
Factors
Survival
Repetition
Uncomfortable
Experiences
Tactics
Students
Fixed
Events
Lines
Best
Concept
Reprogramming
Interleaving
Brain
Interaction
Attention
Mindset
Willing
Engage
Size
Growth
Ambiguity
Social
Through
Given
Safe
Trauma
Focus
Cell
Help
Implementation
Capacity
Stretch
Space
Make
Need
Balance
Better
Classroom
Comfort
Previous
Constantly
Zone
Damaged
Effectively
Yourself
Time
Push
Areas
Order
Look
Exercise
Enriched
Strengths
Learn
Process
Care
Adjust
Empowering
Ideas
Older
Ages
Means
Practice
Teaching
Toys
Movement
Grow
Alter
Community
Way
Paying
Generation
Many
Made
Diet
Pathway
Vs
Work
More
Rats
Create
Being
Having
Stress
Phones
Experienced
Something
Recognize
Headaches
Necessary
Neuroplasticity
Emotion
Environment
Neural
Meditation
Perspective
Traumatic
Positive
Reframe
Change
New
Connects
Affects
Views
Motivating
Both
Rewards
Things
Mindfulness
Unconscious

Neuroplasticity can result from...

National Institute for the Clinical Application of Behavioral Medicine

Questions for discussion

- What kinds of **enriched learning environments** are you providing for your students?
- How are you leveraging the power of **social interaction** to help create new connections in students' brains?
- What connections are you making between your material and students' already-existing connections between concepts (**prior knowledge, experiences, and skills)**?
- In what ways are you engaging students' **emotions** around the concepts you're teaching?
- How are you empowering struggling students through **teaching them about their own brains' neuroplasticity** (growth mindset)?

(S. Frantz?)

Brain-Based Learning and Leading

(applies to helping students learn, or to
leading any group of folks through processes of change)

Things brain-based learning research teaches us:

Attention span:

We can only engage in focused attention for approximately 20 minutes at a time.
We tend to move through 90-minute cycles of energy – ~~moving from alert and~~ engaged to drifty and foggy.

Prior assumptions/prior learning experience:

New material will be connected to prior foundations whether we address them or not. NOTHING IS NEW.

People come to experiences with "cartoon theory." (We learn "cartoon physics" from Wile E. Coyote hanging in the air off a cliff. We learn "cartoon social theory" from watching sitcoms. We learn "cartoon pedagogy" from unsubstantiated advice and assumptions about teaching and from lack of meaningful assessment of learning.) WOW.

YouTube logic

Accessing/addressing the previous connections puts them in play.

Creating vs. receiving meaning: We're here in higher ed b/c we are among the few ~~who learned well from~~ sages on stages & sustained readings.

Learning sticks more when people actively make the connections that give material meaning.

Learning sticks less when we passively receive information – meaning may or may not be made.

Influence of fear on learning:

The #1 factor on student learning is emotions.

Relaxation increases serotonin production, which facilitates the connection-making.

Motivation for learning is based in positive emotions.

Fear and stress impede learning – the stress hormones interfere with the creation of new neural connections.

where's the line b/t fear & challenge?

Ideas for application to class

Options before presenting new content:

Put students' prior assumptions about the material on the table – ask students to spend 5 minutes or so writing (and/or discussing in small groups) their answers to questions related to upcoming class content. Ask students/groups to report out briefly.

For example, in relation to learning about the content of this handout, learners could first be asked to write about and then discuss their responses to these questions: 10-15 min

- *What do you know about listeners' attention spans?*
- *What do you know about the role of prior learning experience to learning new material?*
- *How does learning differ when students actively participate in creating their own meanings and when students passively receive ideas?*

In what ways does fear influence learning? how does fear of speaking/math get in the way? accents? – global or immediate – vulnerability

Have you ever persuaded anyone to do anything?

our students will have prior assumptions about what teaching looks like – you give me the info!

