composed of little more than thin layers of neurons gathered to analyze smell. One layer of cells took in what was smelled and sorted it out into the relevant categories: edible or toxic, sexually available, enemy or meal. A second layer of cells sent reflexive messages throughout the nervous system telling the body what to do: bite, spit, approach, flee, chase.[10]

With the arrival of the first mammals came new, key layers of the emotional brain. These, surrounding the brainstem, look roughly like a bagel with a bite taken out at the bottom where the brainstem nestles into them. Because this part of the brain rings and borders the brainstem, it was called the "limbic" system, from "limbus," the Latin word for "ring." This new neural territory added emotions proper to the brain's repertoire.[11] When we are in the grip of craving or fury, head-over-heels in love or recoiling in dread, it is the limbic system that has us in its grip.

As it evolved, the limbic system refined two powerful tools: learning and memory. These revolutionary advances allowed an animal to be much smarter in its choices for survival, and to fine-tune its responses to adapt to changing demands rather than having invariable and automatic reactions. If a food led to sickness, it could be avoided next time. Decisions like knowing what to eat and what to spurn were still determined largely through smell; the connections between the olfactory bulb and the limbic system now took on the tasks of making distinctions among smells and recognizing them, comparing a present smell with past ones, and so discriminating good from bad. This was done by the "rhinencephalon," literally, the "nose brain," a part of the limbic wiring, and the rudimentary basis of the neocortex, the thinking brain.

About 100 million years ago the brain in mammals took a great growth spurt. Piled on top of the thin two-layered cortex—the regions that plan, comprehend what is sensed, coordinate movement—several new layers of brain cells were added to form the neocortex. In contrast to the ancient brain's two-layered cortex, the neocortex offered an extraordinary intellectual edge.

The *Homo sapiens* neocortex, so much larger than in any other species, has added all that is distinctly human. The neocortex is the seat of thought; it contains the centers that put together and comprehend what the senses perceive. It adds to a feeling what we think about it—and allows us to have feelings about ideas, art, symbols, imaginings.

In evolution the neocortex allowed a judicious fine-tuning that no doubt has made enormous advantages in an organism's ability to survive adversity, making it more likely that its progeny would in turn pass on the genes that contain that same neural circuitry. The survival edge is due to the neocortex's talent for strategizing, long-term planning, and other mental wiles. Beyond that, the triumphs of art, of civilization and culture, are all fruits of the neocortex.

This new addition to the brain allowed the addition of nuance to emotional life. Take love. Limbic structures generate feelings of pleasure and sexual desire—the emotions that feed sexual passion. But the addition of the neocortex and its connections to the limbic system allowed for the mother-child bond that is the basis of the family unit and the long-term commitment to childrearing that makes human development possible. (Species that have no neocortex, such as reptiles, lack maternal affection; when their young hatch, the newborns must hide to avoid being cannibalized.) In humans the protective bond between parent and child allows much of maturation to go on over the course of a long childhood—during which the brain continues to develop.

As we proceed up the phylogenetic scale from reptile to rhesus to human, the sheer mass of the neocortex increases; with that increase comes a geometrie rise in the interconnections in brain circuitry. The larger the number of such connections, the greater the range of possible responses. The neocortex allows for the subtlety and complexity of emotional life, such as the ability to have feelings *about* our feelings. There is more neocortex-to-limbic system in primates than in other species—and vastly more in humans—suggesting why we are able to display a far greater range of reactions to our emotions, and more nuance. While a rabbit or rhesus has a restricted set of typical responses to fear, the larger human neocortex allows a far more nimble repertoire—including calling 911. The more complex the social system, the more essential is such flexibility—and there is no more complex social world than our own.[12]

But these higher centers do not govern all of emotional life; in crucial matters of the heart—and most especially in emotional emergencies—they can be said to defer to the limbic system. Because so many of the brain's higher centers sprouted from or extended the scope of the limbic area, the emotional brain plays a crucial role in neural architecture. As the root from which the newer brain grew, the emotional areas are intertwined via myriad connecting circuits to all parts of the neocortex. This gives the emotional centers immense power to influence the functioning of the rest of the brain—including its centers for thought.

