UNIT 4: DIFFERENT LEARNERS, DIFFERENT MINDS

Section 1: Introduction

Q: Why are we calling some children "learning disabled"?

Henry Ford's invention of the assembly line at the start of the last century introduced the concept of mass production that revolutionized how consumer products were manufactured. Prior to Ford's invention, each car was built individually by a team of skilled mechanics expert in virtually all aspects of automotive assembly. Ford realized that, by making each car identical to the next, he could eliminate the need for tradesmen skilled in all stages of assembly. Instead, the assembly could be broken down so that each mechanic worked at a station specializing in just a single phase of the process. Cars would be passed down a line from station to station as identical copies of each product were built, reducing costs and improving efficiency.

When Henry Ford was growing up, children who lived in rural parts of the country typically attended school in a one-room schoolhouse. Henry Ford went to such a school for eight years of his life. Ironically, as Henry Ford grew up, not only did our nation inherit the innovations he pioneered for mass-producing consumer-products, but we also moved toward a wholesale adoption of a system of education that in many ways resembled the assembly-line process Ford used to manufacture cars. Though the suggestion that schools treat children as if they are cars on an assembly line is in many ways preposterous, the belief persists that our current school system works best, matriculating students with the greatest efficiency, when children can be treated as if they are identical, one to the next, passed from station to station down a line from kindergarten to graduation.

(Opened ScienceTalk sidebar)

Advances in Genetics and Neuroscience

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Dr. Joanna A. Christodoulou works at the intersection of education and neuroscience with roles as a scientist (Department of Brain and Cognitive Sciences at Massachusetts Institute of Technology), clinician (Children's Hospital, Boston), instructor/professor (Harvard University; Department of Communication Sciences and Disorders at MGH Institute of Health Professions), and practitioner.

While educators were grappling with the changing metaphors for teaching and learning, the fields of genetics and neuroscience had been undergoing revolutions of their own. Efforts to map the human genome gained momentum in the 1990s and early 2000s, and technologies for genetic analysis became cost-effective and widely accessible. For the first time, it became practical to identify the
Obviously, children are not identically produced cars, and schools are not assembly lines. And yet, one of the greatest challenges facing teachers in the classroom is how to address the tremendous diversity present in each and every class, and cope with the range of learning differences a classroom can present. Students can differ in the way they learn for any number of reasons. These reasons can be socioeconomic: perhaps the student needs to take on an afterschool job to help out with the family and doesn't have time to study. Or, the reasons can be socio-cultural: perhaps the student is frequently up all night texting or playing video games and isn't getting the sleep she or he needs to learn effectively. Other reasons may be related to how students process information, such as whether they have difficulty...
sounding out words from their spellings, or whether they are easily distracted.

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While the range of factors that determines the diversity of learning in a given classroom can be exceedingly broad and complex, certain aspects of this diversity can be understood in terms of neuroscience. In this unit, we will examine some neurological factors that influence learning diversity, and will begin to think about the strategies that teachers can adopt to begin to address the needs a typical classroom presents.

Richard Konicek-Moran liked to tell the following story based on his research. He taught in New England where the weather is cold. All his students knew that when it's cold outside, you put on a down jacket to stay warm. Konicek-Moran was curious why his students thought the coat kept them warm. So, he gave his students thermometers and asked them to predict what would happen if their thermometer was wrapped up in a cocoon of down. Virtually all of his students predicted the temperature would go up. But, when they tried the experiment, they were surprised to see that wrapping a thermometer in down didn't make the temperature reading increase. Many blamed their equipment. They insisted that their thermometer had to be broken. So, they tried thermometer after thermometer only to discover that all of the thermometers in the classroom had to be broken! Very few arrived at the expected scientific explanation: that the jacket is just an insulator, incapable of generating its own heat.

In this example, the cause of the students' learning difficulties was clear. The children grew up in New England where it's cold, and their experience with down jackets led them to believe that down generates heat. But, in many cases, we can't so easily understand why some children appear to have difficulty learning. All too often, if we don't get the results we expect, when we don't understand, just like Koniceck-Moran's middle school students, we tend to blame the equipment: The child isn't learning because the child is "broken." Sometimes, we even go so far as to label children as "learning disabled": unteachable and incapable of learning.

As we'll discover in the following sections, neuroscience tells us that it's not that the child is "broken," but rather that our teaching approach may be inappropriate, given the needs of the child.

Neuroscience can provide clues as to why certain forms of learning can be difficult for some people but easy for others. Armed with this knowledge, there are many things teachers can do to help students learn more effectively, and these are some of the ideas we will explore in this unit.
Q: Can "disabled" be "normal"?

Nestled in the shadows of the nation's capital is a remarkable institution known as Gallaudet University. As signed into law by Abraham Lincoln in 1864, Gallaudet was originally known as the "Columbia Institution for the Instruction of the Deaf and Dumb and the Blind." Because today virtually all of its students, faculty, and staff are deaf, most classes are conducted in silence, using sign language. At Gallaudet, it's not normal to speak, and one's voice is essentially useless there. The hearing visitor, unschooled in American Sign Language (ASL), cannot even so much as beg for a sip of water without asking for help from a translator.

The campus is fully adapted for life without sound. Where possible, structures avoid right angles, so people who cannot hear someone approaching can see who is nearby. Halls are built extra-wide to accommodate students who gesture while walking side-by-side. Every room is equipped with a button outside the door to flash the lights inside, which substitutes for a knock.

As at any college, the dining halls are alive with students excitedly chatting and gossiping, but hardly a sound is made.

(End of first column online)

Instead, students communicate efficiently using hand gestures that are punctuated by animated movements of the face and body. Students talk on the phone using videophones located throughout the campus. People who are able to hear and are unschooled in ASL, who outside Gallaudet may think of themselves as "normal," are likely to feel very much inferior and out of place in this society where people speak so eloquently with their hands. In effect, those who are "normal" outside become "disabled" inside, turning our definitions of "normality" and "disability" on their heads. Unless people can master ASL, those who are "normal" outside the walls of Gallaudet will be unable to learn, or even use their voice to perform basic important life functions, once inside. On the other hand, those who are deaf, who work and reside within Gallaudet, do not perceive their life in silence as a hindrance or a loss.
In the context of Gallaudet, the person who is "normal" is the person who is handicapped outside Gallaudet. This important fact serves to remind us of something we all know that is all too often forgotten: "Normal" is a relative term, and "normal" or "typical" are not synonyms for "better." As educators, though few of us regularly deal with students who are deaf, all of us are faced on a daily basis with students who exhibit a broad range of differences in ability. Though one student may perform more poorly than others at doing some task in some specific context, it is important to recognize that if this context is changed, or if the task is modified in even a small way, this same student who performs poorly may outperform his or her classmates. Our job as educators is to recognize the degree to which we can influence how well any given student may learn, by simply restructuring the environment or by changing the context for learning so that a difference that was once a disadvantage can be turned into an advantage. Let us look at some of the ways the neuroscience of teaching and learning can help us to do this.
Teachers often despair that students don't pay attention in class. Easily distracted, all too often students chat with friends, listen to iPods®, and text on their phones during times when we expect them to be paying attention to the lesson and whatever else is going on in class. When we encounter this kind of behavior, often our first reaction is to assume the thermometer is broken, that it's the child who has a "behavior problem" and that it's the child's fault that he or she isn't paying attention in class. But just as people vary in how well they are able to see and hear, abilities for attention are tied to neurology, and it is perfectly natural for such abilities to vary among children. Therefore, it is the teacher's job to provide students with a variety of options to help them attend to the material, regardless of how their brains may be wired.

Any classroom will have a few students who have exceptional abilities for attention, as well as a few who are challenged in this area. As professional educators, we don't want to choose which of our students will or will not learn from us. We want all of our students to learn. So it's our commitment as professionals to understand how differences in attention interact with our teaching, and then adjust our approach so that we reach all of our students, not just a few.

