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HOW EMOTIONS ARE MADE

The Secret Life of the Brain

LISA FELDMAN BARRETT

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Lisa Feldman Barrett, Ph.D.

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Introduction: The Two-Thousand-Year-Old Assumption

On December 14, 2012, the deadliest school shooting in U.S. history took place at Sandy Hook Elementary School in Newtown, Connecticut. Twenty-six people inside the school, including twenty children, were massacred by a lone gunman. Several weeks after this horror, I watched the governor of Connecticut, Dannel Malloy, give his annual "State of the State" speech on television. He spoke in a strong and animated voice for the first three minutes, thanking individuals for their service. And then he began to address the Newtown tragedy:

> We have all walked a very long and very dark road together. What befell Newtown is not something we thought possible in any of Connecticut's beautiful towns or cities. And yet, in the midst of one of the worst days in our history, we also saw the best of our state. Teachers and a therapist that sacrificed their lives protecting students.[1]

As the governor spoke the last two words, "protecting students," his voice caught in his throat ever so slightly. If you weren't paying close attention, you might have missed it. But that tiny waver *devastated* me. My stomach instantly knotted into a ball. My eyes flooded. The TV camera panned to the crowd where other people had started to sob too. As for Governor Malloy, he stopped speaking and was gazing downward.

Emotions like Governor Malloy's and mine seem primal—hardwired into us, reflexively deployed, shared with all our fellow humans. When triggered, they seem to unleash themselves in each of us in basically the same way. My sadness was like Governor Malloy's sadness was like the crowd's sadness.

Humanity has understood sadness and other emotions in this way for over two thousand years. But at the same time, if humanity has learned anything from centuries of scientific discovery, it's that things aren't always what they appear to be.

The time-honored story of emotion goes something like this: We all have emotions built-in from birth. They are distinct, recognizable phenomena inside us. When something happens in the world, whether it's a gunshot or a flirtatious glance, our emotions come on quickly and automatically, as if someone has flipped a switch. We broadcast emotions on our faces by way of smiles, frowns, scowls, and other characteristic expressions that anyone can easily recognize. Our voices reveal our emotions through laughter, shouts, and cries. Our body posture betrays our feelings with every gesture and slouch.

Modern science has an account that fits this story, which I call the *classical view of emotion.* According to this view, the waver in Governor Malloy's voice launched a chain reaction that began in my brain. A particular set of neurons — call it the "sadness circuit" — leaped into action and caused my face and body to respond in a certain, specific way. My brow furrowed, I frowned, my shoulders stooped, and I cried. This proposed circuit also triggered physical changes inside my body, causing my heart rate and breathing to speed up, my sweat glands to activate, and my blood vessels to constrict.* This collection of movements on the inside and outside of my body are said to be like a "fingerprint" that uniquely identifies sadness, much like your own fingerprints uniquely identify you.

The classical view of emotion holds that we have many such emotion circuits in our brains, and each is said to cause a distinct set of changes, that is, a fingerprint. Perhaps an annoying coworker triggers your "anger neurons," so your blood pressure rises; you scowl, yell, and feel the heat of fury. Or an alarming news story triggers your "fear neurons," so your heart races; you freeze and feel a flash of dread. Because we experience anger, happiness, surprise, and other emotions as clear and identifiable states of being,

* When I use the word "body" in this book, I am excluding the brain, as in the sentence, "Your brain tells your body to move." To refer to the entire body including the brain, I write "the anatomical body."

it seems reasonable to assume that each emotion has a defining underlying pattern in the brain and body.

Our emotions, according to the classical view, are artifacts of evolution, having long ago been advantageous for survival, and are now a fixed component of our biological nature. As such, they are universal: people of every age, in every culture, in every part of the world should experience sadness more or less as you do — and more or less as did our hominin ancestors who roamed the African savanna a million years ago. I say "more or less" because no one believes that faces, bodies, and brain activity look *exactly* the same each time someone is sad. Your heart rate and breathing and blood flow won't always change by the same amount. Your brow might furrow slightly less by chance or by custom.[2]

Emotions are thus thought to be a kind of brute reflex, very often at odds with our rationality. The primitive part of your brain wants you to tell your boss he's an idiot, but your deliberative side knows that doing so would get you fired, so you restrain yourself. This kind of internal battle between emotion and reason is one of the great narratives of Western civilization. It helps define you as human. Without rationality, you are merely an emotional beast.

This view of emotions has been around for millennia in various forms. Plato believed a version of it. So did Hippocrates, Aristotle, the Buddha, René Descartes, Sigmund Freud, and Charles Darwin. Today, prominent thinkers such as Steven Pinker, Paul Ekman, and the Dalai Lama also offer up descriptions of emotions rooted in the classical view. The classical view is found in virtually every introductory college textbook on psychology, and in most magazine and newspaper articles that discuss emotion. Preschools throughout America hang posters displaying the smiles, frowns, and pouts that are supposed to be the universal language of the face for recognizing emotions. Facebook even commissioned a set of emoticons inspired by Darwin's writings.[3]

The classical view is also entrenched in our culture. Television shows like *Lie to Me* and *Daredevil* are predicated on the assumption that your innermost feelings are exposed by your heart rate or facial movements. *Sesame Street* teaches children that emotions are distinct things inside us seeking expression in the face and body, as does the Pixar movie *Inside Out*. Companies like Affectiva and Realeyes offer to help businesses detect their customers' feelings through "emotion analytics." In the NBA draft, the Milwaukee Bucks evaluate a player's "psychological, character and personality issues" and assess "team chemistry" from facial expressions. And for several decades, the U.S. Federal Bureau of Investigation (FBI) based some of its advanced agent training on the classical view.[4]

More significantly, the classical view of emotion is embedded in our social institutions. The American legal system assumes that emotions are part of an inherent animal nature and cause us to perform foolish and even violent acts unless we control them with our rational thoughts. In medicine, researchers study the health effects of anger, supposing that there is a single pattern of changes in the body that goes by that name. People suffering from a variety of mental illnesses, including children and adults diagnosed with autism spectrum disorder, are taught how to recognize facial configurations for specific emotions, ostensibly to help them communicate and relate to others.

And yet . . . despite the distinguished intellectual pedigree of the classical view of emotion, and despite its immense influence in our culture and society, there is abundant scientific evidence that this view cannot possibly be true. Even after a century of effort, scientific research has not revealed a consistent, physical fingerprint for even a single emotion. When scientists attach electrodes to a person's face and measure how facial muscles actually move during the experience of an emotion, they find tremendous variety, not uniformity. They find the same variety — the same absence of fingerprints — when they study the body and the brain. You can experience anger with or without a spike in blood pressure. You can experience fear with or without an amygdala, the brain region historically tagged as the home of fear.

To be sure, hundreds of experiments offer some evidence for the classical view. But *hundreds more* cast that evidence into doubt. The only reasonable scientific conclusion, in my opinion, is that emotions are not what we typically think they are.

So what are they, really? When scientists set aside the classical view and just look at the data, a radically different explanation for emotion comes to light. In short, we find that your emotions are not built-in but made from more basic parts. They are not universal but vary from culture to culture. They are not triggered; you create them. They emerge as a combination of the physical properties of your body, a flexible brain that wires itself to whatever environment it develops in, and your culture and upbringing, which provide that environment. Emotions are real, but not in the objective sense that molecules or neurons are real. They are real in the same sense that money is real — that is, hardly an illusion, but a product of human agreement.[5]

This view, which I call the *theory of constructed emotion,* offers a very different interpretation of the events during Governor Malloy's speech. When Malloy's voice caught in his throat, it did not trigger a brain circuit for sadness inside me, causing a distinctive set of bodily changes. Rather, I felt sadness in that moment because, having been raised in a certain culture, I learned long ago that "sadness" is something that may occur when certain bodily feelings coincide with terrible loss. Using bits and pieces of past experience, such as my knowledge of shootings and my previous sadness about them, my brain rapidly predicted what my body should do to cope with such tragedy. Its predictions caused my thumping heart, my flushed face, and the knots in my stomach. They directed me to cry, an action that would calm my nervous system. And they made the resulting sensations meaningful as an instance of sadness.

In this manner, my brain *constructed* my experience of emotion. My particular movements and sensations were not a fingerprint for sadness. With different predictions, my skin would cool rather than flush and my stomach would remain unknotted, yet my brain could still transform the resulting sensations into sadness. Not only that, but my original thumping heart, flushed face, knotted stomach, and tears could become meaningful as a different emotion, such as anger or fear, instead of sadness. Or in a very different situation, like a wedding celebration, those same sensations could become joy or gratitude.

If this explanation doesn't make complete sense or even sounds counterintuitive so far, believe me, I am right there with you. After Governor Malloy's speech, as I came back to myself, wiping my tears, I was reminded that no matter what I *know* about emotions as a scientist, I *experience* them much as the classical view conceives them. My sadness felt like an instantly recognizable wave of bodily changes and feelings that overwhelmed me as a reaction to tragedy and loss. If I were not a scientist using experiments to reveal that emotions are in fact made and not triggered, I too would trust my immediate experience.

The classical view of emotion remains compelling, despite the evidence against it, precisely because it's intuitive. The classical view also provides reassuring answers to deep, fundamental questions like: Where do you come from, evolutionarily speaking? Are you responsible for your actions when you get emotional? Do your experiences accurately reveal the world outside you?

The theory of constructed emotion answers such questions differently. It's a different theory of human nature that helps you see yourself and others in a new and more scientifically justified light. The theory of constructed emotion might not fit the way you typically experience emotion and, in fact, may well violate your deepest beliefs about how the mind works, where humans come from, and why we act and feel as we do. But the theory consistently predicts and explains the scientific evidence on emotion, including plenty of evidence that the classical view struggles to make sense of.

Why should you care which theory of emotion is correct? Because belief in the classical view affects your life in ways you might not realize. Think about the last time you went through airport security, where taciturn agents of the Transportation Security Administration (TSA) X-rayed your shoes and evaluated your likelihood as a terrorist threat. Not long ago, a training program called SPOT (Screening Passengers by Observation Techniques) taught those TSA agents to detect deception and assess risk based on facial and bodily movements, on the theory that such movements reveal your innermost feelings. It didn't work, and the program cost taxpayers $900 million. We need to understand emotion scientifically so government agents won't detain us — or overlook those who actually do pose a threat — based on an incorrect view of emotion.[6]

Now imagine that you're in a doctor's office, complaining of chest pressure and shortness of breath, which may be heart attack symptoms. If you're a woman, you're more likely to be diagnosed with anxiety and sent home, whereas if you're a man, you're more likely to be diagnosed with heart disease and receive lifesaving preventive treatment. As a result, women over age sixty-five die more frequently of heart attacks than men do. The perceptions of doctors, nurses, and the female patients themselves are shaped by classical view beliefs that they can detect emotions like anxiety, and that women are inherently more emotional than men . . . with fatal consequences.[7]

Belief in the classical view can even start wars. The Gulf War in Iraq was launched, in part, because Saddam Hussein's half-brother thought he could read the emotions of the American negotiators and informed Saddam that the United States wasn't serious about attacking. The subsequent war claimed the lives of 175,000 Iraqis and hundreds of coalition forces.[8]

We are, I believe, in the midst of a revolution in our understanding of emotion, the mind, and the brain — a revolution that may compel us to radically rethink such central tenets of our society as our treatments for mental and physical illness, our understanding of personal relationships, our approaches to raising children, and ultimately our view of ourselves. Other scientific disciplines have seen revolutions of this kind, each one a momentous shift away from centuries of common sense. Physics moved from Isaac Newton's intuitive ideas about time and space to Albert Einstein's more relative ideas, and eventually to quantum mechanics. In biology, scientists carved up the natural world into fixed species, each having an ideal form, until Charles Darwin introduced the concept of natural selection.

