Discoveries in the Adolescent Brain
Implications for Teaching & Learning

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Modern Understanding Started With An Accident
Phineas Gage
The Brain is the most complex system in the universe
Cognitive Neuroscience

Neuroeducation
Learning In the Brain

Attention + Patterns

Emotion

Working Memory

Long-Term Memory
The Context:

How The Brain Grows
Brain Grows at the Cell Level
Neurons Grow More Connections
Use it or Lose it
Pruning & Growing Dendritic Spines
Some knowledge about the brain is becoming common
Cycles in Cognitive Development

- Single Abstractions
- Abstractions linked
- Multiple Abstractions linked into systems
- Principles
- Direct teacher support
- Low Support
- High Support
- Optimal Level
- Functional Level
- Independent or little support

Skill Level:
- 8
- 12
- 16
- 20
- 24
- 28

Age in Years

Kurt Fischer 2008
Cycles of Brain Growth

• 3 Cycles during adolescence, NOT STAGES
• 10-12 Years (middle school)
• **14-16 Years (Frosh-Soph)**
• **18-20 Years (Seniors +)**
• Cycles have chaos-fractal patterns

(From K. Fischer, 2000)
Inhibitory Controls Among Last to Mature:
• Implusivity
• Distractibility
• Higher Reasoning-Logic
Adolescence:
(not yet fully adult brain)

Age 10-11 to 25/30 years

• Have difficulty recognizing patterns
• Less impulse control
• Less planning/anticipating consequences
• Less emotional control
Errors with emotional valence & salience, BDNF probably generated
Use It or Lose It

Under Stimulated Neuron

A neuron that has been “used” or Stimulated
Implications

• Trained teachers elicit higher performances
• Computers aren’t able to “read” the person
• No errors = little or no learning
• w/ea new skill, performance initially drops

OLD School

Non-expert trainers (just as patient is not a expert just because they’ve experienced medicine, a parent is not an expert just because they drive)
Few controlled mistakes?
Attention + Patterns

Learning
In the Brain

Working Memory

Emotion

Long-Term Memory
We process information to find Patterns
Patterns

• Some have Emotional Significance
• Certain Patterns Change our Attention
Patterns → Recognition → Attention
Implications

• Students must first recognize patterns
• Brain recognizes *large* differences first, then smaller ones... (The snake body easier to spot than head)
• Suggests teaching subtleties *after* teaching initial large differences.

OLD School:
• We did not directly and repeatedly work on pattern recognition
• Students became confused trying to recognize small differences
Emotions

- Powerful learning tool
- Experiences are emotion laden
- *Rarely forgotten when there are personal consequences*
Emotions Affect Learning

If it’s emotionally important, the brain pays attention
Incomplete Frontal Lobe Development In A Group

- What happens to judgment?
- What happens to anticipating how *others* will feel?
- What happens to anticipating how *they* will feel?
Implications

- Learning events with high personal *significance* are better remembered (High valence and salience)
- Learning events with personal *consequence* are better remembered*
- Suggests actual practice (simulated or closed course learning with errors..) better remembered

Old School

We talked, but students did not *experience*

They did not experience significant failure in controlled conditions

*There is a genetic deficit for about 30% of drivers;
Their Perception Is Their Reality

*Perception* of threat
affects the ability to THINK & LEARN
In effect, all animals are under stringent selection pressure to be as stupid as they can get away with.

Richerson & Boyd,
Not By Genes Alone, 2005.

The default state in solving a problem is to do as little as possible.
Brain in default state
Attention

Applied Cognitive Laboratory
University of Utah: David Strayer PI
Attention

• Mirror Systems & Modeling
• Divided Attention
• Limited Capacity (with Working Memory)
• It is NOT a matter of learning styles (EX. visual learner vs. auditory learner is a neuromyth*)

*Pashler, et al 2010 in press
Attention

Multitasking Effectively is a *Myth*
Divided Attention

• Attention Systems are limited: What is it, Where is it?
A Demonstration: Attention Interference

• What did you see?
• What happens when there is a distraction?
• What does that suggest about distracting a driver?
Implications

- The brain doesn’t multitask (This applies to instruction as well as driving)
- The brain pays attention to modeling (both good & bad)
- Interspersed learning better than blocks of concentrated learning
- Weave between classroom-simulation-field

OLD School

Taking notes & listening
Blocks of classroom-simulation, followed by field experience
No field experience until well after “lecture”
Working Memory

