Pay Attention: ADHD Through the Lifespan

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Week 3: Neuroanatomy of ADHD

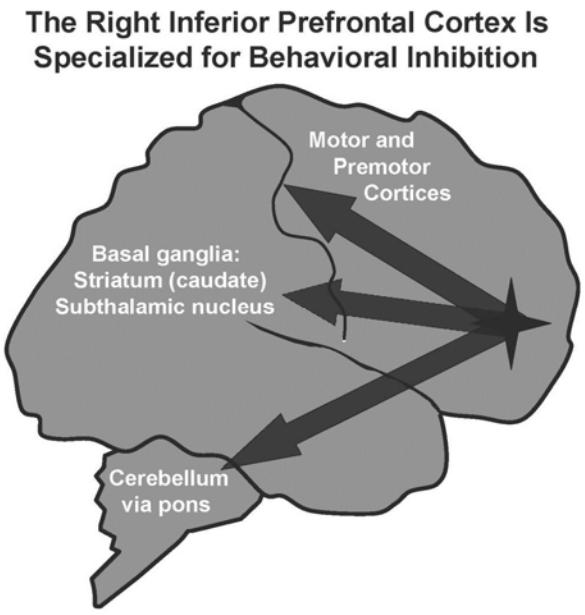
Homework Review

Neuroanatomy of ADHD

Key Brain Regions:

- Orbital prefrontal cortex (PFC)
  - Working memory and executive functions
- Basal Ganglia
  - Motor coordination and procedural knowledge
- Cerebellum
  - Control movement and cognitive processes that require precise timing

There is 3-10% reduction in regional volumes of these brain regions in people with ADHD



Arnsten, A.F.T. *J Pediatr*. 2009 May 1; 154(5): I-S43.

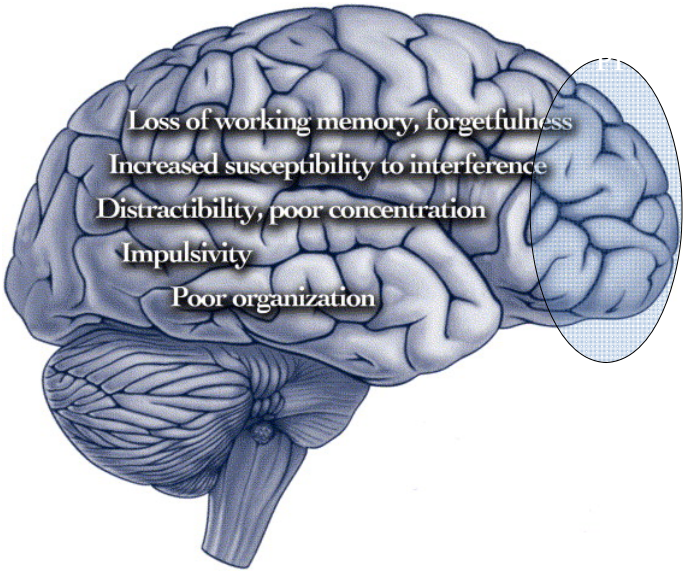


Figure 1. Many of the so-called executive functions are located in the prefrontal cortex (PFC). Damage to the PFC in the right hemisphere in humans can produce a profile of behavioral disinhibition similar to ADHD. *From Arnsten & Li, 2005*

