Overview

1. What is the essential problem in ADHD?
2. Brain differences that underlie ADHD
3. Mystery of ADHD: Role of Emotions
4. Working memory “googles” emotions
5. ADHD WM problems bias emotions
What is essential problem in ADHD?

- **Old**: behavior problems & not listening
- **New**: developmental impairment of the brain’s management system: EF

- Aspects of brain’s EF don’t come online in usual time frame.
- And don’t work consistently

TE Brown, Yale Medical School, 2013

Executive Functions

- Wide range of **central control processes** of the brain
- **Connect, prioritize, and integrate** cognitive functions—moment by moment
- **Like conductor of a symphony orchestra**

TE Brown, Yale Medical School, 2013

“Will you do it and, if so, how and when?”

(Lezak, 2004)

- **Will you do it?** Motivation/Activation
- **How will you do it?** Planning/Organizing
- **When?** Timing/Remembering

TE Brown, Yale Medical School, 2013
Characteristics of ADHD Symptoms

- **Dimensional, not “all-or-nothing”**
  - Everyone sometimes has some impairments in these functions; in ADHD: chronic, severe impairment

- **Situational variability: “If I’m interested”**
  - Most persons with ADHD have a few activities where ADHD impairments are absent

ADHD looks like willpower problem, but it isn’t!

T. Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)

Brown’s Model of Executive Functions Impaired in ADHD

<table>
<thead>
<tr>
<th>Executive Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizing, prioritizing, and activating to work</td>
</tr>
<tr>
<td>Focusing, sustaining focus, and shifting focus to tasks</td>
</tr>
<tr>
<td>Regulating alertness, sustaining effort, and processing speed</td>
</tr>
<tr>
<td>Managing frustration and modulating emotions</td>
</tr>
<tr>
<td>Utilizing working memory and accessing recall</td>
</tr>
<tr>
<td>Monitoring and self-regulating action</td>
</tr>
</tbody>
</table>

1. **Organize, Prioritize, and Activate**

- Difficulty organizing tasks, materials
- Difficulty estimating time, prioritizing tasks
- Trouble getting started on work

T. Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)
2. Focus, Shift, and Sustain Attention

- Loses focus when trying to listen or plan
- Easily distracted—internal/external
- Forgets what was read, needs to re-read (not on self-selected reading)

T. Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)

3. Regulating Alertness, Effort, and Processing Speed

- Difficulty regulating sleep and alertness
- Quickly loses interest in task, especially longer projects; doesn’t sustain effort
- Difficult to complete task on time, especially in writing—“slow modem”

T. Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)

4. Manage Frustration, Modulate Emotion

(Not included in DSM-IV criteria)

- Emotions impact thoughts, actions too much
- Frustration, irritations, hurts, desires, worries, etc., experienced “like computer virus”
- “Can’t put it to the back of my mind”

T. Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)
5. Utilize Working Memory, Access Recall

- Difficulty holding one or several things “on line” while attending to other tasks
- Difficulty “remembering to remember”
- Inadequate “search engine” for activating stored memories, integrating these with current info to guide current thoughts and actions

T.Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)

6. Monitor and Self-Regulate Action

(Not just hyperactive/impulsive behavior)

- Difficulty controlling actions, slowing self and/or speeding up as needed for tasks
- Doesn’t size up ongoing situations carefully
- Hard to monitor and modify own actions to fit situation/aims

T.Brown, Attention Deficit Disorder: The Unfocused Mind in Children & Adults (2005)

A Working Definition of ADHD

T.EBrown, 2013

- a complex syndrome of
- developmental impairments of executive functions,
- the self-management system of the brain,
- a system of mostly unconscious operations.
- These impairments are situationally-specific,
- chronic, and significantly interfere with functioning in many aspects of the person’s daily life.
Executive Functions are complex and operate in dynamic, integrated ways.

