BA 5 & anterior BA 7
    - Heteromodal Cortex posterior BA 7
  - Inferior Parietal Lobule
    - Supramarginal and Angular gyri BA 39 & 40
    - Heteromodal Cortex
  - Intraparietal Sulcus
    - Sensory-motor anterior
    - Visuospatial posterior
    - Most closely associated with neglect
  - Medial Parietal Cortex
    - Somatosensory association cortex BA 5 & 7 (anterior)
    - Heteromodal cortex BA 7 & 31 (posterior)



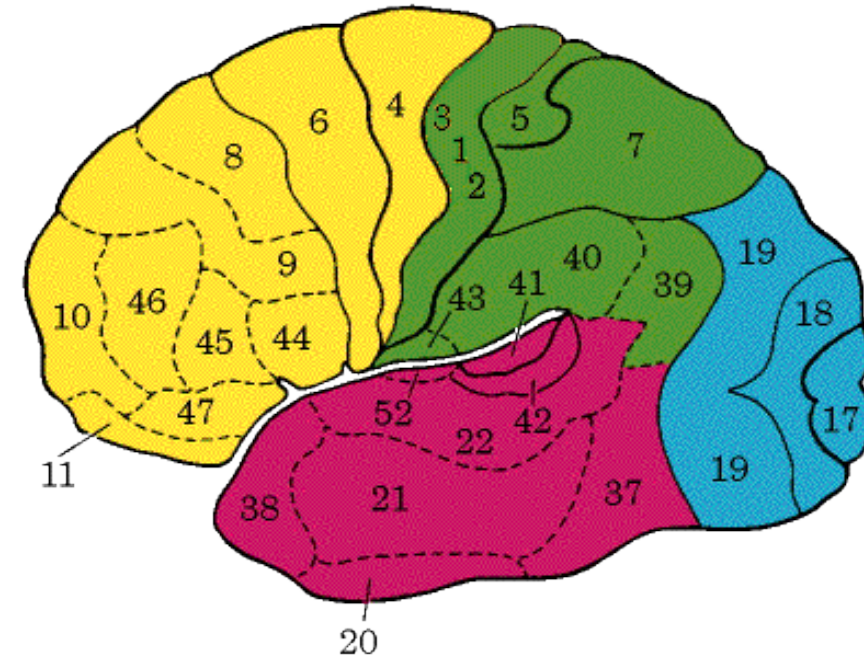
# Attentional Network

- Lateral Intraparietal Sulcus (LIP)
  - “Posterior eye field” critical role in coordinating eye movements
    - Triggers eye movements in response to stimulation
    - Gives directionally tuned responses prior to saccadic eye movements directed to visual targets or remembered locations
  - Brings auditory and visual information into a common frame of reference to promote holistic sense of a single dimension
- 7a
  - Encodes attentional factors
  - Activation does not depend on color, shape, orientation, identity, or location but is mediated by reward value
  - Role in encoding map of salience that is used by LIP to generate motor plans
- Both areas important for coordinate transformations -> remapping of information from retinotopic to egocentric and spatial coordinates
  - LIP mostly involved in creating body-centered representation based on proprioception
  - 7a involved in creating a world-centered representation based on vestibular input and environmental landmarks



