11.

Stress

The dose makes the poison.

— *Paracelsus*

You may have seen the image opposite before. Called the inverted U, this graph teaches us three important principles about the relationship between stress and learning:

1. High levels of stress can impair learning.
2. Moderate levels of stress can improve learning.
3. Low levels of stress can impair learning to the same degree as high levels of stress.

Although I don't imagine you will be shocked with the first principle, it's possible the second and third might catch you off-guard. In a world that often emphasizes the 'pressure-free, hassle-free and effort-free' aspects of life, it can be surprising to learn that stress may not always be a bad thing.

Before exploring how stress can boost memory and learning, there's an important distinction we first need to make.

Body and mind

People often use the terms 'emotions' and 'feelings' interchangeably. But believe it or not, these two words refer to two very different things.

Emotions are the *physical sensations* that occur throughout the body in response to a particular moment or event. Driven by internal chemicals, emotions are things like butterflies in the stomach, tingling of the skin, shortness of breath, etc. Feelings, on the other hand, are the *psychological interpretation* of these bodily sensations. Driven by subjective perception, feelings are the mental experience of physical emotions.

Because this can be somewhat confusing, let's dig a bit deeper.

Emotions are mediated by two small structures located deep within the brain: the amygdala and the hypothalamus. The amygdala receives signals from each of our seventeen senses (!) and uses these to select an emotion relevant to each situation. The hypothalamus, in turn, triggers

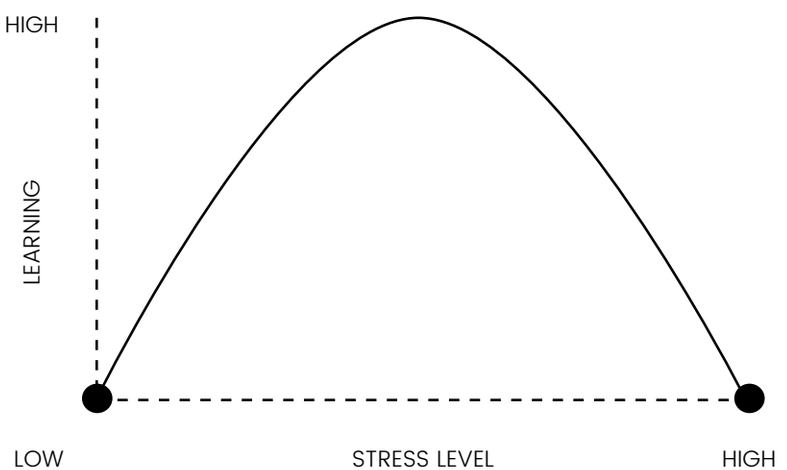


ILLUSTRATION 69. THE INVERTED U



ILLUSTRATION 70. THE SIX BASIC EMOTIONS

the release of chemicals into the body to manifest that emotion. For instance, if you were surrounded by snarling wolves, your amygdala would subconsciously analyze the situation and might select the emotion 'fear'. Your hypothalamus would then release chemicals into your body to speed up your heart rate, dilate your pupils, shorten your breathing, etc. These physical sensations *are* the emotion of fear.

Interestingly, there are only so many chemicals our bodies can produce. For this reason, many researchers believe that the amygdala/hypothalamus combination can really only generate six basic emotions — looking at the babies opposite, can you guess what they are?

Once you recognize that we have a rather limited set of fundamental emotions (joy, fear, anger, surprise, sadness, and disgust), a question arises: where does everything else come from? Humility, nostalgia, embarrassment, jealousy … how do these manifest?

This is where feelings come into play.

Although the body may be restricted in how it can respond to the world, there is no limit to the ways in which we can mentally interpret these physical sensations. Returning to the example above, depending upon your prior wolf knowledge and experiences, you might interpret your racing heart negatively (leading you to feel scared, anxious, foreboding), positively (excited, exhilarated, intrigued), actively (enraged, furious, frenzied), passively (resigned, abandoned, powerless) or any combination of these.

Put simply, thanks to mental interpretations, the six basic emotions can give rise to a nearly infinite array of feelings.