We may assume that students who are best at paying attention are the ones who will learn best. However, it may be surprising to discover that, in some circumstances, the students who are least able to pay attention may be the ones who are able to learn best. Let's begin to look at how understanding the neurology of attention can help us to be more effective teachers, who are able to reach and affect an entire class.

Success Story: Dr. Stephen Shore

Educators supporting students with autism face many challenges in providing them with a meaningful education. Dr. Stephen Shore, Professor of Special Education, who was diagnosed with autism at 18...

View video
how many times the ball is passed.

Anyone Can Be Disabled

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Dr. Matthew H. Schneps is the George E. Burch Fellow in Theoretic Medicine and Affiliated Sciences at the Smithsonian Institution, director of the Laboratory for Visual Learning at Harvard-Smithsonian Center for Astrophysics (CIA), and executive director of the Science Media Group at CIA.

At the end of a long, hard day’s work, perhaps there’s nothing you’d rather do than sit down in a comfortable chair, put your feet up, and curl up with an interesting book. But then, just as you’re getting deep into the story, an inconsiderate neighbor fires up a leaf-blower, creating a racket that makes it impossible for you to concentrate on your interesting book. Libraries have “Quiet, please” signs for a good reason. If you’re trying to concentrate on reading an especially difficult passage, the last thing you want is your attention competing with a distraction that interferes with your ability to learn.

Reading invokes a complex network of attention that serves to reduce our sensitivity to distractions. But, in situations where our senses are overloaded (say, by someone talking loudly in a library), these irrelevant sensory inputs can overwhelm the brain’s ability to focus attention, and learning can become difficult. When your attention becomes divided among many different things at the same time, your ability to concentrate on any one of them is diminished, and learning is impaired.

From time to time, every one of us, without exception, has experienced attention overload caused by sensory distraction. Perhaps the source
of the distraction is an auditory input (say, a person gossiping in the library). Or, maybe what's causing you to divide your attention is something visual (a flashing neon sign outside the window). Or, perhaps the distraction is tactile (a particularly scratchy tag in your shirt). Sometimes, the source of distraction is internal: pain from a sprained ankle, hunger pangs from a skipped meal, or even a persistent nagging thought (remember to buy milk). While we can control how we allocate our attention to a certain extent, more often than not our neurological attention networks are responding involuntarily to sensory inputs from our environment, and there is very little we can do to control this.

When we experience attention overload, we become "learning disabled," at least as long as conditions of cognitive overload persist. You are probably familiar with the consequences: You may find it difficult to follow a complicated train of thought, your reaction times may become slowed, and you may find it difficult to perform precise controlled movements (like threading a needle). When we experience attention overload, all sorts of negative stress-related emotions automatically kick in. We feel frustrated, incompetent, and out-of-control. It happens to all of us.
UNIT 4: DIFFERENT LEARNERS, DIFFERENT MINDS

Section 4:
Learning

Q: What does it mean to learn?

Nothing is quite as frustrating as when you are standing in front of a class giving a lecture, and the students look bored and don't pay attention to you. It feels disrespectful, and eats away at your feelings of competence as a teacher. And yet, even though students are more likely to sit quietly and "pay attention" to a teacher who is entertaining and who is able to "command attention" in class, research shows that such qualities in a teacher don't necessarily correlate with student achievement.

That is not to say that attention doesn't play a role in learning. On the contrary, research in neuroscience shows that attention is a pivotal part of the learning process for many types of learning important in school. However, the word "attention" means different things to different people. For example, if your spouse says, "You never pay attention to me," then you know you're in trouble. In this context, the word "attention" is used to connote a lack of respect, consideration, courtesy, or politeness. But, when neuroscientists use this term in the context of learning, usually they are talking about something very different from the everyday sense of the word.

Attention, in the neurological sense of the word, is not necessarily something a person is able to control, so it has nothing to do with respect or politeness. Instead, neuroscientists use this word to talk about a complex neurological network that helps the brain manage the flow of information coming at it and to filter out information that is irrelevant, while enhancing sensitivity to information important to the task at hand. Attention, in the neurological sense, is a little like the switches and lights in a train yard. The brain is being bombarded by information (sights, sounds, smells, tastes, and sensations) coming at it from the senses, and attention networks act like the track switches and signals to control this flow so that the result isn't just a pileup and chaos.

Attention acts in two ways. It serves to reduce (inhibit) our sensitivity to distractions and enhance (facilitate) our sensitivity to things that are important. For example, when we focus intently on some task (as you are doing now reading this text), inhibitory attention networks are automatically being called into play, and these diminish your sensitivity to sounds and peripheral visual distractions that may detract from the task. At the same time, the attention networks help you become extremely sensitive to the smallest details in the text. You can more easily distinguish subtleties, differentiate one letter from the
next, see the patterns making up words, and quickly make sense of their meaning.

If the brain had unlimited capacity, attention networks wouldn’t be necessary. We could simultaneously pay attention to all the sensory information bombarding our nervous system and process this information accordingly. However, we cannot pay attention to everything at once. Our neuronal resources are limited, and we need to be selective in how our brain allocates the limited resources that are available. This is where attention comes into play.

**Attention Varies**

People vary widely in how well their attention networks serve to control the information bombarding the brain. First, people differ in how sensitive they are to sensory information. Some people can hear high-pitched sounds others cannot, some can see differences in colors others cannot, and some may be very sensitive to touch. So, the amount of information that the brain has to deal with, which comes in on any given sensory channel, differs from person to person. Furthermore, people differ in how well their attention networks filter out the information that comes in. Some people can concentrate intently, focusing on a book while the TV is blaring, while even the slightest sounds would distract another person. Therefore, abilities for attention vary from person to person, sense to sense, and task to task. Some people may be very good at concentrating on something that is interesting to look at, filtering out even the sounds of someone calling their name, but may nevertheless be easily distracted by the scratchy sensation of a tag in their shirt.

Ordinarily, we think of learning as something students do when they master the material presented in class, so that they do well on assessments. But, from the standpoint of neurology, this process is extremely complicated and difficult to describe. We can instead think of learning more simplistically. Learning might be thought of as a process that takes information coming into our minds through our senses, so that we can build mental representations of these inputs that remain in our minds even after the sensory inputs have ceased. We call these mental representations "memories." When seen in this way, learning is what we do when we build new memories from information we perceive through our senses. Learning is powerful because we can access, recall, and mentally manipulate these representations, long after the original sensory input has ceased. Attention networks play a role in learning because these networks determine which streams of sensory information we can access to use in building new memories.

Memory is not well understood by neuroscience, but there are a few properties of memory that have been well studied. For example, it is known that there are different forms of memory, and that these are distinguished by how fragile the memory is and by the quantity of information the memory can hold. Short-term memory sometimes lasts for only a fraction of a second and can barely hold a handful of elements. For example, if a number string is flashed on the screen, you might only be able to recall a few of the numbers, and even then not remember them for more than a few seconds after the event. However, other forms of memory are capable of holding information for a long time. This form of long-term memory is durable and seemingly expandable without limit. For example, maybe you learned a poem or
lines from a play in elementary school and committed it to memory: "What's in a name? That which we call a rose by any other name would smell as sweet." And perhaps those are not the only lines that you've memorized and committed to memory. Yet, such memories sometimes remain accessible for a lifetime.

One theory of memory that applies especially to words is that the volatile short-term memories are converted into longer-term memories that are stable through a process of repetition, sometimes referred to as "rehearsal." For example, if somebody tells you his or her phone number, in order to remember it for more than a few seconds, you might silently repeat the number to yourself, saying the number over and over, rehearsing it until your memory of this number feels stable.