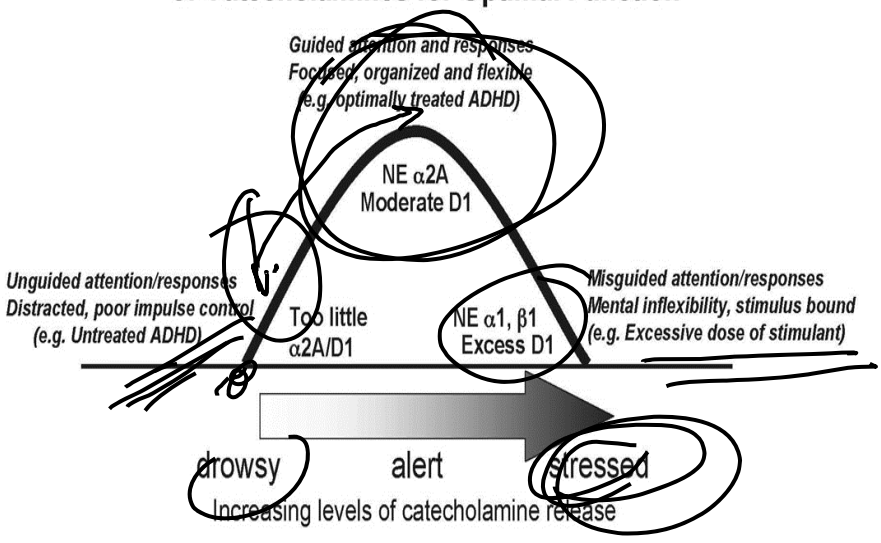
The PFC in ADHD

- ADHD is associated with alterations in the prefrontal cortex (PFC) and its connections to the striatum and cerebellum
  - The PFC is critical for regulating behavior, attention and affect via representational knowledge.
  - The PFC is also important for inhibiting distraction, sustaining attention over a delay and dividing attention.
  - The PFC's right hemisphere is particularly important for behavioral inhibition.
  - More posterior cortical areas are essential for perception and allocating attentional resources.

The PFC in ADHD

- The PFC functions best under conditions of moderate catecholamine (neurotransmitter) release.
- Optimal norepinephrine α2A-receptor stimulation increases "signals".
- Optimal dopamine D1-receptor stimulation decreases "noise".
- Stimulants enhance the release and/or inhibit the reuptake of both dopamine and norepinephrine.
- Both dopamine and norepinephrine contribute to the therapeutic effects of stimulants.
- Excessive doses produce cognitive inflexibility through α1A-, β-, and D1-receptor stimulation.

Mid-Lecture Questions



Arnsten, A.F.T. *J Pediatr*. 2009 May 1; 154(5): I-S43.

Middle Prefrontal Cortex Functions

- Bodily regulation: Autonomic nervous system: sympathetic/parasympathetic
- Attunement: 'resonate' 'feeling felt'
- Emotional Balance: equilibrium, equanimity
- Response flexibility: ability to pause, to put space between input and action; restrain our impulses, consider our options.
- Fear Modulation: 'cortical override' of amygdala-triggered fear response
- Empathy: 'You' maps; attunement plus 'to see' from another's perspective; to sense another's intention and imagine what an event means to another's mind
- Insight: 'me maps' perceive our own mind, 'mental time travel'
- Moral Awareness: 'we maps' the way we think an d behave for the social good
- Intuition: Give access to the 'wisdom of the body' 'heartfelt sense' 'gut feeling' 'bone deep'

Mindsight by Daniel Siegel, M.D.

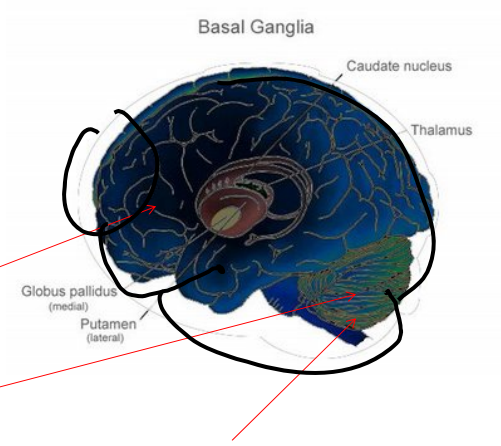
Mid-Lecture Questions

Neuroanatomy of ADHD (cont.)

