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The Science of Stress and How Our Emotions Affect Our Susceptibility to Burno

by Maria Popova

How your memories impact your immune system, why moving is one of the most stressful life-events, and what your parents have to do with your predisposition to PTSD.

I had lived thirty good years before enduring my first food poisoning — odds quite fortunate in the grand scheme of things, but miserably unfortunate in the immediate experience of it. I found myself completely incapacitated to erect the pillars of my daily life — too cognitively foggy to read and write, too physically weak to work out or even meditate. The temporary disability soon elevated the assault on my mind and body to a new height of anguish: an intense experience of stress. Even as I consoled myself with Nabokov's exceptionally florid account of food poisoning, I couldn't shake the overwhelming malaise that had engulfed me — somehow, a physical illness had completely colored my psychoemotional reality.

This experience, of course, is far from uncommon. Long before scientists began shedding light on how our minds and bodies actually affect one another, an intuitive understanding of this dialogue between the body and the emotions, or feelings, emerged and permeated our very language: We use "feeling sick" as a grab-bag term for both the sensory symptoms — fever, fatigue, nausea — and the psychological malaise, woven of emotions like sadness and apathy.

Pre-modern medicine, in fact, has recognized this link between disease and emotion for millennia. Ancient Greek, Roman, and Indian Ayurvedic physicians all enlisted the theory of the four humors — blood, yellow bile, black bile, and phlegm — in their healing practices, believing that imbalances in these four visible secretions of the body caused disease and were themselves often caused by the emotions. These beliefs are fossilized in our present language — melancholy comes from the Latin words for "black" (melan) and "bitter bile" (choler), and we think of a melancholic person as gloomy or embittered; a phlegmatic person is languid and impassive, for phlegm makes one lethargic.

Chart of the four humors from a 1495 medical textbook by Johannes de Ketham

And then French philosopher and mathematician René Descartes came along in the seventeenth century, taking it upon himself to eradicate the superstitions that fueled the religious wars of the era by planting the seed of rationalism. But the very tenets that laid the foundation of modern science — the idea that truth comes only from what can be visibly ascertained and proven beyond doubt — severed this link between the physical body and the emotions; those mysterious and fleeting forces, the biological basis of which

the tools of modern neuroscience are only just beginning to understand, seemed to exist entirely outside the realm of what could be examined with the tools of rationalism.

For nearly three centuries, the idea that our emotions could impact our physical health remained scientific taboo — setting out to fight one type of dogma, Descartes had inadvertently created another, which we're only just beginning to shake off. It was only in the 1950s that Austrian-Canadian physician and physiologist Hans Selye pioneered the notion of stress as we now know it today, drawing the scientific community's attention to the effects of stress on physical health and popularizing the concept around the world. (In addition to his scientific dedication, Selye also understood the branding component of any successful movement and worked tirelessly to include the word itself in dictionaries around the world; today, "stress" is perhaps the word pronounced most similarly in the greatest number of major languages.)

But no researcher has done more to illuminate the invisible threads that weave mind and body together than Dr. Esther Sternberg. Her groundbreaking work on the link between the central nervous system and the immune system, exploring how immune molecules made in the blood can trigger brain function that profoundly affects our emotions, has revolutionized our understanding of the integrated being we call a human self. In the immeasurably revelatory The Balance Within: The Science Connecting Health and Emotions (public library), Sternberg examines the interplay of our emotions and our physical health, mediated by that seemingly nebulous yet, it turns out, remarkably concrete experience called stress.

With an eye to modern medicine's advances in cellular and molecular biology, which have made it possible to measure how our nervous system and our hormones affect our susceptibility to diseases as varied as depression, arthritis, AIDS, and chronic fatigue syndrome, Sternberg writes:

By parsing these chemical intermediaries, we can begin to understand the biological underpinnings of how emotions affect diseases…

The same parts of the brain that control the stress response … play an important role in susceptibility and resistance to inflammatory diseases such as arthritis. And since it is these parts of the brain that also play a role in depression, we can begin to understand why it is that many patients with inflammatory diseases may also experience depression at different times in their lives… Rather than seeing the psyche as the source of such illnesses, we are discovering that while feelings don't directly cause or cure disease, the biological mechanisms underlying them may cause or contribute to disease. Thus, many of the nerve pathways and molecules underlying both psychological responses and inflammatory disease are the same, making predisposition to one set of illnesses likely to go along with predisposition to the other. The questions need to be rephrased, therefore, to ask which of the many components that work together to create emotions also affect that other constellation of biological events, immune responses, which come together to fight or to cause disease. Rather than asking if depressing thoughts can cause an illness of the body, we need to ask what the molecules and nerve pathways are that cause depressing thoughts. And then we need to ask whether these affect the cells and molecules that cause disease.

