Angry Brains

by Kelli Whitlock Burton

It was the last day of school before Christmas break, and Elizabeth Johnston was scrambling to get her 8-year-old son Cameron ready to catch the bus. It was early, he was grumpy, and it was 35 degrees outside.

Hurrying him along, Johnston held out Cameron's black and lime green winter coat, which he had chosen himself just a few weeks earlier.

"It's too puffy," he declared, glaring at the coat with contempt. "I don't want to wear it!"

It was an argument Johnston and her husband Ron had faced on many a cold morning, and she knew it really wasn't about the coat. Like most kids his age, Cameron craves independence. And to most 8-year-olds, being independent isn't just about doing what you want to do. It's about not doing what your parents want you to do. The result, inevitably, is a standoff, just like the one that was unfolding in Johnston's living room.

"But you picked it out yourself," she reminded him. "You wanted this jacket."

Cameron was silent. Since this independent streak began, Johnston has tried to teach her son to consider both sides of a disagreement fairly and with an open mind—the first step in resolving a conflict peacefully. She took a deep breath and tried again.

"It's freezing outside and I don't want you to be cold."

"I won't be cold. You never let me wear what I want to. I'm not a baby!"

And so it went. As Johnston continued to reason with Cameron, the boy began to shout. With every increased decibel, Johnston felt herself react. Her jaw clenched. Her blood pressure began to rise. The school bus was mere minutes from the end of their very long driveway and there was no peaceful resolution in sight.

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There's a familiar ring to this drama that most parents know all too well. But Johnston is more familiar with it than most. As a psychology teacher at Sarah Lawrence, she has spent years analyzing research in the emerging field of "affective neuroscience"—the study of how the brain processes emotions. She and biology faculty member Leah Olson co-teach a popular course called "The Feeling Brain" and are writing a book about the subject. So, while her face flushes with frustration and Cameron goes on and on about how unfair his parents are, Johnston is also keenly aware that the emotional structures in her brain are in high gear, some urging her to act, some encouraging her to be reasonable. Cameron's young brain is spinning, too. And he still won't put on his coat.

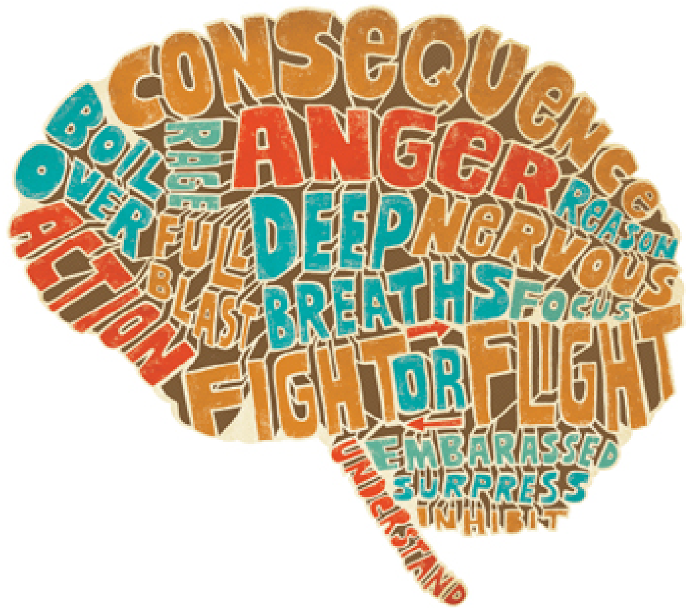


Illustration by Vaughn Fender

Meeting of the minds

When Leah Olson joined the Sarah Lawrence biology faculty in 1987, she started teaching biology classes that overlapped with psychology, examining things like sensory perception or the psyche's effect on the immune system. At that time, she noticed, there were very few studies about the biological basis of emotions, which were considered to be purely mental and therefore beyond the reach of hard science.

But in the mid-nineties, that started to change. "I suddenly started noticing more and more papers that had to do with emotions," she says. She started filing them away, and within a few years, the folder was bulging. One day she e-mailed Johnston, whose expertise is in experimental psychology, with a question about a paper on emotional memory. In the ensuing discussion they realized that there was now plenty of material for a class on the biological basis of emotions.