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Labels Hurt

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Dr. Matthew H. Schneps is the George E. Burch Fellow in Theoretic Medicine and Affiliated Sciences at the Smithsonian Institution, director of the Laboratory for Visual Learning at Harvard-Smithsonian Center for Astrophysics (CfA), and executive director of the Science Media Group at CfA.

People differ in their abilities for attention, and people who are diagnosed with neurological conditions such as attention deficit hyperactivity disorder (ADHD), dyslexia, and autism spectrum disorders often struggle with challenges pertaining to attention and short-term memory that are persistent and outside their control. People with dyslexia and ADHD can be very sensitive to distracting influences in their environment. And people with autism spectrum disorders (and some with dyslexia) can have an opposing difficulty disengaging their attention, so as to shift their awareness and notice something unexpected in the environment.

Though the cause of the attention issues may be neurological, their impact on learning is the same: These students experience the same attention overload any of us feel when our attention is pulled uncontrollably in directions we don't intend. Learning suffers and negative stress-related emotions automatically kick in. These students end up feeling exactly the same way we all do when we're overloaded: frustrated, incompetent, and out-of-control. And the negative consequence of this emotional response is to compound whatever difficulties these students are already experiencing. The net result is that these students find it difficult to learn, and performance suffers. As teachers, we often find ourselves feeling powerless to help.

Image Source: © National Institute of Environmental Health Sciences.

When our classroom includes students with specific neurological diagnoses, it can be very difficult as a teacher to avoid the temptation to label these students "learning disabled" and walk away. They're broken thermometers. We are tempted to think: Of course, they can't learn. But, as we discussed earlier, such reactions are just our human response to things we don't fully understand. When something
Attention interacts with learning in a number of ways. First, attention alters the quality of the sensory input. Have you ever tried to listen to a conversation at a noisy party? Even though it's difficult to follow the thread of the conversation, if the discussion is interesting, you're able to hear and make sense of the conversation despite all the noise and distraction. Attention is what allows you to follow the conversation by directing neurological resources toward sensory events of interest, inhibiting information that distracts. Thus, attention promotes learning by improving the quality of the information perceived by the brain, to ensure that the brain is receiving information coming primarily from the informational event we want to learn.

Have you ever tried to remember a phone number while a friend tries to distract you by saying some random numbers? Attention helps build memories by keeping such distractions at bay, and this allows...
rehearsal to take place unimpeded, enabling the information in short-term memory to make its way into stable long-term memory. If your abilities for attention are poor, or if your attention is otherwise overloaded, you are more likely to be distracted during rehearsal, and this distraction, in turn, could interrupt the process required for building stable memories.

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**Neuroscience-based practical tips for directing student attention**

Julia Volkman is a Montessori mentor who works with the Springfield, Massachusetts Public Schools. Here are some techniques about guiding student attention that she shares with fellow teachers.

First, teachers can help by physically putting their attention on the stimulus of interest. That means you need to have a stimulus of interest and not just be a talking head. This is particularly important in some cultures (as in many Latino cultures) where it is impolite for a child to look an elder directly in the eye. They are taught to look away or down in order to show respect. If teachers say, as we often do, "All eyes should be on me," they can actually be causing stress and conflict in a child from such a culture. Instead, they need a visual aid: a map, a globe, a graph on the chalkboard, an image in a slide...someplace where children are able to focus their vision.

Also, it’s best if the visual aid is not text but requires some interpretation. While reading text is automatic (Raz and Buhl, 2006), associating a photo with a concept is not. It requires encoding and association and that improves retention (Medina, 2008). Thus, photo-based slides draw interest and attention to key concepts, invite storytelling to explain those concepts, and create a more elaborate encoding mechanism thereby improving memory (Medina, 2008).

Next, teachers can incorporate movement in the presentation. For example, rather than hand out materials, have children come up and get them. Poll the students after 10 minutes by asking everyone to stand up and then ask them to sit down if they respond a certain way to a question you ask. The question should not put the children on the spot for a right answer but instead ask for a qualitative response like their opinion on the topic. This gets oxygen flowing to improve attention and engages the students in emotion...their opinion.

In the PreK–K classroom, when we present a lesson, we have memorized specific points of interest in the materials. During the lesson, we draw attention to these points of interest, much like a magician. For example, when pouring water, we notice the sound of the water landing in the glass. We hold the pitcher above the glass and wait for the last drop to fall out (it usually hangs on for a moment or two so this is a truly intentional pause). We notice any drops of water on the tray, on the glass, on the pitcher, and take a small sponge and dab the drips away. So, we are constantly training the powers of attention by noticing everything of relevance in the child’s perceptual field. We also talk sparingly to reduce distractions and allow the visual sense to focus on the mechanics of the procedure. We then let the child do it immediately. We keep the presentation short and make sure the child can step in at the earliest possible moment.

Of course, we know that attention follows interest. So, when presenting a new topic, teachers must find
a way to link the topic with the child’s life. They must help the child understand why he cares about it, why it is relevant to his life. You can do this in many creative ways. You may ask one student in advance to share a story about herself with the class that brings the topic to life. You might tell a short story about the history of the concept...to create a sense of magic, awe, and mystery. For example, share a very brief history of the written alphabet (think of the power it gave the Phoenicians or how it has preserved the Cherokee language) as a prelude to introducing cursive handwriting.

When doing division, one of the PreK and Kindergarten teachers at the Alfred G. Zanetti Montessori Magnet School, Maureen Ryan, likes to give an example relevant to each individual child. "Because I know the children, I can do this. For example, Marcus’s mom sings in the choir and he accompanies her to practice. So, when we are studying division, I say that Marcus has so many people in his choir who all need the same number of cookies after they sing. If we start with this many cookies and we have this many people in our choir, how many cookies will each person get?" So, if you know the children well, you can always find lots of connections between the school curriculum and something that is relevant to their lives. This helps the students build an interest in the topic and, in turn, helps their attention.

In the PreK–K classroom, we actually teach the body mechanics of physically putting your attention on something just as magicians put their attention on a missing coin. Students use these techniques when they want to get the teacher’s attention, something that’s specifically taught as "grace and courtesy" lessons. We teach students to wait nearby and in the line of sight of the person whose attention they want, and look at their eyes. When the teacher’s eyes are looking at the child we say, "Oh, you can see my eyes looking at you, so you know you have my attention."

Also, when a classroom is rowdy, many teachers use a technique that can be very effective: simply turn off the lights and, thus, change the perceptual setting. It redirects the attention in a gentle way. This is particularly effective in signaling transitions. For example, five minutes before lunch a teacher might turn off the lights or turn on some quiet music. This indicates to the children that it is time to put their work away, tidy up, and move on to the next thing. It gently calls their attention to the time of day.

REFERENCES:


Glossary

**neuronal resources**
A term used to describe brain systems recruited for a particular task.
Q: What can we do to help students who struggle?

Attention is required in order to move information in volatile short-term memory to stable memory, and is therefore a critical gateway for learning. So, what can teachers do if they suspect that their students may be having difficulties with attention?

The first thing to keep in mind is that anyone can become "learning disabled" if attention networks are overextended. Therefore, simply telling someone to "pay attention" doesn't help. Imagine you're on the golf course, focusing on lining up a critical putt. Does it help to have your teammates scream, "Concentrate! Don't screw up!"? Probably not. In the same way, telling students to "pay attention, sit straight, and stop fooling around" is likely to do more harm than good. Telling students who are struggling with attention to "pay attention" only adds to their attention load, and increases the chances that they will perform poorly.

As we saw in the previous units, learning can be improved simply by eliminating sources of unnecessary stress. Teachers can accomplish this by simply striving for a more sympathetic tone of voice and approach, and by eliminating unessential stakes in learning (e.g., the "pop quiz") that serve little purpose other than to raise stress levels in students. Urging students to get sufficient rest and sleep can also help, as research has shown that sleep and rest have a beneficial effect on abilities for attention.