Scientific revolutions tend to emerge not from a sudden discovery but by asking better questions. How are emotions made, if they aren't simply triggered reactions? Why do they vary so much, and why have we believed for so long that they have distinctive fingerprints? These questions in and of themselves can be delightfully interesting to ponder. But taking pleasure in the unknown is more than just a scientific indulgence. It's part of the spirit of adventure that makes us human.

In the pages that follow, I invite you to share that adventure with me. Chapters 1–3 introduce the new science of emotion: how psychology, neuroscience, and related disciplines are moving away from the search for emotion fingerprints and instead asking how emotions are constructed. Chapters 4–7 explain how, exactly, emotions are made. And chapters 8–12 explore the practical, real-world implications of this new theory of emotions on our approaches to health, emotional intelligence, child-rearing, personal relationships, systems of law, and even human nature itself. To close the book, chapter 13 reveals how the science of emotion illuminates the age-old mystery of how a human brain creates a human mind.

1

The Search for Emotion's "Fingerprints"

Once upon a time, in the 1980s, I thought I would be a clinical psychologist. I headed into a Ph.D. program at the University of Waterloo, expecting to learn the tools of the trade as a psychotherapist and one day treat patients in a stylish yet tasteful office. I was going to be a consumer of science, not a producer. I certainly had no intention of joining a revolution to unseat basic beliefs about the mind that have existed since the days of Plato. But life sometimes tosses little surprises in your direction.

It was in graduate school that I felt my first tug of doubt about the classical view of emotion. At the time, I was researching the roots of low self-esteem and how it leads to anxiety or depression. Numerous experiments showed that people feel depressed when they fail to live up to their own ideals, but when they fall short of a standard set by others, they feel anxious. My first experiment in grad school was simply to replicate this well-known phenomenon before building on it to test my own hypotheses. In the course of this experiment, I asked a large number of volunteers if they felt anxious or depressed using well-established checklists of symptoms.[1]

I'd done more complicated experiments as an undergraduate student, so this one should have been a piece of cake. Instead, it crashed and burned. My volunteers did not report anxious or depressed feelings in the expected pattern. So I tried to replicate a second published experiment, and it failed too. I tried again, over and over, each experiment taking months. After three years, all I'd achieved was the same failure *eight times in a row.* In science, experiments often don't replicate, but eight consecutive failures is an impressive record. My internal critic taunted me: *not everyone is cut out to be a scientist.*

When I looked closely at all the evidence I had collected, however, I noticed something consistently odd across all eight experiments. Many of my subjects appeared to be unwilling, or unable, to distinguish between feeling anxious and feeling depressed. Instead, they had indicated feeling both or neither; rarely did a subject report feeling just one. This made no sense. Everybody knows that anxiety and depression, when measured as emotions, are decidedly different. When you're anxious, you feel worked up, jittery, like you're worried something bad will happen. In depression you feel miserable and sluggish; everything seems horrible and life is a struggle. These emotions should leave your body in completely opposite physical states, and so they should feel different and be trivial for any healthy person to tell apart. Nevertheless, the data declared that my test subjects weren't doing so. The question was . . . why?

As it turned out, my experiments weren't failing after all. My first "botched" experiment actually revealed a genuine discovery — that people often did not distinguish between feeling anxious and feeling depressed. My next seven experiments hadn't failed either; they'd replicated the first one. I also began noticing the same effect lurking in other scientists' data. After completing my Ph.D. and becoming a university professor, I continued pursuing this mystery. I directed a lab that asked hundreds of test subjects to keep track of their emotional experiences for weeks or months as they went about their lives. My students and I inquired about a wide variety of emotional experiences, not just anxious and depressed feelings, to see if the discovery generalized.

These new experiments revealed something that had never been documented before: everyone we tested used the same emotion words like "angry," "sad," and "afraid" to communicate their feelings but not necessarily to mean the same thing. Some test subjects made fine distinctions with their word use: for example, they experienced sadness and fear as qualitatively different. Other subjects, however, lumped together words like "sad" and "afraid" and "anxious" and "depressed" to mean "I feel crappy" (or, more scientifically, "I feel unpleasant"). The effect was the same for pleasant emotions like happiness, calmness, and pride. After testing over seven hundred American subjects, we discovered that people vary tremendously in how they differentiate their emotional experiences.

A skilled interior designer can look at five shades of blue and distinguish azure, cobalt, ultramarine, royal blue, and cyan. My husband, on the other hand, would call them all blue. My students and I had discovered a similar phenomenon for emotions, which I described as *emotional granularity.*[2]

Here's where the classical view of emotion entered the picture. Emotional granularity, in terms of this view, must be about accurately reading your internal emotional states. Someone who distinguished among different feelings using words like "joy," "sadness," "fear," "disgust," "excitement," and "awe" must be detecting physical cues or reactions for each emotion and interpreting them correctly. A person exhibiting lower emotional granularity, who uses words like "anxious" and "depressed" interchangeably, must be failing to detect these cues.

I began wondering if I could teach people to improve their emotional granularity by coaching them to recognize their emotional states accurately. The key word here is "accurately." How can a scientist tell if someone who says "I'm happy" or "I'm anxious" is accurate? Clearly, I needed some way to *measure an emotion objectively* and then compare it to what the person reports. If a person reports feeling anxious, and the objective criteria indicate that he is in a state of anxiety, then he is accurately detecting his own emotion. On the other hand, if the objective criteria indicate that he is depressed or angry or enthusiastic, then he's inaccurate. With an objective test in hand, the rest would be simple. I could ask a person how he feels and compare his answer to his "real" emotional state. I could correct any of his apparent mistakes by teaching him to better recognize the cues that distinguish one emotion from another and improve his emotional granularity.

Like most students of psychology, I had read that each emotion is supposed to have a distinct pattern of physical changes, roughly like a fingerprint. Each time you grasp a doorknob, the fingerprints that you leave behind may vary depending on the firmness of your grip, how slippery the surface is, or how warm and pliable your skin is at that moment. Nevertheless, your fingerprints look similar enough each time to identify you uniquely. The "fingerprint" of an emotion is likewise assumed to be similar enough from one instance to the next, and in one person to the next, regardless of age, sex, personality, or culture. In a laboratory, scientists should be able to tell whether someone is sad or happy or anxious just by looking at physical measurements of a person's face, body, and brain.

I felt confident that these emotion fingerprints could provide the objective criteria I needed to measure emotion. If the scientific literature was correct, then assessing people's emotional accuracy would be a breeze. But things did not turn out quite as I expected.

• • •

According to the classical view of emotion, our faces hold the key to assessing emotions objectively and accurately. A primary inspiration for this idea is Charles Darwin's book *The Expression of the Emotions in Man and Animals,* where he claimed that emotions and their expressions were an ancient part of universal human nature. All people, everywhere in the world, are said to exhibit and recognize facial expressions of emotion without any training whatsoever.[3]

So, I thought that my lab should be able to measure facial movements, assess our test subjects' true emotional state, compare it to their verbal reports of emotion, and calculate their accuracy. If subjects made a pouting expression in the lab, for instance, but did not report feeling sad, we could train them to recognize the sadness they must be feeling. Case closed.

The human face is laced with forty-two small muscles on each side. The facial movements that we see each other make every day — winks and blinks, smirks and grimaces, raised and wrinkled brows — occur when combinations of facial muscles contract and relax, causing connective tissue and skin to move. Even when your face seems completely still to the naked eye, your muscles are still contracting and relaxing.[4]

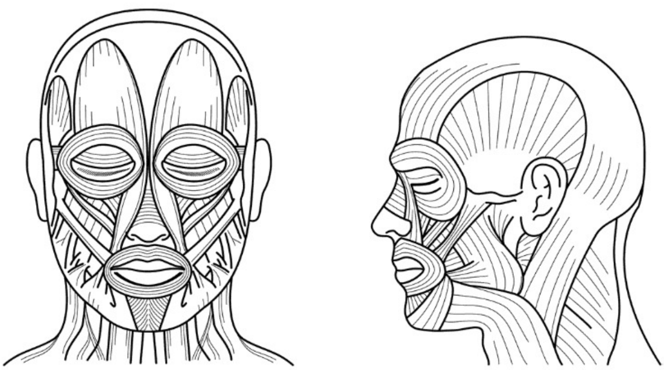

Figure 1-1: Muscles of the human face

According to the classical view, each emotion is displayed on the face as a particular pattern of movements — a "facial expression." When you're happy, you're supposed to smile. When you're angry, you're supposed to furrow your brow. These movements are said to be part of the fingerprint of their respective emotions.

Back in the 1960s, the psychologist Silvan S. Tomkins and his protégés Carroll E. Izard and Paul Ekman decided to test this in the lab. They created sets of meticulously posed photographs, such as those in figure 1-2, to represent six so-called basic emotions they believed had biological fingerprints: anger, fear, disgust, surprise, sadness, and happiness. These photos, which featured actors who were carefully coached, were supposed to be the clearest examples of facial expressions for these emotions. (They might look exaggerated or artificial to you, but they were designed this way on purpose, because Tomkins believed they gave the strongest, clearest signals for emotion.)[5]

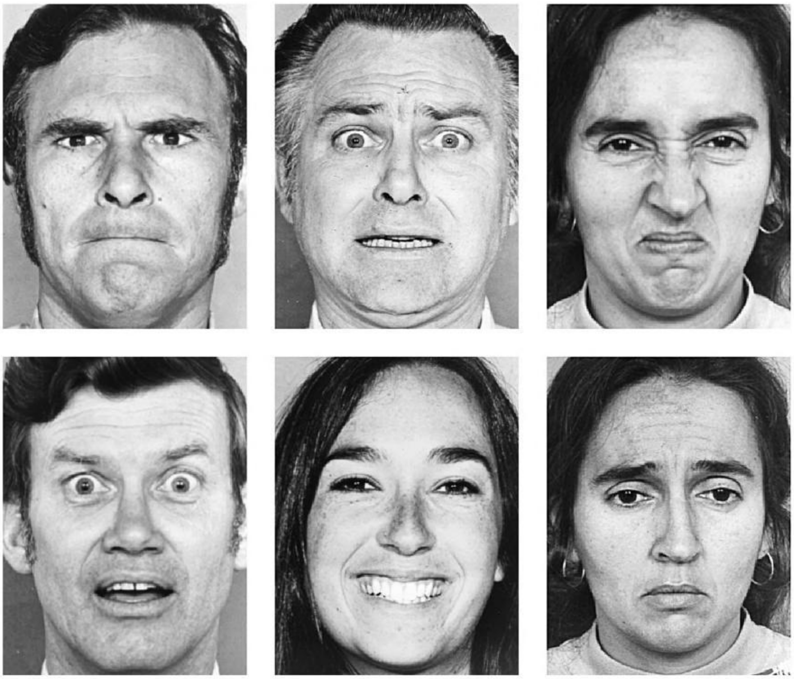

Figure 1-2: Some facial photographs from basic emotion method studies

Using posed photos like these, Tomkins and his crew applied an experimental technique to study how well people "recognize" emotional expressions, or, more precisely, how well they perceive facial movements as expressions of emotion. Hundreds of published experiments have used this method, and it's still considered the gold standard today. A test subject is given a photograph and a set of emotion words, as in figure 1-3.