2

Anatomy of an Emotional Hijacking

Life is a comedy for those who think and a tragedy for those who feel.

HORACE WALPOLE

It was a hot August afternoon in 1963, the same day that the Rev. Martin Luther King, Jr., gave his “I Have a Dream” speech to a civil rights march on Washington. On that day Richard Robles, a seasoned burglar who had just been paroled from a three-year sentence for the more than one hundred break-ins he had pulled to support a heroin habit, decided to do one more. He wanted to renounce crime, Robles later claimed, but he desperately needed money for his girlfriend and their three-year-old daughter.

The apartment he broke into that day belonged to two young women, twenty-one-year-old Janice Wylie, a researcher at *Newsweek* magazine, and twenty-three-year-old Emily Hoffert, a grade-school teacher. Though Robles chose the apartment on New York’s swanky Upper East Side to burglarize because he thought no one would be there, Wylie was home. Threatening her with a knife, Robles tied her up. As he was leaving, Hoffert came home. To make good his escape, Robles began to tie her up, too.

As Robles tells the tale years later, while he was tying up Hoffert, Janice Wylie warned him he would not get away with this crime: She would remember his face and help the police track him down. Robles, who had promised himself this was to have been his last burglary, panicked at that, completely losing control. In a frenzy, he grabbed a soda bottle and clubbed the women until they were unconscious, then, awash in rage and fear, he slashed and stabbed them over and over with a kitchen knife. Looking back on that moment some twenty-five years later, Robles lamented, “I just went bananas. My head just exploded.”

To this day Robles has lots of time to regret those few minutes of rage unleashed. At this writing he is still in prison, some three decades later, for what became known as the “Career Girl Murders.”

Such emotional explosions are neural hijackings. At those moments, evidence suggests, a center in the limbic brain proclaims an emergency, recruiting the rest of the brain to its urgent agenda. The hijacking occurs in an instant, triggering this reaction crucial moments before the neocortex, the thinking brain, has had a chance to glimpse fully what is happening, let alone decide if it is a good idea. The hallmark of such a hijack is that once the moment passes, those so possessed have the sense of not knowing what came over them.

These hijacks are by no means isolated, horrific incidents that lead to brutal crimes like the Career Girl Murders. In less catastrophic form—but not necessarily less intense—they happen to us with fair frequency. Think back to the last time you "lost it," blowing up at someone—your spouse or child, or perhaps the driver of another car—to a degree that later, with some reflection and hindsight, seemed uncalled for. In all probability, that, too, was such a hijacking, a neural takeover which, as we shall see, originates in the amygdala, a center in the limbic brain.

Not all limbic hijackings are distressing. When a joke strikes someone as so uproarious that their laughter is almost explosive, that, too, is a limbic response. It is at work also in moments of intense joy: When Dan Jansen, after several heartbreaking failures to capture an Olympic Gold Medal for speed skating (which he had vowed to do for his dying sister), finally won the Gold in the 1,000-meter race in the 1994 Winter Olympics in Norway, his wife was so overcome by the excitement and happiness that she had to be rushed to emergency physicians at rinkside.

THE SEAT OF ALL PASSION

In humans the amygdala (from the Greek word for "almond") is an almond-shaped cluster of interconnected structures perched above the brainstem, near the bottom of the limbic ring. There are two amygdalas, one on each side of the brain, nestled toward the side of the head. The human amygdala is relatively large compared to that in any of our closest evolutionary cousins, the primates.

The hippocampus and the amygdala were the two key parts of the primitive "nose brain" that, in evolution, gave rise to the cortex and then the neocortex. To this day these limbic structures do much or most of the brain's learning and remembering; the amygdala is the specialist for emotional matters. If the amygdala is severed from the rest of the brain, the result is a striking inability to gauge the emotional significance of events; this condition is sometimes called "affective blindness."