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What Curriculum Developers Can Do

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*Dr. Matthew H. Schneps is the George E. Burch Fellow in Theoretic Medicine and Affiliated Sciences at the Smithsonian Institution, director of the Laboratory for Visual Learning at Harvard-Smithsonian Center for Astrophysics (CfA), and executive director of the Science Media Group at CfA.*

Another, much more sophisticated way educators can help the learning process is to alter the pedagogical approach so as to minimize demands on attention and memory. To see how this can work, let us illustrate the principles involved through an example in arithmetic, using an attention and memory management tool invented in the 15th century by merchants from Treviso, Italy.

To illustrate these principles, take a piece of paper and try doing the following multiplication problem,
longhand, the way you were trained to do when you were a student in school: 247 x 834. (Really try it!)
For our purposes here, the answer isn't important. Instead, pay attention to the process. As you work
the problem, try to notice which parts of the problem place the greatest demands on your short-term
memory and attention.

Did you get 205,998? What parts of the problems required you to remember things for short periods of
time and hold this information in your head while you did other things? These are the parts of the
problem that stressed your abilities for short-term memory and attention.

Chances are that recalling multiplication facts and
performing the single-digit products (e.g., $8 \times 7 = 56$) weren't the most difficult aspects of this
problem. If you are like most people, much more of
your mental effort (commanding attention and
short-term memory resources) was spent tracking
the columns of numbers and dealing with the carry digits.

Imagine you had to deal with lots of other
distractions while you were trying to keep track of
the columns and the carry digits. A small lapse in
your abilities for attention or working memory,
whether caused by neurological differences or
distractions within your environment, could easily
cause you to make an error and do the problem
incorrectly.

Now, let's try the same problem using the
15th-century Treviso method rediscovered by the
mathematician and education researcher Robert
Speiser and his colleagues as an alternate
approach to multiplication that greatly reduces
demands on attention and short-term memory. To
start, a matrix of boxes representing the dimensions
of the product is drawn (for 247 x 834 the matrix is
3-by-3), and the digits of the problem are written
along the top and right-hand sides of this matrix.

Next, diagonals are drawn.

Any pair of numbers (e.g., 7 and 8) is chosen and the product performed and placed into the
corresponding box.

Then, other pairs of numbers are chosen (say, 4 and 8) and the product similarly performed and entered in the box, until all the products have been done.
Finally, to obtain the result, starting at the bottom right corner, the numbers are summed along the diagonal channels, and the sums are written underneath the corresponding channel. Any carry digits are promoted to the next column up and summed along with the other numbers. The answer, 205,998, is found along the bottom left periphery of the box.

The method may look difficult because it's unfamiliar, but it's actually simple once you understand how it works. In fact, research by Speiser and colleagues has shown that it's a highly effective approach. Unlike the traditional algorithm, the Treviso method is relatively impervious to lapses in short-term memory or attention. The traditional approach requires that you hold the product of each two-digit multiplication in your short-term memory while you simultaneously juggle the alignment of columns in the workspace and deal with the disposition of the carry digits.

However, in the Treviso method such demands on short-term memory are minimized because each product is performed separately. The product is immediately placed in its corresponding box before you have a chance to forget the result. Attention load is reduced because the pre-drawn boxes and diagonal lines act as visual guides to ensure everything stays aligned, so you don’t have to keep track of alignment while you're trying to perform arithmetic. The grid also serves as an ever-present visual reminder of where you are in the steps. If a distraction causes you to momentarily lose track of your place, you can look back at your work and pick up the pieces right where you left off. The result is an algorithm for multiplication that is robust against distractions and lapses in attention or short-term memory.

Though it may sound obvious, perhaps the most direct way teachers can reduce demands on attention and short-term memory, and thereby improve student performance, is to simply reduce the memory and attention loads we demand from our students. We can get some hints as to how teachers might be able to help their students do this by taking a look at how major corporations manage
their most important corporate talent.

Corporations recognize that if they required their top executives to answer phones, make appointments, do filing, track budgets, fill out forms, and so forth, the corporate machine would grind to a halt. So corporations protect their scarce "executive resources" by having executives delegate as many attention-demanding tasks to others as is practical. The executives sometimes have a small army of administrative assistants to help deal with the relatively inconsequential tasks,

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and they make use of electronic devices (e.g., cell phones, computers, PDAs, calendars, and other organizers) to help the executives track their work. As a result, the top executives can devote their full attention to tasks that are most important to the corporation, and leave more routine tasks to others, tasks that may not require the same sort of attention.

Teachers can help students manage their attention by helping them offload the more routine, attention-robbing tasks to others. The students may not have access to an army of "executive assistants" (other than their parents), but teachers can nevertheless look for ways to reduce the tension load, and eliminate as many routine tasks from their list of responsibilities as is practical. Web-based calendars with alarms can be used to help students keep track of their class schedules, as well as due dates for homework or tests. Calculators can be used in situations where learning math facts is not a primary goal, and students can be allowed to use computers for spelling and grammar checking where possible. Other techniques to limit demand on attention include the use of headphones to block extraneous sounds, music to mask distractions, and FM amplification systems to isolate a teacher's voice. At the same time, care must be taken so that these executive assistants don't themselves become a burden and a source of distraction. If such tools are used judiciously, they can help students reduce their attention load, and help protect the scarce neurological resources required for learning.

**You can contribute to research**

Many of the tasks teachers ask students to perform place unnecessarily high demands on short-term memory and attention. Regardless of whether or not a given student has a learning disability, such extraneous demands compete for scarce resources essential for learning, and make it needlessly difficult for students to learn. Unfortunately, neuroscientists and education researchers have not been able to develop a magic bag of tricks similar to the Treviso algorithm (see sidebar and video on the left) to solve such problems. Therefore, there is a need for professional educators to help advance this research.

The next time you develop a new lesson plan or look at new approaches to teaching, you may want to examine these approaches for potential working memory and attention bottlenecks, and think about whether you can devise alternative approaches that minimize short-term memory and attention demands. You can then use your classroom as a laboratory to test your improvements: Does this new approach lead to improvements in student performance?

Only through the active involvement of professional educators such as yourself can neuroscience help
bring about new approaches to instruction that will result in advancements that are practical for the classroom.

Interested in doing research? We invite you to share your ideas here!

(Opened TeacherTalk sidebar)

From the Classroom to Research: A Teacher's Journey

Lysandra Sinclaire-Harding has 10 years of experience teaching primary school in the United Kingdom. Driven by a desire to better support her students with learning and behavioral difficulties, she turned to research in neuroscience with support from the Faculty of Education, University of Cambridge.

My journey to the research desk began with Jack, a seven-year-old in my class full of energy and trouble. Whenever Jack entered the room, he demanded attention. During lesson time, he would frequently interrupt with shrieks or shouts. Jack was resourceful and entertaining, but he had a hard time interacting with others. At times he was volatile, aggressive, and easily angered. In the playground he was a risk to the well-being of his peers who kept their distance, never quite sure when they might be on the receiving end of a kick, bite, or punch. Jack struggled with reading and writing, could hardly sit at the desk long enough to try, and would spend day after day outside the classroom for his disruptions.

His mother told me that her pregnancy had been full of scares for Jack's health and she admitted emotionally detaching herself in case he did not survive. Jack's parents separated when he was an infant. The youngest of three children, he was left in his father's care. I wondered if Jack's emotional development had been somehow damaged as a result of this remote relationship with his mother.

By chance we discovered Jack's response to enclosed spaces—a cardboard box he could crawl into or the small space beneath my chair. Whilst inside, he would be still and calm, for once allowing me to read or talk with the rest of the class uninterrupted. It seemed that, in these enclosures, he found a certain sense of security and safety.