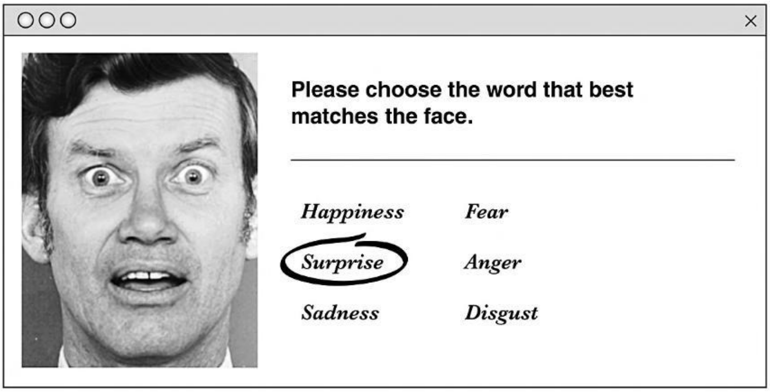

Figure 1-3: Basic emotion method: picking a word to match the face

The subject then chooses the word that best matches the face. In this case, the intended word is "Surprise." Or, using a slightly different setup, a test subject is given two posed photos and a brief story, as in figure 1-4, and then picks which face best matches the story. In this case, the intended face is on the right.[6]

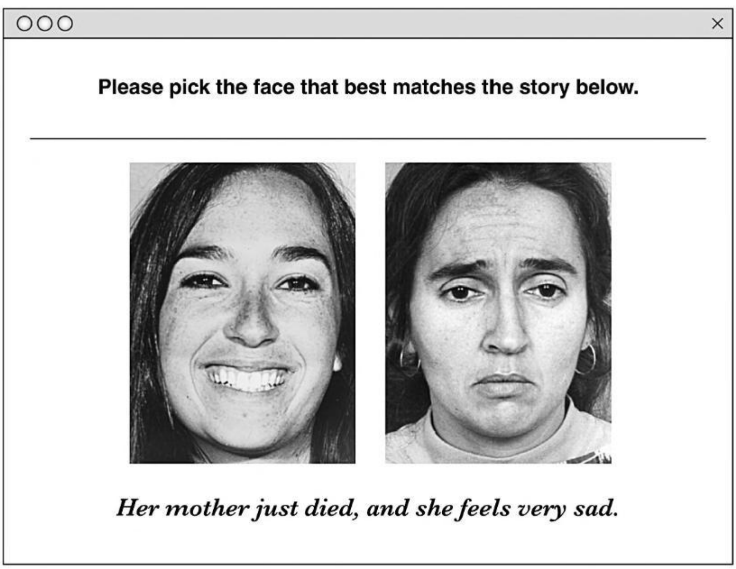

Figure 1-4: Basic emotion method: picking a face to match the story

This research technique — let's call it the basic emotion method — revolutionized the scientific study of what Tomkins's group called "emotion recognition." Using this method, scientists showed that people from around the world could consistently match the same emotion words (translated into the local language) to posed faces. In one famous study, Ekman and his colleagues traveled to Papua New Guinea and ran experiments with a local population, the Fore people, who had little contact with the Western world. Even this remote tribe could consistently match the faces to the expected emotion words and stories. In later years, scientists ran similar studies in many other countries such as Japan and Korea. In each case, subjects easily matched the posed scowls, pouts, smiles, and so on to the provided emotion words or stories.[7]

From this evidence, scientists concluded that emotion recognition is universal: no matter where you are born or grow up, you should be able to recognize American-style facial expressions like those in the photos. The only way expressions could be universally recognized, the reasoning went, is if they are universally produced: thus, facial expressions must be reliable, diagnostic fingerprints of emotion.[8]

Other scientists, however, worried that the basic emotion method was too indirect and subjective to reveal emotion fingerprints because it involves human judgment. A more objective technique, called facial electromyography (EMG), removes human perceivers altogether. Facial EMG places electrodes on the surface of the skin to detect the electrical signals that make facial muscles move. It precisely identifies the parts of the face as they move, how much, and how often. In a typical study, test subjects wear electrodes over their eyebrows, forehead, cheeks, and jaw as they view films or photos, or as they remember or imagine situations, to evoke a variety of emotions. Scientists record the electrical changes in muscle activity and calculate the degree of movement in each muscle during each emotion. If people move the same facial muscles in the same pattern each time they experience a given emotion — scowling in anger, smiling in happiness, pouting in sadness, and so on — and *only* when they experience that emotion, then the movements might be a fingerprint.[9]

As it turns out, facial EMG presents a serious challenge to the classical view of emotion. In study after study, the muscle movements do not reliably indicate when someone is angry, sad, or fearful; they don't form predictable fingerprints for each emotion. At best, facial EMG reveals that these movements distinguish pleasant versus unpleasant feeling. Even more damning,

Figure 1-5: Facial electromyography

the facial movements recorded in these studies do not reliably match the posed photos created for the basic emotion method.[10]

Let's take a moment and consider the implications of these findings. Hundreds of experiments have shown that people worldwide can match emotion words to so-called expressions of emotion, posed by actors who aren't actually feeling those emotions. However, those expressions can't be consistently and specifically detected by objective measures of facial muscle movements when people are *actually feeling* emotion. We all move our facial muscles all the time, of course, and when we look at each other, we effortlessly see emotion in some of these movements. Nevertheless, from a purely objective standpoint, when scientists measure *just the muscle movements themselves,* those movements do not conform to the photographs.

It's conceivable that facial EMG is too limited to capture all the meaningful actions in a face during an emotional experience. A scientist can place about six electrodes on each side of the face before a test subject starts to feel uncomfortable, too few to capture all forty-two facial muscles meaningfully. So scientists also employ an alternative technique called facial action coding (FACS), in which trained observers laboriously classify a subject's individual facial movements as they occur. It's less objective than facial EMG, since it relies on human perceivers, but presumably more objective than matching words to posed faces in the basic emotion method. Nevertheless, the movements observed during facial action coding also don't consistently match the posed photos.[11]

These same inconsistencies show up in infants. If facial expressions are universal, then babies should be even more likely than adults to express anger with a scowl and sadness with a pout, because they're too young to learn rules of social appropriateness. And yet when scientists observe infants in situations that should evoke emotion, the infants do not make the expected expressions. For example, the developmental psychologists Linda A. Camras and Harriet Oster and their colleagues videotaped babies from various cultures, employing a growling gorilla toy to startle them (to induce fear) or restraining their arm (to induce anger). Camras and Oster found, using FACS, that the range of babies' facial movements in the two situations was indistinguishable. Nevertheless, when adults watched these videos, they somehow identified the infants in the gorilla film as afraid and infants in the arm restraint film as angry, even when Camras and Oster blanked out the babies' faces electronically! The adults were distinguishing fear from anger based on the context, without seeing facial movements at all.[12]

Don't get me wrong: newborns and young infants move their faces in meaningful ways. They make many distinctive facial movements when the situation implies that they might be interested or puzzled, or when they feel distress in response to pain or distaste in response to offending smells and tastes. But newborns don't show differentiated, adult-like expressions like the photographs from the basic emotion method.[13]

Other scientists also have demonstrated, as Camras and Oster did, that you take tremendous information from the surrounding context. They graft photographs of faces and bodies that don't belong together, like an angry scowling face attached to a body that's holding a dirty diaper, and their test subjects nearly always identify the emotion appropriate to the body, not the face — in this case, disgust rather than anger. Faces are constantly moving, and your brain relies on many different factors at once — body posture, voice, the overall situation, your lifetime of experience — to figure out which movements are meaningful and what they mean.[14]

When it comes to emotion, a face doesn't speak for itself. In fact, the poses of the basic emotion method were not discovered by observing faces in the real world. Scientists *stipulated* those facial poses, inspired by Darwin's book, and asked actors to portray them. And now these faces are simply assumed to be the universal expressions of emotion.[15]

But they aren't universal. To further demonstrate this, my lab conducted a study using photos from a group of emotion experts — accomplished actors. The photos came from the book *In Character: Actors Acting,* in which actors portray emotions by posing their faces to match written scenarios. We divided our U.S. test subjects into three groups. The first group read only the scenarios, for example, "He just witnessed a shooting on his quiet, tree-shaded block in Brooklyn." A second group saw only the facial configurations, such as Martin Landau's pose for the shooting scenario (figure 1-6, center). A third group saw the scenarios and the faces. In each case, we handed subjects a short list of emotion words to categorize whatever emotion they saw.[16]

For the shooting scenario I just mentioned, 66 percent of subjects who read the scenario alone or with Landau's face rated the scenario as a fearful situation. But for subjects who saw Landau's face alone, devoid of context, only 38 percent of them rated it as fear and 56 percent rated it as surprise. (Figure 1-6 compares Landau's facial configuration to basic emotion method photos for "fear" and "surprise." Does Landau look afraid or surprised? Or both?)

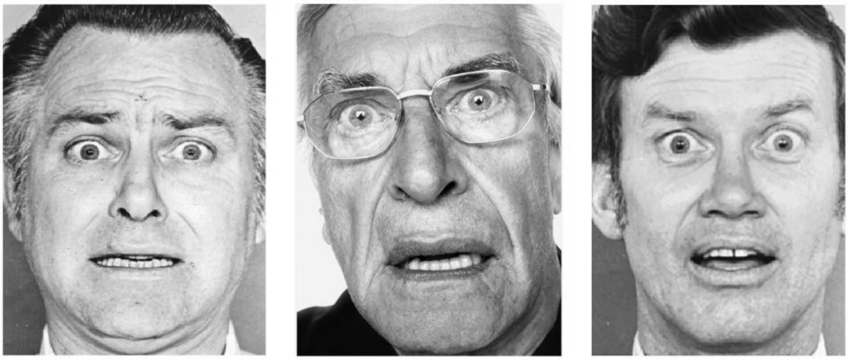

Figure 1-6: Actor Martin Landau (center) flanked by basic emotion method faces for fear (left) and surprise (right)

Other actors' poses for fear were strikingly different from Landau's. In one case, the actress Melissa Leo portrayed fear for the scenario: "She is trying to decide if she should tell her husband about a rumor going around that she is gay before he hears it from someone else." Her mouth is closed and downturned, and her brow is slightly knitted. Nearly three-quarters of our test subjects who saw her face alone rated it as sad, but when presented with the scenario, 70 percent of subjects rated her face as displaying fear.[17]

This sort of variation held true for every emotion that we studied. An emotion like "Fear" does not have a single expression but a *diverse population of facial movements* that vary from one situation to the next.* (Think about it: When is the last time an actor won an Academy Award for pouting when sad?)

