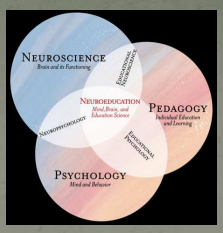

From Bench to Desk and Back

ADHD, neuroscience and the classroom

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PATIENT CARE
TEACHING
RESEARCH
CSG
CHILDREN'S SPECIALTY GROUP

Disclosures

- None

Objectives

- To be familiar with the brain attention network
- To know how the attentional network is disrupted in ADHD
- To be familiar with the state of intervention research in ADHD
- To recognize what can and cannot be gained from neuroscience
- To develop a basic set of tools to help ADHD children in and out of the classroom

Outline

1. The definition of attention
2. The neurobiology of attention
3. Developmental trajectory of attention
4. Atypical attention development in ADHD
5. Modifying attention
6. ADHD in the classroom
7. Current classroom ADHD recommendations
8. Is there neuroscientific support for current recommendations?
9. Is neuroscience relevant to the classroom?

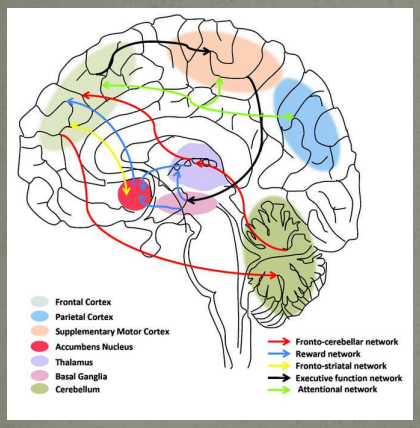
What is attention?

- *"the taking possession by the mind, in clear and vivid form, of one out of what may seem several simultaneously possible objects or trains of thought. …It implies withdrawal from some things in order to deal effectively with others." William James, The Principles of Psychology, 1890.*

The components of attention

- Posner and Petersen (1990; Petersen & Posner, 2012)
  - Alerting/arousal
    - Provoking consciousness
  - Spatial orientation
    - Drawing attention to specific sensory inputs
  - Executive attention
    - Maintaining focus
    - Inhibiting distractions
    - Includes working memory, inhibitory control and cognitive flexibility

The neurobiology of attention



- Arousal
  - Mediated by norepinephrine secretion in the locus coeruleus
- Spatial orientation
  - Involves connections between the parietal lobe and the frontal eye fields
  - Mediated by acetylcholine
- Executive function
  - Connections within the frontal lobe, to the anterior cingulate, and top-down influences
  - Mediated by dopamine

Image courtesy of Purper-Ouakil et al., 2011

Development of attention

- Arousal
  - Present in newborns (Amso & Johnson, 2006)
- Orienting (visual)
  - Begins around 3-6 months and continues to mature through adolescence (Konrad et al, 2005; Luna, Garver, Ubran et al., 2004; Rueda et al, 2004)
- Executive function
  - Starts around 4 months and continues through adolescence (Crone, 2009; Johnson, 1995)
  - Local connectivity indirectly varies with remote connectivity over time (Fair et al., 2007; Hwang, Velanova & Luna, 2010; Luna & Sweeney, 2004)

Atypical attention: ADHD cases

- Justin, 10 year old boy
  - He seems to have strong potential but interrupts in class frequently and cannot sit still
  - Distraction to other students and teacher
  - Phone calls to family reveal similar "rambunctious" behavior at home
- Brooklyn, 7 year old girl
  - She has model behavior in class but appears disengaged, seeming to daydream frequently
  - Has difficulty turning in assignments on time
  - Phone calls to family reveal that she cannot seem to complete a series of tasks, getting stuck in the first task

DSM-5 criteria for ADHD

1. Inattention: >= 6 symptoms of inattention for children up to age 16 or >= 5 symptoms for children over 17 and adults; present for >= 6 months and inappropriate for developmental level
   1. Careless mistakes
   2. Difficulty holding attention on tasks or activities
   3. Does not appear to listen when spoken to directly
   4. Fails to follow through on instructions and fails to finish tasks
   5. Difficulty with organization of tasks or activities
   6. Difficulty with tasks requiring prolonged mental effort
   7. Frequently loses things necessary for tasks or activities
   8. Easily distracted
   9. Often forgetful in daily activities