Lacking emotional weight, encounters lose their hold. One young man whose amygdala had been surgically removed to control severe seizures became completely uninterested in people, preferring to sit in isolation with no human contact. While he was perfectly capable of conversation, he no longer recognized close friends, relatives, or even his mother, and remained impassive in the face of their anguish at his indifference. Without an amygdala he seemed to have lost all recognition of feeling, as well as any feeling about feelings.[1] The amygdala acts as a storehouse of emotional memory, and thus of significance itself; life without the amygdala is a life stripped of personal meanings.

More than affection is tied to the amygdala; all passion depends on it. Animals that have their amygdala removed or severed lack fear and rage, lose the urge to compete or cooperate, and no longer have any sense of their place in their kind's social order; emotion is blunted or absent. Tears, an emotional signal unique to humans, are triggered by the amygdala and a nearby structure, the cingulate gyrus; being held, stroked, or otherwise comforted soothes these same brain regions, stopping the sobs. Without an amygdala, there are no tears of sorrow to soothe.

Joseph LeDoux, a neuroscientist at the Center for Neural Science at New York University, was the first to discover the key role of the amygdala in the emotional brain.[2] LeDoux is part of a fresh breed of neuroscientists who draw on innovative methods and technologies that bring a previously unknown level of precision to mapping the brain at work, and so can lay bare mysteries of mind that earlier generations of scientists have found impenetrable. His findings on the circuitry of the emotional brain overthrow a long-standing notion about the limbic system, putting the amygdala at the center of the action and placing other limbic structures in very different roles.[3]

LeDoux's research explains how the amygdala can take control over what we do even as the thinking brain, the neocortex, is still coming to a decision.

As we shall see, the workings of the amygdala and its interplay with the neocortex are at the heart of emotional intelligence.

THE NEURAL TRIPWIRE

Most intriguing for understanding the power of emotions in mental life are those moments of impassioned action that we later regret, once the dust has settled; the question is how we so easily become so irrational. Take, for example, a young woman who drove two hours to Boston to have brunch and spend the day with her boyfriend. During brunch he gave her a present she'd been wanting for months, a hard-to-find art print brought back from Spain. But her delight dissolved the moment she suggested that after brunch they go to a matinee of a movie she'd been wanting to see and her friend stunned her by saying he couldn't spend the day with her because he had softball practice. Hurt and incredulous, she got up in tears, left the cafe, and, on impulse, threw the print in a garbage can. Months later, recounting the incident, it's not walking out she regrets, but the loss of the print.

It is in moments such as these—when impulsive feeling overrides the rational—that the newly discovered role for the amygdala is pivotal. Incoming signals from the senses let the amygdala scan every experience for trouble. This puts the amygdala in a powerful post in mental life, something like a psychological sentinel, challenging every situation, every perception, with but one kind of question in mind, the most primitive: "Is this something I hate? That hurts me? Something I fear?" If so—if the moment at hand somehow draws a "Yes"—the amygdala reacts instantaneously, like a neural tripwire, telegraphing a message of crisis to all parts of the brain.

In the brain's architecture, the amygdala is poised something like an alarm company where operators stand ready to send out emergency calls to the fire department, police, and a neighbor whenever a home security system signals trouble.

When it sounds an alarm of, say, fear, it sends urgent messages to every major part of the brain: it triggers the secretion of the body's fight-or-flight hormones, mobilizes the centers for movement, and activates the cardiovascular system, the muscles, and the gut.[4] Other circuits from the amygdala signal the secretion of emergency dollops of the hormone norepinephrine to heighten the reactivity of key brain areas, including those that make the senses more alert, in effect setting the brain on edge. Additional signals from the amygdala tell the brainstem to fix the face in a fearful expression, freeze unrelated movements the muscles had underway, speed heart rate and raise blood pressure, slow breathing. Others rivet attention on the source of the fear, and prepare the muscles to react accordingly. Simultaneously, cortical memory systems are shuffled to retrieve any knowledge relevant to the emergency at hand, taking precedence over other strands of thought.