Options after presenting new content:

Return to original thought questions.

or

Allow students to create hypotheses based on the new information. Ask these types of question: *Based on what we have discussed, what do you think would* <u>*not*</u> *work in a given situation? What would happen if X or Y were different? How might your own behavior change if you were to apply these ideas?*

You Can Grow Your Intelligence

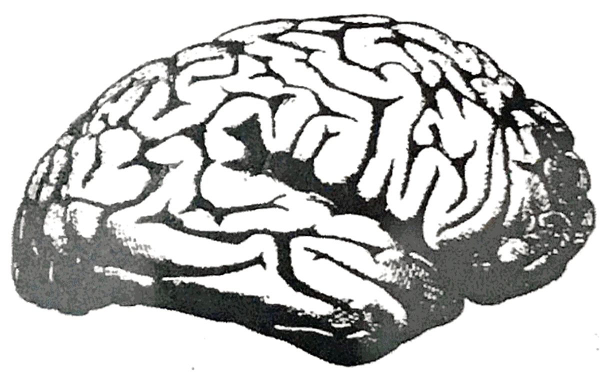
New Research Shows the Brain Can Be Developed Like a Muscle

Many people think of the brain as a mystery. They don't know much about intelligence and how it works. When they do think about what intelligence is, many people believe that a person is born either smart, average, or dumb–and stays that way for life.

But new research shows that the brain is more like a muscle--it changes and gets stronger when you use it. And scientists have been able to show just how the brain grows and gets stronger when you learn.

Everyone knows that when you lift weights, your muscles get bigger and you get stronger. A person who can't lift 20 pounds when they start exercising can get strong enough to lift 100 pounds after working out for a long time. That's because the muscles become larger and stronger with exercise. And when you stop exercising, the muscles shrink and you get weaker. That's why people say "Use it or lose it!

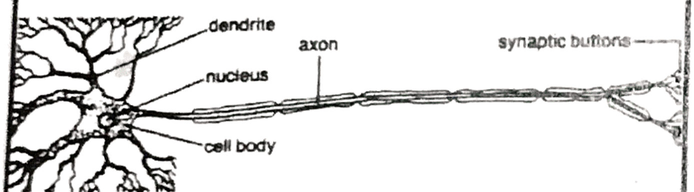
But most people don't know that when they practice and learn new things, parts of their brain change and get larger a lot like muscles do when they exercise.



Inside the cortex of the brain are billions of tiny nerve cells, called neurons. The nerve cells have branches connecting them to other cells in a complicated network. Communication between these brain cells is what allows us to think and solve problems.

A Section of the Cerebrum

When you learn new things, these tiny connections in the brain actually multiply and get stronger. The more that you challenge your mind to learn, the more your brain cells grow. Then, things that you once found very hard or even impossible to do--like speaking a foreign language or doing algebra–seem to become easy. The result is a stronger, smarter brain.



A Typical Nerve cell

How Do We Know the Brain Can Grow Stronger?

Scientists started thinking that the human brain could develop and change when they studied animals' brains. They found out that animals who lived in a challenging environment, with other animals and toys to play with, were different from animals who lived alone in bare cages.

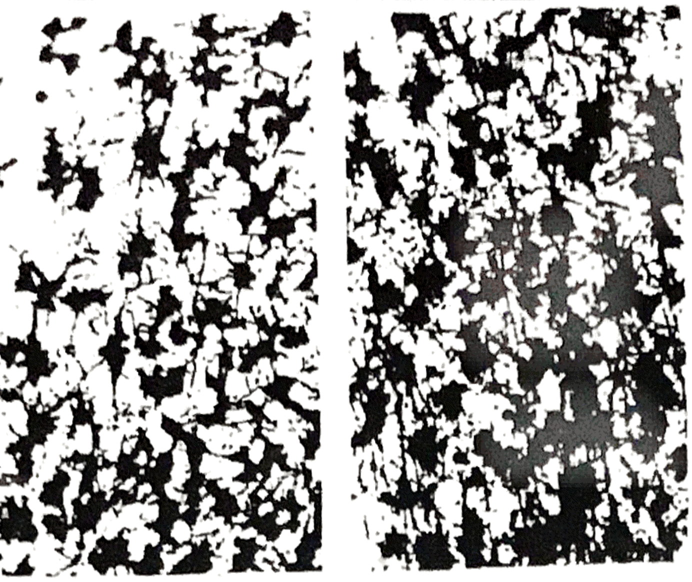
While the animals who lived alone just ate and slept all the time, the ones who lived with different toys and other animals were always active. They spent a lot of time figuring out how to use the toys and how get along with the other animals.

