Theories of Intelligence

Before leaving lecture today: Complete the survey below.

Assignment: Read the following two articles AND complete the "quiz" on D2L. While you are reading, try to identify the main points of each article. Think about what the “take home message” of each article is, and compare and contrast the information and conclusions described in each article.

Source: C.S. Dweck. (1999) Self-theories: Their role in motivation, personality and development (p. 178). Philadelphia: Psychology Press.

Survey - This questionnaire has been designed to investigate your ideas about intelligence. There are no right or wrong answers. We are interested in your ideas. Using the scale below, please indicate the extent to which you agree or disagree with each of the following statements by writing the number that corresponds to your opinion next to each statement.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

1. You have a certain amount of intelligence, and you can’t really do much to change it.
2. Your intelligence is something about you that you can’t change very much.
3. No matter who you are, you can significantly change your intelligence.
4. To be honest, you can’t really change how intelligent you are.
5. You can always substantially change how intelligent you are.
6. No matter how much intelligence you have, you can always change it quite a bit.
7. You can change even your basic intelligence level considerably.

YOU CAN GROW YOUR BRAIN

New Research Shows the Brain Can Be Developed Like a Muscle

Many people think of the brain as a mystery. We don't often think about what intelligence is or how it works. And when you do think about what intelligence is, you might think that a person is born either smart, average, or dumb—either a "math person" or not—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. Scientists have been able to show just how the brain grows and gets stronger when you learn.

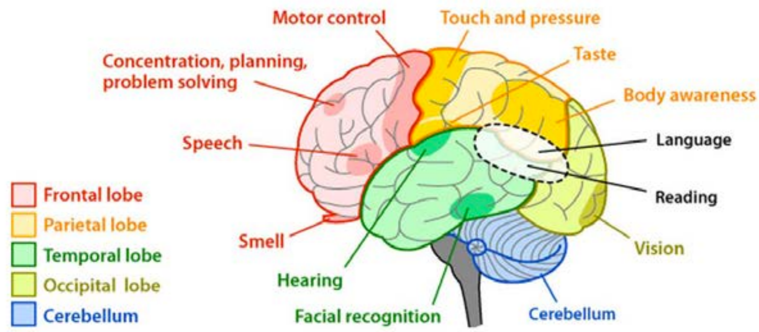

Figure 1 - Image of the human brain, color coded by lobe of the cortex and cerebellum. Regions associated with particular functions are also indicated. Image source: http://askabiologist.asu.edu/what-your-brain-doing

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 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 the muscles do. This is true even for adults. So it's not true that some people are stuck being "not smart" or "not math people." You can improve your abilities a lot, as long as you practice and use good strategies.

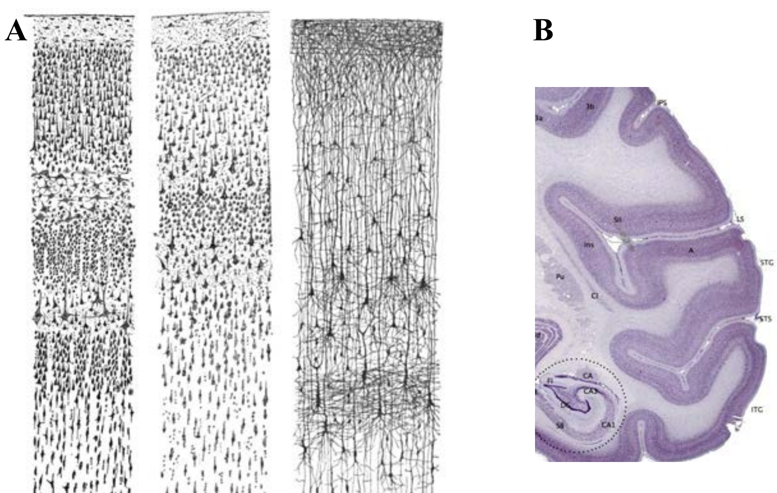

Figure 2 - (A) Three drawings of cortical lamination by Santiago Ramon y Cajal, each showing a vertical cross-section, with the surface of the cortex at the top. Left: Nissl-stained visual cortex of a human adult. Middle: Nissl-stained motor cortex of a human adult. Right: Golgi-stained cortex of a 1½ month old infant. The Nissl stain shows the cell bodies of neurons; the Golgi stain shows the dendrites and axons of a random subset of neurons.**(B)** Macaque brain coronal section, stained so that the cortex is dark purple.