Concerned and intrigued by these complex and contrasting behaviors, I wanted to better understand how children such as Jack experience and manage their emotions at school. I wondered whether such emotional factors create barriers to learning, and I wanted to know whether these negative emotional responses could be explained scientifically. It was with such questions that I turned to cognitive neuroscience.

Each day at school, we ask students to perform a range of cognitive and social tasks such as: planning group projects, learning new vocabulary, or understanding and interpreting class texts. They are expected to remember which resources are needed for class, choose what to prioritize when studying for a test, and even learn how to fit in with a group of friends. The capacities required to support the daily demands of school-life require judgment,
planning, decision making, and social conduct, and are of enormous interest to neuroscientists who define them as "executive functions."

In recent years, "affective neuroscientists" have produced an abundance of empirical breakthroughs and new theories on emotion and its impact on executive functions. Brain images show how specific (prefrontal cortex) regions of the brain are active when a task demands attention and concentration, and how these areas are anatomically at some distance to the deeper (limbic) regions that would usually activate with emotion experience. Evidence of connections between these regions is well established, and they suggest that the emotional reactions of Jack and others like him could help to explain the deficits in attention, decision making, and social functioning that teachers frequently observe and manage in their classrooms.

By way of response to the summons for educators to become critical consumers of neuroscience research, and with support from the Psychology, Neuroscience, and Education Master's program at the University of Cambridge, I developed research questions generated from laboratory findings that I investigated from within the classroom. I collected evidence of moment-by-moment emotional experience, provoked by specific events in English, math, and social studies classes.

In different age groups, brain imaging studies suggest that executive functioning is improved during positive emotional experience whilst negative emotions such as anxiety, frustration, or boredom have the opposite effect. From my experience, and conscious of ongoing concern for boys' educational underachievement, I had a sense that in my investigation, I might find gender differences in emotional response.

**What does neuroscience tell us? Generating research questions for the classroom.**

<table>
<thead>
<tr>
<th>Scientific finding</th>
<th>Education research question</th>
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<tbody>
<tr>
<td>Positive affect enhances executive function.</td>
<td>Do positive emotions support higher-order thinking skills?</td>
</tr>
<tr>
<td>Negative affect provokes autonomic responses leading to stimulus avoidance.</td>
<td>Do negative emotions result in withdrawal from learning tasks?</td>
</tr>
<tr>
<td>The male brain is more sensitive to negative affect due to earlier development of the orbitofrontal cortex.</td>
<td>Are boys more likely than girls to avoid learning tasks that stimulate negative emotional experience?</td>
</tr>
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</table>

I combined observations, interviews, and questionnaires with a technique called "video-stimulated recall," where a videotape of the lesson is replayed to the student during the interview. Behaviors, facial expressions and gestures are captured and students give their interpretations of events, together with their consequent effect on thought processes and feelings, as far as they are able to recall and describe. Emotions were expressed in response to the teacher-student relationship, group work, classroom reading materials, discussion topics, problem solving, and delivery of oral presentations.

Although the methods employed here are a long way from the fMRI laboratory, the findings do support the scientific hypothesis that students are more likely to engage and perform in class if they are experiencing positive emotions such as enjoyment, pride, interest, and satisfaction.
In my study, response to negative emotion was less predictable. Students reported disinterest, boredom, frustration, worry, and shame. However, there was a substantial variation between individual responses to a single event, as well as between gender. Whilst the girls were more articulate in describing their emotions, the boys reported more negative emotion and were more likely to avoid or withdraw from the learning activity than the girls. It seemed that when boys experienced a negative emotion, their ability to take positive action and maintain effort in classroom activities was less than that of the girls.

To conclude, this inquiry and subsequent reflection have provided me with a greater sensitivity to the constant undercurrent of emotion experience in my class. As a consequence, in my teaching and planning I seek out opportunities to support my students in attaching positive emotions to specific learning moments. I also try to be vigilant for signs of frustration, boredom, and anger, and I provide vocabulary for my students to help them identify and describe both positive and negative feelings. Previously, such discussions were timetabled as a separate curricular activity; now my class is encouraged to make meaningful interpretations of their feelings as they relate to their frustrations and successes across all curricular subjects.

But most of all, I am aware of the vulnerability of children such as Jack, whose adverse start in life has left him susceptible to being overwhelmed by negative feelings. For him, as with all of us, attention is a limited resource, and frustrations and anger are constant diversions from the learning opportunities he struggles to maximize.

With guidance from neuroscience research, in my next steps I seek to develop an intervention that can strengthen the socio-emotional competencies of students. Just as Jack sought out momentary safety, I hope to support young people to find their secure space from which they can be challenged to explore and learn.

**Glossary**

**executive function**  
(also referred to as executive capacities) A term describing cognitive resources available or abilities for planning, organizing, carrying out, and evaluating goal-directed behavior.

**affective neuroscience**  
A term used to describe the field of neuroscience investigating questions related to affect, including emotions, goals, etc. Affective neuroscience questions are interrelated with questions in cognitive neuroscience; these fields are considered to overlap significantly.
UNIT 4: DIFFERENT LEARNERS, DIFFERENT MINDS

Section 6:
Other forms of learning

Q: How do we know when a dog is a dog?

The late education researcher Rosalind Driver, King's College, London, who pioneered studies in how children construct their understanding of ideas in science, felt it was important to distinguish "school science" from the science that scientists actually use in research. While a mastery of school science is often measured by abilities for rote memorization (e.g., how well students can regurgitate boldfaced words in a text), success in science as practiced by scientists is measured by the person's abilities to solve problems and make sense of difficult ideas. While memorization certainly plays an important role, this type of learning represents just one relatively minor aspect of science as practiced by scientists in the real world.

Many of the ideas that are traditionally valued in education, such as memorizing the boldfaced vocabulary words in a science text, are tasks that place strong demands on attention and short-term memory, and that lead to learning through a process of rehearsal and repetition. Even though these forms of learning are relatively easy to test, and are therefore emphasized in schools, these do not represent the only forms of learning important in everyday life.

Take, for example, the remarkable abilities we have for classifying objects. Even a four-year-old child can tell that an object is a "dog," whether it's a St. Bernard or a Chihuahua, despite the fact that there are a seemingly infinite number of possible variations in this object's appearance. Even as an adult, most of us would be hard-pressed to articulate the qualities that define "doggyness." And yet, we can confidently distinguish a dog from a cat, or equate a poodle to a Great Dane, despite the fact that we may not be able to describe in words how we accomplish this amazing feat.

Learning the gist of what makes a dog a dog (learning the concept of doggyness) is a form of learning that is distinctly different from the learning we use to memorize a phone number or a list of state capitals. Rote memorization makes use of attention and short-term memory to promote learning through a conscious process of repetition and rehearsal. Learning the gist of doggyness, on the other hand, is to a large extent unconscious.

When we learn the classification "dog," we unconsciously take note of myriad, unarticulated visual nuances common to each of the things we have been told are dogs. We then build our understanding of the concept of dog over time, without consciously rehearsing the factors used to categorize the gist of a dog.

Though there are clear prescriptions for how to teach through rote memorization (make a list of things to memorize, review it over and over, test the learning, repeat, review), we don't yet have a similar prescription to help students learn gist.
And yet, many of the ideas important in life (the ideas that separate school science from meaningful understanding) are concepts that we learn unconsciously in this way, using a process that is very similar to the one we use in learning the gist of a dog. For example, learning to tell the difference between the sound of an oboe and a clarinet, or knowing which kitchen drawer has the bottle opener, are everyday examples of learning that takes place (for the most part) implicitly through gist.

**Implicit Learning**

Implicit learning can be measured by how much we improve with repetition—for example, on the speed at which we complete a task, such as finding a target in a visual field. While people with...