[…]

We are even beginning to sort out how emotional memories reach the parts of the brain

that control the hormonal stress response, and how such emotions can ultimately affect the workings of the immune system and thus affect illnesses as disparate as arthritis and cancer. We are also beginning to piece together how signals from the immune system can affect the brain and the emotional and physical responses it controls: the molecular basis of feeling sick. In all this, the boundaries between mind and body are beginning to blur.

Indeed, the relationship between memory, emotion, and stress is perhaps the most fascinating aspect of Sternberg's work. She considers how we deal with the constant swirl of inputs and outputs as we move through the world, barraged by a stream of stimuli and sensations:

Every minute of the day and night we feel thousands of sensations that might trigger a positive emotion such as happiness, or a negative emotion such as sadness, or no emotion at all: a trace of perfume, a light touch, a fleeting shadow, a strain of music. And there are thousands of physiological responses, such as palpitations or sweating, that can equally accompany positive emotions such as love, or negative emotions such as fear, or can happen without any emotional tinge at all. What makes these sensory inputs and physiological outputs emotions is the charge that gets added to them somehow, somewhere in our brains. Emotions in their fullest sense comprise all of these components. Each can lead into the black box and produce an emotional experience, or something in the black box can lead out to an emotional response that seems to come from nowhere.

Illustration from 'Neurocomic,' a graphic novel about how the brain works. Click image for more.

Memory, it turns out, is one of the major factors mediating the dialogue between sensation and emotional experience. Our memories of past experience become encoded into triggers that act as switchers on the rail of psychoemotional response, directing the incoming train of present experience in the direction of one emotional destination or another.

Sternberg writes:

Mood is not homogeneous like cream soup. It is more like Swiss cheese, filled with holes. The triggers are highly specific, tripped by sudden trails of memory: a faint fragrance, a few bars of a tune, a vague silhouette that tapped into a sad memory buried deep, but not completely erased. These sensory inputs from the moment float through layers of time in the parts of the brain that control memory, and they pull out with them not only reminders of sense but also trails of the emotions that were first connected to the memory. These memories become connected to emotions, which are processed in other parts of the brain: the amygdala for fear, the nucleus accumbens for pleasure — those same parts that the anatomists had named for their shapes. And these emotional brain centers are linked by nerve pathways to the sensory parts of the brain and to the frontal lobe and hippocampus — the coordinating centers of thought and memory.

The same sensory input can trigger a negative emotion or a positive one, depending on

the memories associated with it.

Illustration by Maurice Sendak from ‘Open House for Butterflies’ by Ruth Krauss. Click image for more.

This is where stress comes in — much like memory mediates how we interpret and respond to various experiences, a complex set of biological and psychological factors determine how we respond to stress. Some types of stress can be stimulating and invigorating, mobilizing us into action and creative potency; others can be draining and incapacitating, leaving us frustrated and hopeless. This dichotomy of good vs. bad stress, Sternberg notes, is determined by the biology undergirding our feelings — by the dose and duration of the stress hormones secreted by the body in response to the stressful stimulus. She explains the neurobiological machinery behind this response:

As soon as the stressful event occurs, it triggers the release of the cascade of hypothalamic, pituitary, and adrenal hormones — the brain’s stress response. It also triggers the adrenal glands to release epinephrine, or adrenaline, and the sympathetic nerves to squirt out the adrenaline-like chemical norepinephrine all over the body: nerves that wire the heart, and gut, and skin. So, the heart is driven to beat faster, the fine hairs of your skin stand up, you sweat, you may feel nausea or the urge to defecate. But your attention is focused, your vision becomes crystal clear, a surge of power helps you run — these same chemicals released from nerves make blood flow to your muscles, preparing you to sprint.

All this occurs quickly. If you were to measure the stress hormones in your blood or saliva, they would already be increased within three minutes of the event. In experimental psychology tests, playing a fast-paced video game will make salivary cortisol increase and norepinephrine spill over into venous blood almost as soon as the virtual battle begins. But if you prolong the stress, by being unable to control it or by making it too potent or long-lived, and these hormones and chemicals still continue to pump out from nerves and glands, then the same molecules that mobilized you for the short haul now debilitate you.