This may seem obvious once you pause to consider your own emotional experiences. When you experience an emotion such as fear, you might move your face in a variety of ways. While cowering in your seat at a horror movie, you might close your eyes or cover them with your hands. If you're uncertain whether a person directly in front of you could harm you, you might narrow your eyes to see the person's face better. If danger is potentially lurking around the next corner, your eyes might widen to improve your peripheral vision. "Fear" takes no single physical form. Variation is the norm. Likewise, happiness, sadness, anger, and every other emotion you know is a diverse *category,* with widely varying facial movements.[18]

If facial movements have so much variation within an emotion category like "Fear," you might wonder why we find it so natural to believe that a wide-eyed face is the universal fear expression. The answer is that it's a stereotype, a symbol that fits a well-known theme for "Fear" within our culture. Preschools teach these stereotypes to children: "People who scowl are angry. People who pout are sad." They are cultural shorthands or conventions. You see them in cartoons, in advertisements, in the faces of dolls, in emojis — in an endless array of imagery and iconography. Textbooks teach these stereotypes to psychology students. Therapists teach them to their patients. The media spreads them widely throughout the Western world. "Now, wait just a minute," you might be thinking. "Is she saying that our culture has *created* these expressions, and we all have *learned* them?" Well . . . yes. And the classical view perpetuates these stereotypes as if they are authentic fingerprints of emotion.

To be sure, faces are instruments of social communication. Some facial movements have meaning, but others do not, and right now, we know pre-

* In this book, I use initial capitals and double quotation marks to denote an emotion in general, such as "Fear," as opposed to a single instance of fear.

cious little about how people figure out which is which, other than that context is somehow crucial (body language, social situation, cultural expectation, etc.). When facial movements do convey a psychological message — say, raising an eyebrow — we don't know if the message is always emotional, or even if its meaning is the same each time. If we put all the scientific evidence together, we cannot claim, with any reasonable certainty, that each emotion has a diagnostic facial expression.[19]

• • •

In my search for unique fingerprints of emotion, I clearly needed a more reliable source than the human face, so next I looked to the human body. Perhaps some telling changes in heart rate, blood pressure, and other body functions would provide the necessary fingerprints to teach people to recognize their emotions more accurately.

Some of the strongest experimental support for bodily fingerprints comes from a famous study by Paul Ekman, the psychologist Robert W. Levenson, and their colleague Wallace V. Friesen, published in the journal *Science* in 1983. They hooked up test subjects to machines to measure changes in the autonomic nervous system: variations in heart rate, temperature, and skin conductance (a measure of sweat). They also measured variations in arm tension, rooted in the skeletomotor nervous system. They then used an experimental technique to evoke anger, sadness, fear, disgust, surprise, and happiness, and observed the physical changes during each emotion. After analyzing the data, Ekman and his colleagues concluded that they had measured clear and consistent changes in these bodily responses, relating them to particular emotions. This study seemingly established objective, biological fingerprints in the body for each of the studied emotions, and today it remains a classic in the scientific literature.[20]

The famous 1983 study evoked emotion in a curious way — by having test subjects make and hold a facial pose from the basic emotion method. To evoke sadness, for example, a subject would frown for ten seconds. To evoke anger, a subject would scowl. While face-posing, subjects could use a mirror and were coached by Ekman himself to move particular facial muscles.[21]

The idea that a posed, so-called facial expression can trigger an emotional state is known as the facial feedback hypothesis. Allegedly, contorting your face into a particular configuration causes the specific physiological changes associated with that emotion in your body. Try it yourself. Knit your brows and pout for ten seconds — do you feel sad? Smile broadly. Do you feel happier? The facial feedback hypothesis is highly controversial —

there is wide disagreement on whether a full-blown emotional experience can be evoked this way.[22]

The 1983 study did, in fact, observe bodily changes as people posed the required facial configurations. This is a remarkable finding: just posing a particular facial configuration changed the test subjects' peripheral nervous system activity, even while they were comfortably motionless in a chair. Their fingertips were warmer when posing a scowl (anger pose). Their heartbeats were faster when posing scowls, wide-eyed startle (fear pose), and pouts (sad pose) when compared to the poses for happiness, surprise, and disgust. The remaining two measures, skin conductance and arm tension, did not distinguish one facial configuration from another.[23]

Even so, you must take some additional steps before you can claim that you've found a bodily fingerprint for an emotion. For one thing, you must show that the response during one emotion, say, anger, is different from that of other emotions — that is, it's specific to instances of anger. Here, the 1983 study starts having some difficulty. It showed some specificity for anger but not for the other emotions tested. That means the bodily responses for different emotions were too similar to be distinct fingerprints.

In addition, you must show that no other explanations can account for your results. Then, and only then, can you claim to have found physical fingerprints for anger, sadness, and the rest. The 1983 study is, for this reason, subject to an alternative explanation, because the test subjects were given instructions for how to pose their faces. Western subjects could conceivably identify most of the target emotions from these instructions. This understanding can actually produce the heart rate and other physical changes Ekman and colleagues observed, a fact that was unknown when these studies were conducted. This alternative explanation is borne out by their later experiment with an African tribe, the Minangkabau of West Sumatra. These volunteers had less understanding of Western emotions and did not show the same physical changes as Western test subjects; they also reported feeling the expected emotion much less frequently than the Western subjects did.[24]

Other subsequent research has evoked emotions using a variety of different methods but has not replicated the original physiological differences observed in the 1983 paper. Quite a few studies employ horror movies, tearful chick flicks, and other evocative material to bring on particular emotions, while scientists measure subjects' heart rate, respiration, and other bodily functions. Many such studies found great variability in physical measurements, meaning no clear pattern of bodily changes that distinguished emotions. In other studies, scientists did find distinguishing patterns, but different studies often found *different* patterns, even when using exactly the same film clips. In other words, when studies distinguished anger from sadness from fear, they did not always replicate one another, implying that the instances of anger, sadness, and fear cultivated in one study were different from those cultivated in another.[25]

When faced with a large collection of diverse experiments like this, it's hard to extract a consistent story. Fortunately, scientists have a technique to analyze all the data together and reach a unified conclusion. It's called a "meta-analysis." Scientists comb through large numbers of experiments conducted by different researchers, combining their results statistically. As a simple example, suppose you wanted to check if increased heart rate is part of the bodily fingerprint of happiness. Rather than run your own experiment, you could do a meta-analysis of other experiments that measured heart rate during happiness, even incidentally (e.g., the study could be about the relationship between sex and heart attacks and have nothing centrally to do with emotion). You would search for all the relevant scientific papers, collect the relevant statistics from them, and analyze them *en masse* to test the hypothesis.

Where emotions and the autonomic nervous system are concerned, four significant meta-analyses have been conducted in the last two decades, the largest of which covered more than 220 physiology studies and nearly 22,000 test subjects. None of these four meta-analyses found consistent and specific emotion fingerprints in the body. Instead, the body's orchestra of internal organs can play many different symphonies during happiness, fear, and the rest.[26]

You can see this variation easily in an experimental procedure used by laboratories around the world, where test subjects perform a difficult task such as counting backward by thirteen as fast as possible, or speaking about a polarizing topic like abortion or religion, while being ridiculed. As they struggle, the experimenter berates them for poor performance, making critical and even insulting remarks. Do all the test subjects get angry? No, they don't. More importantly, those who do feel angry show different patterns of bodily changes. Some people fume in anger, but some cry. Others become quiet and cunning. Still others just withdraw. Each behavior (fuming, crying, planning, withdrawing) is supported by a different physiological pattern in the body, a detail long known by physiologists who study the body for its own sake. Even small changes in body posture, like lying back versus leaning forward with arms crossed, can completely alter an angry person's physiological response.[27]

When I address audiences at conferences and present these meta-analyses, some people become incredulous: "Are you saying that in a frustrating, humiliating situation, not everyone will get angry so that their blood boils and their palms sweat and their cheeks flush?" And my answer is yes, that is exactly what I am saying. As a matter of fact, earlier in my career, when I was giving my first talks about these ideas, you could see variations in anger firsthand in audience members who *really* didn't like the evidence. Sometimes they would shift around in their seats. Other times they shook their head in a silent "no." Once a colleague yelled at me while his face turned red and he stabbed his finger in the air. Another colleague asked me, in a sympathetic tone, if I had ever felt real fear, because if I'd ever been seriously harmed, I would never be suggesting such a preposterous idea. Yet another colleague said he would tell my brother-in-law (a sociologist of his acquaintance) that I was damaging the science of emotion. My favorite example involved a much more senior colleague, built like a linebacker and towering a foot above me, who cocked his fist and offered to punch me in the face to demonstrate what real anger looks like. (I smiled and thanked him for the thoughtful offer.) In these examples, my colleagues demonstrated the variability of anger far more handily than my presentation did.

What does it mean that four meta-analyses, summarizing hundreds of experiments, revealed no consistent, specific fingerprints in the autonomic nervous system for different emotions? It doesn't mean that emotions are an illusion, or that bodily responses are random. It means that on different occasions, in different contexts, in different studies, within the same individual and across different individuals, *the same emotion category involves different bodily responses.* Variation, not uniformity, is the norm. These results are consistent with what physiologists have known for over fifty years: different behaviors have different patterns of heart rate, breathing, and so on to support their unique movements.[28]

Despite tremendous time and investment, research has not revealed a consistent bodily fingerprint for even a single emotion.

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My first two attempts to find objective fingerprints of emotion — in the face and body — had led me smack into a closed door. But as they say, when a door closes, sometimes a window opens. My window was the unexpected realization that an emotion is not a *thing* but a category of instances, and any emotion category has tremendous variety. Anger, for example, varies far more than the classical view of emotion predicts or can explain. When you're angry at someone, do you shout and swear or do you seethe quietly? Do you tease back in reproach? How about widening your eyes and raising your eyebrows? During these times, your blood pressure might go up or down or stay the same. You might feel your heart beating in your chest, or not. Your hands might become clammy, or they might remain dry . . . whatever best prepares your body for action in that situation.

How does your brain create and keep track of all these diverse angers? How does it know which one fits the situation best? If I asked how you felt in each of these situations, would you give a detailed answer like "aggravated," "irritated," "outraged," or "vengeful" automatically with little effort? Or would you answer "angry" in each case, or simply, "I feel bad"? How do you even know the answer? These are mysteries that the classical view of emotion doesn't acknowledge.