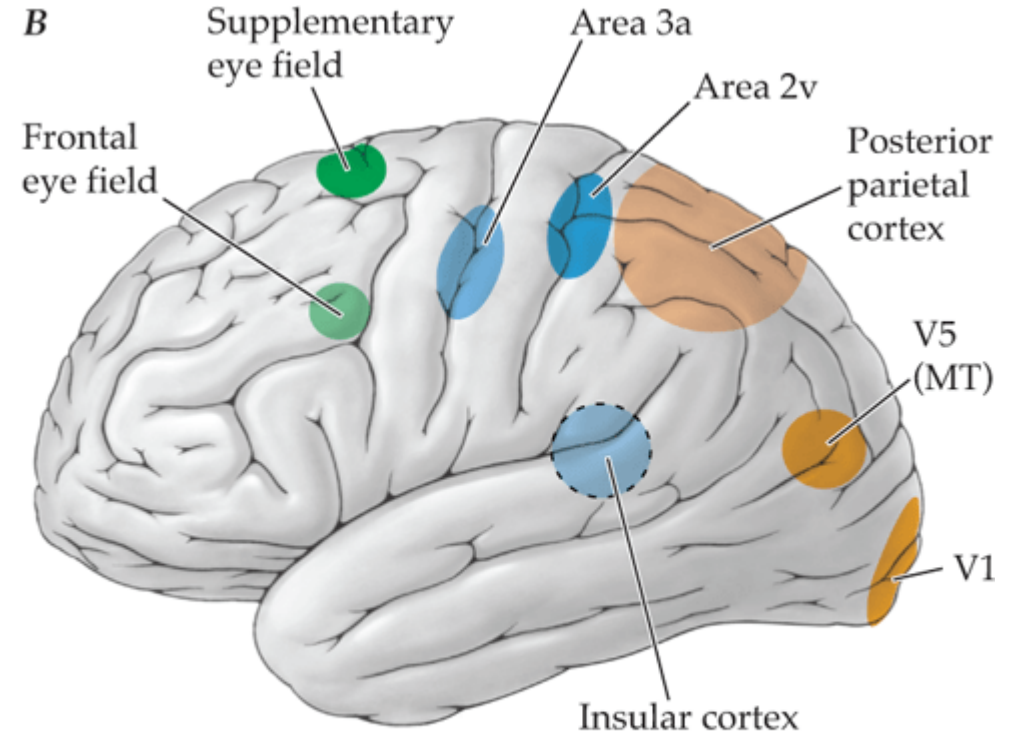
# Attentional Network

- BA 5, medial portion of parietal cortex
  - Role in spatial attention relevant for reaching, grasping, tactile search and manual exploration
  - Somatosensory receptive fields directionally tuned in arm and body centered coordinates
  - Related to stimulus significance and motor planning rather than actual execution of the movement
    - Active during latency between cue and presentation and response, indicating relationship to thinking of a motor plan



# Attentional Network

- FEF mainly motor, overt attention shifts, also active in covert shifts
  - FEF projects to premotor, striatum, superior colliculus, and subthalamic nucleus
    - Direct access to pathways that control head, eye, and limb movement necessary for scanning and exploration of space
    - FEF may be profoundly influenced by (and also probably profoundly influences) visual information at a relatively early stage of analysis
  - Receives auditory input -> mediate orientation to auditory stimuli
  - Receives extensive input from limbic areas (cingulate cortex)
    - Important in directing exploratory movements toward motivationally relevant segments of extra personal space
- Supplementary Eye Field (SEF)
  - Motor action fields defined relative to object-centered coordinates



Source: John H. Martin:  
Neuroanatomy Text and Atlas, Fourth Edition,  
<http://neurology.mhmedical.com>  
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# Attentional Network

- Relationship between frontal and parietal nodes of attentional network
  - Sensory representations (parietal) necessary for guiding exploration (motor-frontal), exploration necessary for updating representations
  - FEF & posterior parietal have common connections
    - Ensure that both get the same information
    - Rapidly survey vast information related to motivational salience, spatial representations, and motor strategies
    - Supports parallel processing

# Attentional Network

- Relationship between frontal and parietal nodes of attentional network
  - Posterior Parietal
    - Not a repository for multimodal spatial map but critical gateway
      - links distributed channels of spatially relevant information with each other and with multiple channels of motor output related to orienting, reaching, grasping, scanning, exploration
    - Sculpts salience and trajectory-based template of extra personal space
  - FEF
    - Plays a critical role in converting plans and intentions into specific sequences of motor acts that shift the focus of attention
    - Selects and sequences the individual acts needed to navigate and explore the landscape
  - Limbic (cingulate gyrus)
    - Critical role in identifying the motivational relevance of extrapersonal events
    - Sustaining level of effort during the execution of attentional tasks
- Phenomenon of spatial attention is not sequentially additive product of perception, motivation, and exploration but an emergent, relational quality of the network as a whole

# Acute Confusional State

- Symptoms
  - Defective vigilance
  - Attention either wanders aimlessly or is inappropriately focused on irrelevant stimuli
  - Skilled behavior (e.g., using utensils) vulnerable to interference, impersistence, perseveration
  - Stream of thought loses coherence due to frequent intrusions from competing thoughts, sensations
  - Hallucinations
  - Delusions
  - Agitation
  - Disorientation
  - Dysgraphia, Dyscalculia
  - Faulty judgment, Blunted insight