Inside the outer layer of the brain—called the cortex—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.

When you learn new things, these tiny connections in the brain actually multiply and get stronger. The more 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—become easier. The result is a stronger, smarter brain.

How Do We Know That The Brain Can Grow Stronger?

Scientists started thinking the human brain could develop and change when they studied adult animals' brains. They found 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 to get along with other animals.

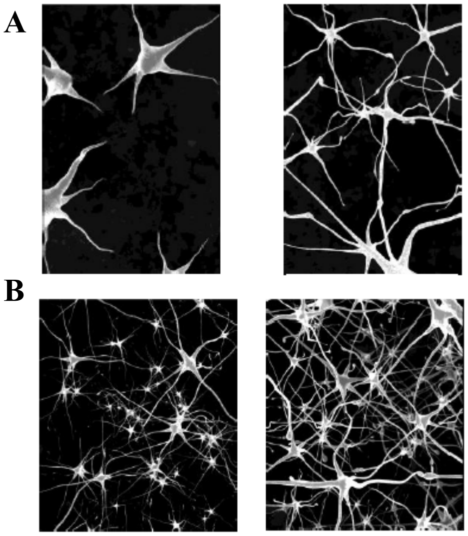

Figure 3 - (A) Neurons from the brain of animals living alone in their cages (left) and neurons froms the same brain region in an animal living with other animals and toys (right).(B) Growth of neuronal connections from birth (left) to six years old (right).

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 adult 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.

Can Adults Grow Their Brains?

Scientists have recently shown that adults can grow the parts of their brains that control their abilities—like the ability to do math or even to juggle.

In one study, scientists found a group of adults who were not jugglers. They taught half how to practice juggling in the right way. These people practiced for a long time and got much better at juggling. The other half didn't practice, and didn't get better.

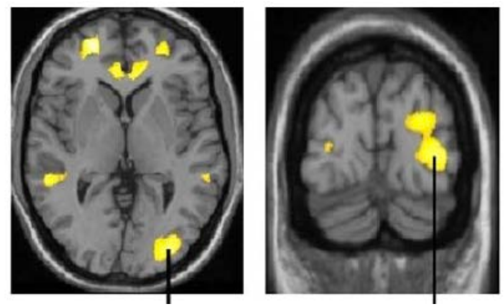

Figure 4 - Scan of a represetative adult from the study, showing the increases in grey matter (where neuron cell bodies are located) following training the individual to juggle.

Next, the scientists used a brain scanner to compare the brains of the two groups of people. They found that the people who learned how to juggle actually grew the parts of their brains that control juggling skills—the visual and motor areas. Their brains had changed, so they actually had more ability.

This was surprising because these people said before the study that they couldn't juggle—just like some people say they're "not good at math." But when they learned good strategies for practicing and kept trying, they actually learned and grew their brains.

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

A Formula For Growing Your "Math Brain": Effort + Good Strategies + Help From Others

Scientists have also found that learning to juggle is a lot like getting better at math. When people learn and practice new ways of doing algebra or statistics, it can grow their brains—even if they haven't done well in math in the past.

Strengthening the "math" part of your brains usually happens when you try hard on challenging math problems. But it's not just about effort. You also need to learn skills that let you use your brain in a smarter way.

If you use a bad strategy, you may not learn—even if you try hard. A few people study for math by doing the same set of easy problems and skipping the hard ones, or just re-reading the textbook, because it feels easier. Yet when it comes time to do the test, they don't do well because they didn't work on problems that stretched their brains and taught them new things. When this happens, they may even say "I'm just not smart at math."

But the truth is that everyone can become smarter at math if they practice in the right way. If a weight lifter watched other people exercise all day long, he wouldn't get any stronger. And if someone tried to learn how to juggle by just reading a book about juggling, they wouldn't learn. You actually have to practice the right way—and usually that means the hard way—to get better at something. In fact, scientists have found that the brain grows more when you learn something new, and less when you practice things you already know.

This means that it's not just how much time and effort you put in to studying math, but whether, when you study, you learn something new and hard. To do that, you usually need to use the right strategies. People often learn those good strategies from others, like teachers or students who do well. Luckily, strategies are easy to learn if you get help.

The Truth About "Smart" and "Dumb"

People aren't "smart" or "dumb" at math. 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.

