The Neurobiology Of Learning

John W. Pelley, PhD
john.pelley@ttuhsc.edu
www.ttuhsc.edu/SOM/success/
“The purpose of an educational institution is to lead the students, who initially believe the educational institution is there to educate them, to the realization that they must educate themselves.”

“They must ...learn how to learn [integratively]...”

From Willis Hurst, MD, Medscape [and Pelley]
Main Points Today

1. Students need to transform themselves from receiver role to producer role.
   - Receiving information vs producing understanding
   - Transformation: not demanded, but taught

2. Deliberate practice produces expert learning skills.
   - Responsibility for learning lies with student.
   - Learning skills are identical to clinical skills.

3. The brain is wired to predispose thinking/learning “styles.”
   - Learning style is an insight for Deliberate Practice
   - Growth Mindset requires knowing how the brain works.
Your Thalamus Distributes My Biochemistry Lectures To Your Cerebral Hemispheres

Thalamus volume setting is high or low (gain control)
Low Gain vs. High Gain

• Talk it out – “low gain” thalamic activity; seeking more input; more active
  – Extraversion; low arousal level – too quiet
  – Lower cerebral blood flow, augmentation of “evoked response,” lower doses of sedatives

• Think it through – “high gain” thalamic activity; reducing input; more reclusive
  – Introversion; high arousal level – too loud
  – Higher cerebral blood flow, reduction of “evoked response,” higher doses of sedatives
Why is it important to know how the brain works?

Answer: It affects “Mindset” – and mindset affects performance

Growth vs Fixed Mindset

Growth mindset
• “You can always change how intelligent you are.”
• Hard work, work smart

Fixed Mindset
• “You have a certain amount of intelligence and you can’t change it.”
• Work should be effortless for smart people.
Mindset Comparison

Fixed Mindset
- Success based on innate ability
- Failure is dreaded, feared.
- Least likely to succeed

Growth Mindset
- Success based on hard work and learning
- Failure is a challenge to adapt.
- Most likely to succeed
Growth Mindset
Through Deliberate Practice

• Designed specifically to improve performance
  – Myth: “Practice makes perfect.”
  – Reality: “Perfect practice makes perfect.”
  – Reality: “Deliberate practice is perfect practice.”

• Deliberate Practice: Practice correcting weaknesses.
  – Deliberate practice requires self-awareness ... and self-acceptance.

• Need to avoid automated behavior
  – Loss of focus and attention, esp. while reading

(K. Anders Erickson, “Deliberate Practice and the Acquisition and Maintenance of Expert Performance in Medicine and Related Domains.” Academic Medicine, 2004;79:October Suppl.70-S81.)
Deliberate Practice Characteristics

• Applied to limitation in skill
• Can be repeated a lot
  – Feedback continuously available
  – Most effective with experienced teacher
• Not work, not play – focused effort; demanding
  – Need to avoid automated behavior
  – Not much fun; motivation critical
• Highly demanding mentally; tiring
• Not aimed at minimum standards
  – Self-actualization is the standard
• 10 years, 10,000 hours – Gladwell, “Outliers”
Myers-Briggs Personality Type – What It Is

- Mental Model; many others also useful
- Normal differences between people
- Persistent tendencies (choices)
  - Do not change once established
  - e.g. Folding your arms, throwing a ball, writing your name
- Comfort zone for thinking; requires less effort than the opposite
  - Use of opposite is a conscious effort
Myers-Briggs Personality Type – What It Isn’t

• Not a measure of intelligence
• Not a “limitation”
• No negative aspects
• No psychopathology
• No stereotype
What Do Those Letters Mean?

- Four dimensions of preferences
  - Extraversion (E) vs. Introversion (I)*
  - Sensing (S) vs. Intuition (N)*
  - Thinking (T)* vs. Feeling (F)
  - Judging (J) vs. Perceiving (P)*

*Pelley’s type
Prefrontal Pause

• Talk for a minute with your neighbor about what your preference might be:
  – Think better with “facts and specifics”
  – Think better with “big picture and connections”

• Try to give an example
Sensing (S) vs. Intuition (N)

• What information do you give the *most* attention to?
• Sensing types give their attention to specifics
• Intuitive types give their attention to the big picture
• Everyone does both, but only *one* is preferred.
  – Use of opposite is deliberate; not automatic
Test Taking Style

• N style
  – First, seek answer that matches poorly memorized knowledge
  – Rule out answer choices
  – Don’t fit pattern
  – Big picture learning establishes patterns

• S style
  – Seek answer that matches memorized knowledge
  – Re-read question to stimulate recall
  – Memorization learning requires recognition
Memorization vs. HOTS

• Memorization
  – Recognition: remembering facts/details and their “organization” (choose the symptoms of heart attack)
  – Preferred by sensing types

• Higher Order Thinking Skills (HOTS)
  – Grouping: “organizing” facts into patterns
  – Comparing: relationships between patterns (list the causes of chest pain)
  – Preferred by intuitive types
Figure 8.3 Comparison of aptitude and achievement of the sixteen types in liberal arts

Integrative Learners

Linear Learners
Can We Change Our Own Brain?
Developing Expert Skills – Transforming The Brain

• How do we change our brains?
• Learning efficiency: What is the “illusion of memory?”
• What does brain anatomy tell us about how we learn?
• Clinical skill areas of the brain
Sleep Helps Us Forget - or, Learn

• Forgetting Can Be A Good Thing
  – Neurologic protection: no cluttering with irrelevant information.