These effects of stress exist on a bell curve — that is, some is good, but too much becomes bad: As the nervous system secretes more and more stress hormones, performance increases, but up to a point; after that tipping point, performance begins to suffer as the hormones continue to flow. What makes stress “bad” — that is, what makes it render us more pervious to disease — is the disparity between the nervous system and immune system’s respective pace. Sternberg explains:

The nervous system and the hormonal stress response react to a stimulus in milliseconds, seconds, or minutes. The immune system takes parts of hours or days. It takes much longer than two minutes for immune cells to mobilize and respond to an invader, so it is unlikely that a single, even powerful, short-lived stress on the order of moments could have much of an effect on immune responses. However, when the stress turns chronic, immune defenses begin to be impaired. As the stressful stimulus hammers on, stress

hormones and chemicals continue to pump out. Immune cells floating in this milieu in blood, or passing through the spleen, or growing up in thymic nurseries never have a chance to recover from the unabated rush of cortisol. Since cortisol shuts down immune cells' responses, shifting them to a muted form, less able to react to foreign triggers, in the context of continued stress we are less able to defend and fight when faced with new invaders. And so, if you are exposed to, say, a flu or common cold virus when you are chronically stressed out, your immune system is less able to react and you become more susceptible to that infection.

Illustration from 'Donald and the…' by Edward Gorey. Click image for more.

Extended exposure to stress, especially to a variety of stressors at the same time — any combination from the vast existential menu of life-events like moving, divorce, a demanding job, the loss of a loved one, and even ongoing childcare — adds up a state of extreme exhaustion that leads to what we call burnout.

Sternberg writes:

Members of certain professions are more prone to burnout than others — nurses and teachers, for example, are among those at highest risk. These professionals are faced daily with caregiving situations in their work lives, often with inadequate pay, inadequate help in their jobs, and with too many patients or students in their charge. Some studies are beginning to show that burnt-out patients may have not only psychological burnout, but also physiological burnout: a flattened cortisol response and inability to respond to any stress with even a slight burst of cortisol. In other words, chronic unrelenting stress can change the stress response itself. And it can change other hormone systems in the body as well.

One of the most profound such changes affects the reproductive system — extended periods of stress can shut down the secretion of reproductive hormones in both men and women, resulting in lower fertility. But the effects are especially perilous for women — recurring and extended episodes of depression result in permanent changes in bone structure, increasing the risk of osteoporosis. In other words, we register stress literally in our bones.

But stress isn't a direct causal function of the circumstances we're in — what either amplifies or ameliorates our experience of stress is, once again, memory. Sternberg writes:

Our perception of stress, and therefore our response to it, is an ever-changing thing that depends a great deal on the circumstances and settings in which we find ourselves. It depends on previous experience and knowledge, as well as on the actual event that has occurred. And it depends on memory, too.

The most acute manifestation of how memory modulates stress is post-traumatic stress disorder, or PTSD. For striking evidence of how memory encodes past experience into

triggers, which then catalyze present experience, Sternberg points to research by psychologist Rachel Yehuda, who found both Holocaust survivors and their first-degree relatives — that is, children and siblings — exhibited a similar hormonal stress response.

This, Sternberg points out, could be a combination of nature and nurture — the survivors, as young parents for whom the trauma was still fresh, may well have subconsciously taught their children a common style of stress-responsiveness; but it's also possible that these automatic hormonal stress responses permanently changed the parents' biology and were transmitted via DNA to their children. Once again, memory encodes stress into our very bodies. Sternberg considers the broader implications:

Stress need not be on the order of war, rape, or the Holocaust to trigger at least some elements of PTSD. Common stresses that we all experience can trigger the emotional memory of a stressful circumstance — and all its accompanying physiological responses. Prolonged stress — such as divorce, a hostile workplace, the end of a relationship, or the death of a loved one — can all trigger elements of PTSD.

Among the major stressors — which include life-events expected to be on the list, such as divorce and the death of a loved one — is also one somewhat unexpected situation, at least to those who haven't undergone it: moving. Sternberg considers the commonalities between something as devastating as death and something as mundane as moving:

One is certainly loss — the loss of someone or something familiar. Another is novelty — finding oneself in a new and unfamiliar place because of the loss. Together these amount to change: moving away from something one knows and toward something one doesn't.

[…]

An unfamiliar environment is a universal stressor to nearly all species, no matter how developed or undeveloped.

In the remainder of the thoroughly illuminating The Balance Within, Sternberg goes on to explore the role of interpersonal relationships in both contributing to stress and shielding us from it, how the immune system changes our moods, and what we can do to harness these neurobiological insights in alleviating our experience of the stressors with which every human life is strewn.