This is true even for adults who have struggled for a long time to learn something. Dr. Wittenberg, a scientist from Wake Forest University, said "We used to think adults can't form new brain connections, but now we know that isn't true… The adult brain is like a muscle, and we need to exercise it."

People who don't know this can miss out on the chance to grow a stronger brain. They may think they can't do it, or that it's too hard. It does take work to learn, just like becoming stronger physically or becoming a better juggler does. Sometimes it even hurts! But when you feel yourself get better and stronger, you realize that all the work is worth it!

References:

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"Cajal cortex drawings" by User:Looie496 created file, Santiago Ramon y Cajal created artwork - "Comparative study of the sensory areas of the human cortex" by Santiago Ramon y Cajal, published 1899, ISBN 9781458821898. Licensed under Public domain via Wikimedia Commons - http://commons wikimedia.org/wiki/File:Cajal_cortex_drawings.png#mediaviewer/File:Cajal_cortex_drawings.png

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CREATING THE FUTURE

MINDWARE AND THE METACURRICULUM

D. N. Perkins, Ph.D.

One of the most fundamental questions that can be asked about intelligence is: "What is intelligence made of?" That is, what in the human mind and brain leads us to think and act more intelligently? Is intelligence simply a more efficient nervous system? Is it a matter of knowing a lot? Is it being a reflective thinker?

All these factors and more certainly appear to contribute to day-to-day intelligent behavior. Yet many people are dogged "nativists." That is, they believe that "real" human intelligence is entirely innate. You are born with certain neural equipment, that neural equipment has a certain mental horsepower measured by IQ tests, and this is the horsepower you have to work with for the whole of your life. Many people believe there is no such thing as becoming more intelligent in any fundamental sense. To be sure, anyone can learn a great deal of practical value in accordance with his or her abilities. But getting smarter in a basic sense? No.

A fundamental challenge to this nativist position has developed in recent years among educators and psychologists. Many are coming to the conclusion that intelligence is, to a substantial degree, learnable. In addition to accumulating knowledge and skills, people can in a fully real and powerful sense become more intelligent.

Neural, Experiential, and Reflective Intelligence

Not everyone agrees on this point. Indeed, a battle has raged among psychologists for several decades about the true nature of intelligence. Some psychologists consider intelligence a matter of the efficiency of the nervous system, genetically determined, not very subject to environmental influence, and adequately measured by IQ tests. They advocate what might be called a *neural view* of intelligence. Other psychologists have argued that highly intelligent behavior always occurs in a specialty. It involves expertise in a particular area of endeavor, such as violin playing, carpentry, or physics. They advocate what might be called an *experiential view* of intelligence. Experience and its cumulative lessons count for more than anything else. Still other psychologists emphasize how good thinking depends on good mental management-knowing what questions to ask yourself, using problem-solving strategies, monitoring and striving to direct and improve your own thinking. They advocate what might be called a *reflective view* of intelligence.

Considered in perspective, the debate appears somewhat misplaced. Proponents of each camp are trying to lay claim to the "one true intelligence," when there is no particular reason to believe that intelligent behavior has a single cause. Indeed, each camp has compelling arguments for the influence of the factors it highlights. It is time to accept this reality and acknowledge that intelligence is not monolithic. Intelligence has multiple principal causes.

I suggest a framework that recognizes three basic dimensions to intelligence: the neural dimension, the experiential dimension, and the reflective dimension. Rather than rivals, these three should be considered contrasting causal factors that all contribute substantially to intelligent behavior. Such a formulation dissolves a fruitless debate and sets the stage for asking what education can do to cultivate these three dimensions of intelligence.

Of them all, reflective intelligence offers the best target of opportunity for education because reflective intelligence is the most learnable of the three. Research evidence suggests that the neural component of intelligence does not change very much with instruction or practice, although there are nutritional and maturational effects. Experiential intelligence in a particular area takes years to build. But better practices of mental management, strategy use, and metacognition can be cultivated in much shorter periods-not overnight, but in months rather than years, years rather than decades.

Mindware

If reflective intelligence is the target of opportunity, then we should examine its nature more deeply. What is it "made of?" Is it a bag of tricks, a bundle of attitudes, a repertoire of habits?