And these are just part of a carefully coordinated array of changes the amygdala orchestrates as it commandeers areas throughout the brain (for a more detailed account, see Appendix C). The amygdala's extensive web of neural connections allows it, during an emotional emergency, to capture and drive much of the rest of the brain—including the rational mind.

THE EMOTIONAL SENTINEL

A friend tells of having been on vacation in England, and eating brunch at a canalside cafe. Taking a stroll afterward along the stone steps down to the canal, he suddenly saw a girl gazing at the water, her face frozen in fear. Before he knew quite why, he had jumped in the water—in his coat and tie. Only once he was in the water did he realize that the girl was staring in shock at a toddler who had fallen in—whom he was able to rescue.

What made him jump in the water before he knew why? The answer, very likely, was his amygdala.

In one of the most telling discoveries about emotions of the last decade, LeDoux's work revealed how the architecture of the brain gives the amygdala a privileged position as an emotional sentinel, able to hijack the brain.[5] His research has shown that sensory signals from eye or ear travel first in the brain to the thalamus, and then—across a single synapse—to the amygdala; a second signal from the thalamus is routed to the neocortex—the thinking brain. This branching allows the amygdala to begin to respond *before* the neocortex, which mulls information through several levels of brain circuits before it fully perceives and finally initiates its more finely tailored response.

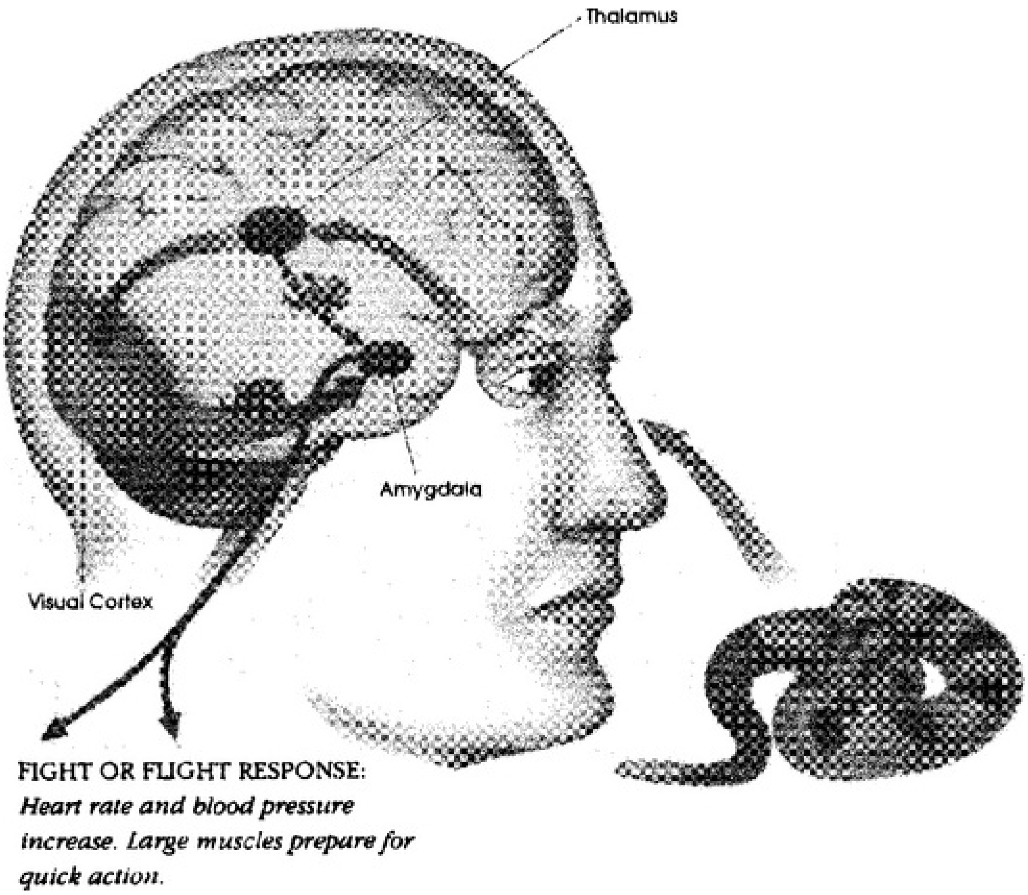
LeDoux's research is revolutionary for understanding emotional life because it is the first to work out neural pathways for feelings that bypass the neocortex. Those feelings that take the direct route through the amygdala include our most primitive and potent; this circuit does much to explain the power of emotion to overwhelm rationality.

