

Brains on *Fire!*

*Seven Trade-Offs That Create
Cognitive Diversity Among Gifted Learners*

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Goal for this Talk:

To provide a partial answer to the age old question...

*If all of these students are gifted,
then why are they all so different?*

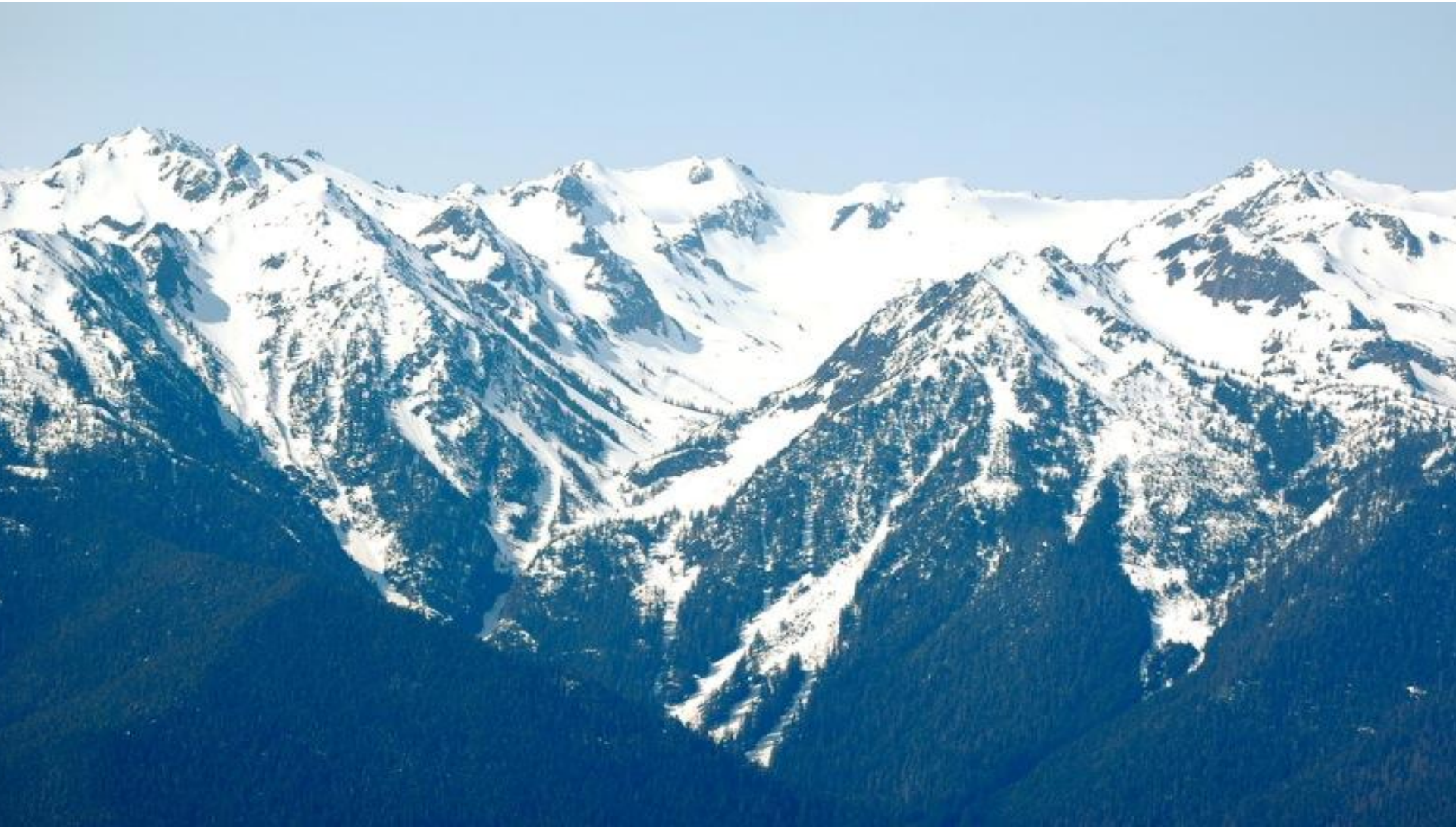


Diverse Gifts



- Even when all are identified through the same process, tremendous heterogeneity appears.
- Some succeed, others struggle.
- Many perform identical tasks in different ways.
- What accounts for this diversity?

A truly complete answer requires
A wide variety of perspectives...



Understanding Gifted Children: The Five “DyNaMITE” Perspectives

1. Development
2. Neurobiology (“wiring”)
3. Motivation/Interest
4. Temperament
5. Experience



Today we'll limit our perspective to

Neurobiology:

or the brain-based sources
of cognitive differences



Key Point

There isn't a single type of "gifted cognition," or one optimal pattern of brain function.

Instead, brains can incorporate a variety of cognitive features, each of which may be better suited for some functions than others.





These cognitive features are like the ingredients in a recipe: The relative amounts and identities of each determines the “product”

Trade-Offs



Importantly, many of these cognitive ingredients” seem to come in reciprocal pairs—that is, they exist in a “zero sum” relationship with another trait, so that more of one means less of the other.

We’ll discuss seven key pairs of cognitive trade-offs.

Together they explain much of the variation in how (and how successfully) different gifted students perform different tasks

Understanding these trade-offs can have benefits for:



- Understanding and appreciating cognitive differences
- Understanding how different kinds of students can best be taught and learn
- Understanding how to form cooperative relationships between individuals of different cognitive types

Key Benefit:

Weakness in one area often points to corresponding strength.