Anatomical structures involved in activity (movement) are smaller in individuals with ADHD as compared to controls

Basal ganglia—caudate and globus pallidus (dopamine receptor-rich areas)

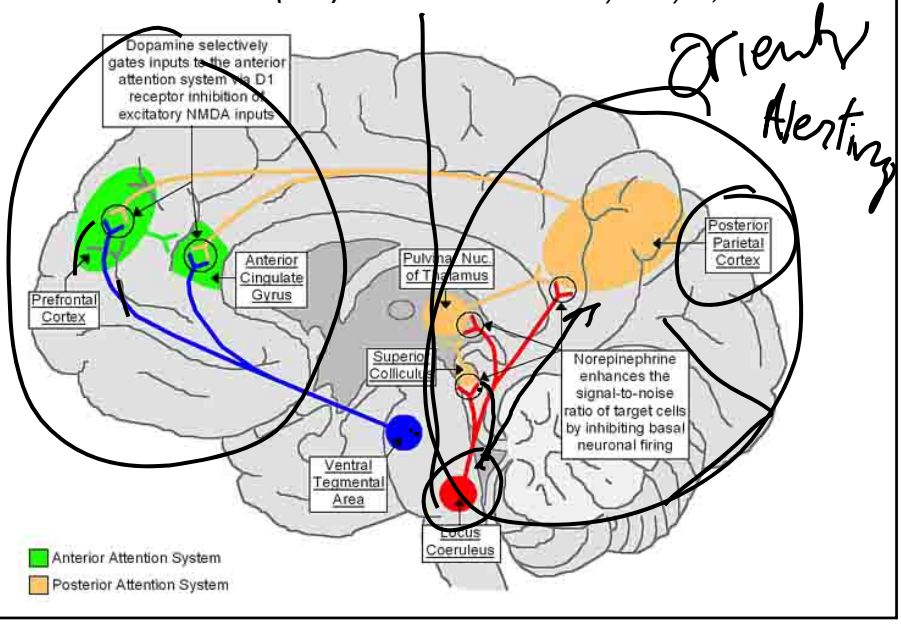
Cerebellum (linked to dopamine receptor-rich areas in the basal ganglia and cortex)



- Smaller **cerebellar vermis** (line in center, between lobes)

Dual Systems of Attention

Plitzska S *et al.* (1996) *J Am Acad Child Adolesc Psychiatry 35,* 264-272

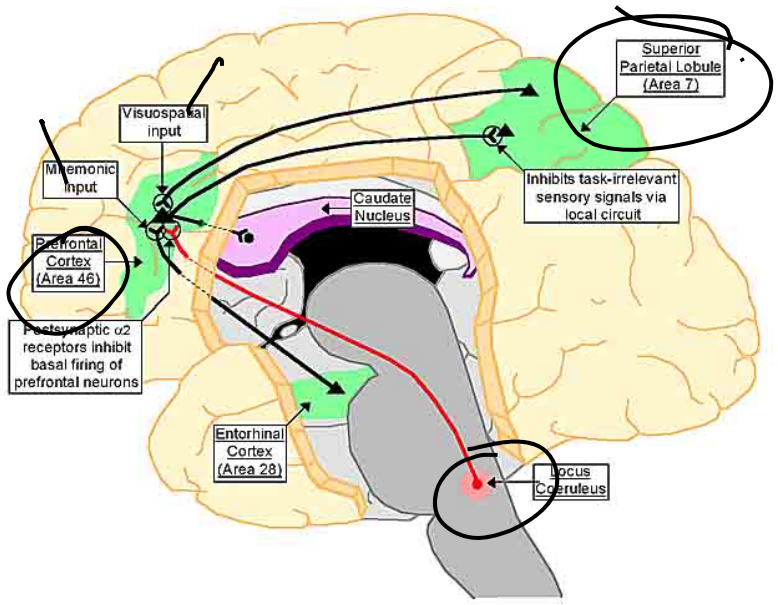


Dual Systems of Attention

Posterior (rear) system: orients to and engages novel stimuli; localized to the superior parietal cortex, the superior colliculus and the pulvinar. It receives dense NE innervation from the locus ceruleus which inhibits the spontaneous activity of postsynaptic neurons thereby increasing signal to noise ratio of target neurons (i.e. orientation)