• The brain is designed to forget.
  – New synapses grow during the day.
  – Unneeded synapses pruned overnight; saves energy
  – Valuable synapses strengthened into long term memory (= consolidation)
“Grow Baby, Grow”

Wikimedia Commons the free media repository
To Sleep, Perchance To Replay

- Replay of activity
- Non-dreaming deep sleep
- Emotional only
- Pruning of unimportant experience
- Valuable experience consolidated
Can You Find The Sittin’ And Readin’ Dendritic Tree?

- Control left, long-term potentiated (LTP) cells sensitized right
- Tree of LTP markedly increased (hippocampus “rehearsal”).
- Dendritic trees are “processing power.”
- Prefrontal dendritic growth increases analytic skill.

1. Complete learning cycle
2. Sleep (5 REM cycles)
Experiential Learning Cycle
Achieving Long Term Potentiation

(Kolb, 1984, p.21)

- **What is it? [Recognize]**
  - Experience new information [Sense]
  - Observations and reflections
- **What does it mean? [Integrate]**
  - Formation of abstract concepts and generalizations
- **Can it be used? [Act]**
  - Testing implications of concepts in new situations

Concrete experience
Experiential Learning By The Brain

Thinking Skills
- Abstract hypotheses

Memory Skills
- Reflective observation

Sensory Skills
- Concrete experience

Some Motor Skills
- Active testing

Adapted from Zull, 2002, The Art of Changing the Brain
Clinical Reasoning Skills

- Communication Skills
- Diagnosis Skills
- Basic Science Skills
- H&P Skills
- Past and Present
- Future
Short Circuits

Experiential Learning Cycle
• It is easy to bypass frontal processing
• Frontal processing = decision making + action

Complete Processing
• Concept mapping and question analysis (group study) prevent “short circuits.”

• Short Circuit
  – “Looking at” reading: occipitotemporal activity
  – “Hearing”: parietotemporal activity

• Complete Circuit
  – “Looking for” reading
  – “Listening for” in lecture
  – Increased attention; informed decisions
Neurobiological Effects of Concept Mapping

• First, a look at concept mapping
• Neurobiology of learning with concept maps
• Deliberate Practice and concept maps
How many learning strategies are found in concept mapping?

1. Inspectional (analytical) reading
   - “Looking for”
2. Outlining
3. Paraphrasing
4. Cluster construction
5. Comparing
6. Verbalizing (group or individual)
7. ?
Anatomy Of A Concept Map

• Key terms enclosed in “bubbles”
• Fact = two connected bubbles
• Connections can contain verbs
  – describes concept relationship
• Branch points represent groupings and organization
• Cross-links are comparisons and cause-and-effect; integrative thinking
Example map of water demonstrating the basic components of hierarchical concept maps. Note the cross-link (bold arrow) between the concepts motion and states. Reproduced with permission from Cambridge University Press.\textsuperscript{14}
Overview of Mapping

List – Group – Compare

1. **List** important terms
2. **Group** by major topic
3. **Compare** by drawing cross-links

All three steps require use of Deliberate Practice in reading
Figure 2. Low-Scoring Concept Map

Reproduction of a hand-written concept map of seizures by a first-year resident. Note the absence of cross-links and the consistent use of 2 to 3 levels of hierarchy, resulting in a low score.
Concept Mapping and DP

• One of the following will be harder to do than the others

1. Focus and attention
   – (sensory/temporal/prefrontal)

2. Identifying the grouping terms
   – (prefrontal/temporal)

3. Identifying subtopics
   – (prefrontal/temporal)

4. Organizing relationships
   – (prefrontal/temporal)

5. Drawing the map
   – (prefrontal/motor)
Reproduction of a hand-written concept map of *seizures* by a resident in the second- and third-year group. Note the complexity of the map as manifested by frequent cross-links and the consistent use of 5 to 7 levels of hierarchy, resulting in a higher map score.
DP Outcomes From Concept Mapping

• Slow at first as most-limiting brain function undergoes development
  – Limiting function is identified and practiced

• Faster processing during consolidation of skill areas
  – Capacity to make decisions faster
  – Capacity to access long term memory faster

• Capacity to retain fact (declarative) memory increased

• Transfer of skill to other problem solving venues
More About Maps

• Remember that maps are living documents; they grow as you learn
• Maps don’t have to include everything
• Maps are the best study notes
• Maps allow you to compare your thinking
  — ...and improve it!
Question analysis

- Each answer choice is studied in depth to establish conditions that rule out or accept
- Understanding the correct answer.
  - Minimum knowledge to rule-in the correct answer
- Understanding the wrong answers.
  - Minimum knowledge to rule-out the wrong answers
  - Rephrasing the question
- Check SuccessTypes book at website
Question Analysis: “Ruling-Out” Thinking

• Questions – ultimate learning objectives
  – Shows how are topics tested
  – Shows how you have to think

• Understanding a question
  – Many do not test memorization, but organization and integration.

• Teachers believe that they have addressed each “wrong” answer
  – Called rational alternatives
  – Each answer is correct for a different question.
Problem Solving Essentials – Summary Thoughts

• Team contribution is critical
  – Learning “types” develop the non-preferred function faster when they hear it (experience!)
  – Develop “inter”-dependence

• Mental functions are skills, not intelligence!

• Mental functions are developed through Deliberate Practice.
Recap

• Experiential learning “flows” through the cortex
  – Always completed through action (gives emotion)
  – Personality type reflects time allocation.

• Experiential learning develops both:
  1. Cognitive memory
  2. Critical thinking skills

• Long-term memory is external evidence of dendritic tree growth (temporal cortex).

• Critical thinking (analytic) skill is external evidence of dendritic tree growth (prefrontal cortex).