I didn't know it at the time, but as I considered emotion categories in all their diversity, I was unwittingly applying a standard way of thinking in biology called *population thinking,* which was proposed by Darwin. A category, such as a species of animal, is a population of unique members who vary from one another, with no fingerprint at their core. The category can be described at the group level only in abstract, statistical terms. Just as no American family consists of 3.13 people, no instance of anger must include an average anger pattern (should we be able to identify one). Nor will any instance necessarily resemble the elusive fingerprint of anger. What we have been calling a fingerprint might just be a stereotype.[29]

Once I adopted a mindset of population thinking, my whole landscape shifted, scientifically speaking. I began to see variation not as error but as normal and even desirable. I continued my quest for an objective way to distinguish one emotion from another, but it wasn't quite the same quest anymore. With growing skepticism, I had only one place left to look for fingerprints. It was time to turn to the brain.*

Scientists have long studied people with brain damage (brain lesions) to try to locate an emotion in a specific area of the brain. If someone with a lesion in a particular area of the brain has difficulty experiencing or perceiv-

* For a quick overview of brain terminology — neurons, lobes, and so on — see appendix A.

ing a particular emotion, and only that emotion, then this would be considered evidence that the emotion specifically depends on the neurons in that region. It's a bit like finding out which circuit breakers in your house control which parts of your electrical system. Initially, all breakers are on and your house runs normally. When you shut off one breaker (giving your electrical system a lesion of sorts) and observe that your kitchen lights no longer function, you've discovered a purpose of the breaker.

The search for fear in the brain is an instructive example because for many years, scientists have considered it a textbook case of localizing emotion to a single brain area — namely, the amygdala, a group of nuclei found deep in the brain's temporal lobe.* The amygdala was first linked to fear in the 1930s when two scientists, Heinrich Klüver and Paul C. Bucy, removed the temporal lobes of rhesus monkeys. Lacking an amygdala, these monkeys approached objects and animals that would normally frighten them, like snakes, unfamiliar monkeys, or others that they'd avoided before the surgery, without hesitation. Klüver and Bucy attributed these deficits to an "absence of fear."[30]

Not long afterward, other scientists began studying humans with amygdala damage to see if those patients continued to experience and perceive fear. The most intensively studied case is a woman known as "SM," afflicted with a genetic disease that gradually obliterates the amygdala during childhood and adolescence, called Urbach-Wiethe disease. Overall, SM was (and still is) mentally healthy and of normal intelligence, but her relationship to fear seemed quite unusual in laboratory tests. Scientists showed her horror movies like *The Shining* and *The Silence of the Lambs,* exposed her to live snakes and spiders, and even took her through a haunted house, but she reported no strong feelings of fear. When SM was shown wide-eyed facial configurations from the basic emotion method's set of photos, she had difficulty identifying them as fearful. SM experienced and perceived other emotions normally.[31]

Scientists tried unsuccessfully to teach SM to feel fear, using a procedure commonly called fear learning. They showed her a picture and then immediately blasted a boat horn at one hundred decibels to startle her. This sound was meant to trigger SM's fear response if she had one. At the same time, they measured SM's skin conductance, which many scientists believe to be a measure of fear and is related to amygdala activity. After many repe-

* Actually, we have two amygdalae, one each in the left and right temporal lobes.

titions of the picture followed by the horn blast, they showed SM the picture alone and measured her response. People with intact amygdalae would have learned to associate the picture with the startling sound, so if just shown the picture, their brain would predict the horn blast and their skin conductance would jump. But no matter how many times scientists paired the picture and the loud sound, SM's skin conductance didn't increase when viewing the picture alone. The experimenters concluded that SM could not learn to fear new objects.[32]

Overall, SM seemed fearless, and her damaged amygdalae seemed to be the reason. From this and other similar evidence, scientists concluded that a properly functioning amygdala was the brain center for fear.

But then, a funny thing happened. Scientists found that SM could see fear in body postures and hear fear in voices. They even found a way to make SM feel terror, by asking her to breathe air that was loaded with extra carbon dioxide. Lacking the normal degree of oxygen, SM panicked. (Don't worry, she was not in danger.) So SM could clearly feel and perceive fear under some circumstances, even without her amygdalae.[33]

As brain lesion research progressed, other people with amygdala damage were discovered and tested, and the clear and specific link between fear and the amygdala dissolved. Perhaps the most important counterevidence came from a pair of identical twins who lost the supposed fear-related parts of their amygdalae to Urbach-Wiethe disease. Both were diagnosed at the age of twelve, have normal intelligence, and have a high school education. Despite their identical DNA, equivalent brain damage, and a common environment both as children and adults, the twins have very different profiles regarding fear. One twin, BG, is much like SM: she has similar fear-related deficits yet experiences fear when breathing carbon dioxide–loaded air. The other twin, AM, has basically normal responses during fear: other brain networks are compensating for her missing amygdalae. So we have identical twins, with identical DNA, suffering from identical brain damage, living in highly similar environments, but one has some fear-related deficits while the other has none.[34]

These findings undermine the idea that the amygdala contains the circuit for fear. They point instead to the idea that the brain must have multiple ways of creating fear, and therefore the emotion category "Fear" cannot be necessarily localized to a specific region. Scientists have studied other emotion categories in lesion patients besides fear, and the results have been similarly variable. Brain regions like the amygdala are routinely important to emotion, but they are neither necessary nor sufficient for emotion.[35]

This is one of the most surprising things I learned as I began to study neuroscience: a mental event, such as fear, is not created by only one set of neurons. Instead, combinations of different neurons can create instances of fear. Neuroscientists call this principle *degeneracy.* Degeneracy means "many to one": many combinations of neurons can produce the same outcome. In the quest to map emotion fingerprints in the brain, degeneracy is a humbling reality check.[36]

My lab has observed degeneracy while performing brain scans on volunteers. We showed them evocative photos, with subject matter like skydiving and bloody corpses, and asked them how much bodily arousal they felt. Men and women reported equivalent feelings of arousal, and both had increased activity in two brain areas, the anterior insula and early visual cortex. However, women's feelings of arousal were more strongly linked to the anterior insula, while men's were more strongly linked to visual cortex. This is evidence that the same experience — feelings of arousal — was associated with different patterns of neural activity, an example of degeneracy.[37]

Another surprising thing I learned while training to be a neuroscientist, along with degeneracy, is that many parts of the brain serve more than one purpose. The brain contains *core systems* that participate in creating a wide variety of mental states. A single core system can play a role in thinking, remembering, decision-making, seeing, hearing, and experiencing and perceiving diverse emotions. A core system is "one to many": a single brain area or network contributes to many different mental states. The classical view of emotion, in contrast, considers particular brain areas to have dedicated psychological functions, that is, they are "one to one." Core systems are therefore the antithesis of neural fingerprints.[38]

To be clear, I'm not saying that every neuron in the brain does exactly the same thing, nor that every neuron can stand in for every other. (That view is called equipotentiality, and it's been long disproved.) I am saying that most neurons are multipurpose, playing more than one part, much as flour and eggs in your kitchen can participate in many recipes.

The reality of core systems has been established through virtually every experimental method in neuroscience, but it's most easily seen with brain-imaging techniques that observe the brain in action. The most common method is called functional magnetic resonance imaging (fMRI), which can peer harmlessly into the heads of living people who are experiencing emotion or perceiving emotion in others, recording the changes in magnetic signals related to firing neurons.[39]

Even so, scientists employ fMRI to search for emotion fingerprints throughout the brain. If a particular blob of brain circuitry shows increased activation during a particular emotion, researchers reason, that would be evidence that the blob computes the emotion. Scientists initially focused their scanners on the amygdala and whether it contains the neural fingerprint for fear. One key piece of evidence came from test subjects who looked at photos of so-called fear poses from the basic emotion method while in the scanner. Their amygdalae increased in activity compared to when they viewed faces with neutral expressions.[40]

As research continued, however, anomalies emerged. Yes, the amygdala was showing an increase in activity, but only in certain situations, like when the eyes of a face were staring directly at the viewer. If the eyes were gazing off to the side, the neurons in the amygdala barely changed their firing rates. Also, if test subjects viewed the same stereotyped fear pose over and over again, their amygdala activation rapidly tapered off. If the amygdala truly housed the circuit for fear, then this habituation should not occur — the circuit should fire in an obligatory way whenever it is presented with a triggering "fear" stimulus. From these contrary results, it became clear to me — and ultimately to many other scientists — that the amygdala is not the home of fear in the brain.[41]

In 2008, my lab along with neurologist Chris Wright demonstrated why the amygdala increases in activity in response to the basic emotion fear faces. The activity increases in response to *any* face — whether fearful or neutral — *as long as it is novel* (i.e., the test subjects have not seen it before). Since the wide-eyed, fearful facial configurations of the basic emotion method occur rarely in everyday life, they are novel when test subjects view them in brain-imaging experiments. These findings, and others like them, provide an alternative explanation for the original experiments that don't require the amygdala to be the brain locus of fear.[42]

Over the past two decades, this back-and-forth trajectory, with evidence followed by counterevidence, has occurred in research on every brain region that has ever been identified as the neural fingerprint of an emotion. So my lab set out to settle the question of whether brain blobs are really emotion fingerprints once and for all. We examined *every* published neuroimaging study on anger, disgust, happiness, fear, and sadness, and combined those that were usable statistically in a meta-analysis. Altogether, this comprised nearly 100 published studies involving nearly 1,300 test subjects across almost 20 years.[43]

To make sense of this large amount of data, we divided the human brain virtually into tiny cubes called voxels, the 3-D version of pixels. Then, for every voxel in the brain during every emotion studied in every experiment, we recorded whether or not an increase in activation was reported. Now we could compute the probability that each voxel would show an increase in activation during the experience or perception of each emotion. When the probability was greater than chance, we called it statistically significant.

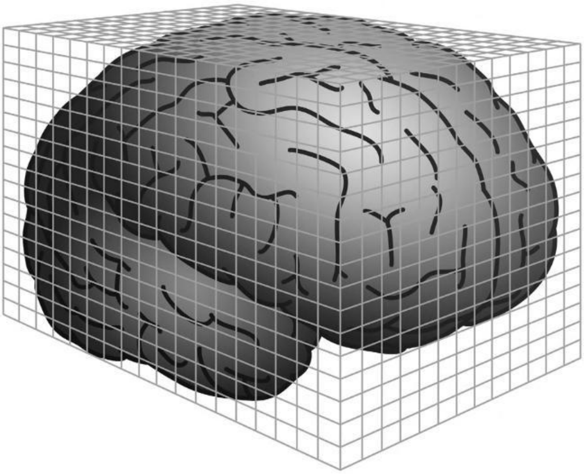

Figure 1-7: The human brain divided into voxels

Our comprehensive meta-analysis found little to support the classical view of emotion. The amygdala, for example, did show a consistent increase in activity for studies of fear, more than what you'd expect by chance, but only in a quarter of fear experience studies and about 40 percent of fear perception studies. These numbers fall short of what you'd expect for a neural fingerprint. Not only that, but the amygdala also showed a consistent increase during studies of anger, disgust, sadness, and happiness, indicating that whatever functions the amygdala was performing in some instances of fear, it was also performing those functions during some instances of those other emotions.

Interestingly, amygdala activity likewise increases during events usually considered non-emotional, such as when you feel pain, learn something new, meet new people, or make decisions. It's probably increasing now as you read these words. In fact, every supposed emotional brain region has also been implicated in creating non-emotional events, such as thoughts and perceptions.