These animals had more connections between the nerve cells in their brains. The connections were bigger and stronger, too. In fact, their whole brains were about 10% heavier than the brains of the animals who lived alone without toys.

The animals who were exercising their brains by playing with toys and each other were also "smarter"--they were better at solving problems and learning new things.

Even old animals got smarter and developed more connections in their brains when they got the chance to play with new toys and other animals. When scientists put very old animals in the cages with younger animals and new toys to explore, their brains grew by about 10%!

Blackwell, L.S. (2002). Psychological mediators of student achievement during the transition to junior high school: The role of implicit theories. (Doctoral Dissertation, Columbia University, 2002.) UMI # 3048094



Nerves in brain of animal living in bare cage.	Brain of animal living with other animals and toys.

Children's Brain Growth

Another thing that got scientists thinking about the brain growing and changing was babies. Everyone knows that babies are born without being able to talk or understand language. But somehow, almost all babies learn to speak their parents' language in the first few years of life. How do they do this?

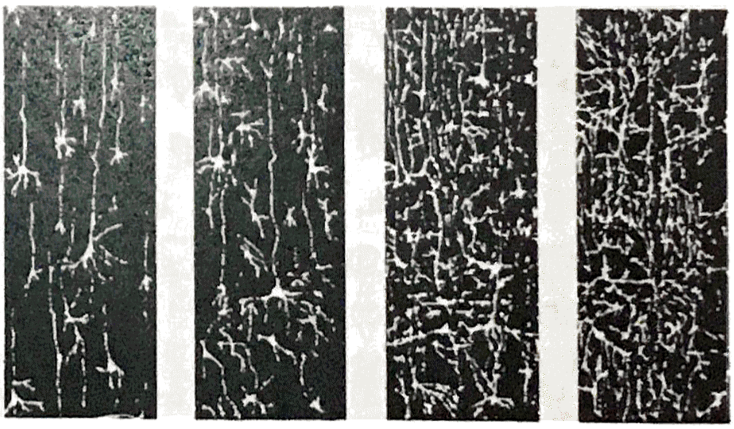
The Key to Growing the Brain: Practice!

From the first day they are born, babies are hearing people around them talk–all day, every day, to the baby and to each other. They have to try to make sense of these strange sounds and figure out what they mean. In a way, babies are exercising their brains by listening hard.

Later, when they need to tell their parents what they want, they start practicing talking themselves. At first, they just make goo-goo sounds. Then, words start coming. And by the time they are three years old, most can say whole sentences almost perfectly.

Once children learn a language, they don't forget it. The child's brain has changed–it has actually gotten smarter.

This can happen because learning causes permanent changes in the brain. The babies' brain cells get larger and grow new connections between them. These new, stronger connections make the child's brain stronger and smarter, just like a weightlifter's big muscles make them strong.



Newborn	3months	15 months	2 years

Development of nerve cells in the brain from birth to 2 years old. The nerve cells grow both in size and in number of connections between them.

The Real Truth About "Smart" and "Dumb"

No one thinks babies are stupid because they can't talk. They just haven't learned how to yet. But some people will call a person dumb if they can't solve math problems, or spell a word right, or read fast--even though all these things are learned with practice.

At first, no one can read or solve equations. But with practice, they can learn to do it. And the more a person learns, the easier it gets to learn new things–because their brain "muscles" have gotten stronger!

The students everyone thinks is the "smartest" may not have been born any different from anyone else. But before they started school, they may have started to practice reading. They had already started to build up their "reading muscles." Then, in the classroom, everyone said, "That's the smartest student in the class."