--So--



*When you find a weakness,
Look for the corresponding strength*

These are the seven key trade-offs



1. Automaticity vs. Mindfulness
2. Semantic vs. Episodic Memory
3. Analytical vs. Intuitive Reasoning
4. “Linear” vs. “Interconnected” Reasoning
5. Verbal vs. Non-Verbal Reasoning
6. Focused vs. Diffuse Attention
7. “Fine Detail” vs. “Big Picture” Reasoning

Automaticity vs. Mindfulness



Automaticity often supported by Procedural Learning and Memory System

- “How skills”
- Rules, procedures, rote facts
- Skills made automatic through practice
- Motor and language branches
- IQ testing: correlates with processing speed
- Achievement testing: correlates with fluency



Procedural Tasks

Discriminating heard word sounds; articulating spoken sounds and words; breaking words down into component sounds; mastering phonics and decoding and encoding words; grammar and syntax; forming written letters; writing conventions and punctuation; mastering math rules and procedures and rote facts (calculation); sequences like months and days; reading the clock; class procedures, tying laces, dressing, utensils, etc.

Automatic Procedural Skills



- Crucial for most “basic skills”
- Automatic, fast, efficient, reproducible
- Perform without conscious thought, so working memory can be better devoted to higher level tasks

A Key Dynamic:



Inadequate automaticity requires conscious compensation—i.e., use of active working memory or a more “mindful” approach

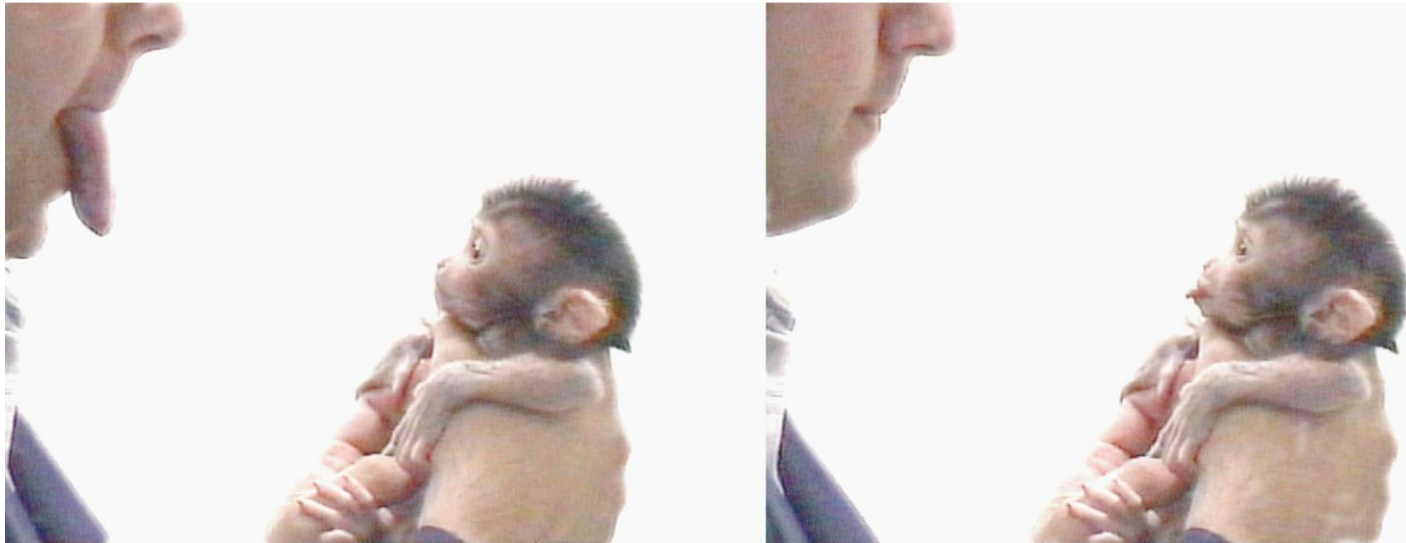
Pluses and minuses



Good automaticity makes you fast, reliable, efficient, and readily able to focus on higher level skills when the lower ones are mastered.

Poor automaticity requires increased mindfulness, which can make you slower and more liable to overload, but also makes you more aware of what you're doing, and more liable to innovate.

Two More Key Points About Procedural Learning



1. Implicit vs. explicit learning: implicit (observational) learning governed by procedural memory, and when poor rules must be mastered explicitly.
2. Social functions are largely procedural.

Teaching and Learning

One key is preventing the cycle of working memory overload:

