The Adolescent Brain

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Outline

1. The adolescent brain in the context of adolescent development
2. New insights from medical imaging
3. Brain-behavior associations and opportunities
4. New challenges for the adolescent brain
Take home points

- The adolescent brain is not a defective adult brain
- Adolescence, and adolescent brain development, is a process
- Many behaviors we associate with adolescents are part of that process
- Modern society presents new challenges for the adolescent brain
The adolescent brain in the context of adolescent development
Adolescent Development

• Adolescence has been described as a period of extreme instability or “normal psychosis”
• 80% of adolescents cope well with process
  – 30% easy and continual
  – 40% some stressful periods with calm periods
  – 30% very tumultuous development
Adolescent Development

- Biological, social, emotional, intellectual growth may be totally asynchronous
  - Tanner stages: I-V
  - Adolescent stages: Early, middle, late
  - Ages
  - School segmentation: Middle, high, college
Tasks of Adolescence

1. Assigning increased importance to *body image* and acceptance of one’s body
2. Achieve *independence* from parents
3. Adopt *peer* codes and lifestyle
4. Establishing sexual, ego, vocational and moral *identities*

*The adolescent brain is key for all of these tasks*
Stages of adolescent development

• Early:
  – Begins with puberty
  – Ends around age 14

• Middle:
  – Begins around age 15 (entering high school)
  – Ends at conclusion of high school (around age 18)

• Late:
  – Begins around age 18
  – Ends around age 25
Early adolescence

Now you're a TEENAGER, Brad!
Early adolescence

• Biology
  – Puberty onset – rapid physical changes
    • Girls: breast buds, pubic hair development, start of growth spurt
    • Boys: 1-2 years after girls, testicular and penile growth, pubic hair
Early adolescence

- Independence-Dependence struggle
  - Less interest in parental/family activities
  - Less inclined to accept parental advice or criticism
Early adolescence

• Peer Group Involvement
  – Best friend
  – “Mean girls”
Early adolescence

- **Concrete Operational:**
  - Ages 7 to 11
    - Thought is logical, flexible, organized
      - but only when dealing with concrete information they can directly perceive
    - Can operate on reality
Early adolescence

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- **Formal Operational:**
  - Age 11 and older
    - Capable of abstract thought
      - Capable of deductive reasoning
        - Start with a theory
        - Test hypotheses to see which work in the real world
Clinical correlates

• Assess patient’s ability to reason abstractly

• Example of concrete thinking:
  – MD: “How did you sleep last night?”
  – Patient: “On my back.”
Early adolescence

- Identity Development
  - Abstract thinking usually begins internally leading to increased self-interest and fantasy
  - Vocational goals may a bit fantastic
  - Need for greater privacy
  - Journals, diaries
Middle adolescence
Middle adolescence

• Biology
  – Puberty changes rapidly occurring
    • Boys: many reaching peak height velocity, changes in skin and voice, some can grow facial hair
    • Girls: breasts are now nearly fully developed, menarche begins
Middle adolescence

• **Body Image Concerns**
  – Most females have finished majority of pubertal changes
  – More time spent on making body more attractive
    • Clothes, jewelry, makeup more important
  – Eating disorders may be established during this stage
Middle adolescence

- Independence-Dependence Struggle
  - Conflicts more prevalent
  - More time to peers, less to parents
Middle adolescence

- Peer Group Involvement
  - Intense involvement in peer subculture
  - Conformity with peer values, codes, dress
  - Increased involvement in dating
Middle adolescence

- Identity Development
  - Less idealistic vocational interests
    - May lead to self-esteem issues or depression
  - Feeling of omnipotence and immortality
    - MVAs, suicide, drug use, pregnancy, STDs
Late Adolescence
Late Adolescence

- Biology
  - Puberty finishing or complete
Late Adolescence

• Body Image Concerns
  – Typically accepting of body
  – May have found own style of dress, hair, jewelry
Late Adolescence

• “Emergent adults”
• Independence-Dependence Struggle
  – Better able to think ideas through and express them
  – Parents are “cool” again
Late Adolescence

• Peer Group Involvement
  – More comfortable with own values and identity
  – Selection of partner more based on understanding and enjoyment than peer acceptance
Late Adolescence

• Identity Development
  – Better able to delay, compromise, set limits
  – Practical vocational goals
  – Further refinement of moral, religious, sexual values
New insights from medical imaging
Adolescent development

- Change
- Process
- Transition
Brain volume increase driven by change in environment
Data Base (1991-present)

- Longitudinal Assessment (~ 2 year intervals)
  - Imaging (fMRI)
  - Neuropsychological / Clinical

- 8000+ Scans from 3000+ Subjects
  - 25 Clinical Populations
    - Including: ADHD, Autism Spectrum, Bipolar Disorder, Depression, OCD,

Thank you to Dr Jay Giedd, NIH
The Neuron

- Dendrites
- Cell body (the cell’s life support center)
- Axon
- Terminal branches of axon
- Myelin sheath

Neuronal Impulse

Donald Bliss, MAPB, Medical Illustration
New insights into the adolescent brain

- White Matter
- Gray Matter
White Matter

Male (152 scans from 90 subjects)
Female (91 scans from 55 subjects)
95% Confidence Intervals
Myelin $\rightarrow$ Increased Speed

Signal “hops” between nodes of Ranvier
More than just maximizing speed ...