They don't realize that any of the other students could learn to do as well if they exercised and practiced reading as much. Remember, all of those other students learned to speak at least one whole language already– something that grownups find very hard to do. They just need to build up their "reading muscles" too.

What Can You Do to Get Smarter?

Just like a weightlifter or a basketball player, to be a brain athlete you have to exercise and practice. By practicing you make your brain stronger. You also learn skills that let you use your brain in a smarter way--just like a basketball player learns new moves.

But many people miss out on the chance to grow a stronger brain because they think they can't do it, or that it's too hard. It does take work, just like becoming stronger physically or becoming a better ball player does. Sometimes it even hurts! But when you feel yourself get better and stronger, all the work is worth it!

Blackwell, L.S. (2002). Psychological mediators of student achievement during the transition to junior high school: The role of implicit theories. (Doctoral Dissertation, Columbia University, 2002.) UMI # 3048094

Claims We Make in This Book

You may not agree with the last point, but we hope to persuade you of it. Here, more or less unadorned in list form, are some of the principal claims we make in support of our argument. We set them forth more fully in the chapters that follow.

Learning is deeper and more durable when it's *effortful*. Learning that's easy is like writing in sand, here today and gone tomorrow.

We are *poor judges* of when we are learning well and when we're not. When the going is harder and slower and it doesn't feel productive, we are drawn to strategies that feel more fruitful, unaware that the gains from these strategies are often temporary.

Rereading text and *massed practice* of a skill or new knowledge are by far the preferred study strategies of learners of all stripes, but they're also among the *least productive*. By massed practice we mean the single-minded, rapid-fire repetition of something you're trying to burn into memory, the "practice-practice-practice" of conventional wisdom. Cramming for exams is an example. Rereading and massed practice give rise to feelings of fluency that are taken to be signs of mastery, but for true mastery or durability these strategies are largely a waste of time.

Retrieval practice—recalling facts or concepts or events from memory—is a more effective learning strategy than review by rereading. Flashcards are a simple example. Retrieval strengthens the memory and interrupts forgetting. A single, simple quiz after reading a text or hearing a lecture produces better learning and remembering than rereading the text or reviewing lecture notes. While the brain is not a muscle that gets stronger with exercise, the neural pathways that make up a body of learning do get stronger, when the memory is retrieved and the learning is practiced. Periodic practice arrests forgetting, strengthens retrieval routes, and is essential for hanging onto the knowledge you want to gain.

When you *space out practice* at a task and get a little rusty between sessions, or you interleave the practice of two or more subjects, retrieval is harder and feels less productive, but the effort produces longer-lasting learning and enables more versatile application of it in later settings.

Trying to solve a problem *before being taught the solution* leads to better learning, even when errors are made in the attempt.

The popular notion that you learn better when you receive instruction in a form consistent with your preferred *learning style*, for example as an auditory or visual learner, is *not supported by the empirical research*. People do have multiple forms of intelligence to bring to bear on learning, and you learn better when you "go wide," drawing on all of your aptitudes and resourcefulness, than when you limit instruction or experience to the style you find most amenable.

When you're adept at extracting the *underlying principles or "rules"* that differentiate types of problems, you're more successful at picking the right solutions in unfamiliar situations. This skill is better acquired through *interleaved and varied practice* than massed practice. For instance, interleaving practice at computing the volumes of different kinds of geometric solids makes you more skilled at picking the right solution when a later test presents a random solid. Interleaving the identification of bird types or the works of oil painters improves your ability both to learn the unifying attributes within a type and to differentiate between types, improving your skill at categorizing new specimens you encounter later.

We're all *susceptible to illusions* that can hijack our judgment of what we know and can do. Testing helps calibrate our judgments of what we've learned. A pilot who is responding to a failure of hydraulic systems in a flight simulator discovers quickly whether he's on top of the corrective procedures or not. In virtually all areas of learning, you build better mastery when you use testing as a tool to identify and bring up your areas of weakness.