Chunking

Focus on one procedural skill at a time

Keyboard

Formula Card

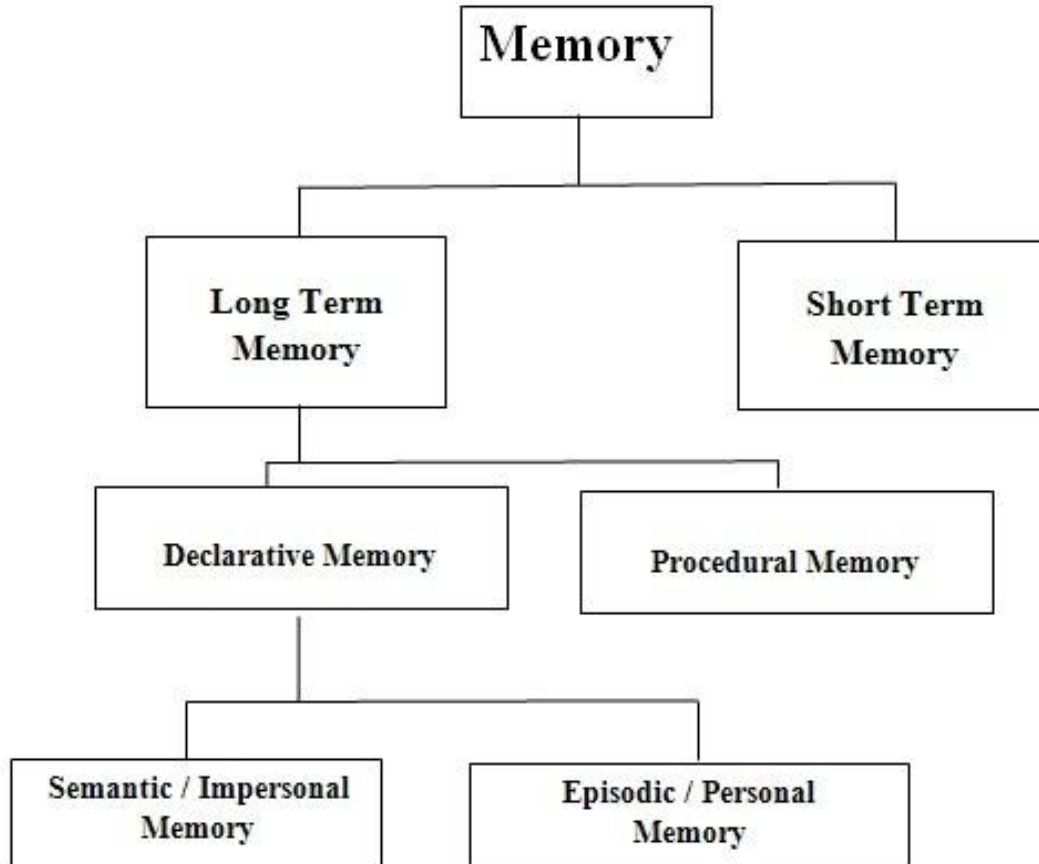
- Make rules explicit, using written rules, examples, etc.



Semantic vs. Episodic Memory

A photograph of a wooden desk with a yellow lined notebook and an orange pencil. The notebook is open, showing two pages with light blue horizontal lines. The pencil is positioned in the bottom right corner of the frame, pointing towards the center. The text "Semantic vs. Episodic Memory" is written in black, bold font across the middle of the notebook pages.

The Branches of Memory



Different Forms of Factual Memory



- Semantic: Abstract
- Non-contextual
- Impersonal
- Generalized, Generic
- “Completed” patterns
- Definitions

- Episodic: Scene-Based
- Specific Time and Place
- Personal
- Particular, Specific
- “Separated” patterns
- Cases, Examples

Episodic Memory

Speech Professor Duane Smith:

“If I hear a song, or smell something, or see an article of clothing or a car from a particular year, I can immediately imagine a scene on a particular day, or event. It drives my wife crazy because we’ll be listening to the radio, and I’ll talk about how it takes me back to 1985 when I was standing with a group of buddies at In-N-Out Burger on a Saturday night listening to that song, and what we were talking about, and she’ll say, ‘Can’t you ever just listen to the song?’”

Episodic Memory: Jack Laws

If we say 'robin' what does that make you think of?

“Different robins, definitely. My mind starts jumping to robins that I’ve experienced, rather than a single generalized robin, or the Platonic ideal of the robin...”-

Jack Laws, naturalist



Episodic Memory

Advantages – store vivid individual details, attend to novelty and exceptions, rich associations and connotations, divergent thinking, ideas in context / applications

Disadvantages – hard to ‘sound bite’, lots of data to organize and sequence, slow, inefficient



Teaching and Learning

Teaching differences: Students who strongly favor either semantic or episodic memory will differ greatly in what they consider a distraction and what is essential.

Semantic-biased students: just the facts

Episodic-biased students may need context,
cases to store data

One family...



Analytical vs. Intuitive Reasoning

A top-down view of a yellow notepad with light blue horizontal lines, resting on a wooden surface. The notepad is partially unrolled, with the top edge curled over. A yellow pencil with a silver eraser and a sharp lead tip lies on the right side of the notepad. The text 'Analytical vs. Intuitive Reasoning' is printed in a bold, black, sans-serif font in the center of the page.

Analytical Thinking



1. Licensee shall pay future costs of the prosecution of Paragraph 1. Which are reasonably necessary to obtain a filing, prosecuting and maintaining foreign countries with foreign applications to be filed within ten (10) years from the date of the filing of the application in the country.