Here's the most important part: the relationship between emotions and feelings is a two-way street. In other words, psychological interpretations can feedback to and alter physical sensations. For instance, if you interpret the wolves as threatening, this mental label can cause the release of additional chemicals that further speed up your heart rate. Conversely, if you interpret the wolves as funny, this mental label can cause the release of different chemicals that slow down your heart rate. In other words, *feelings* can exacerbate or diminish *emotions*.

So what?

This is all well and good, but what does any of this have to do with stress?

Simply put, stress is a feeling — not an emotion. For an event to be stressful, it must be psychologically interpreted as such.

Some people parachute out of an airplane, get a rush of chemicals (adrenaline, endorphins, etc.) and interpret this as 'excitement'. This feeling will feedback, alter the chemical flow and generate specific physical and mental changes. Other people parachute out of an airplane, get exactly the same rush of chemicals (adrenaline, endorphins, etc.), and interpret this as 'stress'. This feeling will feedback, alter the flow of chemicals in a different way and generate different physical and mental changes. Same situation, same chemicals, same physical sensations — but the interpretation changes everything.

This is all to say that if a person does not interpret a specific emotion as stressful, then everything we explore below will become null and void.

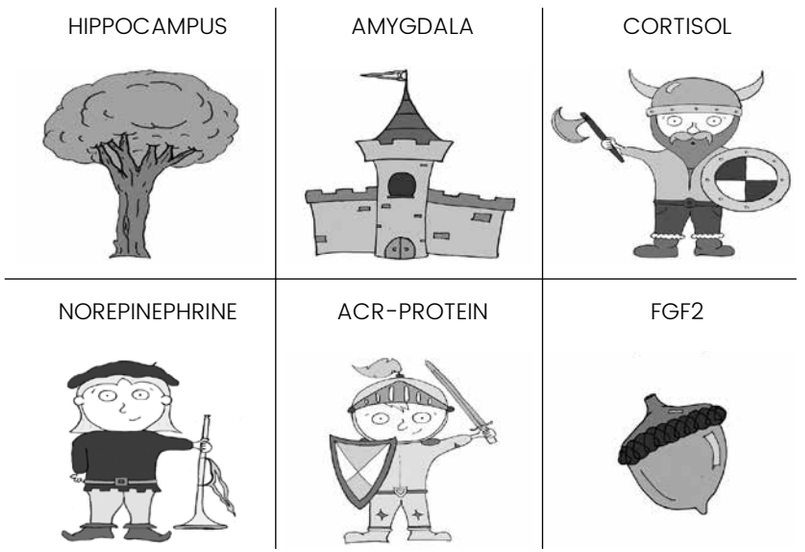


ILLUSTRATION 71. THE STORY OF STRESS — CAST OF CHARACTERS

It's showtime

To understand the impacts of stress there are several key players we must become acquainted with.

CAST OF CHARACTERS

Hippocampus: The gateway to memory. Composed of billions of specialized cells called neurons that process new information and lead to the formation of new memories. We can imagine neurons as trees and the hippocampus as a dense forest.

Amygdala: The selector of emotions. Heavily connected to and in constant communication with the hippocampus. We can imagine the amygdala as a castle tasked with protecting the hippocampus forest.

Cortisol: The primary stress hormone. In the body, it elevates blood sugar and regulates blood pressure. In the brain, it kills neurons within the hippocampus. We can imagine cortisol as a barbarian driven to cut down the hippocampus forest.

Norepinephrine: A secondary stress hormone. In the body, it increases heart rate and respiration. In the brain, it alerts the amygdala that cortisol is present. We can imagine norepinephrine as a messenger tasked with sending out a warning whenever the barbarian arrives.

ARC-proteins: **A**ctivity-**r**egulated **c**ytoskeleton-associated proteins. Developed in the amygdala, they have two jobs: to combat cortisol and to strengthen neurons. We can imagine ARC-proteins as a knight driven to fight the barbarian *and* as a gardener driven to help the hippocampus forest flourish.

FGF2: **F**ibroblast **g**rowth **f**actor **2**. These proteins lead to the growth of brand new neurons. We can imagine FGF2 as seeds which will (eventually) sprout into new trees.