DSM-5 criteria for ADHD

- Hyperactivity/Impulsivity: >= 6 symptoms of hyperactivity/impulsivity for children up to age 16 or >= 5 symptoms for children over 17 or adults; present for >= 6 months to an extent that is disruptive and inappropriate for developmental level
  - Fidgeting
  - Difficulty staying in seat
  - Running or climbing in inappropriate situations
  - Unable to perform leisure activities or play quietly
  - Always "on the go"
  - Talks excessively
  - Interrupts constantly

Mapping neurobiology to clinical symptoms (Goldstein & Goldstein, 1998)

- Impulsivity and planning
  - "Planning requires the efficient choice of strategies and the ability to self-monitor, self-correct, flexibly shift, and adjust to feedback." (Goldstein and Naglieri, 2008, p. 862)
  - Executive dysfunction
- Inattention
  - Decreased ability to initiate action in everyday activities
    - Importantly, function may be relatively normal in new or less repetitive/less effortful situations (Goldstein & Naglieri, 2008)
  - Executive dysfunction
- Hyperactivity
  - Hyperarousal
- Problems modulating gratification
  - Difficulty adjusting to changing stimuli, parameters or reward sensitivity (Kollins, Lane, & Shapiro, 1997)
  - Executive dysfunction
- Emotional regulation
  - Difficulty integrating and separating emotion and cognition
  - Executive dysfunction

The ADHD brain

- Decreased global cortical volume (Batty et al, 2010; Shaw et al., 2006)
- Increased local connectivity and reduced remote connectivity (Wang et al., 2009)
- Possible impact of disrupted visual feed-forward and feedback pathways on attention development (Amso & Scerif, 2016)
- Genetic links exist but are unlikely to be simple
  - Gene-environment interactions (Sheese et al., 2007)

Strategies for change: current classroom management paradigms

- Establish rules and routines
- Focus on organization
- Outline expectations
- Multiple modes of instruction
- Decrease distractions
- Repetition
- Work with parents

*Strategies informed by the Department of Education (https://www2.ed.gov/rschstat/research/pubs/adhd/adhd-teaching_pg3.html), Helpguide.org (https://www.helpguide.org/articles/add-adhd/teaching-students-with-adhd-attention-deficit-disorder.htm), and ADDitude magazine (https://www.additudemag.com/teaching-strategies-for-students-with-adhd/)

Strategies for change: neurobiological and behavioral approaches

- Lab-based programs
  - Indirect interventions (Hülsken, 2001; Slaughter and Gopnik, 1996; Veenstra, van Geert, & van der Meulen, 2012)
- Educational programs
  - Direct educational interventions (Arcos-Tirado, Farnández Martín, & Hinojo Lucena, 2004; Kerns et al., 1999; Klingberg et al., 2002; Langberg, Epstein, Urbanowicz, Simon, and Graham, 2008; Pelham, Massetti et al., 2005; Pfiffner et al., 2007; Shalev, L. et al., 2003)
- Psychological interventions
  - CBT strategies focus on underlying cognitive etiologies and modifying behavior while instructing self-control and mindfulness (Antshel & Barkley, 2008; Meichenbaum & Goodman, 1971; Tang et al, 2007, 2009; Valls-Llagostera et al., 2015; Zylowska et al., 2007)
- Parent training
  - Targeting parent-child interactions at home (Barkley, 1997; Jones, Daley, Hutchings, Bywater, & Eames, 2008; Mikami, Lerner, Griggs, McGrath, & Calhoun, 2010; Sanders, Markie-Dadds, Tully, & Bor, 2000)

Studies using laboratory paradigms

- Veenstra, van Geert, & van der Meulen (2012) studied improvement on a computer task looking at behavior with a computer mouse in a groups of ADHD, ASD and typically learning Dutch children ages 3-6
- Intervention: computer game of "Hide and Seek" where children are instructed to click on objects to find a specific person (www.samenslim.nl)
- Outcome: assessment of 6 behaviors
  1. Incorrect object clicks (errors)
  2. Number of clicks during instruction moments (response inhibition)
  3. No clicks during clicking moments (response inhibition)
  4. Response times (reaction times)
  5. Number of clicks during clicking moments (response inhibition)
  6. Repeated clicks on the same object (perseveration)
- Results
  - Children with ADHD experienced improvements in reaction time, errors, response inhibition and perseveration over repeated trials
- Conclusion: Computer programs designed to improve executive function can lead to behavior change in ADHD children