View video

**Deaf Gain**

Dr. M. Diane Clark is a professor of Educational Foundations and Research at Gallaudet University in Washington, DC, where she teaches educational psychology and statistical methods.

What is the impact of learning through the eyes in contrast to learning through the ears? What is the impact of using a visual language rather than an auditory language? The Science of Learning Center on Visual Language and Visual Learning (VL2) was established to gain a greater understanding of what influences the acquisition and use of language, both written and signed, through the visual modality. Research by VL2 investigators Matthew Dye (University of Illinois), Peter Hauser (RIT/NTID), and Daphne Bavelier (University of Rochester [Dye, M.W.G., Hauser, P.C. & Bavelier, D. (2009), Is Visual Selective Attention in Deaf Individuals Enhanced or Deficient? The Case of the Useful Field of View, PLoS One, 4, e5640] found that adolescents and adults who are profoundly deaf from birth have enhanced abilities for visual spatial attention. In other words, these profoundly deaf individuals are better able to notice the occurrence of events that take place away from the current focus of gaze. So for example, if they're concentrating on studying the structure of some interesting symbol here on this page (e.g., ![Symbol](image)), the people who are deaf are more likely to notice something else interesting popping up elsewhere on the page, which a person who is not deaf is likely to miss. This sensitivity in people who are deaf is sometimes referred to as "deaf gain."
Even though neuroscientists have long recognized that learning gist differs fundamentally from other forms of learning that we associate with rote memorization, the neuroscience underlying gist is only just now coming under study. One finding relevant to our discussion on individual differences in learning is that abilities for learning gist don't necessarily correspond to abilities for rote memorization.

Just because a student may have a great deal of difficulty with attention or short-term memory, and consequently have difficulty memorizing names, numbers, or other rote facts, he or she may not show any difficulties learning gist, and in some cases may even outperform those who otherwise memorize well. Let us illustrate this finding with some recent examples drawn from the field of dyslexia, a neurological disorder that impairs abilities for spelling and reading, known to be associated with difficulties in visual attention and short-term memory.

Being deaf results in a redistribution of resources for spatial attention so as to make those who are deaf more sensitive to visual information in the peripheral parts of the visual field. Though deafness is generally perceived as a disability, deafness tends to reorganize the brain so as to enhance certain abilities for vision, and provide people who are deaf with cognitive advantages over people who are able to hear.

What is the impact of learning through the eyes in contrast to learning through the ears? What is the impact of using a visual language rather than an auditory language? The Science of Learning Center on Visual Language and Visual Learning (VL2) was established to gain a greater understanding of what influences the acquisition and use of language, both written and signed, through the visual modality. Our discoveries provide insight into the principles of human communication and optimal practices in education.

VL2 has established a Center to support leading researchers from a variety of disciplines to understand basic principles of visual learning and to translate those findings into educational practices. Our research looks at learning at how the brain functions, how visual cognition develops, as well as how one's culture impacts development. The Center's long history of close association with underrepresented people leads to mentoring of deaf and hard of hearing students to become future scientists.
Q: Can not paying attention be good for learning?

If you have been teaching for a number of years, one of the great delights is to see your former students—now grown up—come back to tell you how they’ve turned out. It's always wonderful to hear from students who succeed, and sometimes students surprise us. A student who may have done very poorly while in your class, once grown up may have gone on to achieve great things.

But how does this happen? Performance in school is supposed to predict and facilitate performance later in life. Why then do some of those who perform so poorly in school nevertheless do well later? The answers to such questions are complex and may have something to do with the difference between "school science" and "real science" that Rosalind Driver talked about earlier. Perhaps aspects of performance important in real life are not being emphasized or measured in school, and some students do well later in life because these different forms of learning are emphasized and valued in their chosen careers.

People with neurological learning impairments can be among those who come back and surprise the teacher. People with autism spectrum disorders, dyslexia, or attention deficit hyperactivity disorder (ADHD) struggle tremendously in school, but sometimes do well later in life. For example, the animal researcher and author, Dr. Temple Grandin, attributes much of her success to her autism, which has given her the ability to imagine the world from the perspective of an animal. She uses these insights to understand animal behavior. John Elder Robison, an expert in audio and electronics who never graduated from high school, links his strong interests in electronics to his Asperger's syndrome, and this has led him to become successful in his career despite doing poorly in school. Others, such as the education researcher Dr. L. Todd Rose, who struggled with ADHD as a child and only barely completed school, nevertheless earned a PhD from Harvard, and achieved many important accomplishments in the field of education.

Among those with dyslexia, it has long been noted that many people perform well in visually intensive
careers despite the fact that they have considerable difficulty with reading and writing. One study showed that people with dyslexia are overrepresented in art schools, and another showed a similar overrepresentation among business entrepreneurs. Certainly, there are numerous examples of accomplished people with dyslexia who struggled in school and yet achieved recognition later in life. These include artists such as Chuck Close, writers such as John Irving, and Nobel Prize-winning scientists such as Carol W. Greider and Baruj Benacerraf, all of whom achieved success in their careers despite the fact that they struggled in school.

Such examples reiterate the need for us to question what we mean by "learning disability." For here we see that the students with "impairments," who perform poorly in school, can be among those who come back as adults having achieved great things in their careers. Their performance in school did little to predict what they achieved later in life. Thinking back to the example of Gallaudet University, where the hearing person becomes the one who is "disabled" in an environment where everyone speaks ASL, the definition of "disabled" can be turned on its end when the context is changed. Therefore, perhaps we need to revisit the context of learning currently valued in school, and broaden our definition of learning to include ideas that are more broadly useful in life outside of school. Opening the door to other contexts for learning, and using these as a measure of success, we can raise the achievement levels of all students in our classrooms, and hopefully do away with ambiguous labels like "learning disability" that do more harm than good.

Let us examine how inabilities for attention, traditionally thought of as impairments to learning, can help us turn the definition of "disability" upside down, so as to help those with attention difficulties turn this challenge into a strength. We will illustrate this idea with examples drawn from research about people with dyslexia.

Sensory attention is important in learning because it helps students focus on a task and prevent the influence of irrelevant distractions that interrupt the rehearsal required by the learning at hand. But these attention networks are actually serving two functions that are distinct: On the one hand, attention increases our sensitivity to information that's important at the moment (facilitation); on the other hand, attention decreases our awareness of stimuli thought to be irrelevant (inhibition). Attention therefore acts like a seesaw. It increases our awareness of some things, but at the same time decreases
our awareness of other things. This seesaw quality of attention can lead to learning advantages in people whose abilities for attention are poor.

**Attention Deficits Also Can Lead to Strengths**

Attention difficulties can lead to advantages because attention networks sometimes make mistakes. The brain is being bombarded by sensory information, and attention networks guess which of these bits of sensory information are important, are deserving of scarce cognitive resources, or can be safely ignored. Attention is therefore acting like the editor of a newspaper. Editors guess which stories are going to be most interesting and important to the paper's readers and set those stories on page one in big boldface type, but they bury other stories deemed to be less important in a tiny column on page 52.

Because editors are guessing, they sometimes make mistakes. Unless they get direct feedback from their readers (say, in the form of letters to the editor), there is no way they can know in advance whether or not any given bit of news will be important to a reader such as you. Maybe what is most important to you is a tiny little personal ad on page 52. But, because the editor put a story about the mayoral race on page one, you spent all your time reading a story that turned out not to be very important to you, and caused you to overlook the personal ad that could have changed your life forever.

(End of first column online)

Sensory attention networks are making similar guesses. Unless they get feedback from the brain, they can sometimes hinder learning by directing precious neuronal resources to page-one items that are in hindsight not so important, and bury on page 52 the sensory information that could change your life. This can happen especially if the important information comes as a surprise, so that the brain doesn't have time to provide feedback that consciously redirects the flow of information (say, by telling the eyes to look elsewhere).