Let's dim the lights and start the show …

ACT I: DR JEKYLL

Sometimes stress can be sudden, acute and short-lived. For instance, those ten minutes before you step on stage to deliver a presentation. During these periods of short-term stress, here's what happens:

Raise curtain

Scene I: When stress begins, cortisol floods into the hippocampus and begins attacking neurons.

Scene II: This attack triggers the release of norepinephrine which flows into the amygdala, signalling the need for back-up.

Scene III: The amygdala releases ARC-proteins into the hippocampus. These proteins begin to combat cortisol.

Scene IV: The battle between ARC-proteins and cortisol triggers the release of FGF2. This protein embeds itself throughout the hippocampus.

Scene V: As the stressful situation draws to a close, cortisol flees the hippocampus and ARC-proteins begin repairing the damaged neurons, making each thicker and stronger than before the battle.

Scene VI: Approximately two weeks later, FGF2 comes to fruition and new neurons sprout throughout the hippocampus. These neurons immediately take up the task of processing new information (learning).

Lower curtain

Thinking back to the inverted U at the beginning of this chapter, it should now make a bit more sense why *moderate* stress can boost memory and learning.

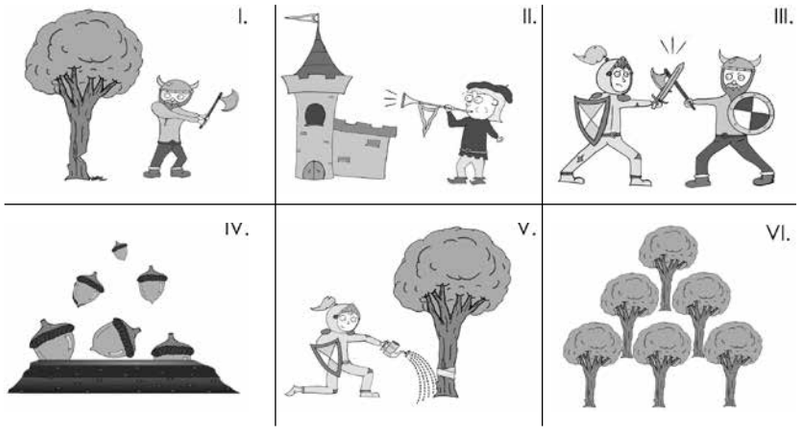


ILLUSTRATION 72. ACT I — THE RESPONSE TO ACUTE STRESS

First, during short-lived stress, ARC-proteins strengthen neurons within the hippocampus leading to the formation of deeper memories for that moment. It's as if ARC-proteins tell the hippocampus, 'Whatever caused that cortisol release must be important; please remember it.'

In addition, moderate stress triggers the release of FGF2 which leads to the formation of new neurons in the hippocampus. Unfortunately, these neurons take about two weeks to sprout. So how does this improve learning?

In the short-term, it doesn't. If you experience moderate stress today, this might improve your learning two weeks from now but will do nothing for the present moment. However, in the long-term, this process begins to make sense. If you experience moderate stress every day (triggered by errors, failed predictions and unexpected events) you will have new neurons sprouting *all the time*. Since these new neurons are dedicated to processing new information, general learning will be greatly enhanced.

However, despite these benefits, stress is not always rainbows and sunshine …

ACT II: MR HYDE

Sometimes stress lasts for a prolonged period. For instance, if you've got 30 days to complete an important project, you might spend weeks worrying about the impending deadline. During these periods of long-term stress, here's what happens:

Raise curtain

Scene I: When stress begins, cortisol floods into the hippocampus and begins attacking neurons.

Scene II: This attack triggers the release of norepinephrine which flows into the amygdala, signalling the need for back-up.

Scene III: The amygdala releases ARC-proteins into the hippocampus. These proteins begin to combat cortisol.

Scene IV: The battle between ARC-proteins and cortisol triggers the release of FGF2. This protein embeds itself throughout the hippocampus.

Scene V: As the stressful situation continues, more cortisol is pumped into the hippocampus. Eventually, stores of ARC-proteins run dry and cortisol begins *killing* neurons once and for all.

Scene VI: As neurons die, stores of FGF2 run dry and no new seeds are planted. Cortisol continues killing neurons and, since no new ones sprout to take their place, the hippocampus begins to wither away.