Studies using educational programs

- Campeno-Martinez et al. (2017) studied the effect of a educational intervention on Spanish children ages 7-10 diagnosed with ADHD
- Intervention: Educational Intervention Program to Increase Attention and Reflexivity (Gargallo, 2000)
  - 25 sessions, 2 sessions per week, 20-30 minutes each
  - Contains "questions with uncertain responses and problems with alternative solutions in which the response in not immediately obvious. The intervention techniques used include enhancement of time delay, attention and discrimination; and increase in problem-solving capacity, analysis of detail, response delay, verbal self-monitoring, analysis of detail, and use of cognitive strategies." (Campeno-Martinez et al., 2017, p. 68).
- Outcome measure: scores on Escalas Magallanes Screening Scale for Attention Deficits and Other Developmental Problems in Children (EMA-DDA) as measured by teachers and parents
  - Subscales of ADHD-hyperactivity, ADHD-inattention, Aggressivity, Social Isolation, and Anxiety
- Results
  - Decreased aggressivity reported by teachers
  - Decreased social isolation reported by parents
  - Trend towards decreased ADHD symptoms

PASS (Planning, Attention, Simultaneous, Successive) theory (Naglieri & Das, 2005)

- Planning: addresses cognitive control and strategy development
- Attention: addresses focus on particular task to exclusion of others
- Simultaneous: integration into a coherent whole
- Successive: developing a process chain
- Addressing specific difficulties in an individual child can be helpful
- Interventions that show successful planning leads to academic achievement encourage more planning
  - Math (Cormier, Carlson & Das, 1990; Kar, Dash, Das & Carlson, 1992; Naglieri and Gottling, 1995, 1997; Naglieri & Johnson, 2000)
  - Reading (Haddad, Garcia, Naglieri, et al., 2003)

Are current classroom strategies supported by scientific evidence?

- Yes, at least indirectly
  - Establish rules and routines
    - Lab and classroom interventions
  - Focus on organization
    - Lab, classroom and psychological interventions
  - Outline expectations
    - Lab and classroom interventions
  - Multiple modes of instruction
    - Unclear
  - Decrease distractions
    - General principles
    - Increased visual stimuli can lead to reduced cell firing to target stimuli (Desimone & Duncan, 1995)
  - Repetition
    - All studies

Is there direct transfer?

- Evidence for direct transfer from neuroscience to classroom strategies is lacking
- No studies have shown consistent benefits from various neurological tools such as EEG
  - AAN (2016) recommended against using EEG markers for the diagnosis of ADHD

The neuroscientist vs the educator

Neuroscientist	Educator
• Molecular signals	• Psychology
• Networks and connectivity	• Behavior
• Specificity	• Generalizability

Are there direct benefits from neuroscience for education?

- Issues of scale lead to potential differences in operations
- Concerns regarding external validity
- Brain structure is not deterministic
  - Neuroplasticity
  - Lessons from neurology—we treat patients not EEGs, neonatal brain damage can be misleading
- Neuroscience can unhelpfully confuse the picture
  - Weisberg, Keil, Goodstein et al. (2008): individuals less able to appropriately assess explanations of psychological phenomenon when irrelevant neuroscience added
- Tautological
  - Of course learning changes the brain
    - If educational strategies lead to improvement in education, does neuroanatomical change even matter? And vice versa.
  - Neuroscience can elucidate neuroanatomical bases for known successful educational strategies
- There will not be a direct way to use neurological testing in a classroom
  - Too expensive
  - Too invasive and time consuming
  - Unclear evidence of direct applicability

Integration is important

- Scaffolding is key—normalizing neurobiological function with medication will not likely be able to replace the behavioral and educational importance of classroom learning strategies
  - CBT for ADHD can improve symptoms, especially when combined with medication (Rostain & Ramsay, 2006; Safren, Otto, Sprich, et al., 2005)
  - "The only role for educators here is to each these children who are now better prepared to learn." Bowers, 2016, p. 608
- Perhaps the best approach is not top-down (neuroscience to education) but bottom-up (education to neuroscience)

Conclusions

- Development of the brain attention network occurs throughout childhood and early adulthood
- Connections between various parts of the brain are responsible for the various functions of attention
- Disruptions in long-range connections are likely a component of atypical attention development in ADHD
- Laboratory, classroom and therapeutic interventions have shown efficacy in improving ADHD symptoms
- Direct transfer of neuroscience into the classroom is unlikely to be the path forward
- Scaffolding is important in using neuroscientific and behavioral evidence to help children with ADHD

Questions?

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