Overall, we found that *no brain region contained the fingerprint for any single emotion.* Fingerprints are also absent if you consider multiple connected regions at once (a brain network), or stimulate individual neurons with electricity. The same results hold in experiments with other animals that allegedly have emotion circuits, such as monkeys and rats. Emotions arise from firing neurons, but no neurons are exclusively dedicated to emotion. For me, these findings have been the final, definitive nail in the coffin for localizing emotions to individual parts of the brain.[44]

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By now, I hope you see that for a very long time, people have held a mistaken view of emotions. Many research studies claim to have identified physical fingerprints that distinguish one emotion from another. Nevertheless, these supportive studies are found within a *much larger* scientific context that doesn't support the classical view.*

Some scientists might say that the contrary studies are simply wrong; after all, experiments on emotion can be pretty tricky to pull off. Some areas of the brain are really difficult to see. Heart rate is influenced by all kinds of factors that have nothing to do with emotion, like how much sleep test subjects had the night before, whether they had any caffeine in the last hour, and whether they are sitting, standing, or lying down. It's also challenging to make test subjects experience emotion on cue. Trying to evoke blood-curdling fear or brain-boiling anger is against the rules: all universities have Institutional Review Boards that prevent people like me from inflicting too much emotional agony on innocent volunteers.[45]

But even considering all these caveats, far more experiments call the classical view into doubt than we would expect by chance, or even due to inad-

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* I sometimes hear comments from emotion researchers who subscribe to the classical view: "What about these other fifty studies, with these thousands of subjects, that show incontrovertible evidence for emotion fingerprints?" Yes, there are many such confirmatory studies, but a theory of emotion must explain all the evidence, not just the portion that supports the theory. One must not point to fifty thousand black dogs as proof that all dogs are black.

equate experimental methods. Facial EMG studies demonstrate that people move their facial muscles in many different ways, not one consistent way, when feeling an instance of the same emotion category. Large meta-analyses conclude that a single emotion category involves different bodily responses, not a single, consistent response. Brain circuitry operates by the many-to-one principle of degeneracy: instances of a single emotion category, such as fear, are handled by different brain patterns at different times and in different people. Conversely, the same neurons can participate in creating different mental states (one-to-many).

I hope you've caught the pattern emerging here: *variation is the norm.* Emotion fingerprints are a myth.

If we want to truly understand emotions, we must start taking that variation seriously. We must consider that an emotion word, like "anger," does not refer to a specific response with a unique physical fingerprint but to a group of highly variable instances that are tied to specific situations. What we colloquially call emotions, such as anger, fear, and happiness, are better thought of as emotion categories, because each is a collection of diverse instances. Just as instances of the category "Cocker Spaniel" vary in their physical attributes (tail length, nose length, coat thickness, running speed, and so on) more than genes alone can account for, so might instances of "Anger" vary in their physical manifestations (facial movements, heart rate, hormones, vocal acoustics, neural activity, and so on), and this variation might be related to the environment or context.[46]

When you adopt a mindset of variation and population thinking, so-called emotion fingerprints give way to better explanations. Here's an example of what I mean. Some scientists, using techniques from artificial intelligence, can train a software program to recognize many, many brain scans of people experiencing different emotions (say, anger and fear). The program computes a statistical pattern that summarizes each emotion category and then — here's the cool part — can actually analyze new scans and determine if they are closer to the summary pattern for anger or fear. This technique, called pattern classification, works so well that it's sometimes called "neural mind-reading."

Some of these scientists claim that the statistical summaries depict neural fingerprints for anger and fear. But that's a gigantic logical error. The statistical pattern for fear is not an actual brain state, just an abstract summary of many instances of fear. These scientists are mistaking a mathematical average for the norm.[47]

My collaborators and I applied pattern classification to our meta-analysis of brain-imaging studies of emotion. Our computer program learned to classify scans from about 150 different studies. We found patterns across the brain that predict better than chance whether the test subjects in a specific study were experiencing anger, disgust, fear, happiness, or sadness. These patterns are not emotion fingerprints, however. The pattern for anger, for example, consists of a set of voxels across the brain, but that pattern need not appear in any individual brain scan for anger. The pattern is an abstract summary. In fact, no individual voxel appeared in all the scans of anger.[48]

When properly applied, pattern classification is an example of population thinking. A species, you may recall, is a collection of diverse individuals, so it can be summarized only in statistical terms. The summary is an abstraction that does not exist in nature — it does not describe any individual member of the species. Where emotion is concerned, on different occasions and in different people, different combinations of neurons can create instances of an emotion category like anger. Even when two experiences of anger feel the same to you, they can have different brain patterns via degeneracy. But we can still summarize many varying instances of anger to describe how, in abstract terms, they might be distinguishable from all the varying instances of fear. (Analogy: no two Labrador Retrievers are identical, but they're all distinguishable from Golden Retrievers.)

My long search for fingerprints in the face, body, and brain brought me to a realization that I had not expected — that we need a new theory of what emotions are and where they come from. In the chapters that follow, I introduce you to this new theory, which accounts for all the findings of the classical view as well as all the inconsistencies you've just seen. By moving beyond fingerprints and following the evidence, we will seek a better and more scientifically justified understanding, not only of emotion but also of ourselves.

2

Emotions Are Constructed

Please take a look at the black splotches in figure 2-1.

Figure 2-1: Mystery blobs

If this is your first time viewing these blobs, your brain is working hard to make sense of them. Neurons in your visual cortex are processing the lines and edges. Your amygdala is firing rapidly because the input is novel. Other brain regions are sifting through your past experiences to determine if you've encountered anything like this input before and are conversing with your body to prepare it for an as-yet-undetermined action. Most likely, you are in a state called *experiential blindness,* seeing only black blobs of unknown origin.

To cure your experiential blindness, look at the image on page 308 (appendix B). Then come back to this page. You should no longer see formless blobs but a familiar object.

What just happened in your brain to change your perception of these blobs? Your brain added stuff from the full photograph into its vast array of prior experiences and *constructed* the familiar object you now see in the blobs. Neurons in your visual cortex changed their firing to create lines that aren't present, linking the blobs into a shape that isn't physically there. You are, in a manner of speaking, hallucinating. Not the scary "I'd better get to the hospital" kind of hallucination, but the everyday "my brain is built to work like this" hallucination.

Your experience with figure 2-1 reveals a couple of insights. Your past experiences — from direct encounters, from photos, from movies and books — give meaning to your present sensations. Additionally, the entire process of construction is invisible to you. No matter how hard you try, you cannot observe yourself or experience yourself constructing the image. We needed a specially designed example to unmask the fact that construction is occurring. You consciously experienced the shift from unknown to known because you saw figure 2-1 both before and after you had the relevant knowledge to draw on. The process of construction is so habitual that you might never again see this figure as formless shapes, even if you try hard to un-see it and recapture experiential blindness.

This little magic trick of the brain is so common and normal that psychologists discovered it time and time again before they understood how it worked. We will call it *simulation.* It means that your brain changed the firing of its own sensory neurons in the absence of incoming sensory input. Simulation can be visual, as with our picture, or involve any of your other senses. Ever have a song playing in your head that you can't get rid of? That audio hallucination is also a simulation.[1]

Think of the last time someone handed you a red, juicy apple. You reached out for it, took a bite, and experienced the tart flavor. During those moments, neurons were firing in the sensory and motor regions of your brain. Motor neurons fired to produce your movements, and sensory neurons fired to process your sensations of the apple, like its red color with a blush of green; its smoothness against your hand; its crisp, floral scent; the audible crunch when you bit into it; and its tangy taste with a hint of sweetness. Other neurons made your mouth water to release enzymes and begin digestion, released cortisol to prepare your body to metabolize the sugars in the apple, and perhaps made your stomach churn a bit. But here's the cool thing: just now, when you read the word "apple," your brain responded to a certain extent as if an apple were actually present. Your brain combined bits and pieces of knowledge of previous apples you've seen and tasted, and changed the firing of neurons in your sensory and motor regions to construct a mental instance of the concept "Apple." Your brain simulated a nonexistent apple using sensory and motor neurons. Simulation happens as quickly and automatically as a heartbeat.[2]

For my daughter's twelfth birthday, we exploited the power of simulation (and had some fun) by throwing a "gross foods" party. When her guests arrived, we served them pizza doctored with green food coloring so the cheese looked like fuzzy mold, and peach gelatin laced with bits of vegetables to look like vomit. For drinks, we served white grape juice in medical urine sample cups. Everybody was exuberantly disgusted (it was perfect twelve-year-old humor), and several guests could not bring themselves to touch the food as they involuntarily simulated vile tastes and smells. The *pièce de résistance,* however, was the party game we played after lunch: a simple contest to identify foods by their smell. We used mashed baby food — peaches, spinach, beef, and so on — and artfully smeared it on diapers, so it looked exactly like baby poo. Even though the guests knew that the smears were food, several actually gagged from the simulated smell.[3]

Simulations are your brain's guesses of what's happening in the world. In every waking moment, you're faced with ambiguous, noisy information from your eyes, ears, nose, and other sensory organs. Your brain uses your past experiences to construct a hypothesis — the simulation — and compares it to the cacophony arriving from your senses. In this manner, simulation lets your brain impose meaning on the noise, selecting what's relevant and ignoring the rest.

The discovery of simulation in the late 1990s ushered in a new era in psychology and neuroscience. Scientific evidence shows that what we see, hear, touch, taste, and smell are largely simulations of the world, not reactions to it. Forward-looking thinkers speculate that simulation is a common mechanism not only for perception but also for understanding language, feeling empathy, remembering, imagining, dreaming, and many other psychological phenomena. Our common sense might declare that thinking, perceiving, and dreaming are different mental events (at least to those of us in Western cultures), yet one general process describes them all. Simulation is the default mode for all mental activity. It also holds a key to unlocking the mystery of how the brain creates emotions.[4]

Outside your brain, simulation can cause tangible changes in your body. Let's try a little creative simulation with our bee. In your mind's eye, see the bee bouncing lightly on the petal of a fragrant white flower, buzzing around as it searches for pollen. If you're fond of bees, then the flutter of imaginary wings is right now causing other neurons to prepare your body to move in for a closer look — preparing your heart to beat faster, your sweat glands to fill, and your blood pressure to decrease. Or if you have been badly stung in the past, your brain may ready your body to run away or make a swatting motion, formulating some other pattern of physical changes. Each time your brain simulates sensory input, it prepares automatic changes in your body that have the potential to change your feeling.

Your bee-related simulations are rooted in your mental *concept* of what a "Bee" is. This concept not only includes information about the bee itself (what it looks and sounds like, how you act on it, what changes in your autonomic nervous system allow your action, etc.), but also information contained in other concepts related to bees ("Meadow," "Flower," "Honey," "Sting," "Pain," etc.). All this information is integrated with your concept "Bee," guiding how you simulate the bee in this particular context. So, a concept like "Bee" is actually a collection of neural patterns in your brain, representing your past experiences. Your brain combines these patterns in different ways to perceive and flexibly guide your action in new situations.[5]

Using your concepts, your brain groups some things together and separates others. You can look at three mounds of dirt and perceive two of them as "Hills" and one as a "Mountain," based on your concepts. Construction treats the world like a sheet of pastry, and your concepts are cookie cutters that carve boundaries, not because the boundaries are natural, but because they're useful or desirable. These boundaries have physical limitations of course; you'd never perceive a mountain as a lake. Not everything is relative.[6]

Your concepts are a primary tool for your brain to guess the meaning of incoming sensory inputs. For example, concepts give meaning to changes in sound pressure so you hear them as words or music instead of random noise. In Western culture, most music is based on an octave divided into twelve equally spaced pitches: the equal-tempered scale codified by Johann Sebastian Bach in the seventeenth century. All people of Western culture with normal hearing have a concept for this ubiquitous scale, even if they can't explicitly describe it. Not all music uses this scale, however. When Westerners hear Indonesian gamelan music for the first time, which is based on seven pitches per octave with varied tunings, it's more likely to sound like noise. A brain that's been wired by listening to twelve-tone scales doesn't have a concept for that music. Personally, I am experientially blind to dubstep, although my teenage daughter clearly has that concept.