ARTICLE 30 - PATENT

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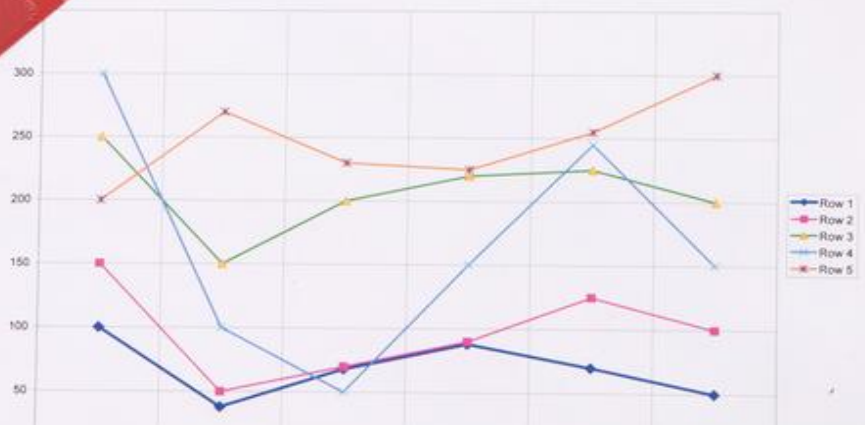
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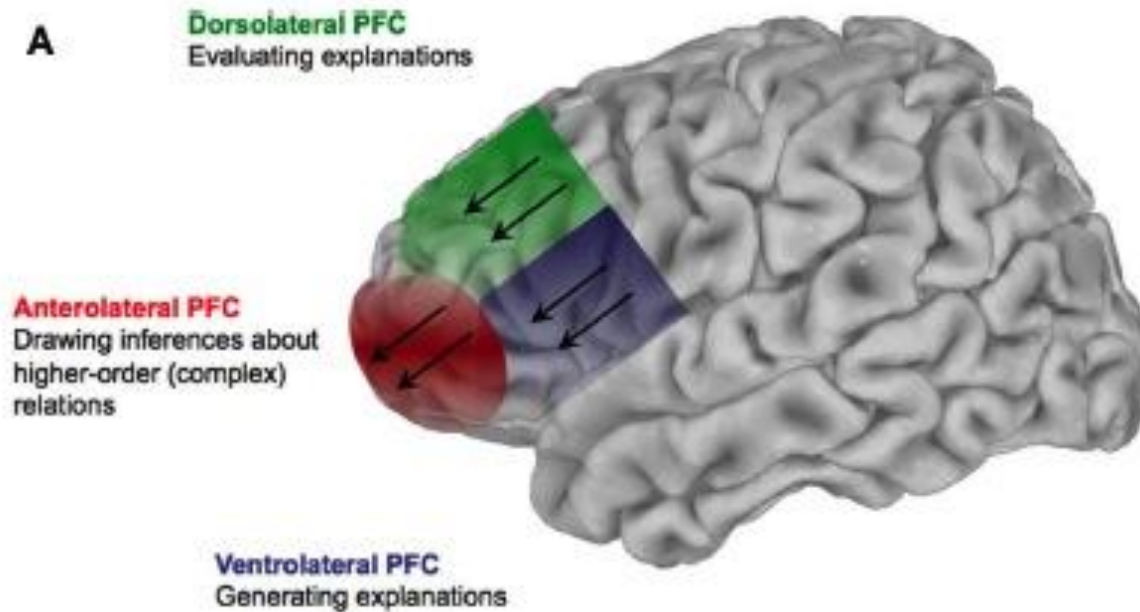
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Analytical Thinking



- Conscious Process
- *Directed* Focus
- Selection, Trial-and-Error, Sequencing
- Working Memory-Intensive, Tedious

Analytical Expertise

Physics Experts

Organize Facts to Principles

Physics Novices

Learn Separate Facts

Chess Experts

Recognize Positions as Patterns

Chess Novices

See Individual Positions

Artists

Analyze What's Seen

Non-Artists

'See'



Analytical Expertise

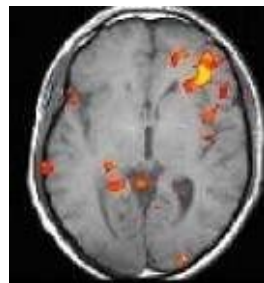
Eye
Movements



Artist



Novice



← Analyzes!



← Sees

Intuitive Thinking



Intuitive Thinking

“You have the answer before you are able to put it into words. It is all done subconsciously. This has happened many times and I know when to take it seriously. “

- Dr. Barbara McClintock, Nobel Prize in Medicine

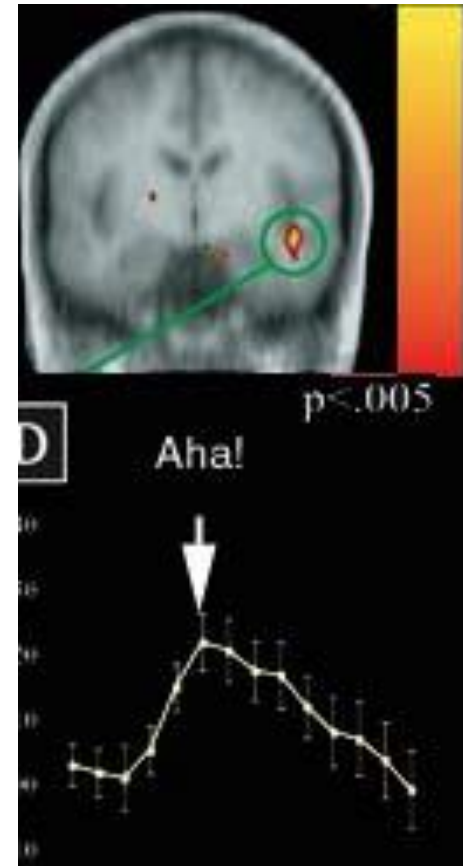
Problem Stated

Incubation Period / Distraction

Sudden Discovery

What single word can form a familiar compound word or phrase with the following 3 words?

pine – crab - sauce



Jung-Beeman, 2004

“It is by logic that we prove. It is by intuition that we discover.” – Henri Poincare

Intuitive Expertise

“Disgusted by my lack of success, I went to spend a few days at the seaside and think of other things. One day, while walking along the cliffs, the idea came to me...” – Henri Poincare

“ I do my best thinking after playing the violin for a half hour.” - Albert Einstein

“When I feel well and in a good humor, or when I am taking a drive or walking after a good meal, or in the night when I cannot sleep, thoughts crowd into my mind as easily as you could wish...” – Wolfgang Mozart