The conventional view in neuroscience had been that the eye, ear, and other sensory organs transmit signals to the thalamus, and from there to sensory processing areas of the neocortex, where the signals are put together into objects as we perceive them. The signals are sorted for meanings so that the brain recognizes what each object is and what its presence means. From the neocortex, the old theory held, the signals are sent to the limbic brain, and from there the appropriate response radiates out through the brain and the rest of the body. That is the way it works much or most of the time—but LeDoux discovered a smaller bundle of neurons that leads directly from the thalamus to the amygdala, in addition to those going through the larger path of neurons to the cortex. This smaller and shorter pathway—something like a neural back alley—allows the amygdala to receive some direct inputs from the senses and start a response *before* they are fully registered by the neocortex.

This discovery overthrows the notion that the amygdala must depend entirely on signals from the neocortex to formulate its emotional reactions. The amygdala can trigger an emotional response via this emergency route even as a parallel reverberating circuit begins between the amygdala and neocortex. The amygdala can have us spring to action while the slightly slower—but more fully informed—neocortex unfolds its more refined plan for reaction.

LeDoux overturned the prevailing wisdom about the pathways traveled by emotions through his research on fear in animals. In a crucial experiment he destroyed the auditory cortex of rats, then exposed them to a tone paired with an electric shock. The rats quickly learned to fear the tone, even though the sound of the tone could not register in their neocortex. Instead, the sound took the direct route from ear to thalamus to amygdala, skipping all higher avenues. In short, the rats had learned an emotional reaction without any higher cortical involvement: The amygdala perceived, remembered, and orchestrated their fear independently.

“Anatomically the emotional system can act independently of the neocortex,” LeDoux told me. “Some emotional reactions and emotional memories can be formed without any conscious, cognitive participation at all.” The amygdala can house memories and response repertoires that we enact without quite realizing why we do so because the shortcut from thalamus to amygdala completely bypasses the neocortex. This bypass seems to allow the amygdala to be a repository for emotional impressions and memories that we have never known about in full awareness. LeDoux proposes that it is the amygdala's subterranean role in memory that explains, for example, a startling experiment in which people acquired a preference for oddly shaped geometric figures that had been flashed at them so quickly that they had no conscious awareness of having seen them at all![6]



A visual signal first goes from the retina to the thalamus, where it is translated into the language of the brain. Most of the message then goes to the visual cortex, where it is analyzed and assessed for meaning and appropriate response; if that response is emotional, a signal goes to the amygdala to activate the emotional centers. But a smaller portion of the original signal goes straight from the thalamus to the amygdala in a quicker transmission, allowing a faster (though less precise) response. Thus the amygdala can trigger an emotional response before the cortical centers have fully understood what is happening.

Other research has shown that in the first few milliseconds of our perceiving something we not only unconsciously comprehend what it is, but decide whether we like it or not; the "cognitive unconscious" presents our awareness with not just the identity of what we see, but an opinion about it.[7] Our emotions have a mind of their own, one which can hold views quite independently of our rational mind.