Lower curtain

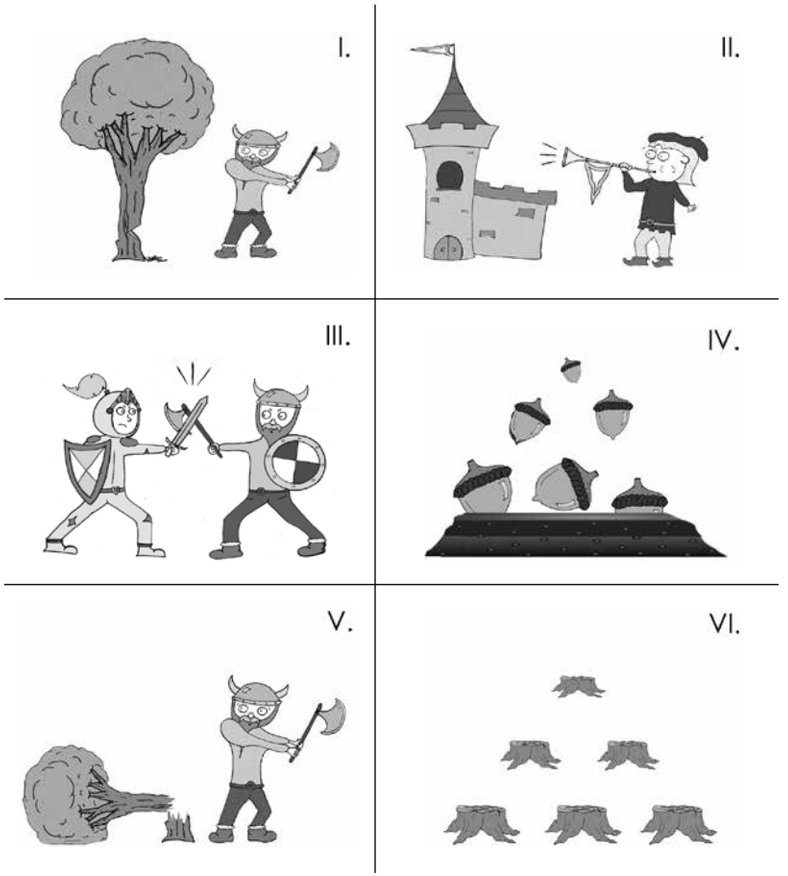


ILLUSTRATION 73. ACT II — THE RESPONSE TO PROLONGED STRESS

Thinking back to the inverted U, it should now make a bit more sense why *high* stress can impair learning.

As ARC-proteins and FGF2 die away, cortisol has free reign to damage and destroy our gateway to memory. To make matters worse, as the hippocampus withers away our ability to access previously formed long-term memories becomes impaired. This means that prolonged stress not only makes it difficult to learn *new* information, but also cuts us off from *old* information learnt in the past.

Although this process might seem illogical, it actually serves an important purpose. Imagine you're trapped in a very bad situation and have no way to escape — say, stuck in a bear-trap deep in the woods and help won't arrive for three days. In this instance, you don't really want to make deep, vivid memories. Rather, seeing as you're helpless and there's no continuous lesson to learn, it makes far more sense to block out as much negativity as possible and simply survive until the ordeal is over. This is what the long-term stress response does: it helps prevent memories from forming during helpless situations.

However, rarely in the modern world do we get stuck in bear traps. More often than not, we experience prolonged stress within our jobs, families and responsibilities. In these instances, the long-term stress response can prove a dangerous liability leading to lost jobs, conflicting families and shirked responsibilities.

One last thing

We've learnt why high stress can be bad and why moderate stress can be good, but what about the third principle of the inverted U? How could no stress be just as bad as excess stress?

In the absence of stress, cortisol *does not* flood into the hippocampus. In the absence of cortisol, the amygdala *does not* release ARC-proteins. In the absence of ARC-proteins, FGF2 *is not* released and new neurons *do not* form. In other words, without stress, all those chemicals that bolster memory and facilitate learning simply lay dormant. This means that in a perfect world without errors, failed predictions or unexpected events, the hippocampus slips into pause mode.