For example, EF of “focus”

• Does not mean
  • as in holding the camera still to take a photo of an unmoving object
• Does mean
  • as in focusing on the task of driving a car

Development of Brain Structures that Support Executive Functions

❖ Structures and functions that support EF not fully developed in early childhood for anyone

❖ Neural networks underlying EF begin development at 2-4 years old, but don’t fully develop until one’s 20s

Executive Functions: Development and Demands

❖ EF capacity develops through childhood, into adolescence, and beyond; it is not fully present in early childhood

❖ Environmental demands for EF increase with age, from preschool through adulthood

❖ EF impairments often are not noticeable by age 12 yrs!
New Understandings of ADHD & Emotions

When Are ADHD Impairments Noticeable?

- Some are obvious very early and are noticeable in preschool years
- Some are not noticeable until middle elementary or junior high
- Some are not apparent until child leaves home to go to college or later

2. Brain differences underlying ADHD (temporary and/or longer term)

- Delay in unfolding of brain development that supports executive functions
- Impaired white matter connections between brain regions
- Impaired control of oscillations that coordinate brain region communications
- Inadequate release/reloading of transmitter chemicals at synapses

ADHD sx may be temporary or longer-term

4 Trajectories for Inattention Sx

- 2000 Canadian kids followed age 6 to 12 yrs
- Annual tchr ratings of inattn & hyper separately
  1. Inattn probs-minimal/stable 46%
  2. Inattn probs-significant 17%
  3. Inattn increasing w/age 18%
  4. Inattn decreasing w/age 19%

(Pingault, et al, 2011)
Results of Different Trajectories

- Kids w/ highest levels of tchr-reported inattention in grades K-12
- Had higher rate of no diploma
- 71% hadn't earned diploma by 23 yo
- Only 12% of kids w/ lower tchr-reported inattention had no diploma by 23 yo

TE Brown, Yale Medical School, 2013

Cortex Maturation in ADHD vs NC

- MRI studies of 40K cortex sites in 223 youths with ADHD vs matched controls
- Brain maturation was delayed ~3yrs in specific regions in ADHD youths vs NC
- Frontal areas of cortex slower in ADHD
- Medial PFC developed lagged 5 yrs

(Shaw, et al. PNAS, Nov. 2007)

The Brain Matures Later in ADHD

Shaw et al. (2007) PNAS
Is ADHD Brain Wired Differently?

- New model shifts focus from regional brain abnormalities to dysfunction in distributed network organization.
- DTI shows converging evidence for white matter pathology & disrupted anatomical connectivity in ADHD
  
  (Konrad & Eichoff, Human Brain Mapping, 2010)

TE Brown, Yale Medical School, 2013

Structural & Functional Connectivity in ADHD

- fMRI and DTI (diffusion tensor imaging) show connectivity between brain regions is impaired in ADHD
- Shown in default mode network at rest and in failure to attenuate DMN during active task performance
- Overall white matter volume is reduced in children & adolescents with ADHD
  
  Konrad & Eichhoff (2010); Nagel, Bathula, Herling, et al, (2011)

TE Brown, Yale Medical School, 2013

Meta-Analysis of 55 fMRI studies of ADHD Children & Adults vs Controls (Cortese, Castellanos, et al, 2012)

- ADHD involves dysfunctions in multiple large scale brain networks
- Mostly hypoactivation in control networks
- Also hyperactivation in default & visual circuits
- Inconsistency in ADHD results from faulty inter-regulation between networks

TE Brown, Yale Medical School, 2013
Chemical Dynamics of Brain also contribute to impairments of ADHD

- Not due to overall “imbalance of chemicals” (not too much/too little salt in soup)
- But to inadequate release and/or reloading of transmitter chemicals in countless infinitesimal network junctions
- Except for “messages” re priority interests or fear of imminent unpleasantness

3. The Mystery of ADHD: Situational Variability of Symptoms

- Why focus for this, but not that? “If it really interests me” (attraction)
- Why focus then, but not now? “If I feel the gun to my head” (fear)

2 hypotheses re: motivation in ADHD

“Willpower” vs Erectile Dysfunction of the Mind
How does the brain determine motivation to ignore or attend, to do or not do now?

- Motivation is not a unified variable; it is not just “gas in the tank.” It is idiosyncratic and specific to particular tasks and settings.

- Each perception, thought, or task is instantly screened by the brain’s “google search” that pulls up relevant, unconscious memories throughout cortex; these compete to activate approach, avoidance and/or disinterest.