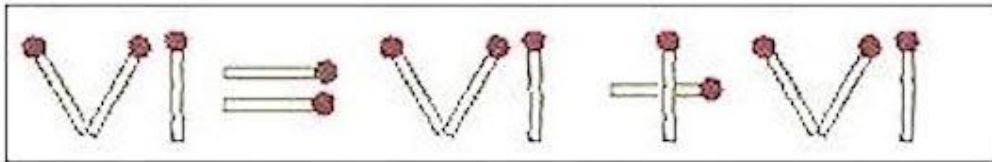
Activation of Distant or Novel Associations

Where chemists get ideas:
60% abandon problem
47% before bed
45% vacation



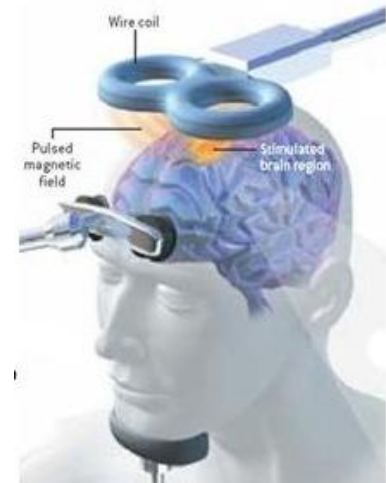
Intuitive Thinking

Turning Down & Turning Up the Brain
(stimulate right ATL and inhibit left ATL)




Move one match to make the statement true.

Increase Intuitive Solutions by 2-Fold



Learning and Teaching

Analytical  Intuitive

Analytical – expert tips, organize information

Intuitive – recognize ‘not working’ pattern,
more time, not conscious

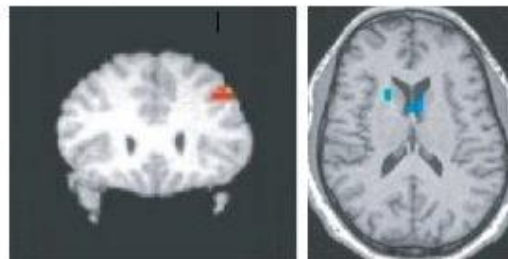


A photograph of a wooden desk with a yellow notepad and a pencil. The notepad is open, showing lined pages. The pencil is orange and is positioned in the bottom right corner of the frame. The text "Linear vs Interconnected Thinking" is written in the center of the notepad.

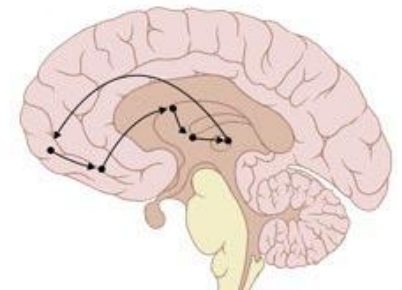
“Linear” vs “Interconnected” Thinking

Linear Thinking

Direct
Rule-Based, Algorithmic
Convergent
Quick, Automatic
Reliable, Reproducible



Filoteo, 2004

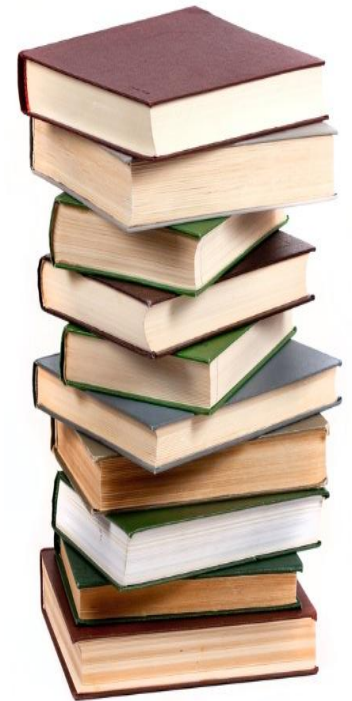


Frontostriatal Circuits



Linear and Rule-Based Expertise

“Arthur was "an eager and able student" and was allowed to skip grades several times in primary school. “ – re: Dr. Arthur Kornberg, Nobel Prize in Physiology

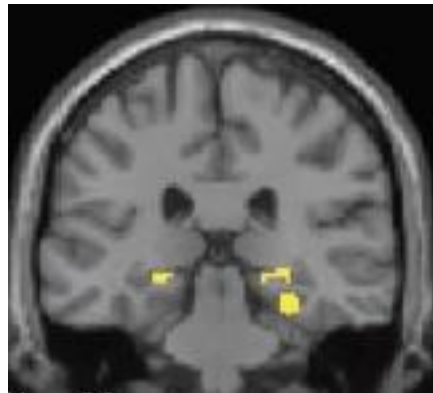


“The boy’s earliest recognition was on the basis of what the teachers called his phenomenal memory...” - Child C, Children Above 180 IQ

Strong Memory and Retrieval
Rule-Based Learning and Thinking
School often easy

Interconnected Thinking

Indirect , Interconnected
Case-Based, Context Based
Exceptions to Rule, Novelty
Divergent, Experience-Based
Slow, Erratic



Medial Temporal Lobe

Interconnected Expertise

“Things are as they are because of their relationships with everything else. You can’t just look at anything in isolation.”