Although this might not sound horrible, it's important to remember that *everything* degrades with time. As such, the longer the hippocampus remains on 'pause', the more susceptible it becomes to the natural ravages of time. Without ARC-proteins, neurons within the hippocampus will naturally deteriorate and die away. Similarly, without FGF2 no new neurons will be formed to replace the old. As neurons fade away, so too does our ability to remember and learn.

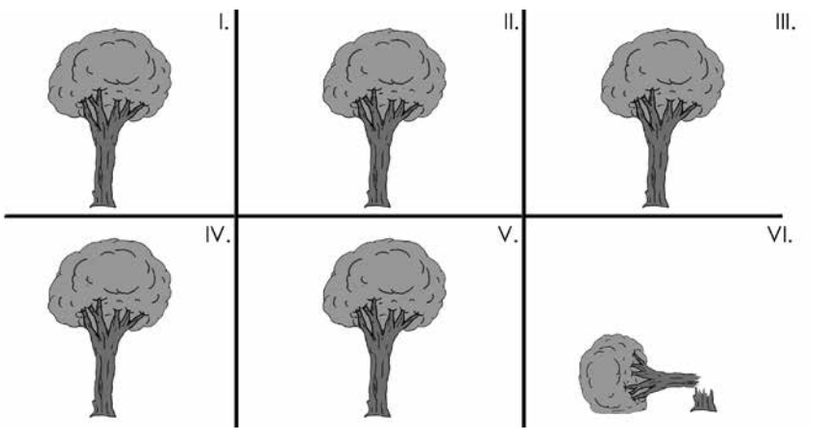


ILLUSTRATION 74. ACT III — THE RESPONSE TO ZERO STRESS

Implications for leaders, teachers and coaches

1. Leverage emotional shifts to boost memory

You may have heard that emotions enhance memory. Although this is basically true, there is a bit more to the story.

Since emotions are simply chemicals flowing throughout your body, it is impossible to ever turn them off (unless you somehow manage to rid your body of all chemicals … which, I worry, might be fatal). This means *every* memory has an emotion attached to it. For this reason it can't be emotions *per se* that enhance memories; rather, it's one specific feature of the emotional process that does it.

As we learnt earlier, norepinephrine triggers the release of ARC-proteins into the hippocampus which, in turn, strengthen newly formed memories. Here's the secret: stress is not the only feeling that triggers the release of norepinephrine. In truth, this hormone is released any time someone undergoes a sudden and/or powerful emotional shift.

If you swing from happy to sad, angry to scared, or surprised to disgusted this will release norepinephrine and boost memory. Similarly, if you swing from sort-of happy to ecstatic, somewhat sad to depressed, or mildly angry to irate, the same thing will occur.

So when it comes to leveraging emotions to increase influence, we must determine what emotions others might already be experiencing and consider ways to either heighten, lessen or shift these. In a sea of sadness, joy stands out; but in a sea of joy, sadness wins the day.

Furthermore, keeping anyone happy, scared or sad for too long will wear away any potential memory boost. It's therefore important to consider what emotional *journey* you wish to take others on. If you attempt to be upbeat, happy and funny during an entire two-hour presentation you will invariably find the audience wavering by the end. The most impactful lessons don't only make us laugh … they make us laugh, cry, gasp and growl.

BURNING QUESTION 1:

FLASHBULB MEMORIES

'There are some moments in my life that I remember in incredible detail. What's going on here?'

We all have several ridiculously vivid memories from our past. Some are positive (the moment your first child was born, for example) while some are negative (the moment you heard Princess Diana died).

These lucid, detailed recollections are called *flashbulb memories* and for decades researchers thought they were only created following moments that were deeply *meaningful* (events that form an integral aspect of our personal identity) and deeply *emotional* (events that were intensely shocking, surprising or caused a sudden chemical flux within the body).

Here's the rub: everyone has flashbulb memories of events that were neither meaningful nor emotional. For instance, I

can vividly remember a time when I was in the backseat of my mum's Jeep Wagoneer, looking out the front windshield at a personalized licence plate on a nearby car that read 'mop'. As far as I can tell, this moment wasn't particularly startling or life changing — yet there it is: rising like Mount Everest above the mists of my childhood memories.