Sensory attention networks can also make a mistake that hinders learning when the information is something we learn implicitly, without conscious awareness. For example, learning visual gist is something that happens without conscious awareness, such as when we learn the myriad, subtle visual distinctions that make a dog a dog. Under such circumstances, a person who has superb abilities for sensory attention may learn poorly, while the person whose abilities for attention are poor may be more likely to learn well.

Imagine you are commuting by subway, deeply absorbed in a novel. The process of reading invokes inhibitory attention networks that help you focus on your book. You become oblivious to your surroundings. Perhaps you become so absorbed in your reading that you no longer are aware of the constant clicking of the tracks, or the sounds of the people coming and going from the train car. You lose track of time, lose awareness of your surroundings, and perhaps don't even notice you missed your stop! Though your excellent abilities for attention served you well for the task of reading, they also caused you to fail to notice important information that would have helped you realize that you had arrived at your stop. In this case, when the important task was to notice you had reached your stop, strong abilities for attention were a detriment that caused you to do something you didn't intend.

Whether or not excellent abilities for attention can be regarded as a talent or a deficit therefore depends entirely on the context. Attention is a talent if the context of learning requires focus and diminished sensitivity to distraction, but the same abilities for attention can be a deficit if the learning context requires awareness of a broader, holistic set of factors that are difficult to explicitly define. Simply by changing the
task we require of our students, we can turn a student who is performing poorly into a student who performs at high levels.

This observation points to two important lessons for educators:

First, it suggests that we can improve achievement for all students, regardless of their neurological predisposition, simply by addressing both ends of the seesaw of attention when we teach and evaluate our students. All too often, instructional strategies tend to overemphasize one end of the seesaw. We tend to emphasize teaching approaches that place high demands on abilities for focused attention by relying on the use of words, text, and/or numbers. Instruction at the opposite end of the seesaw, which builds knowledge through images, stories, models, experiences, and metaphor, tends to be deemphasized in the classroom once students learn to read. And yet, the implicit learning that is possible through mechanisms of distributed attention is no less valid than the learning that takes place through focused attention. To make better use of the capabilities that all students bring to learning, presentations grounded in words, text, and numbers should be balanced by other forms of instruction that build intuition through implicit learning, and that make use of neurological abilities people are capable of at the opposite end of the seesaw. For example, consider the words we use to help students categorize a dog: "a dog is a carnivorous mammal that is a domesticated variant of the gray wolf, characterized by a long snout and acute sense of smell." These words should be balanced with instruction that provides students with rich experiences—visits to pet shops, movies, storybooks, pictures, and physical interactions with pets—to help students grasp the gist of a dog by making use of attentional mechanisms on the opposite end of the seesaw.

Moreover, this balanced approach shouldn't stop with instruction. The assessments we use should also be balanced. Written assessments, which depend on abilities for focused attention, should be supplanted with other forms of assessment—e.g., posters, presentations, models, movies, drawings, pictures, and stories—that draw on a more implicit understanding, and students should be judged on whichever approach shows them in the best light. Doing so, we are likely to discover that a number of the children in our classroom are learning disabled. And as teachers, we will begin to feel more successful in that we can reach all students in our charge.

The second point we can take away from the parable of the subway pertains to the very question of whether or not we as educators should be labeling such great numbers of our students as learning disabled. People who learn differently, such as those with dyslexia, ADHD, or autism spectrum disorders, and who tend to exhibit tremendous struggles while in school, sometimes go on to perform at extraordinarily high levels later in life. Once out of school, these individuals sometimes blossom. Some have become Nobel Laureates, distinguished writers, and successful business entrepreneurs. The fact that they succeed only after they exit the educational system is a sad commentary on how schools sometimes fail these people. This suggests that the assessments we are using in schools do not effectively judge the capabilities of our students, outside some narrow context that has meaning only in the classroom.

Both the parable of the subway and the story of Gallaudet, remind us that what we think of as an inherent deficit can be turned into an asset simply by changing the task we ask our students to perform. Therefore, it is entirely possible that many of those
students we now label as learning disabled, whom we perhaps think of as broken thermometers, fail to show their capabilities only because we are not offering assessments that reveal their strengths. In perpetuating labels such as "learning disabled," we do our profession harm by encouraging a way of thinking that actively neglects the capabilities these children possess. Instead of labeling the students as "broken," we as educators might think of ourselves as neuroscientists, and take careful note of the strengths we observe among our students who think differently. Knowing what these strengths are, recognizing that they may draw on capabilities that sit on a less familiar end of the seesaw of attention, we can then apply our creativity to find new ways to build upon these strengths. Doing so, we not only might uncover ways to help all students learn and achieve, but also might further our own creative potential as professionals who are carrying out cutting-edge work at the intersection of neuroscience and education.

(Opened ScienceTalk sidebar)

**Dyslexia: An Example**

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*Dr. Matthew H. Schneps is the George E. Burch Fellow in Theoretic Medicine and Affiliated Sciences at the Smithsonian Institution, director of the Laboratory for Visual Learning at Harvard-Smithsonian Center for Astrophysics (CfA), and executive director of the Science Media Group at CfA.*

Neuroscience research in the field of dyslexia has concentrated primarily on trying to understand the reasons for impairments in reading and spelling. Consequently, research into how dyslexia may provide advantages for cognitive functions in fields other than reading has lagged behind, and only recently has research begun to emerge suggesting that dyslexia may be linked to advantages for tasks that are important in science, mathematics, art, and other visually intensive fields. Here, we will briefly review some of the evidence suggesting that dyslexia may be linked to advantages, and look at how instruction can build on these strengths.

**Peripheral Recognition**

MIT researchers Gadi Geiger and Jerome Lettvin observed that when a pair of letters is separated by a large angle, people find it more difficult to name briefly flashed letter pairs when the angle is large. They found that people with dyslexia were able to name the letter pairs at larger angles (in one case about twice as far out) compared to people who were typical readers. The effect was more pronounced on the right side in people who were English native speakers and on the left side for people who were Hebrew native speakers. This work suggested dyslexia may be linked to advantages in the periphery, in situations where attention is divided between the center and the periphery, and that this phenomenon may be linked to hemispheric differences tied to experience with reading.
Peripheral Reactions
Andrea Facetti of the University of Padova, Italy, observed that people with dyslexia respond more quickly to an unexpected flash of light in peripheral parts of the visual field, especially when the flash occurs on the right side. This suggests that people with dyslexia are more sensitive to the occurrence of unexpected peripheral events, and that there may be hemispheric differences in this response.

Holistic Processing
Psychologist Catya von Karolyi of the University of Wisconsin showed that people with dyslexia are faster (compared to typical readers) at spotting logical errors in geometric drawings known as "impossible figures." These are line drawings that, if imagined as a three-dimensional object, would be physically impossible to build. Determining whether a drawing is "impossible" calls upon abilities to simultaneously compare information across a broad expanse, suggesting that people with dyslexia have strengths for this form of peripheral visual integration.

Learning Scenes
A team of researchers led by Matthew Schneps of the Harvard-Smithsonian Center for Astrophysics and James Brockmole from the University of Notre Dame measured how well students were able to implicitly learn the spatial layout of blurry photographs resembling medical x-rays or radiograms. They assembled hundreds of photographs of natural scenes—pictures of cityscapes, buildings, countryside, and so on—and blurred these pictures so that most of the details in the photographs were no longer recognizable. They found that while both people with dyslexia and typical readers could learn the photographs equally well when the images were sharp and detailed, only the people with dyslexia showed evidence of learning when such photographs were blurred. This suggests that people with dyslexia have advantages for learning from blurry information characteristic of information visible in the periphery. Try this for yourself!