All new learning requires a *foundation of prior knowledge*. You need to know how to land a twin engine plane on two engines before you can learn to land it on one. To learn trigonometry, you need to remember your algebra and geometry. To learn cabinetmaking, you need to have mastered the properties of wood and composite materials, how to join boards, cut rabbets, rout edges, and miter corners.

In a cartoon by the *Far Side* cartoonist Gary Larson, a bug-eyed school kid asks his teacher, "Mr. Osborne, can I be excused? My brain is full!" If you're just engaging in mechanical repetition, it's true, you quickly hit the limit of what you can keep in mind. However, if you practice *elaboration,* there's no known limit to how much you can learn. Elaboration is the process of giving new material meaning by expressing it in your own words and connecting it with what you already know. The more you can explain about the way your new learning relates to your prior knowledge, the stronger your grasp of the new learning will be, and the more connections you create that will help you remember it later. Warm air can hold more moisture than cold air; to know that this is true in your own experience, you can think of the drip of water from the back of an air conditioner or the way a stifling summer day turns cooler out the back side of a sudden thunderstorm. Evaporation has a cooling effect: you know this because a humid day at your uncle's in Atlanta feels hotter than a dry one at your cousin's in Phoenix, where your sweat disappears even before your skin feels damp. When you study the principles of heat transfer, you understand conduction from warming your hands around a hot cup of cocoa; radiation from the way the sun pools in the den on a wintry day; convection from the life-saving blast of A/C as your uncle squires you slowly through his favorite back alley haunts of Atlanta.

Putting new knowledge into a *larger context* helps learning. For example, the more of the unfolding story of history you know, the more of it you can learn. And the more ways you give that story meaning, say by connecting it to your understanding of human ambition and the untidiness of fate, the better the story stays with you. Likewise, if you're trying to learn an abstraction, like the principle of angular momentum, it's easier when you ground it in something concrete that you already know, like the way a figure skater's rotation speeds up as she draws her arms to her chest.

People who learn to *extract the key ideas from new material and organize them into a mental model* and connect that model to prior knowledge show an advantage in learning complex mastery. A mental model is a mental representation of some external reality.[1] Think of a baseball batter waiting for a pitch. He has less than an instant to decipher whether it's a curveball, a changeup, or something else. How does he do it? There are a few subtle signals that help: the way the pitcher winds up, the way he throws, the spin of the ball's seams. A great batter winnows out all the extraneous perceptual distractions, seeing only these variations in pitches, and through practice he forms distinct mental models based on a different set of cues for each kind of pitch. He connects these models to what he knows about batting stance, strike zone, and swinging so as to stay on top of the ball. These he connects to mental models of player positions: if he's got guys on first and second, maybe he'll sacrifice to move the runners ahead. If he's got men on first and third and there is one out, he's got to keep from hitting into a double play while still hitting to score the runner. His mental models of player positions connect to his models of the opposition (are they playing deep or shallow?) and to the signals flying around from the dugout to the base coaches to him. In a great at-bat, all these pieces come together seamlessly: the batter connects with the ball and drives it through a hole in the outfield, buying the time to get on first and advance his men. Because he has culled out all but the most important elements for identifying and responding to each kind of pitch, constructed mental models out of that learning, and connected those models to his mastery of the other essential elements of this complex game, an expert player has a better chance of scoring runs than a less experienced one who cannot make sense of the vast and changeable information he faces every time he steps up to the plate.

Many people believe that their intellectual ability is hardwired from birth, and that failure to meet a learning challenge is an indictment of their native ability. But every time you learn something new, *you change the brain*—the residue of your experiences is stored. It's true that we start life with the gift of our genes, but it's also true that we become capable through the learning and development of mental models that enable us to reason, solve, and create. In other words, the elements that shape your intellectual abilities lie to a surprising extent within your own control. Understanding that this is so enables you to see failure as a badge of effort and a source of useful information—the need to dig deeper or to try a different strategy. The need to understand that when learning is hard, you're doing important work. To understand that striving and setbacks, as in any action video game or new BMX bike stunt, are essential if you are to surpass your current level of performance toward true expertise. Making mistakes and correcting them builds the bridges to advanced learning.