– John Muir Laws, *Laws Field Guide to the Sierra Nevada*

“...the question is, “Who was the President of the United States in 1845,” and you get a story from me about the build up in the conflict over slavery, and you have characters...and I’m only relatively answering the question, although the content’s all in there...” – Douglas Merrill, ex-CIO Google

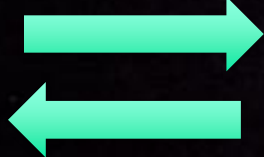
Simple vs. Real World Problem Solving



- One or limited solutions
- Well-defined question
- Structured rules and answers

- Multiple or unknown solutions
- Poorly defined questions
- Unstructured rules and answers

Learning and Teaching

Linear  Interconnected

Make time for unstructured problems
Problem scoping

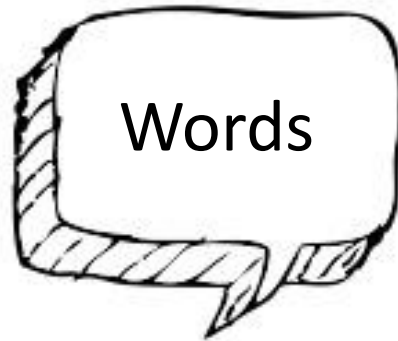
Bring the real world into the classroom



Verbal vs. Non-Verbal Thinking



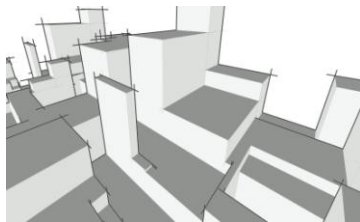
Words vs. Non-Words (Visual, Spatial, Sensory)



Visual



Spatial



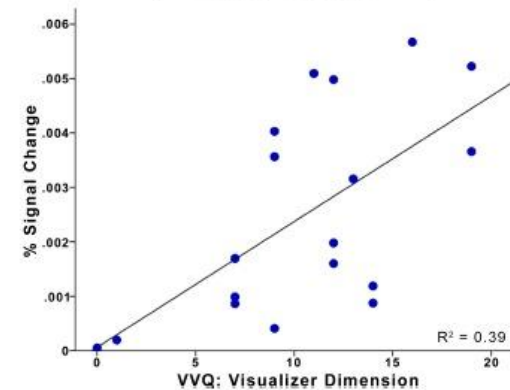
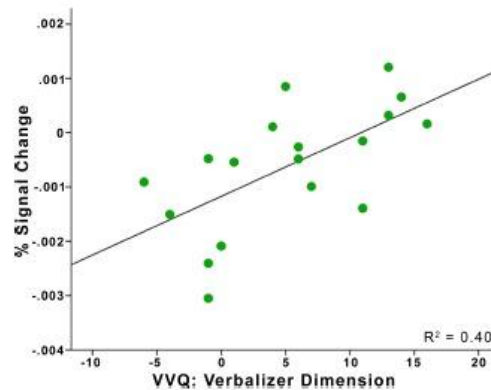
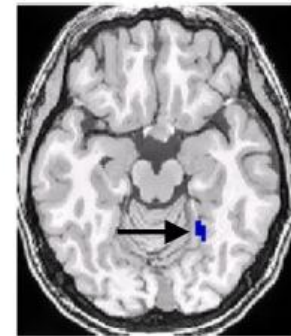
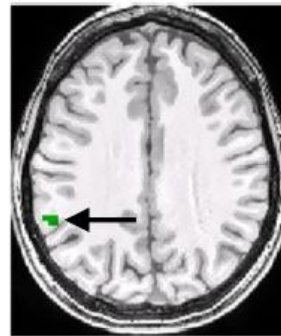
Sensory



Verbal and Visual Thinkers Differ with Words and Pictures

Verbal Thinkers Process Pictures Through Verbal Areas

Visual Thinkers Process Words Through Picture Areas



Different Styles of Expertise

“I’m going to tell you everything as a story, because that’s how I experience the world.” –Sarah Andrews, Geologist, Mystery Author, Dyslexic

“Words are totally absent from my mind when I really think.”
- Jacques Hadamard, mathematician

“Sometimes I do imagine the ideas as if they were a machine.... Sometimes I imagine there are parts to them and there are lever arms and there are parts that you turn. You turn this a little bit here and something big happens over there. I can sort of see the connection of it...there is a kinesthetic component to it.”

– Matt Schneps, astrophysicist

Domain-Based Expertise

Musicians- More Musical Analysis and Instrument Activation

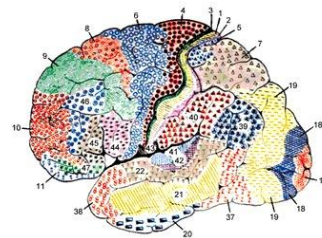
Athletes – More Kinesthetic Imagery Activation- Tennis, Golf