In 2007, they taught the first class on "The Feeling Brain." They had room for 15 students; three times that many tried to register. The course is popular not only among science students but also among graduate students in child development and performing artists interested in the expression of emotion in their creative work.

Now, Johnston and Olson are writing a book on the subject, which should have a broad appeal as well. Due out from Norton later this year, it will offer the general reader an overview of how emotions are processed in the brain— and expand how we understand and control our emotions in everyday life.

The case of Phineas Gage

The field of affective neuroscience (so dubbed in 1998 by Washington State University scientist Jaak Panskepp) combines theories in neuroscience, biology, and psychology with new brainimaging technologies to create a figurative and literal picture of the anatomy of human feelings. This multidisciplinary field has grown rapidly over the past 10 to 15 years, changing the way we look at the relationship between emotion and cognition.

Traditionally, the study of cognitive neuroscience excluded emotion, focusing instead on decision-making, attention, perception, and reason. The prevailing theory was that the brain had two parts—one for emotion and one for cognition—which functioned independently of each other. Not everyone followed that line of thinking, however. Dissenters have voiced their opinion for more than a century. Take, for example, Dr.

John Harlow.

In September of 1868, Harlow took on the highly unusual case of Phineas Gage, a foreman on a railroad project near Cavendish, Vermont. Gage suffered an horrific injury when the blasting powder he was tamping into a rock exploded, sending a 14-pound, nearly 4-foot long iron rod hurling toward his head. The rod pierced his left eye, passed through his brain's prefrontal cortex, and shot out of the top of his head, landing some 80 feet away.

Miraculously, Gage was up and walking within a few minutes of the explosion. He remained under Harlow's care for more than two months and eventually recovered from the injury, holding a number of jobs, including as a stagecoach driver in Chile. He died in 1880, 12 years after the accident.

After his death, Harlow learned from Gage's family and friends that his post-accident personality was that of a stranger. Once described as responsible, energetic, polite, and business-savvy, Gage had become easily angered, fitful, undependable, and prone to profane outbursts. His employers at the railroad company, who previously cited him as one of their best foremen, refused to hire him back. Gage's injury was to his frontal lobe—specifically, the prefrontal cortex. Often called the brain's CEO, the prefrontal cortex is responsible for rational tasks like problem solving, decision making, and a host of other executive functions. Why, then, did Gage undergo such drastic emotional changes following the head trauma? Harlow claimed the case provided evidence of an alternate possibility—that the prefrontal cortex works in concert with other areas of the brain involved in emotional processing. Perhaps the notion of two brains was just wrong. This concept was not easy to swallow. Over the next 120 years, the majority of the scientific community held tight to the two-brain theory, even after more reports of personality change following brain injury surfaced. Then, in 1990, a team at Bell Laboratories in New Jersey developed something called functional magnetic resonance imaging—fMRI for short. This noninvasive technology allows scientists to identify which parts of the brain are involved in different tasks. When a region of the brain is active, blood flow to that region increases. In studies using fMRI, participants are asked to perform a variety of mental tasks, such as solving a mathematical problem, watching a sad movie, or choosing between the lesser of two evils. By monitoring blood flow during those exercises, scientists can detect which parts of the brain are involved in those specific tasks.

For the first time, a picture of the living brain began to emerge, and it looked nothing like scientists thought it would. Study after study showed that emotion triggers activity all across the brain, including in the prefrontal cortex. What's more, structures known to play a role in higher reasoning were also involved in emotional processing, which many scientists had thought unlikely, if not downright impossible.

But the interrelation between the two makes intuitive sense. "Pure cognition without emotion is useless," Johnston says, because emotion is what motivates you to act. "Even things that are thought to be very rational decision-making situations depend on emotion to push you one way or the other. You have to care enough about something to choose it."

Your brain on conflict

Much of the brain's emotional center can be found in the limbic system, which lies beneath the outer surface of the brain. Many of the major players in emotional processing can be found here including the amygdala, hippocampus, hypothalamus, and the insula. Each of these structures has a role in our emotional processing.

