How the brain works, how it develops, what can go wrong and how to improve your brain health

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What you will learn in this session

- How the brain works
- How the brain changes, especially around adolescence.
- What happens when the brain does not function right: sicknesses of brain and mind
- How can we keep our brain and mind in good health
1. Your brain, and how it works.
The brain is a jell-O like organ inside the skull, with billions of nerve cells (neurons), making trillions of connections (or synapses).
Nerve cells, or neurons are like cables transmitting messages.

The nerve cell (or neuron)

Dendrites (input, the keyboard)

Cell body (Processing, the chip)

Axon (Transmit cables)

Axon terminals (output, the monitor)
Nerve cells communicate by chemical messengers (neurotransmitters). Messages are transmitted between nerve cells by chemical signals (neurotransmitters) released at the synapses, or gaps between cells.
What brain region is involved in this task?

N- Back Test

Press when you see the number (n) 2 digits ago

WORKING MEMORY
The frontal cortex is the central Processor, or “CEO” of the brain. It is responsible for planning, strategizing and using judgement. This part of the brain has a growth burst in childhood followed by reorganizing and pruning during teenage years.

Where did Phineas Gage’s crowbar enter the brain?
Where did Phineas Gage’s crowbar enter the brain?
Did you have a STROOPs! Effect?

Healthy persons activate Anterior cingulate when they Detect errors

Selective ATTENTION
Cingulate, the error monitor
The amygdala regulates emotion. It is involved in recalling the emotional aspects of specific memories. Brain imaging studies show that this part of the brain is overactive when a person is having an excessive emotional response to stress, such as real, or imagined danger.

Which part of the brain is in an overdrive here?
Which brain region might not have functioned in the famous patient H. M. and the movie Memento?

The hippocampus (Sea horse) is the “Hard Drive” in the brain. This part of the brain is particularly sensitive to stress. When it’s not functioning, that could lead to memory and thinking difficulties.
How memory works
Who is this person?
What brain region is underactive in Michael J Fox and may be overactive in Samuel Jackson and Howard Hughes?
2. How the brain changes, especially around adolescence.
What about adolescence?

“At your age, Tommy, a boy’s body goes through changes that are not always easy to understand.”
The brain begins development soon after conception, and looks like a complete brain by the time you are born...

How much does the brain grow after that?
Cognition

Social cognition

Which of these might the teenagers/ young adults be better at? And why?
1. Brain **anatomical** changes during adolescence.
Which are the last parts of the brain to mature?

Dorsolateral Prefrontal cortex

Superior temporal cortex

Temporo-Parietal junction

The Social brain.
Does the brain grow further as you develop into your teenage And youth?
Systems that come “on-line” during adolescence

EMERGENCE OF
• Executive function
• Affect regulation
• Stress response

MEDIATED BY
• Increasing efficiency, reduced redundancy
• Cognitive control, increasing connectivity
• Hormonal systems
Stages of brain development

- **Neurogenesis**
  - 1st se.
  - 2nd se.
  - 3rd se.
  - 20s
  - 30s

- **Neural differentiation**

- **Neural migration**

- **Synaptogenesis**

- **Synaptic pruning**

- **Myelination and network differentiation**

**Prenatal**

**Postnatal**
Excitatory (Glutamatergic) neurons

Synapse density

Cortex

Midbrain

Pyr
Diminishing redundancy (plasticity) but increasing efficiency
Prefrontal cortex is the last to mature
2. Changes in brain function: Emergence of neural connectivity

N. Dosenbach et al.. Science. Vol. 329, September 10, 2010,
3. Development of **neurochemical** regulatory pathways during childhood and adolescence

Melchitsky and Lewis 2004; Rosenberg and Lewis 1995; Insel 2010
4. Maturation of **Stress response systems** during adolescence
Hormones, stress and adolescence

McEwan et al

Stress may be a double edged sword
Brain development in childhood and adolescence: Summary

- **Structure:** Emergence of abstract thinking and executive function related to plasticity changes of diminishing redundancy but increasing efficiency

- **Function:** Emergence of Cognitive control and emotion regulation are related to integration of network connectivity

- **Neurochemical:** Integration and fine-tuning of excitatory and inhibitory systems

- **Hormonal:** Emerging ability to coping with stress is related to regulation of HPA axis by higher cortical cognitive control
3. Why teenagers are at high risk for the onset of emotional difficulties.
As the brain develops, the nerve cell networks become more efficient and more streamlined by the elimination of unnecessary connections. This process is called “pruning”, and happens during teenage years.
Where in the brain might the abnormalities be
In adolescent psychiatric disorders?

- Temporal lobe
- Frontal lobe

Reality distortion

Decreased cognition and goal directed behavior
One neurotransmitter, for example, is dopamine (above). An imbalance of this neurotransmitter can cause brain diseases such as Parkinson’s disease (too little dopamine) and schizophrenia (too much dopamine).
Dopamine Theory of Schizophrenia

- Too much dopamine in lower brain regions → Positive symptoms
- Too little dopamine in higher brain regions → Negative symptoms

Normal
Why does the illness develop? Genetic factors are the best known causes.
Several, not one possible genes in schizophrenia
And bipolar disorder

RGS4

NRG1

Neuregulin

A-7 nicotinic Receptor gene

COMT
What is psychosis?

This refers to a state of mind when a person has difficulty in understanding the differences between beliefs and experiences which are real versus those that are not real. Usually, these difficulties are due a difficulty in how the brain functions.

The causes for psychotic symptoms are many.
4. How you can keep your brain and mind fit and healthy.
Knowing more about the brain and its disorders can help prevent many problems in the future.
Avoid too much stress.

Too much stress is bad for the brain and may cause symptoms such as anxiety, depression and confused thoughts.

Stress and the brain
Addiction is a Developmental Disease: It Starts Early

Cannabis consumption at age 18 and later risk of schizophrenia

- Child: <12, 1.5%
- Teen: 12-17, 67%
- Young Adult: 18-25, 26%
- Adult: >25, 5.5%
Be aware of the effects of too much stress.

Depression
Anxiety
Not sleeping
Confused thoughts
Difficulty to concentrate
Falling grades
Anger and irritability
Not being able to trust people

etc.
The brain develops (and preserves) better the more you make it intellectually (reading, solving problems). The simple rule about nerve cells is, “use it, or lose it!”
Brain is like a muscle!

Physical exercise as well as
Brain exercise can build and
Protect the brain
Wear your seat belt! Wear helmets

Head injuries can make it more likely to develop psychiatric disorders.

Get enough sleep!

Sleep loss may trigger the beginning of more serious psychiatric symptoms.
How to maintain good Brain health?

Stay away from illegal drugs!

Drugs damage the brain—no question about that. Although damage done by some drugs can be reversed, some drugs may change brain function permanently. Why take the chance?

Eat right!

Your brain needs energy to work its best.
The brain needs proper nutrition for its development.
Antioxidants, which remove toxic compounds accumulating in the body, may protect the brain.

Researchers at MMHC are studying the efficacy of N-acetyl aspartate, an antioxidant in the treatment of schizophrenia.
Diets rich in omega-3 fatty acids may protect the brain.

- Researchers at MMHC are studying the efficacy of omega 3 fatty acids in preventing psychosis.
Take home points

- Profound brain changes happen during adolescence.
- Adolescence is a period of high risk for psychiatric disorders.
- Knowledge about the brain and its development in health and those at risk, and brain “maintenance” can help in prevention of emotional disorders.