Visual Experts – Greater Activation of Visual Recognition Areas

Creative Story Generation – More Activation of R Prefrontal



-
-
-



Learning and Teaching

Recognize the translation process between words and non-words

Expression will be easiest in a preferred system

Non verbal thinkers – projects, analogies



Focused vs. Diffuse Attention



Focused Attention



Diffuse Attention

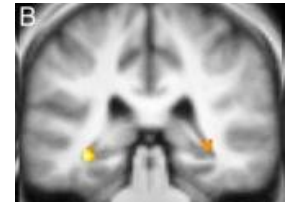
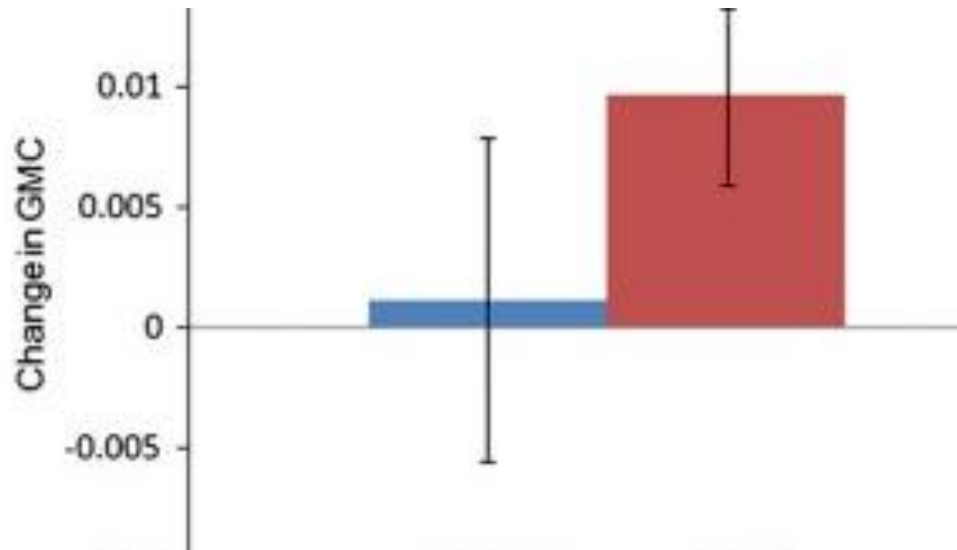


Focused Attention

Focused attention training can improve working memory and different types of problem solving



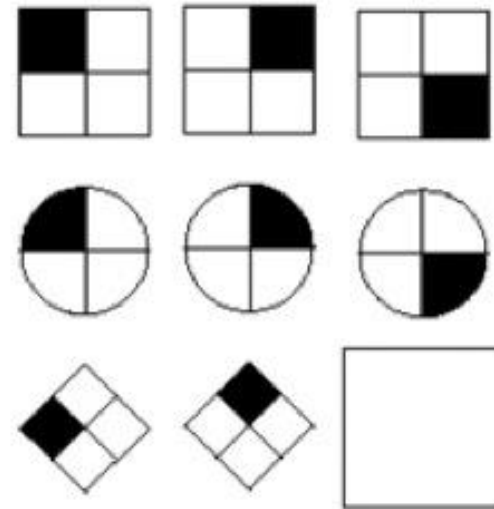
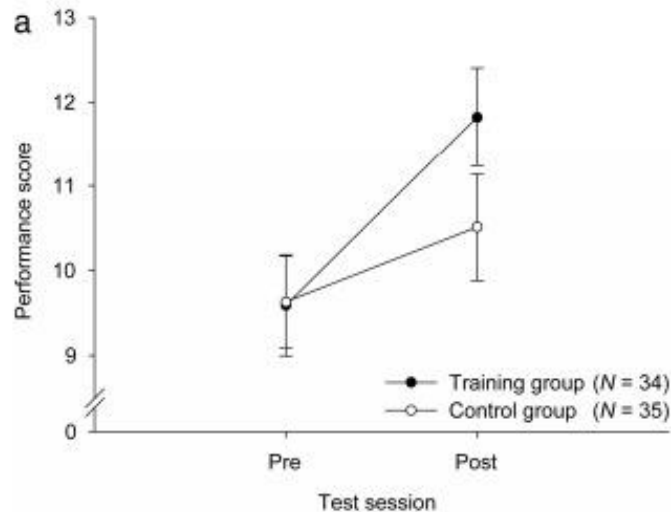
Focused Attention Training (Mindfulness)



Grows Gray Matter in Hippocampus

Attention Training Improves Fluid Intelligence

Attention → Working Memory → Fluid Intelligence



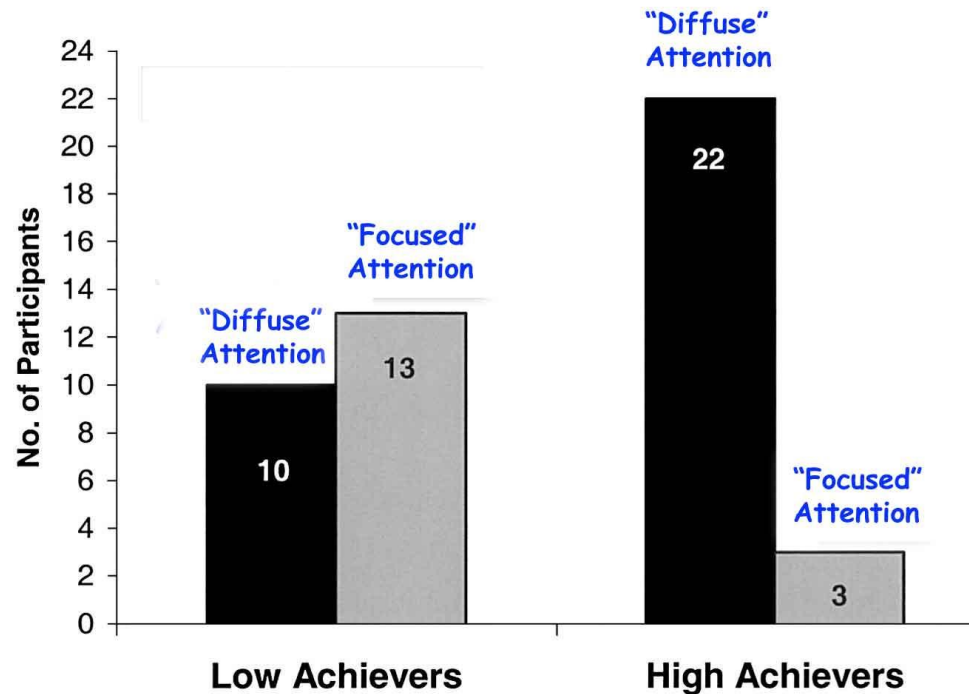
Diffuse Attention

(Reduced Latent Inhibition)