Needless to say, these 'neutral' memories have led researchers to question everything we thought we knew about this phenomenon. Currently, no one can predict *when* flashbulb memories will occur, explain *why* they form or describe *how* they happen (though most theories emphasize the role of the amygdala and ARC-proteins).

This is all to say that, although flashbulb memories are a cool occurrence, there is nothing we can yet do to leverage them to boost memory or learning.

My apologies for this less-than-thrilling news.

2. Mix it up

Low levels of stress can impair memory and learning. This means that if the process you typically use to influence others becomes formulaic, repetitive and predictable, this could drive others into a low-stress state and hinder their ability (or willingness) to remember new information.

Frequent, short bursts of moderate stress, however, can boost memory and lead to sustained learning improvements. This means if you mix and match the structure, format, activities, discussions and stories you employ when influencing others, you will make it difficult for them to form simple predictions and ensure they must actively engage with each new moment. By keeping others on their toes, you can maintain a moderate level of stress and enhance their ability (and willingness) to remember new information.

BURNING QUESTION 2:

BRAIN TRAINING PART 2

'Wait … is stress the secret to keeping my brain healthy and active?'

In a manner of speaking, yes.

Novelty is one of the primary ingredients for keeping the brain agile and responsive. Each time you undertake a new activity, learn a new skill or dive into a new situation, this leads to *moderate* levels of stress. As we learnt earlier, moderate stress experienced every day can lead to a steady flow of FGF2 and the continual growth of new neurons within the hippocampus. Since these new neurons process new information, they (in essence) are what keep us learning and growing.

So, as we learnt in Chapter 6, don't worry about brain training games (they will only make you better at chunking information within each game). Instead, try new and scary things. Take up an instrument. Learn a new language. Try cooking a new dish. Continually jumping into novel, unpredictable situations will increase your chances of keeping your mind flexible and your memories active.

Just remember not to take any new activity *too* seriously. Once you begin feeling excess anxiety or undue pressure, it's time to move on. When playing with stress, there is a fine line between helping and harming your brain.



ILLUSTRATION 75. NOVELTY IS THE KEY TO AN ACTIVE BRAIN

3. Beware of state-dependency

In Chapter 4 we explored state-dependency: the idea that the chemicals flowing throughout our bodies as we learn form an integral aspect of what we learn (remember the thought experiment of collecting business cards while at an 'alcohol friendly' networking event?).

By now, you're well aware that *emotions are chemicals*. This means that emotional state-dependency is a real possibility. For instance, information always painted in a sad light might be difficult to access when in a happy situation. Similarly, concepts always presented as frightening could be tricky to recall when feeling relaxed.

The best way to address state-dependency is to embrace *variety*. If you want to ensure information is freely available across any situation, it's worth varying the emotions tied to it during the teaching and learning process. Try to find the good and the bad in any topic: the happy and the sad, the infuriating and the reassuring.

Conversely, if information is best understood only in a certain light (such as the consequences and repercussions of war) or skills applicable only during very specific emotional circumstances (such as combat tactics), then embrace the relevant emotion during all learning and practice sessions.

4. Safety first

It's unfortunate, but many people see learning as frightening, intimidating, threatening … in short, highly stressful. If this feeling is never addressed it's possible some people will switch off before you (as a leader, teacher or coach) have even begun. For this reason, it is worthwhile *early on* to create an environment that allows everyone to feel psychologically safe. Here are some tips to help that happen:

» Ask questions and genuinely listen to the answers. This will allow others to feel as though they have a voice and are respected.
» Display vulnerability and highlight your own imperfections (perhaps by sharing a less-than-flattering story from your past).

This will allow others to lower their guard and view you as an ally.

» Offer options and choices. This will allow others to display agency and recognize the role they play in the learning process.
» Collaborate. This will allow others to feel supported and view you as a partner.

The sooner people feel safe to speak up, interact and make mistakes, the sooner they will re-interpret 'stressful' emotions as exciting, fun and intriguing.

5. Employ physical and mental de-stressing techniques

Seeing as emotions are physical, many primary de-stressing techniques directly target the body. The concept is simple: if you can change the chemicals, you can change the emotion.

Arguably the best (and easiest) example of this is *deep breathing*. As you inhale, receptors in your lungs trigger the release of a chemical that slows the release of cortisol and norepinephrine. As you exhale, different chemicals are released that slow heart rate and reduce blood pressure. After a short time, those physical sensations commonly interpreted as 'stress' are gone and a new interpretation (feeling) can emerge.