All those things and more. One encompassing way to describe reflective intelligence is to say that it is made of "mindware." Just as kitchenware consists in tools for working in the kitchen, and software consists in tools for working with your computer, mindware consists in tools for the mind. A piece of mindware is anything a person can learn -- a strategy, an attitude, a habit -- that extends the person's general powers to think critically and creatively.

Mindware does three jobs, all of which concern the organization of thought. It works to *pattern, repattern, and depattern* thinking. Concerning patterning, a student may not have an organized approach to, for example, writing an essay. There are a number of strategies that help to *pattern* the writing process, not in rigid ways but in flexible and fruitful ways. As to repatterning, a person may suffer from bad thinking or learning practices. For example, many students adopt the strategy of reading something over and over as a way of understanding and remembering it. Research shows that this is not in fact a very effective strategy. Students need to *repattern* their reading, adopting more powerful strategies.

As to depatterning, a person may suffer from overly rigid or narrow ways of approaching problems and managing situations. For instance, people display a strong tendency to look at situations in one-sided ways. Also, people generally fail to question their tacit assumptions. Brainstorming, assumption identification, and other tactics of exploratory thinking can help people to *depattern* their thinking, opening it up to more possibilities and evading the ruts of habit and prejudice.

Practice Does Not Make Perfect

While the notion of mindware to pattern, repattern, and depattern thinking may sound like inevitable common sense, it actually strikes a sharp contrast with a common misconception about developing thinking: the "practice makes perfect" notion. Many efforts to cultivate thinking do little more than encourage youngsters to engage in a lot of hit-or-miss attempts at thinking, through collaborative learning activities, class discussions, project work, and so on.

Such initiatives are fine as far as they go. Certainly we should applaud any effort to make classrooms more thoughtful settings. Surely this is a necessary condition for any progress in this promising area of learnable intelligence. But necessary conditions are not always sufficient conditions. In this case, there is reason to believe that practice alone is not enough. Indeed, mere practice can lead youngsters to entrench their old patterns of thinking rather than repatterning and depatterning to develop more effective thinking.

This is where *reflective* intelligence truly lives up to its name. Mere practice is not a very reflective process. In contrast, activities in which people think about their thinking, learn good ways of patterning, repatterning, and depatterning, and adapt this "mindware" to their own needs or even invent their own mindware, are much more likely to develop thinking. Better thinking typically means not just smoother, faster thinking, which practice alone would yield, but fundamentally reorganized thinking, which requires pointblank attention to mindware.

Toward the Metacurriculum

The examples of mindware that I have given so far are rather general. What about the subject matters? Many psychologists have argued in recent years that general skills of thinking are no substitute for knowledge in particular subject matters.

I agree with this strongly. Moreover, each subject matter brings with it not only important "content" to master but its own specialized mindware. For example, any discipline has problem-solving strategies of special importance to it-in physics, such methods as energy balance equations; in literature, attention to fundamental dimensions of stories such as plot, character, and setting; in writing, such strategies as free writing; and so on.

Likewise, any discipline has its distinctive ways of explaining and justifying ideas, ways which differ somewhat from subject matter to subject matter. Mathematics highlights formal deductive proof; the sciences emphasize empirical evidence from experiments; history depends on evidence from primary sources; and so on. In summary, every discipline has its distinctive "mindware," consisting of those problem-solving strategies, ways of validating ideas, and other practices that help to pattern, repattern, or depattern thinking in fruitful ways.

Unfortunately, what schools principally teach is a curriculum of content -- the facts and procedures of a subject matter. Overwhelmingly, textbooks purvey the facts of history, the algorithms of arithmetic, the formulas of science. There is little explicit attention either to general purpose mindware or to the distinctive mindware for each of the subject matters. What is missing, one might say, is the *metacurriculum* -- the "higher order" curriculum that deals with good patterns of thinking in general and in the subject matters.

How, then, to develop such mindware in students? One solution is to offer special courses focused on the art of thinking. In my view, well-designed interventions of this sort are worthwhile. But they are not likely to prove feasible on a wide scale in the already crowded school curriculum. And they are not enough. Abundant research shows that the subject matters desperately need a direct injection of thoughtfulness, a "mindware booster shot." I am an advocate of what is often called *infusion* -- integrating the teaching of new concepts in a deep and far-reaching way with subject matter instruction. The marriage of curriculum and metacurriculum can provide students with the mindware to make the subject matters more understandable, thought-provoking, and connected with their lives.