Anterior (frontal) system in the PFC and the anterior cingulate: subserves the executive system. It is modulated by ascending DA fibers from the VTA. DA suppresses spontaneous activity of target neurons and reduces their responsivity to new inputs (i.e. better focusing)

Mid-Lecture Questions



Himelstein J et al, THE NEUROBIOLOGY OF ATTENTION-DEFICIT HYPERACTIVITY DISORDER, *Frontiers in Bioscience*, 5: 461-478, April 1, 2000

Review of ADHD Neural Networks

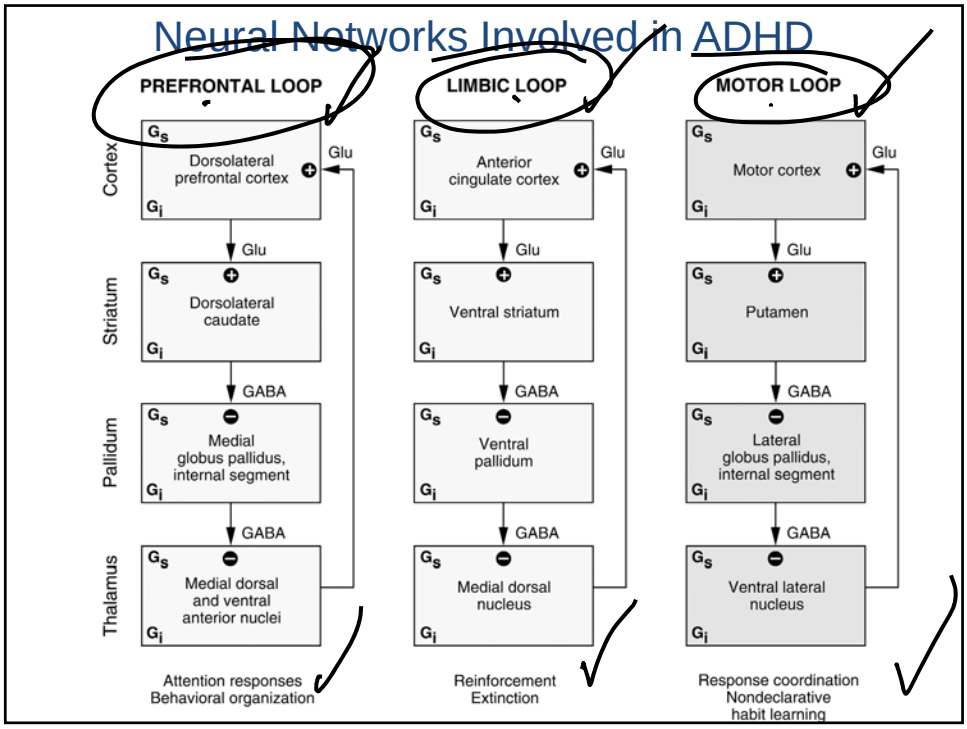
- The **frontal-striatal circuit**: Associated with deficits in response suppression, freedom from distraction, working memory, organization, and planning, known as the "cool" EF network
- The **frontal-limbic circuit**: Associated with symptoms of emotional dyscontrol, motivation deficits, hyperactivity-impulsivity, and proneness to aggression, known as the "hot" EF network
- The **frontal-cerebellar circuit**: Associated with motor coordination deficits, and problems with the timing and timeliness of behavior, known as the "when EF" network

Nigg, J. T., & Casey, B. (2005). An integrative theory of attention-deficit/hyperactivity disorder based on the cognitive and affective neurosciences. *Development and Psychology, 17*, 785-806.

Castellanos, X., Sonuga-Barke, E., Milham, M., & Tannock, R. (2006). Characterizing cognition in ADHD: Beyond executive dysfunction. *Trends in Cognitive Science, 10,* 117-123.

Sagvolden, T., Johansen, E. B., Aase, H., & Russell, V. A. (2005). A dynamic developmental theory of attention-deficit/hyperactivity disorder (ADHD) predominantly hyperactive-impulsive and combined subtypes. *Behavioral and Brain Sciences, 28*, 397-408.

Neural Networks Involved in ADHD



Quiz Questions