Each time we experience an emotion, information is shuttled back and forth between the limbic system and the prefrontal cortex. Although we don't yet have an exact picture of how this works, studies suggest it may go something like this:

During your son's hockey game, he gets hit in the back of the head by a thug-like player on the opposing team. "Oh, come on, it wasn't that bad!" a woman behind you yells as the coach tends to your son, who is still lying on the ice. As you take all this in, an almond-shaped
structure deep within your brain called the amygdala is firing away, riveting your attention on these threats.

The amygdala automatically activates the sympathetic nervous system. Your heart is pounding, your breathing gets shallow, and your body is ready to fight or flee. But first, your body freezes, giving your brain a chance to decide what action to take.

Your son sits up, gingerly gets to his feet, and starts to skate toward the bench. His teammates tap their sticks on the ice to show their relief. "What a lightweight," the woman comments. You turn to glare at her. The insula, which is located deep in the cerebral cortex, receives signals that the body is agitated, and you become conscious that you're really angry. You want to yell at this woman, maybe even slap her.

"Can we finally play some hockey now?" the woman says loudly. You are feeling scared for your son, guilty that you ever let him play this game in the first place, and furious at this obnoxious woman. But in the front of your brain, your prefrontal cortex is taking in the whole scenario and examining your options. What would happen if you yelled at this woman? Would she become violent? Would your son be embarrassed? Would the consequences of your actions be worth acting at all? Part of you doesn't want to make a scene, but part of you really, really does.

What happens next? The anterior cingulate cortex, which evaluates the differing signals from the amygdala and the prefrontal cortex, decides whether or not you should act on your impulses. Research shows that just suppressing your angry feelings is unlikely to work—eventually the anger will boil over and you'll end up in your own hockey brawl. But there are ways to regulate strong feelings. You can take slow, deep breaths, which not only calms your sympathetic nervous system, but also switches your attention to something other than your anger. Labeling your emotions or verbalizing them helps, too (it's the "use your words" strategy we teach toddlers): exercising the temperate prefrontal cortex inhibits the hot-headed amygdala.

Of course, some people are better at controlling their emotions than others. Physiological variations, bodily processes, thoughts, and memories all come into play. The good news is that control can be learned. As you practice regulating your emotions—whether through techniques like "counting to 10" or more formal mental exercises like meditation—the neural pathways in your brain actually change, which means you'll be less likely to make a scene at the next hockey game.

Of course, the brain doesn't really work in sequential fashion. All of these structures are active throughout the entire situation, along with the hippocampus and cerebellum, as well as regions of the brain that were once thought to be relegated to pure reason.