# Acute Confusional State

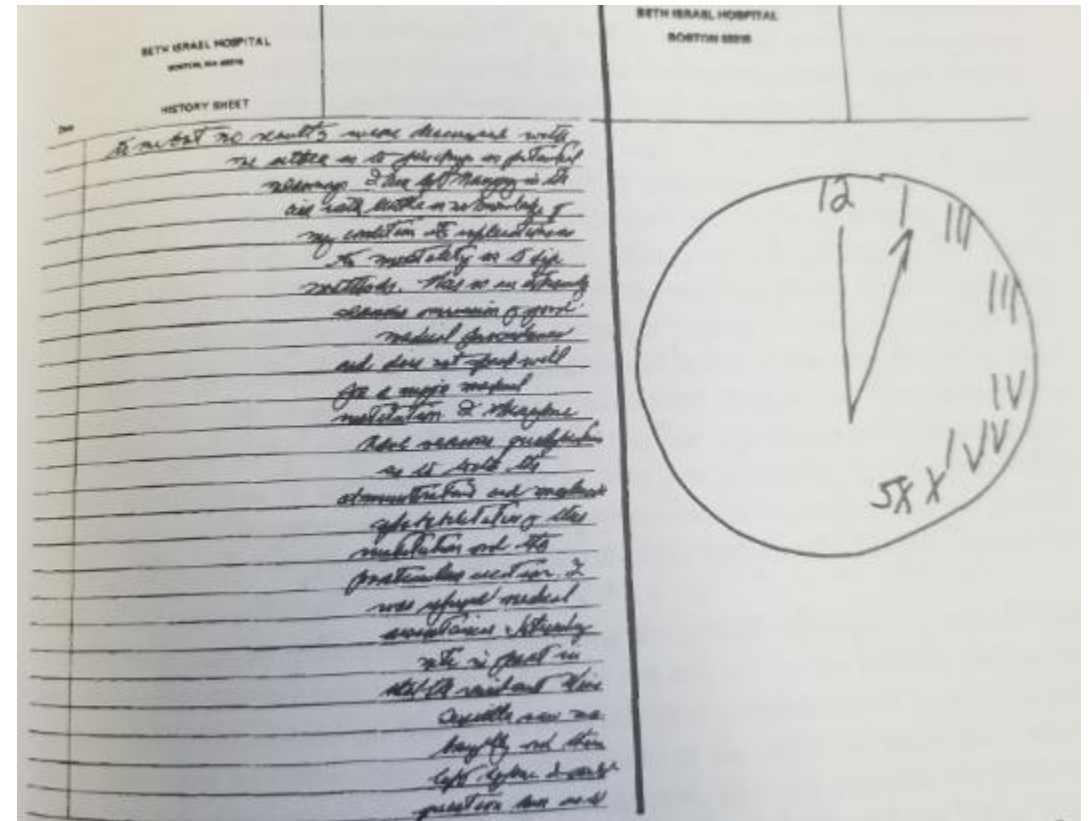
- **Toxic-Metabolic Encephalopathies**
  - Interference of nutritional requirements, acid-base balance, electrolyte environment
  - Hepatic failure, anemia, hyperglycemia, anoxia, acidosis
  - Withdrawal from alcohol, barbiturates, opiates, psychoactive drugs, hypnotics, sedatives, tranquilizers, antidepressants
  - Mostly due to neurotransmitter interference - cholinergic
- **Environmental stressors** in vulnerable individuals
  - Sensory deprivation
  - Immobilization (treatment for multiple trauma)
  - Interference with circadian rhythms (intensive care units)
  - Elderly, preexisting neurological diseases

# Acute Confusional State

- Multifocal brain lesions
  - Meningitis, anoxia, fat embolism, closed head injury
- Epilepsy/Seizures
  - Disrupts electrical or structural integrity of the ARAS
- Space-occupying lesions
- Focal lesions
  - Parahippocampal-fusiform-lingual gyri, posterior parietal, inferior prefrontal regions interfere with top-down modulation of attentional matrix