- Reduced ability to screen irrelevant stimuli from conscious awareness (distractible!)
- Associated openness, extroversion, increased creativity, mental illness
- ‘Permeability of Consciousness’

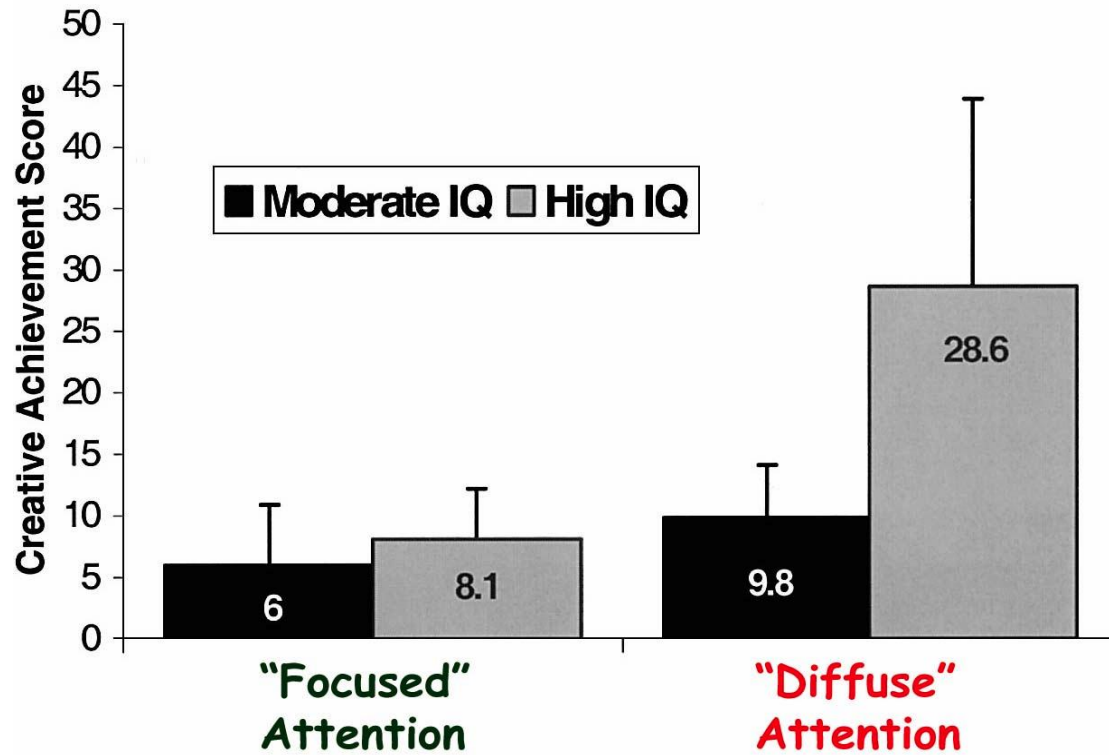
Increased Creative Achievement with Diffuse Attention




Higher Creative Achievement Associated with "Diffuse" Attention

Diffuse Attention More Important Than High IQ for Creativity

Higher Creativity with Diffuse Attention



Learning and Teaching

Focused Attention  Diffuse Attention

Focus can be sharpened – go deep

Divergent thinking can be stimulated - model



A photograph of a wooden desk with a yellow lined notebook and a pencil. The notebook is open, showing two pages with light blue horizontal lines. A yellow pencil is lying on the right page. The text "Fine Detail vs. Big Picture Reasoning" is written in black on the right page.

“Fine Detail” vs. “Big Picture” Reasoning



Fine Detail vs. Big Picture



- Fine details: discriminating closely related sounds, visual images, concepts, terms, etc.; performing simple tasks quickly and accurately (e.g., calculations, spelling, grammar, precise motor movements); precise definitions and distinctions. Trees vs. forest. Handwriting, phonics, names and dates, Where's Waldo...
- Big Picture: Context, gist, theme, symbolism, judgment, distant connections. Reading faces, poetry, literature, historical and political theory, process

Function Correlates with Structure

Cognitive functions emerge as circuits are formed between functional clusters of brain cells (called minicolumns).

Connections between adjacent clusters of cells with similar functions results in enhanced fine detail functions like expert precision, speed, detail resolution, and efficiency. E.g., upgrading processor without adding functions can make a good calculator even better.

Connections between distant clusters results in enhanced “big picture” functions like gestalt, gist, or context detection, judgment, etc.

Autism (local circuits) vs. dyslexia (distant circuits)

Teaching and Learning

Fine Detail: Bottom up, details first, build picture as you go.

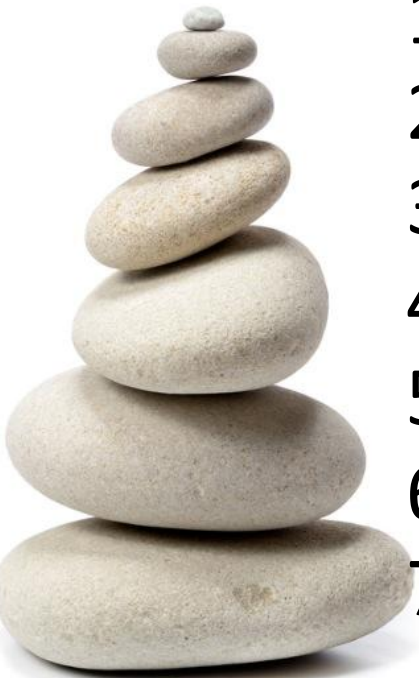
Big Picture: Top down, sketch big picture first, fill in details later.



Future Directions



Better understanding of differences leads to better teaching and use.



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