- It is what your are thinking about RIGHT NOW!
Attention + Emotions

Working Memory
What you are Focused on Right Now
(1 item only)

Long-Term Memory

Cowan, 2005
3-4 Items Activated, Readily Accessible

Working Memory

1 Item Focused Upon
Mental Reserves

- 1 task 100% max available

- 2 tasks 50% max available for each task
2 Tasks

• Each task needs 1 hemisphere
• 3rd task?
Mental Reserves

• 3 tasks 33% for each?
• Some tasks need more mental reserve, Ex. Driving, finding buttons, reading text
3 Tasks

- No hemisphere/brain available
- Performance drops precipitously

Charron & Koechlin, 2010
Ophir, Nass, & Wagner, 2009
Decision Making:

Combines

Emotion + Attention + Memory
Decision Making

New Information

Working Memory

Compared to LTM

- Info. Inconsistent w/LTM info.
  - Information Rejected or Inhibited

- Info. Consistent w/LTM
  - Information Accepted

Decision Making

• We THINK we’re are making a conscious choice
• But the mind has already decided
• 1\textsuperscript{st} Decision is made non-consciously
• 2\textsuperscript{nd} Then we are consciously “let in on it”
• How do we train for this?
• Train for BOTH non-conscious & conscious levels
Decision Making

New Information

Working Memory

Compared to LTM

Info. Inconsistent w/LTM info.

Information Rejected or Inhibited

Info. Consistent w/LTM

Information Accepted
Implications

- WM easily overloaded
- WM can be trained to have more information readily available (Cogmeg®)
- **Skills moved up to automaticity** frees more Working Memory & more Attention Reserves for processing current information
- Genetic deficits interfere, but may possibly be trained around
- Vigilance may last only 10-30 minutes... More accidents?

Old School

Lots of information, few or no pauses,
Passive initial learning (student is the “receiver” of information)
Students play catch up
Long-Term Memory

Stabilizes in about 10-14 days
Long-Term Memory

• Memory stabilizes after about 10-14 days\textsuperscript{1}
• Distributed Practice Effect, Practice events further apart are harder, but produce longer lasting memory\textsuperscript{2}
• Test Effect, Repeated Practice under real conditions is better than only a few real practices.\textsuperscript{3}
• Suggests Behind the Wheel in subtle-threshold conditions can be very important

\textsuperscript{1} Schenck, J. (2003)
\textsuperscript{3} Roediger, H.L., & Karpicke, J. D. (2006).
Implications

• Experiential learning better remembered than classroom lecture
• Practices/tests spaced
• ACTION + creates BDNF & strong memories

Old School

Testing typically within a day or two of classroom lecture
Assessments lacked authentic/simulated conditions
BDNF (Brain Derived NeuroFactor) promotes dendrite growth & connections,

Generated by experience & physical activity
Genetic Issues

- 30% may be have a mutation reduces/prevents traditional experiential learning* (Clearly procedural memories are made—why the difference in procedural memory?)
- Apparently several possible procedural memories
- Alternative training may be needed, possibly different developmental learning curve
- RNA silencing protein? Dopamine role?

Considerations

• Trained teachers elicit higher performances
• No errors = little or no learning
• w/ea new skill, performance initially drops
• directly and repeatedly work on pattern recognition
• Students become confused trying to recognize small differences
• Brain recognizes large differences first, then smaller ones...
• Suggests teaching subtleties after initial large differences.
• Learning events with high personal significance are better remembered (High valence and salience)
• Learning events with personal consequence are better remembered*
• Suggests actual practice (simulated or closed course learning with errors... are better remembered
• The brain doesn’t multitask (This applies to instruction as well as driving)
• The brain pays attention to modeling (both good & bad)
• Interspersed learning better than blocks of concentrated learning
• Weave between classroom-simulation-field
• Train for BOTH non-conscious & conscious levels (automaticity)
• WM easily overloaded
• WM can be trained to have more information readily available (Cogmed®)
• Neuroerognomics of attention & vigilance
• Vigilance may be trained? Monitor with Doppler Sonography—TDS Transcranial Doppler Sonography- portable
• Experiential learning better remembered than classroom lecture
• Practices/tests spaced
• ACTION + creates BDNF & strong memories
• 30% with genetic variation reduces experiential learning, possible alternative training needed
References


• Parasuraman, R., & Rizz, M., Neuroergonomics: The brain at work, Vol. 195177614