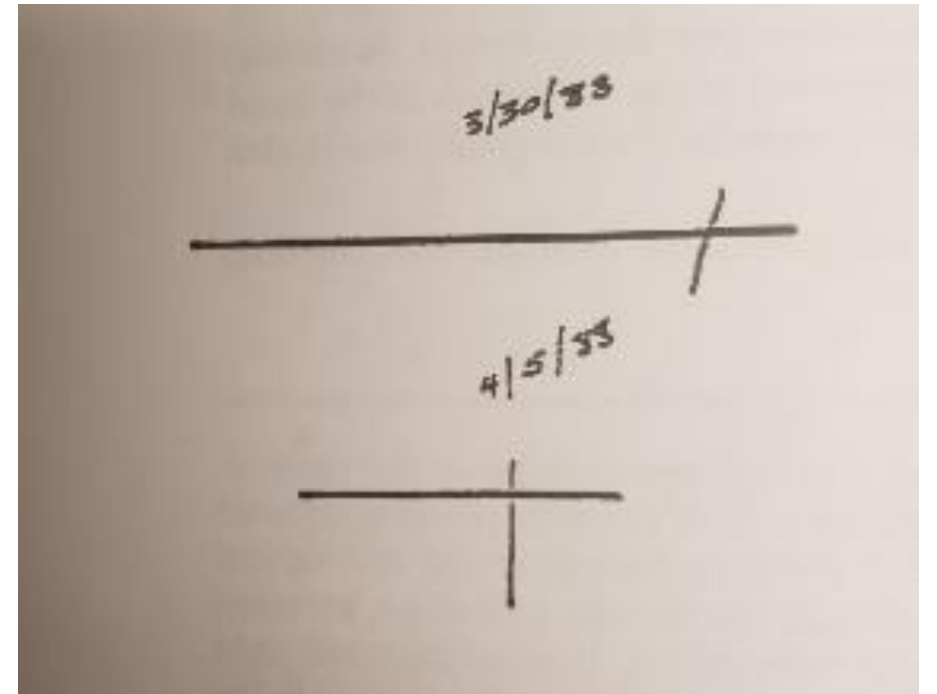
# Neglect

- Behave as if half of the universe does not exist
  - May not shave, groom, dress one side
  - Fail to eat food on one side
  - Omit reading the left half of words
  - Leave a very wide left margin
- Not a disorder of seeing, hearing, or moving.
- Disorder of looking, detecting, listening, and exploring



# Neglect

- Line Bisection Test
  - Neurologically intact people place midpoint slightly left of midline
    - Left neglect pts will place it to the right
  - Degree of rightness depends on line length
    - Suggesting that the sensory information about the total line is processed
    - Neglect happens post-sensory -> internal representation is affected



# Neglect

- Patients asked to retrieve landmarks when taking one perspective looking toward the cathedral along Piazza del Duomo in Milan
  - Able to recall landmarks on right side
  - When asked to take the other perspective, they again recalled right side, which previous were on left and not recalled
  - Failure of internal attentional spotlight to highlight left side features unless they are on the right side of the minds eye



- Neglect Dyslexia
  - Don't read words on the left
  - Left part of words are not read
  - Sometimes respects morphological boundaries and lexical structure
  - Nonwords more prone to neglect than real words
  - Suggest the whole word is encoded but neglect is superimposed onto the mental representation

# Neglect

- Neglected items are processed implicitly
  - Subject shown two identical line drawing of houses, one had flames on the left
    - Subject reported no difference between them
    - When asked which one they'd want to live in they selected the one without flames but could not articulate why
  - Subject shown 2 identical bank notes, one was torn on the left
    - Reported no difference between them
    - When asked which one they preferred, select the intact one, could not articulate why

# Neglect

- Functional anatomy of Unilateral Neglect
  - Right-side lesion
    - Lesions on the right side cause left neglect
    - Left lesion typically do not cause right neglect
    - Theory is that right side -> bilateral attention, whereas left side -> only right side attention
  - Lesion was previously believed to be related to only inferior parietal lobule
    - Attentional network includes frontal lobes, cingulate gyrus, striatum, and thalamus

# ADHD

- Affect 3-7% of school-aged children
- In order to be diagnosed symptoms must have occurred before the age of 7
- 3 Subtypes
  - Inattentive
    - Girls more than boys
    - Easily distracted
    - Forgetful, misplacing items
    - Difficulty focusing/ staying on task
  - Hyperactive
    - Boys more than girls
    - Fidgety
    - Impatient
    - Impulsive
    - Overly talkative
  - Combined/Mixed



# ADHD

- Affective Components
  - Lack of emotional control
  - Poor/inappropriate motivation
- Attentional/Cognitive Components
  - Problem solving
  - Planning (including time estimation, temporal foresight)
  - Orienting
  - Alerting
  - Cognitive flexibility
  - Sustained attention
  - Response inhibition
  - Working memory
- Motor Components
  - Poor motor coordination
  - Poor handwriting
  - Clumsiness