Another example is called *progressive muscle relaxation*. In a nutshell, this technique is the systematic tensing, holding and releasing of different muscle groups. As each muscle group is tensed, that physical effort burns off excess cortisol within the body. As each muscle group is relaxed, blood pressure drops and heart rate slows. To experience this sensation, simply make a really tight first with your right hand, hold it for five seconds, then release and relax it. Again, after a short time, the physical sensations of stress will disappear and a new interpretation can emerge.

Importantly, as we learnt earlier, feelings can feedback on and influence emotions. As such, there are many secondary de-stressing techniques that directly target the mind. Meditation; mindfulness; exposure therapy. The main goal of these mental de-stressing techniques is not to stop the physical sensations of stress from occurring; it's to re-frame and re-build interpretations. The idea is that if you can re-label stressful emotions as exciting, intriguing or funny (or if you can remove every label full-stop), this will shift the chemical response of your body.

BURNING QUESTION 3:

MIND BLANKS

'Sometimes when I'm in the middle of a presentation, I suddenly blank out. One moment everything is there; the next I can hardly remember my name. What's going on?'

Ah, the dreaded mind blank!

In Chapter 5 we learnt about the mind wipe. As a reminder, whenever the ventral attention network registers a threat, it will automatically erase anything you were just thinking about (presumably so you can focus all your attention on the threat).

During a mind blank, the process is the same: something catches your attention (say, a flash of light in your peripheral vision); this registers as a threat and your mind is suddenly wiped clean. However, what makes mind blanks unique is that they occur during *important moments*: presentations, performances,

exams. For this reason, we tend to interpret this sudden memory dump as highly stressful which, in turn, triggers the release of cortisol and starts a stress feedback-loop, making it incredibly difficult to get back on track.

In other words, a mind blank is an innocuous mind wipe laden with stress and pressure.

So is there anything you can do?

The best remedy is to target the body. My favourite technique is the squat. When a mind blank occurs and the stress feedback-loop begins, step away from whatever you're doing, place your back against a wall, dip into a deep squat and hold for 30 to 60 seconds. This is meant to be difficult. As you struggle to maintain the squat, your exhausted muscles will begin burning off excess cortisol and you will start breathing deeply. This will almost certainly lead you to re-interpret your rapid heartbeat and tingling skin as exhaustion instead of stress.

Once you've re-interpreted the bodily sensations, the stress cycle will abate and you can re-engage with the task at hand. However, *do not* return to the exact point you were at when the mind blank occurred. Rather, return to a previous, already completed moment: for instance, quickly repeat a story you've already told, re-answer a question you've already tackled or re-read a paragraph you've already scanned. By returning to an earlier moment, you will have a much easier time accessing information and triggering relevant associations which will help you push past the mind-blank moment.

Now, I'm not an idiot. I realize there will be times when you can't stand up and say 'Gimme a sec, y'all, I'm just gonna pop a squat real quick!' Luckily, if squatting is not an option you can mimic this by sustaining a tight fist, pushing your hands down hard against a table top, or shifting all your weight over one slightly bent leg. Anything that drives a particular muscle or muscle group to exhaustion should have the same impact.

AT A GLANCE

Moderate stress can boost memories and general learning (though high stress and no stress can be detrimental).

- » Emotions are physical sensations within the body. Feelings are mental interpretations of these physical sensations.
- » Stress is a feeling, not an emotion.
- » During moderate stress, ARC-proteins support neurons in the hippocampus (boosting memory) and FGF2 grows new neurons (boosting learning).
- » During high stress, cortisol kills neurons and the hippocampus withers.
- » During no stress, neurons naturally degrade and the hippocampus withers.

APPLICATIONS

1. Leverage emotional *shifts* to boost memory.
2. Mix up activities to maintain moderate stress.
   - » *Novelty* is one of the best tools to maintain brain health and flexibility.
3. Beware of emotional state dependency.
4. Safety first.
5. Employ physical and mental de-stressing techniques.
   - » Mind wipe + stress = mind blank.
   - » Remember to pop a squat!