Cognition & Emotion are Integrated in learning history of each individual

“Emotion and cognition cannot be dissociated in the brain…affective significance determines how the amygdala helps separate the significant from the mundane.”

( L. Pessoa, 2013)

“All information processing is emotional…emotion is the energy level that drives, organizes, amplifies and attenuates cognitive activity.”

(K. Dodge, 1991)

How does the brain “google” to choose responses to thoughts or tasks?

- “amygdala contributes as much to positive reinforcement as to negative” (E. Murray, 2009)

- “Amygdalar neurons help track gradations of both positive and negative value moment to moment” *

- Basolateral amygdala integrates info re: response cost, incentive valence & prior learning history to guide decisions re action*

*( L. Pessoa, 2013)
Amygdala is a major hub for connecting perceptions, thoughts, images to rest of the cortex.

- Amygdala outputs to 64 of 72 regions in cortex.
- More recent studies show 1K separate cortical & subcortical pathways.

Amygdala's "googling" is filtered for context

- Amygdala responses are strongly context dependent

- Amygdala flexibly integrates stimulus valence with current goals, motivations, and contextual demands.


Context Matters!

Where we are and who we're with shapes which of our emotions are most intense in the moment:

A clinical example:

"Would you like a cookie?"

TE Brown, Ph.D., Yale Medical School
Emotions May Shift as Context Shifts

- A student who works hard to get every term paper in on time may suddenly not care about a paper because his girlfriend broke up with him and is dating someone else.

- A student whose interest in completing papers is generally lukewarm may suddenly intensify interest and work hard on paper so he can maintain eligibility to stay on his team.

Theresa E. Brown, Ph.D., Yale Medical School

Motivational Output

- The rapid-fire calculus of the amygdala and related networks sorts competing priorities emergent from the individual's learning history to mobilize, shape or defer action.

- Output from the amygdala reaching multiple brain regions quickly alters functional connectivity that activates (or doesn't) both body and brain.

Theresa E. Brown, Ph.D., Yale Medical School

Chemistry of Motivation in ADHD

- Dysfunction of dopamine reward pathway has been associated with motivation deficit in ADHD (Volkow, 2009, 2010)

- Yet dysfunction of dopamine reward system is not unitary or constant in ADHD; it is dynamic and situationally specific

- Motivation deficit in ADHD may be linked to ADHD impairments of working memory & constriction of focus

Theresa E. Brown, Ph.D., Yale Medical School
How and why do those with ADHD have more problems with motivation?

Children & adults with ADHD experience similar emotions to others of similar age. Yet they have more difficulty in:
- recognizing,
- responding to,
- and managing their emotions
This causes impairments in motivation.

Mike
21 year-old university student

“My Dad always said I’m smart, but just lazy; maybe he’s right. I got put on academic probation, now I have to drop out. I’m always spacing out and can’t get started on anything until the last minute. I tried my friend’s ADHD med; it helped a lot, but my dad doesn’t want me evaluated for ADHD; he says meds are like steroids.

Mike

- Social anxiety
- Family skepticism
- Possible Selves
- Hidden concerns
- Sexuality
- Unacknowledged burdens
Sarah
50 year-old homemaker & mother

“I’ve been married 25 years, have 3 great kids, and had a decent career as a journalist, but I just got fired because I couldn’t prioritize and keep up with my work. Since menopause I’ve had trouble keeping track of things and getting work done. It’s been getting worse. I’m scared I may be getting Alzheimer’s.”

TE Brown, Yale Medical School, 2013

Sarah

- Empty nest & re-entry to job
- Fears of dementia
- Estrogen and executive functions
- Demoralization
- Medications

Problems with Emotions in ADHD: brakes & ignition

- Much discussion about problems of emotion in ADHD focuses solely on putting the brakes on excessive expression of anger/frustration (Barkley & Fischer, 2010; Spencer, Vanseveren, Sumner, et al., 2011; Shaw, Stringaris, Nigg & Leibenluft, 2014)

- But many with ADHD have greater difficulty with ignition—getting started on doing things they need to do, keeping other relevant goals in mind (Brown, 2013)

TE Brown, Ph.D., Yale Medical School
Emotions: A missing piece in ADHD

- Problems with emotions are not explicitly included in DSM diagnostic criteria for ADHD
- Yet emotions—positive and negative—play a critical role in:
  - prioritizing and getting started on tasks
  - sustaining or shifting interest/effort
  - holding thoughts in active memory
  - choosing to engage in or avoid tasks/situations

Diagnostic Boundaries between ADHD & other disorders involving emotions?