# ADHD

- Strong genetic contribution
  - Heritability between 60-90%
  - Genes implicated related to regulation of neurotransmitters
- Environmental factors
  - Prenatal factors
    - Maternal alcohol exposure
      - Structural brain anomalies in cerebellum
      - Children frequently hyperactive, disruptive, impulsive, increased risk of psychiatric disorders
    - Maternal smoking 2.7 fold increase risk for ADHD
  - Peri-natal factors
    - Very low birth weight
    - Pregnancy & birth complications
  - Post-natal factors
    - Nutritional deficiencies (essential fatty acids omega 3 & omega 6)
    - Deprivation of social environment

# ADHD



- **Frontostriatal Network**

- Lateral prefrontal cortex, dorsal anterior cingulate cortex, caudate nucleus, putamen

- **Hypoactivity**

- Anterior cingulate, dorsolateral prefrontal, inferior prefrontal, orbitofrontal, basal ganglia, thalamus, & parietal cortex

- **Reduction in volume**

- Total cerebral volume, prefrontal cortex, basal ganglia, dorsal anterior cingulate, corpus callosum, & cerebellum

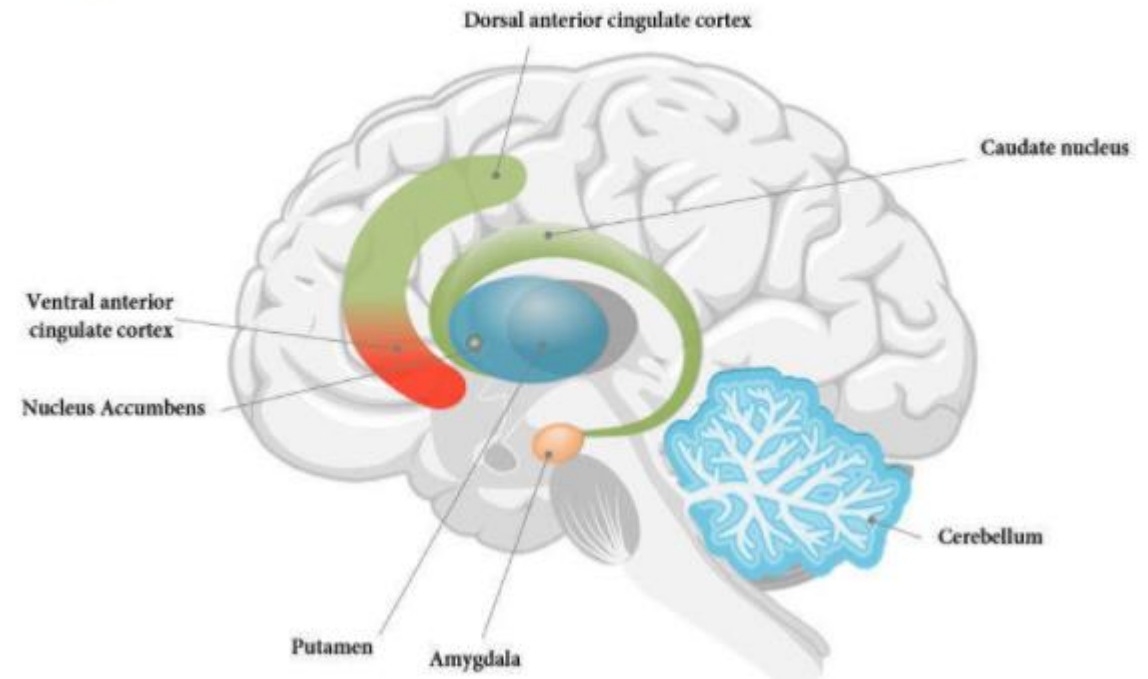
- **Delay in brain maturation**

- Grey matter peaks 3 years delayed – most prominent in prefrontal regions

- **White matter abnormalities**

- Corpus callosum, inferior parietal, occipito-parietal, inferior frontal, inferior temporal cortex
- Decrease the speed of neuronal communication

## Frontostriatal Circuit



# ADHD

- Dysregulation of noradrenaline/ norepinephrine and dopamine neurotransmitter systems
  - Methylphenidate
    - Increases dopamine signaling
      - Blocking DA reuptake
      - Increases extra-cellular levels
      - Disinhibition of receptors
    - Inhibits norepinephrine reuptake
  - Dextroamphetamine
    - Increase synaptic activity of DA & NE
      - Increases release into synapse
      - Decrease reuptake
- EEG typically reveals frontal slowing -> high amplitude theta (4-8Hz)
  - SMR training to decrease theta and increase beta
- Sometimes alpha/theta train is used
- ADHD EEG profiles have been found with excesses of delta, theta, alpha, and beta
  - One size does not fit all