• Synchrony
• Integration
Things are connected

• Temporally coupled developmental trajectories
  → fire together → wire together → grow together?
  → Seen on EEG and fMRI
New insights into the adolescent brain

• White Matter
• Gray Matter
Gray Matter Development in Healthy Children & Adolescents
(1412 Scans from 540 Subjects)

Frontal Lobe Gray Matter

Volume in ml

Age in years
Gray Matter Thickness:
Up to 25 years
Prefrontal Cortex

- “Executive” functions
  - Long term strategy
  - Planning
  - Organization
  - Impulse control
- Integrates input from rest of the brain
Many questions remain

• What influences the process?
  • Parenting
  • Medications
  • Diet
  • Video games
White Matter vs Gray Matter

White Matter
– Linear increase
– Not different by region

Gray Matter
– Inverted “U”
– Regionally specific
Summary of anatomic MRI of the brain during typical pediatric development

- White Matter Increase (Myelination)
- Inverted U Gray Matter (Synaptic Pruning?)
- Relatively late maturation of:
  - Prefrontal Cortex
Summary of functional MRI of the brain during typical pediatric development

- Increased integration of widely distributed brain circuitry
  - More efficient neuronal processing?
Brain-behavior associations and opportunities
What are risky teen behaviors?

- Substance use
- Sexual behavior
- Aggression
- Conflicts with parents
Correlations between adolescent brain development and behavior

- Increased risk taking → Increased experiences to grow from
- Greater peer affiliation → Facilitate separation from natal family
- Evolutionary advantages?
Risks for psychopathology during adolescence

Typical behavior changes
↑ Risk taking
↑ Novelty seeking
↑ Social priorities

Depression
Hormonally mediated limbic effects preceding maturation of cognitive-regulatory system

Substance Abuse
↓ Sensitivity to hangover, sedation, and motor impairment
↑ Hippocampal vulnerability
How can we approach adolescent behavior as a developmental process?

- Policy
- Clinicians
Policy

CONTROL

Licensing

Just say no..

PERMISSIVE

They can’t help it

PROTECT
Driving policy

• Graduated driving laws
  – Adjust as teens go through further developmental stages
Alcohol policy

• Should alcohol laws change?
Clinical

• Communication as a tool
• Ask questions without judgment
• Allow the adolescent to be part of the plan
• Focus on teen’s strengths (not deficits)
Communication

- Motivational interviewing
  - What do you think about [this behavior]? 
  - What are the benefits of [this behavior]?
  - What do you think you’d like to do to change?
  - What are the barriers to this change?
  - How can we overcome them?
<table>
<thead>
<tr>
<th>Neuroscience findings</th>
<th>Response</th>
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<tbody>
<tr>
<td>Immature Abstract thinking</td>
<td>Understand exploratory behaviors</td>
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| Social brain – vulnerability to peers                       | • Plan for failures with peers  
• Peer mentoring                                                      |
| Sensation seeking – risky behavior with peers               | Graduated licensing                                                      |
| Immature ability to understanding of others and self        | • Education and communication needs to be appropriate for cognitive states  
• Motivational and solution-focused approaches                  |
| Heightened threat perception                                | Sensitive to professional faces / behaviour                              |

Thank you to Russ Viner, PhD
What kills teens?

- Accidents (MVA)
- Homicide
- Suicide

ALL ARE PREVENTABLE DEATHS

You can help prevent them
You CAN make a difference

• If you can connect with a teen you may make a huge impact

• “I hated my teenage years, I hated everyone. I remember I had two adults that I trusted, one was my English teacher, the other was my pediatrician. Without their support and influence, I don’t know how I would have made it.”
  – Matt, former patient, reflecting on teen years
New challenges for the adolescent brain
A modern media society

• Today’s adolescents are growing up in a media-saturated society
• This generation has been called “digital natives”
• No longer a balance of “real life” and online time
  – “My online life IS my real life!”
A modern media society

- Vast majority of teens have internet access, most go online every day
- Over 75% of younger and middle teens use social media, among older adolescents the estimates are over 90%
- Many teens access via smartphones multiple times per day
A modern media society

• **Benefits** to new media
  – Exposure to new ideas, people and cultures
  – Opportunities for civic engagement
  – Able to maintain relationships across distance
A modern media society

• Risks to new media
  – Exposure to inappropriate ideas and people
  – Opportunities for risky behavior
  – Difficult to sever negative relationships
Two new media concerns

• Multitasking
• Problematic internet use
Multitasking

- In a study using experience sampling method, a sample of older adolescents received text messages at random intervals over one week.

Multitasking

• In each text, they were asked:
  – Are you online now?
  – If so, how long have you been online?
  – What are you doing online?

• They were also asked to estimate their own internet use
Multitasking

• Results
  – Consistent overestimation of time online
  – Frequent multitasking
Multitasking

• Results
  – Consistent overestimation of time online
  – Frequent multitasking: 56.5% of time online participants reported more than one internet activity
Figure 1 Cluster Dendrogram of Internet Use Activities
Multitasking

• Bad?
  – Does multitasking impeded adolescents’ ability to track time online?
  – Some studies show decreased concentration among adolescents who multitask
  – Time spent on IM while doing homework has been associated with lower test scores
Multitasking

• New normal?
  – Some studies have shown that physicians spend up to 16% of their days multitasking
  – Is multitasking part of our modern strategies to complete necessary tasks in a single work day?
Problematic internet use

- A new public health concern
- Early definitions used term “internet addiction” and considered this similar to gambling or substance use addictions
- Many different measurement scales
- Prevalence rates as high as 25%
Problematic internet use

- One study asked older adolescents and health care providers to give symptoms of PIU
- They sorted the symptoms into categories
- The symptoms and categories were used to make a map
Problematic internet use

• Next steps:
  – How to measure?
  – How to treat?
Modern media society and the adolescent brain

• Brain development associated with new experiences and exposures
  – Do media exposures promote brain development?
  – How do they compare to offline exposures?

• Will media multitasking impact the patterns in which white matter develop?

• Does PIU have potential for addictive responses in the brain similar to substance use?
Review

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