- Many deficits of ADHD are shared with other disorders and some differences between ADHD and other disorders may be quantitative rather than qualitative
  (Banaschewski, et al, 2005)
- e.g. "irritability" can be differentiated between ADHD and bipolar
  ADHD (+)
  depression (++)
  bipolar (+++)
  (Mick, et al, 2005)

How ADHD can affect emotions:

Reactions to small frustrations or transient wishes can gobble up all the space in your mind—like a computer virus
- frustration/anger
- hurt feelings
- "got to have it now"
- "what if?"
- Emotional flooding: too much of one emotion
**Flooding with one emotion**

While flooded with one emotion, persons with ADHD tend to forget about other relevant facts or emotions. They may forget their love & wish to protect the person—friend, parent, child, co-worker who frustrated or angered them and say or do things that are too hurtful.

TE Brown, Ph.D., Yale Medical School

---

**Too Little Emotion**

Some with ADHD report that they have too little emotion for tasks that are actually important to them; they can’t get started! Usually this involves getting stuck in the concerns of the moment and not responding to the bigger picture, the longer term.

TE Brown, Ph.D., Yale Medical School

---

**Examples of Too Little Emotion for the Bigger Picture**

- Tired when waking up, snooze alarm repeats while forgetting recent warning from boss
- Impulsive purchase using funds needed for an important upcoming expense

TE Brown, Ph.D., Yale Medical School
**ADHD “Hyperfocus” can bias and impair motivation**

Focused too intensely on one goal or task, you may forget other goals you have or how actions of the moment may affect your bigger picture. Like one who is watching a basketball game through a telescope, you may miss other relevant aspects of the situation.

---

**ADHD Working Memory Impairments can bias and impair motivation**

- Is important for holding in mind multiple thoughts and emotions, relevant to any specific situation or task.
- Impairment in working memory is a key aspect of ADHD.
- Often people with ADHD are unable to keep multiple emotions in mind at the same time so they can prioritize.

---

**Stimulant Medications Used for ADHD may help modulate emotion**


---

Thomas E. Brown, Ph.D., Yale Medical School
New Understandings of ADHD & Emotions

Strategies to Manage Too Little and Too Much Emotion

- Try to anticipate vulnerable situations
- Consider medication coverage times
- Utilize less stressful times & contexts
- Use tools to refresh bigger picture
- Elicit support from others
- Recognize inevitability of some lapses

Key Points

1. Essential problem in ADHD is developmental impairment of EF
2. Brain differences that underlie ADHD include delay in maturation of some EF areas, disrupted regional communications and inconsistent neuronal communication.
3. Those with ADHD often have chronic difficulties with motivation in many, but not all situations

Key Points

4. Chemistry of motivation is modulated by complex processes resulting from amygdalar integration of idiosyncratic emotion-laden memories embedded in perceptions and various cognitive networks
5. Working memory & focusing impairments characteristic of ADHD may impair motivation by causing emotional flooding or constricted focus
**Implications**

- ADHD assessments should inquire about domains where patients are well-motivated as well as those areas where they have difficulty.
- Recognize that ADHD medications alone do not force patients into doing any specific tasks.
- If usual interventions are not working, explore conflicting, possibly unrecognized motives which may be impeding problem resolution.
- For some, psychotherapeutic consideration of conflicting motives may facilitate resolution.

TE Brown, Ph.D., Yale Medical School

**Books by Thomas E. Brown, Ph.D.**
(www.DrThomasEBrown.com)

- "Smart but Stuck: Emotions in Teens and Adults with ADHD" – 2014
- "A New Understanding of ADHD in Children and Adults: Executive Function Impairments" – 2013
- "Attention Deficit Disorder: The Unfocused Mind in Children and Adults" - 2005