Thank You



[The neurobiological basis of ADHD \(nih.gov\)](#)

[Frontiers | Cognitive Neuroscience of Attention Deficit  
Hyperactivity Disorder \(ADHD\) and Its Clinical Translation |  
Human Neuroscience \(frontiersin.org\)](#)

[Neurobiology of Attention Deficit Hyperactivity Disorder  
\(ADHD\) - A Primer \(psychscenehub.com\)](#)

[Neurobiology of Attention Deficit/Hyperactivity Disorder |  
Pediatric Research \(nature.com\)](#)

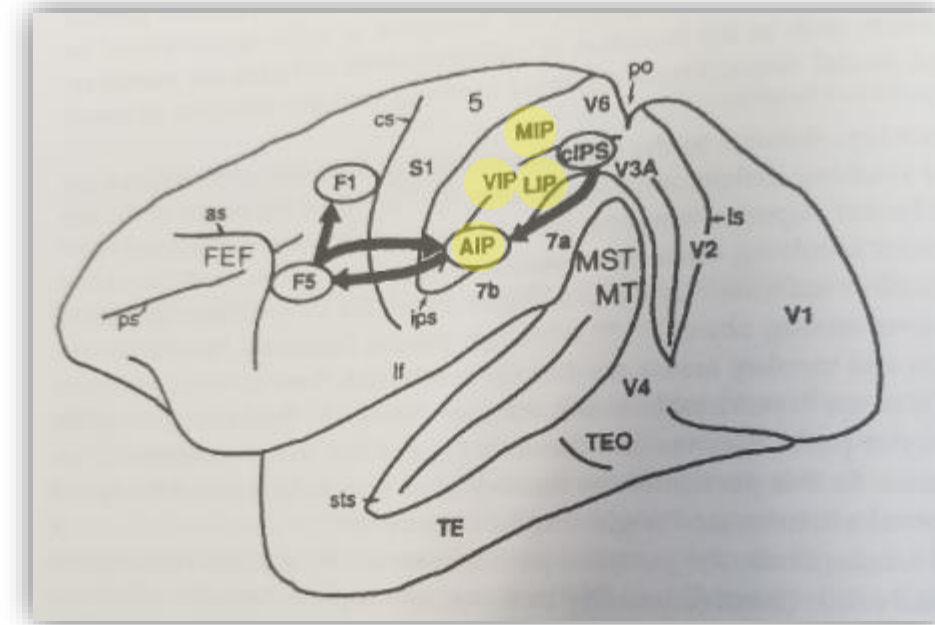
- Inferior frontostriatal circuit
  - Less activation in motor inhibition tasks in the circuit to prevent motion
  - Control movement SMA anterior cingulate cortex, right striatum, left thalamus
    - Problem with dopamine
      - Decision making
      - Movement
      - Motivation
  - Reduced activation in right dorsal – inattentive
  - Overall decrease in activity
  - Problem with communication with frontal lobe and motor control or posterior parietal attention areas
- Medications
  - Adderol Ritalin
  - Stimulants
  - Increase availability norepinephrine and dopamine
  - Side effects difficulty sleeping loss of appetite headaches



- Interfere with bottom-up ARAS
- Interference of top-down frontal, parietal, limbic
- multifocal damage distributed throughout the cerebral cortex that influences domain-specific attentional modulations

# Attentional Network

- There is not a unitary spatial map, there are several mappings of behaviorally relevant targets in terms of motor strategies
- MIP
  - Reach toward a visual target
- AIP
  - Connected to premotor area
  - Coordinated manual grasping of complex visual objects
- VIP
  - Integrate the process of grasp under visual guidance
- LIP
  - Parietal reach area
  - Visually guided arm movements
  - Manual grasping
  - Tactile exploration



# Attentional Network

- Limbic components
  - Cingulate
    - Anterior
      - Global attentional engagement
      - Dorsal anterior
        - Responds to behaviorally relevant cues & during the planning and execution of reaching movements
    - Posterior
      - Differentiated lateralized shifts of motivational relevance & focalized attention
      - Direction of displacement of eye movements rather than location of target
        - Activity is relative to last eye movement not absolute depending on target location

- Where is the selector?
  - At first it was believed to at very low levels in the brainstem
  - Cocktail party effect
  - Network including neocortex, thalamus, brainstem
  
- Mental arithmetic & auditory distractors
  - Decreased activity in auditory cortices