Concepts also give meaning to the chemicals that create tastes and smells. If I served you pink ice cream, you might expect (simulate) the taste of strawberry, but if it tasted like fish, you would find it jarring, perhaps even disgusting. If I instead introduced it as "chilled salmon mousse" to give your brain fair warning, you might find the same taste delicious (assuming you enjoy salmon). You might think of food as existing in the physical world, but in fact the concept "Food" is heavily cultural. Obviously, there are some biological constraints; you can't eat razor blades. But there are some perfectly edible substances that we don't all perceive as food, such as *hachinoko,* a Japanese delicacy made of baby bees, which most Americans would vigorously avoid. This cultural difference is due to concepts.[7]

Every moment that you are alive, your brain uses concepts to simulate the outside world. Without concepts, you are experientially blind, as you were with the blobby bee. With concepts, your brain simulates so invisibly and automatically that vision, hearing, and your other senses seem like reflexes rather than constructions.

Now consider this: what if your brain uses this same process to make meaning of the sensations from *inside your body*—the commotion arising from your heartbeat, breathing, and other internal movements?

From your brain's perspective, your body is just another source of sensory input. Sensations from your heart and lungs, your metabolism, your changing temperature, and so on, are like the ambiguous blobs of figure 2-1. These purely physical sensations inside your body have no objective psychological meaning. Once your concepts enter the picture, however, those sensations may take on additional meaning. If you feel an ache in your stomach while sitting at the dinner table, you might experience it as hunger. If flu season is just around the corner, you might experience that same ache as nausea. If you are a judge in a courtroom, you might experience the ache as a gut feeling that the defendant cannot be trusted. In a given moment, in a given context, your brain uses concepts to give meaning to internal sensations as well as to external sensations from the world, all simultaneously. From an aching stomach, your brain constructs an instance of hunger, nausea, or mistrust.[8]

Now consider that same stomachache if you're sniffing a diaper heavy with pureed lamb, as my daughter's friends did at her gross foods birthday party. You might experience the ache as disgust. Or if your lover has just walked into the room, you might experience the ache as a pang of longing. If you're in a doctor's office waiting for the results of a medical test, you might experience that same ache as an anxious feeling. In these cases of disgust, longing, and anxiety, the concept active in your brain is an *emotion concept.* As before, your brain makes meaning from your aching stomach, together with the sensations from the world around you, by constructing an instance of that concept.

An instance of *emotion.*

And that just might be how emotions are made.

• • •

Back when I was in graduate school, a guy in my psychology program asked me out on a date. I didn't know him very well and was reluctant to go because, honestly, I wasn't particularly attracted to him, but I had been cooped up too long in the lab that day, so I agreed. As we sat together in a coffee shop, to my surprise, I felt my face flush several times as we spoke. My stomach fluttered and I started having trouble concentrating. Okay, I realized, I was wrong. I am clearly attracted to him. We parted an hour later — after I agreed to go out with him again — and I headed home, intrigued. I walked into my apartment, dropped my keys on the floor, threw up, and spent the next seven days in bed with the flu.

The same neural process of construction that simulates a bee from blobs also constructs feelings of attraction from a fluttering stomach and a flushing face. An emotion is your brain's *creation* of what your bodily sensations mean, in relation to what is going on around you in the world. Philosophers have long proposed that your mind makes sense of your body in the world, from René Descartes in the seventeenth century to William James (considered the father of American psychology) in the nineteenth; as you will learn, however, neuroscience now shows us how this process — and much more — occurs in the brain to make an emotion on the spot. I call this explanation the *theory of constructed emotion:*[9]

> In every waking moment, your brain uses past experience, organized as concepts, to guide your actions and give your sensations meaning. When the concepts involved are emotion concepts, your brain constructs instances of emotion.

If a swarm of buzzing bees is squeezing underneath your front door while your heart is pounding in your chest, your brain's prior knowledge of stinging insects gives meaning to the sensations from your body and to the sights, sounds, smells, and other sensations from the world, simulating the swarm, the door, and an instance of fear. The exact same bodily sensations in another context, like watching a fascinating film about the hidden lives of bees, might construct an instance of excitement. Or if you see a picture of a smiling cartoon bee in a children's book, reminding you of a beloved niece whom you took to a Disney movie, you could mentally construct the bee, the niece, and an instance of pleasant nostalgia.

My experience in the coffee shop, where I felt attraction when I had the flu, would be called an error or misattribution in the classical view, but it's no more a mistake than seeing a bee in a bunch of blobs. An influenza virus in my blood contributed to fever and flushing, and my brain made meaning from the sensations in the context of a lunch date, constructing a genuine feeling of attraction, in the normal way that the brain constructs any other mental state. If I'd had exactly the same bodily sensations while at home in bed with a thermometer, my brain might have constructed an instance of "Feeling Sick" using the same manufacturing process. (The classical view, in contrast, would require feelings of attraction and malaise to have different bodily fingerprints triggered by different brain circuitry.)[10]

Emotions are not reactions to the world. You are not a passive receiver of sensory input but an active constructor of your emotions. From sensory input and past experience, your brain constructs meaning and prescribes action. If you didn't have concepts that represent your past experience, all your sensory inputs would just be noise. You wouldn't know what the sensations are, what caused them, nor how to behave to deal with them. With concepts, your brain makes meaning of sensation, and sometimes that meaning is an emotion.

The theory of constructed emotion and the classical view of emotion tell vastly different stories of how we experience the world. The classical view is intuitive — events in the world trigger emotional reactions inside of us. Its story features familiar characters like thoughts and feelings that live in distinct brain areas. The theory of constructed emotion, in contrast, tells a story that doesn't match your daily life — your brain invisibly constructs everything you experience, including emotions. Its story features unfamiliar characters like simulation and concepts and degeneracy, and it takes place throughout the whole brain at once.

This unfamiliar story creates a challenge because people expect stories with familiar structures. Every superhero story is assumed to have a villain. Every romantic comedy requires an attractive couple faced with a humorous misunderstanding that turns out all right in the end. Our challenge here is that the dynamics of the brain, and how emotions are made, do not follow a linear, cause-and-effect sort of story. (This challenge is common in science; for example, in quantum mechanics, the distinction between a cause and an effect is not meaningful.) Nevertheless, every book must tell a story, even for a nonlinear subject like brain function. Mine will occasionally have to defy the usual linear framework of human storytelling.

For now, my aim is simply to give you some intuition about the construction of emotion and why this scientific explanation makes sense. We'll see later that this theory incorporates the most up-to-date, neuroscientific understanding of how the brain works, and it explains the great variation in emotional experiences and perceptions in everyday life. It can help us figure out how instances of happiness, sadness, anger, fear, and other emotion categories are constructed by the same brain mechanism that constructed the blobby bee, the juicy apple, and the smell of poo from mashed baby food, with no need for emotion circuits or other biological fingerprints.

• • •

I'm not the first person to propose that emotions are made. The theory of constructed emotion belongs to a broader scientific tradition called *construction,* which holds that your experiences and behaviors are created in the moment by biological processes within your brain and body. Construction is based on a very old set of ideas that date back to Ancient Greece, when the philosopher Heraclitus famously wrote, "No man ever steps in the same river twice," because only a mind perceives an ever-changing river as a distinct body of water. Today, constructionism spans many topics including memory, perception, mental illness, and, of course, emotion.[11]

A constructionist approach to emotion has a couple of core ideas. One idea is that an emotion category such as anger or disgust does not have a fingerprint. One instance of anger need not look or feel like another, nor will it be caused by the same neurons. Variation is the norm. Your range of angers is not necessarily the same as mine, although if we were raised in similar circumstances, we will likely have some overlap.

Another core idea is that the emotions you experience and perceive are not an inevitable consequence of your genes. What's inevitable is that you'll have *some kinds* of concepts for making sense of sensory input from your body in the world because, as we learn in chapter 5, your brain has wiring for this purpose. Even single-celled animals can make sense of changes in their environment. But *particular* concepts like "Anger" and "Disgust" are not genetically predetermined. Your familiar emotion concepts are built-in only because you grew up in a particular social context where those emotion concepts are meaningful and useful, and your brain applies them outside your awareness to construct your experiences. Heart rate changes are inevitable; their emotional meaning is not. Other cultures can and do make other kinds of meaning from the same sensory input.[12]

The theory of constructed emotion incorporates ideas from several flavors of construction. One flavor, called social construction, studies the role of social values and interests in determining how we perceive and act in the world. An example would be whether or not Pluto is a planet, which is a decision not based in astrophysics but in culture. Spherical rocks in space are objectively real and come in various sizes, but the idea of a "Planet," representing a particular combination of features of interest, is made up by people. Each of us understands the world in a way that is useful but not necessarily true in some absolute, objective sense. Where emotion is concerned, social construction theories ask how feelings and perceptions are influenced by our social roles or beliefs. For example, my perceptions are influenced by the fact that I am a woman, a mother, an atheist who is culturally Jewish, and a rather pale person living in a country that once enslaved people for having more melanin in their skin than I do. Social construction tends to ignore biology, however, as irrelevant to emotion. Instead, the theories suggest that emotions are triggered differently depending on your social role. Social constructionist theories, then, are primarily concerned with social circumstances in the world outside you, without considering how those circumstances affect the brain's wiring.[13]

Another flavor of construction, known as psychological construction, turns this focus inward. It proposes that your perceptions, thoughts, and feelings are themselves constructed from more basic parts. Some nineteenth-century philosophers viewed the mind like a big chemistry set, combining simpler sensations into thoughts and emotions the way that atoms combine to make molecules. Others saw the mind as a set of all-purpose parts, like Lego blocks, that contribute to various mental states like cognitions and emotions. William James proposed that our incredibly varied emotional experiences are constructed from common ingredients. “Emotional brain processes,” he wrote, “not only resemble the ordinary sensorial brain-processes, but in very truth are nothing but such processes variously combined.” In the 1960s, the psychologists Stanley Schachter and Jerome Singer famously injected test subjects with adrenaline — without the subjects’ knowledge — and saw them experience this mysterious arousal as anger or euphoria, depending on the context surrounding them. In all these views, an instance of anger or elation does not reveal its causal mechanisms — a marked contrast to the classical view, where each emotion has a dedicated mechanism in the brain, and the same word (e.g., “sadness”) names the mechanism and its product. In recent years, a new generation of scientists has been crafting psychological construction-based theories for understanding emotions and how they work. Not every theory agrees on every assumption, but together they assert that emotions are made, not triggered; emotions are highly variable, without fingerprints; and emotions are not, in principle, distinct from cognitions and perceptions.[14]

You might be surprised to learn that these same principles of construction appear to hold for the brain’s physical architecture, an idea called neuroconstruction. Consider two neurons that are connected by a synapse. Clearly these brain cells exist in an objective sense. But there is no objective way to tell whether the two neurons are part of a unit called a “circuit” or “system,” or whether each neuron belongs to a separate circuit where one “regulates” the other. The answer depends entirely on human perspective. Similarly, your brain’s interconnections are not inevitable consequences of your genes alone. We know today that experience is a contributing factor. Your genes turn on and off in different contexts, including the genes that shape your brain’s wiring. (Scientists call this phenomenon plasticity.) That means some of your synapses literally come into existence because other people talked to you or treated you in a certain way. In other words, construction extends all the way down to the cellular level. The macro structure of your brain is largely predetermined, but the microwiring is not. As a consequence, past experience helps determine your future experiences and perceptions. Neuroconstruction explains how human infants are born without the ability to recognize a face but can develop that capacity within the first few days after birth. It also explains how early cultural experiences — for instance, how often your caregivers were in physical contact with you, and whether you slept alone in a crib or in a family bed — differentially shape the wiring of the brain.[15]

The theory of constructed emotion incorporates elements of all three flavors of construction. From social construction, it acknowledges the importance of culture and concepts. From psychological construction, it considers emotions to be constructed by core systems in the brain and body. And from neuroconstruction, it adopts the idea that experience wires the brain.