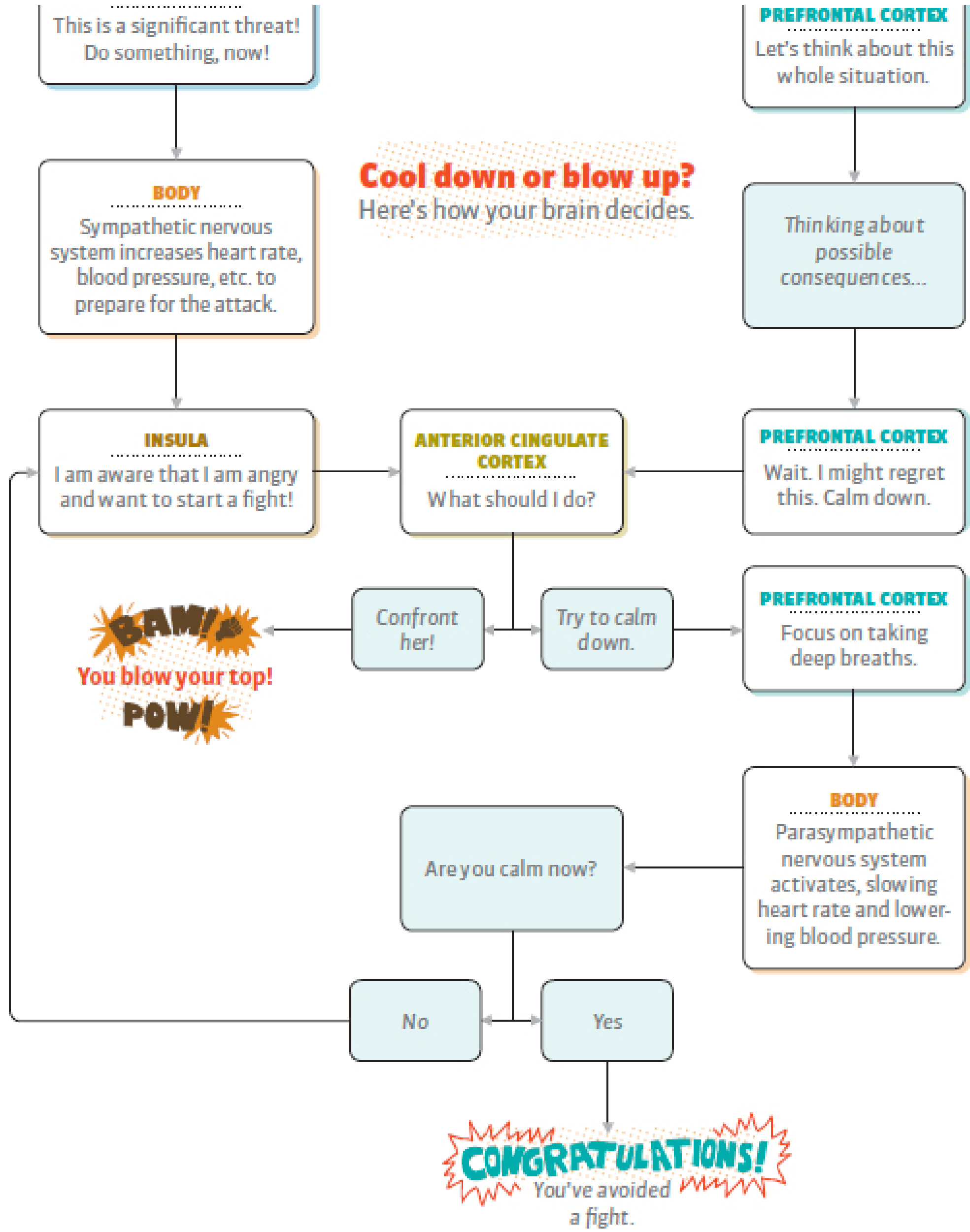
"As you begin to learn about it, you begin to have a real awe for the complexity of emotion," Olson says. "I walk around every day with a better understanding of who I am as a person because I have a greater understanding of the full range of emotions."

The end of the jacket wars

Adolescents are famous for their moodiness and rash behavior, the woe of parents everywhere. Turns out, at least some of that agitation can be blamed on the prefrontal cortex. It's responsible for impulse control and modulating behavior, and it's the last region of the brain to reach maturation, not developing fully until a person's mid-20s. "Children's and adolescents' brains aren't fully capable of regulating emotions," Olson says. "Parents have to be the prefrontal cortex for the kids."

Which is exactly why Johnston and her husband were trying to get their son to wear a coat on a cold winter morning— and why Cameron was having none of it.

"That's the kind of thing that requires a lot of emotional regulation on our part," Johnston says. "We were both trying very hard to engage our prefrontal cortexes and come up with ways to help our son regulate his emotions." Cameron was getting stuck on one aspect of the situation—the puffiness of the jacket—and Johnston was trying to encourage him to see other aspects of the jacket, such as its ability to prevent hypothermia. In the end, they both won. Johnston invoked her parental powers and made Cameron put on the puffy jacket. Cameron set off into the near-freezing temperatures in proper attire, grumbling under his breath at the injustice. Later, Johnston forestalled any future outerwear battles by implementing what psychologists call "situation modification": she changed the problematic part of the scenario. Cameron now wears a neoprene jacket over a warm sweatshirt. Neither is puffy. Both are warm. Peace is restored.



Freelance science writer Kelli Whitlock Burton lives in Ohio with a husband, two dogs, and twin 16-year-olds with underdeveloped prefrontal cortexes.

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