Many Parts of the Brain Make our Life Diverse

Understanding the roles of the amygdala and the prefrontal cortex.

KEY POINTS

- The brain is not one unified entity but an amalgamation of modules with different functions and operating characteristics.
- The prefrontal cortex operates slowly and is logical and precise, while the limbic system works fast and is dominated by emotion and impulse.
- In many ways these two modules are complementary opposites, often in conflict but extremely effective when coordinated well.

To understand our brains, there is no insight more fundamental than this: The mind is modular (LeDoux, 2003). This means the brain is not one single, unitary entity but an amalgamation of different modules or parts. The modules have different names, anatomical locations, functions, operating characteristics and, to some extent, different agendas. This is why internal conflict—once thought to be an oxymoron—is not only possible but common.

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The brain has many modules, but this post will focus on two, because they are such important characters in the drama of our internal life.

The Prefrontal Cortex and the Limbic System
A great deal of our moment-to-moment experience results from the interplay of these two parts of the brain. When you understand this interplay, you will understand a lot about how the mind works (Shapiro, 2020a; 2020b).

The prefrontal lobe of the cerebral cortex performs the functions of logical analysis, planning for the future, and self-control. The limbic system is responsible for motivation and emotion, with one particularly important part, the amygdala, playing a key role in the fight-or-flight response and feelings of fear and anger.

Anatomically, the cerebral cortex is the top of the brain, and the prefrontal cortex is the very front part of it (before the “frontal” cortex). The limbic system is located toward the core of the brain and includes lower, midbrain structures.

Brain anatomy reflects brain evolution. The midbrain structures evolved first, which is why the limbic system was once known as "the reptilian brain." The catchy phrase is not literally true, but it reflects the fact that the limbic systems of humans and other advanced animals are not hugely different. The cerebral cortex evolved much later, mostly during human evolution, and our species has a prefrontal cortex totally unlike anything found in other animals.

Conflicting but Complementary Opposites

In many ways, the prefrontal cortex and limbic system are opposites. One reason why mental life is so often conflictual, confusing, and difficult is that these two modules frequently push us in different directions—that is, they recommend different behaviors. However, when coordination between the two modules is optimized, they become complementary opposites that, together, produce more effective behavior than either could produce on its own.

How are the prefrontal cortex and limbic system opposites?

The functioning of the prefrontal cortex is rational and logical, at least to a considerable extent. The functioning of the limbic system is dominated by emotion.

The prefrontal cortex can produce cognition that is analytical, conceptual, interpretive, and complex. It is capable of thinking things through and
understanding the reasons for events, their meanings, and their implications for the future. On the other hand, information processing by the amygdala and other limbic structures is based simply on association—learning what goes with what, like Pavlov’s dogs (classical conditioning), without a role for reasoning.

Cortical cognition can be precise, fine-grained, and nuanced; quantitative thinking is the province of the cortex. The limbic system's amygdala works in cognition that is simple, concrete, and approximate. The amygdala thinks in black and white, while the prefrontal cortex can think in shades of gray.

The Tortoise and the Hare

The prefrontal cortex thinks relatively slowly and carefully, with conscious, labor-intensive efforts to figure things out. The amygdala reacts automatically, impulsively, and extremely fast (in milliseconds), and its operation is mostly unconscious.

Metaphorically, the amygdala has something like a huge file of snapshots of all the threatening situations it has ever faced. When enough stimulus features of a present situation match one of those snapshots, the amygdala sets off the emotional, physiological, and behavioral responses that were appropriate in the original situation.

In people with Post-Traumatic Stress Disorder, this is the mechanism that triggers flashbacks. I once treated a client who was assaulted in a room where coffee was brewing. Years later, the smell of coffee made this woman nauseous—and yet she knew there was no causal connection between the coffee and her assault.

How can we explain this seeming contradiction? With the prefrontal cortex and the amygdala working at cross-purposes. Her prefrontal cortex knew she was safe, but her amygdala had learned that the smell of coffee meant stomach-turning victimization. My client felt nauseous because the limbic system has nerve pathways extending downward into the body, allowing it to influence many of our biological functions, including digestion, heart rate, breathing, and hormone production. This is why strong emotions (i.e., limbic system arousal) cause powerful physical sensations such as “butterflies in the stomach,” and this is why we say we “feel it in our gut” when we make
judgments based on emotion. Cortical cognitions are not accompanied by physical sensations, so we know they take place in our heads.

Different modules of the brain evolved to handle different kinds of situations. The amygdala is geared toward physical confrontations and emergencies that require fast responses, and other parts of the limbic system are good at processing emotional information that is not structured in logical form. The prefrontal cortex is equipped for complicated situations in which there is plenty of time to think. Some combination of the two is optimal for complicated, emotionally charged situations that require us to think on our feet. Most interpersonal problems seem to be of this type.

Of all the bad advice in pop psychology books designed with sales, not science, in mind, perhaps the worst is that we should “go with our gut.” Like most bad advice, it has an element of truth: The limbic system is not stupid, just emotional and intuitive. Nonetheless, limbic responding is simplistic, vulnerable to all kinds of biases, and impulsive. Prisons and bankruptcy courts are filled with people who went with their gut.

Our limbic system needs cortical restraints and guidance, and the prefrontal cortex is more effective when infused with limbically-based emotional and intuitive information. Psychological functioning is optimized when these two modules operate in partnership even though, like most partners, they sometimes come into conflict.

References