• • •

The theory of constructed emotion tosses away the most basic assumptions of the classical view. For instance, the classical view assumes that happiness, anger, and other emotion categories each have a distinctive bodily fingerprint. In the theory of constructed emotion, *variation* is the norm. When you are angry, you might scowl, frown mildly or severely, shout, laugh, or even stand in eerie calmness, depending on what works best in the situation. Your heart rate likewise might increase, decrease, or stay the same, whatever is necessary to support the action you are performing. When you perceive someone else as angry, your perceptions are similarly varied. An emotion word such as "anger," therefore, names a population of diverse instances, each one constructed to best guide action in the immediate circumstance. There is no single difference between anger and fear, because there's no single "Anger" and no single "Fear." These ideas are inspired by William James, who wrote at length on the variability of emotional life, and by Charles Darwin's revolutionary idea that a biological category, such as a species, is a population of unique individuals.[16]

You can think about emotion categories like cookies. There are crisp ones, chewy ones, sweet ones, savory ones, large, small, flat, rounded, rolled, sandwiched, floured, flourless, and more. The members of the category "Cookie" vary tremendously but are deemed equivalent for some purpose: to be a tasty snack or dessert. Cookies need not look the same or be created with the same recipe; they are a population of diverse instances. Even within a more fine-grained category like "Chocolate Chip Cookie," there is still diversity created by the type of chocolate, the amount of flour, the ratio of brown sugar to white sugar, the fat content of the butter, and the time spent chilling the dough. Likewise, any category of emotion such as "Happiness" or "Guilt" is filled with variety.[17]

The theory of constructed emotion dispenses with fingerprints not only in the body but also in the brain. It avoids questions that imply a neural fingerprint exists, like "Where are the neurons that trigger fear?" The word "where" has a built-in assumption that a particular set of neurons activates every time you and everyone else on the planet feel afraid. In the theory of constructed emotion, a category of emotion such as sadness, fear, or anger has no distinct brain location, and each instance of emotion is a whole-brain state to be studied and understood. Therefore we ask how, not where, emotions are made. The more neutral question, "How does the brain create an instance of fear?" does not presume a neural fingerprint behind the scenes, only that experiences and perceptions of fear are real and worthy of study.

If instances of emotion are like cookies, then the brain is like a kitchen, stocked with common ingredients such as flour, water, sugar, and salt. Beginning with these ingredients, we can create diverse foods such as cookies, bread, cake, muffins, biscuits, and scones. Likewise, your brain has core "ingredients," which we called core systems in chapter 1. They combine in complex ways, roughly analogous to recipes, to produce diverse instances of happiness, sadness, anger, fear, and so on. The ingredients themselves are multipurpose, not dedicated to emotions but participating in their construction. Instances of two different emotion categories, such as fear and anger, can be made from similar ingredients, just as cookies and bread both contain flour. Conversely, two instances of the same emotion category, like fear, will have some variation in their ingredients, just as some cookies have nuts and others do not. This phenomenon is our old friend degeneracy at work: different instances of fear are constructed by different combinations of the core systems throughout the brain. We can describe the instances of fear together by a pattern of brain activity, but this pattern is a statistical summary and need not describe any actual instance of fear.[18]

My kitchen analogy, like all analogies in science, has its limits. A brain network, as a core system, is not a "thing" like flour or salt. It's a collection of neurons that we view as a unit, statistically speaking, but only a subset of those neurons participate at any given time. If you have ten feelings of fear that involve a particular brain network, each feeling can involve different neurons from the network.* This is degeneracy at the network level. Additionally, cookies and bread are discrete, physical objects, whereas instances

* If you prefer sports analogies, a network is like a baseball team. In a given moment, only nine out of the team's twenty-five players participate, and the nine may change at any time, yet we say that "the team" won or lost the game.

of emotion are momentary snapshots of continuous brain activity, and we merely perceive these snapshots as discrete events. Nevertheless, you may find the kitchen analogy useful to imagine how interacting networks produce diverse mental states.[19]

The core systems that construct the mind interact in complex ways, without any central manager or chef to run the show. However, these systems cannot be understood independently like the disassembled parts of a machine, or like so-called emotion modules or organs. That's because their interactions produce new properties that are not present in the parts alone. By analogy, when you bake bread with flour, water, yeast, and salt, a new product emerges from the complex, chemical interplay of the ingredients. Bread has its own emergent properties, like "crustiness" and "chewiness," that are not present in its ingredients alone. In fact, if you try to identify all the ingredients by tasting the finished bread, you are in for a difficult time. Consider the salt: bread doesn't taste salty even though salt is absolutely essential. Similarly, an instance of fear cannot be reduced to mere ingredients. Fear is not a bodily pattern — just as bread is not flour — but emerges from the interactions of core systems. An instance of fear has irreducible, emergent properties not found in the ingredients alone, such as unpleasantness (as your car skids out of control on a slippery highway) or pleasantness (on an undulating rollercoaster). You cannot reverse-engineer a recipe for an instance of fear from a feeling of fear.[20]

Even if we did know the ingredients of emotion but studied them only in isolation, we'd get an inaccurate understanding of how they work together to construct emotion. If we study salt in isolation by tasting and weighing it, we will not understand how it contributes to the creation of bread. That's because salt interacts chemically with the other ingredients during baking: controlling yeast growth, shoring up the gluten in the dough, and, most importantly, enhancing flavor. To understand how salt transforms a recipe of bread, you must watch it work in context. Likewise, each ingredient of emotion must be studied in the context of the rest of the brain that influences it. This philosophy, known as holism, explains why I get different results each time I bake bread in my own kitchen, even using exactly the same recipe. I weigh every ingredient. I knead the dough for the same amount of time. I set the oven to the same temperature. I count the number of sprays of water I spritz into the oven to make the bread crusty. It's all very systematic, and yet, the result is sometimes lighter, sometimes heavier, sometimes sweeter. That's because baking has additional context that the recipe doesn't menfreely label the vocal sounds, without accompanying stories, and again, only the laughing sounds were categorized as expected (although they labeled the sounds as "laughing" rather than "happy"). So why did Sauter and her team observe universality when we did not?[15]

In late 2014, Sauter and her colleagues inadvertently solved the mystery. They revealed that their experiment included an extra step not reported in their original publication: a step that's rich in conceptual knowledge. After the Himba participants heard an emotion story but before they listened to any sound pairs, they were asked to describe how the target person in the story was feeling. To help them in this task, Sauter and colleagues "allowed participants to listen several times to a given recorded story (if needed), *until they could explain the intended emotion in their own words.*" Whenever Himba participants described something other than the English emotion concept, they received negative feedback and were told to try again. Test subjects who were unable to provide the expected description were disqualified from the experiment. In effect, Himba participants were not permitted to listen to any sounds, let alone pick the ones that matched the story, until they had *learned* the corresponding English emotion concepts. When we attempted to replicate Sauter and colleagues' experiment, we used only the methods in their published paper, without the extra, unreported step, so our Himba test subjects did not have the opportunity to learn English emotion concepts before listening to the vocalizations.[16]

There was one other difference between our experimental method and the one used by Sauter and her colleagues. Once a Himba participant had explained the emotion concept satisfactorily—let's say it was sadness—Sauter's team played a pair of sounds, such as a cry and a laugh, and the subject chose the better match for sadness. The participant then heard more pairs of sounds, *each one containing a cry:* perhaps a cry and a sigh, then a cry and a scream, and so on. From each pair, the participant selected one sound as the better match for sadness. If the Himba participants were not confident of the link between cries and sadness at the beginning of these trials, they certainly were by the end. Our experiments avoided this problem. In each trial, Maria would read a story (through the translator), then present a pair of sounds, and then have the participant choose the best match. Trials were in random order (e.g., a sadness trial, followed by an anger trial, followed by a happiness trial, and so on), which is a standard way to avoid learning within this type of experiment. We saw no evidence of universality.[17]

known about "emotional expressions" and "emotion recognition" from a scientific point of view.[22]

What might the science of emotion look like today had someone drawn different conclusions from those original studies? Consider Ekman's account of his first visit to the Fore tribe in New Guinea:

> I asked them to make up a story about each facial expression [photograph]. "Tell me what is happening now, what happened before to make the person show this expression, and what is going to happen next." It was like pulling teeth. I am not certain whether it was the translation process, or the fact that they have no idea what it was I wanted to hear or why I wanted them to do this. Perhaps making up stories about strangers was just something the Fore didn't do.

Ekman might be right, but it is also possible that the Fore did not understand or accept the concept of a facial "expression," which implies an internal feeling that seeks release in a set of facial movements. Not all cultures understand emotions as internal mental states. Himba and Hadza emotion concepts, for example, appear to be more focused on actions. This is also true of certain Japanese emotion concepts. The Ifaluk of Micronesia consider emotions as transactions between people. To them, anger is not a feeling of rage, a scowl, a pounding fist, or a loud yelling voice, all within the skin of one person, but a situation in which two people are engaged in a script—a dance, if you will—around a common goal. In the Ifaluk view, anger does not "live" inside either participant.[23]

When you look at the development and history of the basic emotion method, there's a surprising amount to criticize from a scientific standpoint. Over twenty years ago, the psychologist James A. Russell catalogued many of the concerns. And remember that the "six basic facial expressions" were not a scientific discovery; the Western architects of the basic emotion method stipulated them, actors posed them, and a science was built around them. There is no known validity to these particular facial poses, and studies that use more objective methods like facial EMG and facial coding do not find evidence that people routinely make these movements in real life during episodes of emotion. Yet scientists continue to use the basic emotion method regardless. After all, it produces very consistent results.[24]

Each time a scientific "fact" is overturned it leads to new avenues for discovery. The physicist Albert Michelson won a Nobel Prize in 1907 for disproving a conjecture made by Aristotle, that light travels through empty