Peripheral Integration
An investigation by researchers from the Harvard-Smithsonian Center for Astrophysics (Schneps, Rose, Greenhill, and Pomplun) tested astronomers with dyslexia and those without for their sensitivity to an underlying double-peaked pattern obscured by visual noise in a graph (characteristic of emission...
from a black hole). The research team found that the astrophysicists with dyslexia were more sensitive to the pattern, and better at detecting it, when the peaks were separated by a large visual angle. This experiment, based on a real-world task important in astrophysics, demonstrates that scientists with dyslexia have advantages sensing subtle visual patterns in the periphery.

Overall, this research suggests that dyslexia may be linked to advantages in perceiving global information relevant to learning visual gist, sensed by the periphery. While it may not be immediately obvious how this might be important in contexts traditionally valued in schools, it's not difficult to imagine how such advantages might be important in many real-life situations, especially in careers related to science, mathematics, art, or other visually intensive pursuits.

For example, the ability to rapidly sense and respond to something unexpected, noticed out of the corner of one's eye, could be useful for careers related to biology, where an ability to notice a predator rustling in the bushes might help a researcher understand some animal's sudden change in behavior.

Abilities to rapidly spot "impossible figures" might be helpful for careers in mathematics, engineering, or physics. Impossible figures underlie the fanciful drawings of M. C. Escher that defy the laws of physics. Looking at these, perhaps you can imagine how an ability to sense logical errors in such images might be helpful in these fields.

Likewise, advantages in learning the spatial layout of some blurry image could be a skill important to a radiologist searching for a tumor in an x-ray. Here, an ability to learn and compare one x-ray to another, and notice subtle changes in a blurry-looking picture could have lifesaving consequences for a patient.

Perhaps the most direct evidence that dyslexia can lead to visual advantages that are important in science comes from the study of the astronomers with dyslexia. Astronomers use these graphs to search for black holes (collapsed stars whose gravity...
is so strong nothing, not even light, can escape). Astronomers search for black holes deep in space by looking for a characteristic double-peaked pattern emitted by material orbiting the collapsed star. If the emission is strong, the pattern is obvious, and the black hole is easy to spot. But, usually these patterns are weak and noticing the presence of the subtle pattern can be difficult. A heightened sensitivity for this kind of visual processing could be valuable for people involved in such scientific research.

Though these differences have been found in research, the differences in neurology responsible for such advantages is not yet understood. A likely possibility is that these visual advantages result from differences in abilities for attention that, as we discussed earlier, can lead to advantages sensing visual gist, and in responding to unexpected events. We emphasize that this research is only in its infancy, and much of this work remains to be confirmed. For example, researchers do not yet know whether such advantages apply to all people with dyslexia, or only some subset of those who are struggling readers. However, the trend is clear: Dyslexia appears to be linked to visual strengths in observing the gist of a scene, or noting information that occurs unexpectedly in the periphery. Such abilities are clearly valuable in real-life situations. Even though these individuals may perform poorly when asked to read in school settings, the situation is different in scientific careers. These dyslexic scientists can perform at very high levels, so long as they manage to advance to careers for which they can build on their strengths. It appears that they can even outperform those who generally are considered "unimpaired."

Glossary

**autism spectrum disorders**
A diagnostic category describing a developmental disability that primarily impacts socioemotional functioning. Clinicians rely on criteria described by the Diagnostic and Statistical Manual of Mental Disorders (DSM), most typically, in three categories: social interaction, verbal and nonverbal communication, and repetitive behaviors or interests.
dyslexia
A term describing a learning disability that is defined by difficulty with single word reading, often impacting negatively text comprehension. Other secondary associations include difficulties with processing sounds of language accurately or automatically and socioemotional challenges.

attention deficit hyperactivity disorder (ADHD)
A diagnostic category describing a developmental disability that primarily impacts attention capacities with secondary difficulties most often observed in behavior and learning environments. Clinicians rely on criteria for reaching a diagnosis of ADHD using the Diagnostic and Statistical Manual of Mental Disorders (DSM), most typically.
Q: What can teachers do about learning differences in the classroom?

Let us review the steps that educators can take to honor and build upon the learning diversity in their classrooms.

- **Whether or not a person is considered to have a "disability" depends on a dynamic interaction between the demands of the task and the strengths of the person.** Sometimes, a person who appears impaired in one context will perform at superlative levels when the context is changed. Teachers can improve the performance of their students simply by changing the context of their teaching and by giving students opportunities to find alternate ways to learn, even if these alternatives may not be traditionally used in schools.

- **Labels such as "learning disabled" can hurt,** and can trigger an automatic neurological reaction associated with negative emotions that further impairs learning so as to deepen the struggles a student may face. Using negative labels creates a threat based on a negative stereotype, which interferes powerfully with school success. Be supportive and encourage the student to work with you to find a solution: "Of course this is hard, and of course you will be able to do it. But we're going to have to get creative with how we approach this, and I need you to work with me to help figure out the best way."

- **If students struggle with certain ways of thinking, the task we are asking them to do is probably not well matched to their neurology.** As a consequence, if we are asking students to do something that was never designed for their brains, they will have to work very hard. As a teacher, it's important to respect the extra work the student is going to have to do. For example, the task of reading was designed over the centuries to work well with a certain set of neurological capabilities. If a student's neurology is not well matched to this task, this student will need to force her or his brain to perform in ways that are less than optimal. This takes work, and the student will have to work harder than most other people. Teachers can recognize this extra effort by accommodating for extra time or allowing the use of calculators, which are not cheating. Help the student feel comfortable accepting this compensation.

- If students don't pay attention, it does not necessarily mean they are being disrespectful or
lacking in discipline. Yelling at students to "pay attention" is not likely to help, and will probably hurt. Attention is a semiautomatic neurological response that helps people deal with the overwhelmingly vast amount of information constantly bombarding their senses. **Though people can control some aspects of attention, many are automatic and outside a person's control.** Traditional approaches to learning place strong demands on attention and short-term memory. People can become "learning disabled" by overloading their capacity for attention or memory. Teachers can help people learn more effectively by eliminating any unessential demands

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on attention or memory and by generally revising instructional methods so that the demands on attention and memory are minimized.

- Some forms of learning, such as learning the gist of a sound (implicit learning needed to distinguish a banjo from a guitar), occur with little conscious awareness, and do not place the same demands on neural networks for attention. **Such forms of learning, though not emphasized in schools, are vitally important in many aspects of life.**
- **People vary in their abilities for attention,** and people are sometimes very sensitive to changes in their environment, while others may not notice such changes. Some people who have difficulties with the forms of learning that place heavy demands on attention may not experience difficulties with the forms of learning that are associated with "gist."
- **Attention networks act like a seesaw,** by enhancing some information while inhibiting other information. Focused attention can inhibit peripheral awareness and reduce a person's awareness of gist. Therefore, strong abilities for attention can hinder learning of gist, leading to a situation where a person who is "learning impaired" outperforms the person otherwise considered "unimpaired."
- **New research suggests that people with dyslexia sometimes exhibit enhanced abilities for peripheral awareness that lead to advantages important in fields such as science, mathematics, or art.** Many people with "learning disabilities" perform at very high levels in careers where their special abilities are well matched to the demands of the field. **Educators can reach and help many more students to learn by emphasizing skills that are important and valued in real-world contexts,** as opposed to "school science" contexts that tend to be artificial and overemphasize demands on memorization and attention.
- **People learn in many different ways;** therefore, teachers should devise assessments that encourage alternate ways to show individual competencies and progress, and that honor each student's own strengths and approach.
Reading with Half a Brain

Brooke Smith had the left side of his brain removed at age 11. Phonology is believed to be located in the left side of the brain. Therefore, it is astonishing that Brooke is able to read. Using...

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UNIT 4: DIFFERENT LEARNERS, DIFFERENT MINDS

Section 9: Resources


