TOPIC

02

HOW STRESS AFFECTS YOUR BRAIN

Understanding the neurobiology of stress is key and this topic provides insights into how the brain responds to challenging situations and the potential long-term effects on mental health.

LEARNING OBJECTIVES

THIS TOPIC IS DESIGNED AROUND THE FOLLOWING MAIN LEARNING OBJECTIVES:

01

Explain stress from an evolutionary approach

To explain the evolutionary approach to stress.

02

Describe biological approach to stress

To describe the various biological stages of stress based on the General Adaptation Syndrome.

03

Understand stress hormones and their impact

To present examples of stress hormones and explain their impact on the body.

04

Explain neuroplasticity and stress

To define neuroplasticity and how it is related to stress.

COMPETENCES

THIS TRAINING CONTENT IS DESIGNED TO HELP YOU ACQUIRE THE FOLLOWING COMPETENCES:

01 **Empathy**: Ability to understand and share the feelings of another.

02 **Interpersonal Skills**: Exhibits acceptable standards of professional conduct. Listens carefully. Develops and maintains positive working relationships with all constituents.

03 **Self-perception**: Observe and interpret one's own behaviours, thoughts, and feelings, and using those observations and interpretations to define oneself.

04 **Self-regulation**: Ability to understand and manage your behaviour and your reactions to feelings and things happening around you.

05 **Tolerance to Stress**: Continue to act effectively under time pressure, dealing with disagreement, opposition, and adversity.

06 **Resilience**: Capacity to withstand or to recover quickly from difficulties, toughness.

INTRODUCTION TO THE PHYSIOLOGY OF STRESS

Survival of the Fittest – 'Fight or Flight'

Over time, all species (including humans!) have evolved different mechanisms to ensure their survival. The most basic survival instincts have long evolutionary history, one such instinct is what is referred to as 'fight or flight'. This mechanism evolved as a way to alert humans for any immediate danger and to act in a way that will ensure our survival – either through running away to avoid the danger or by preparing the body to fight back (Scoville, 2019).

A stressful situation — whether something environmental, such as a tight work deadline or psychological such as constant worry about losing a job – can trigger our fight or flight response and a complex interplay of neural processes in the brain that produce well-orchestrated physiological changes. Understanding the neurobiology of stress is key, as it provides insights into how the brain responds to challenging situations and the potential long-term effects on mental health.

THE MAIN STRESS HORMONES

The brain responds to stress by sending a message to release 'stress hormones' like epinephrine (adrenaline), cortisol, and norepinephrine. Here is what you need to know about each of them:

Cortisol

Cortisol is the main stress hormone, it increases blood sugar levels and boosts energy production, whilst suppressing other functions like digestion, reproduction, and immunity.

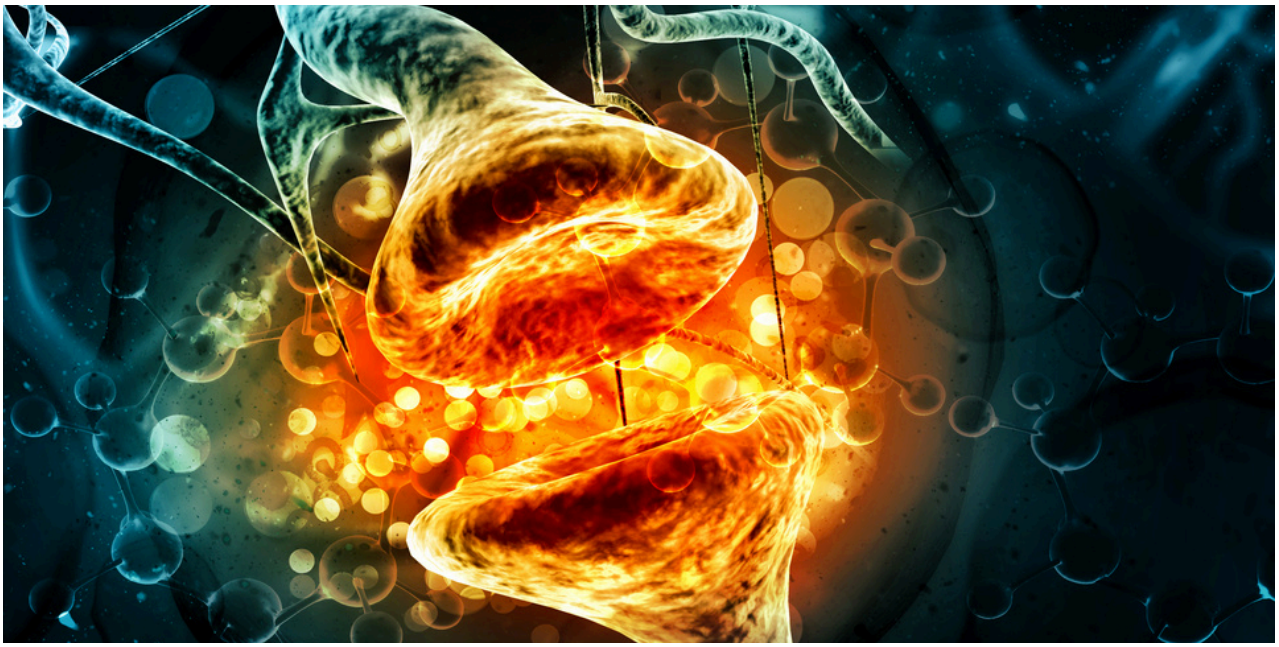
Adrenaline (Epinephrine)

Adrenaline is the hormone most associated with the "fight or flight" response. It's released in large amounts and has a number of effects on the body, including increasing heart rate and blood pressure.

Noradrenaline (Norepinephrine)

Norepinephrine is similar to epinephrine but is released in smaller amounts. Norepinephrine boosts alertness and vigilance, but too much can lead to anxiety, irritability, and difficulty sleeping.

Let's get to know each of one of them.



MiND YOUR

Cortisol

1 When it's Released

Cortisol is often referred to as the "stress hormone" because it's released in response to stress, but it's also involved in various daily activities.

2 Triggers

Stressful situations, low blood sugar, the body's natural circadian rhythm (peaks in the morning).

3 Functions

Increases glucose in the bloodstream, enhances brain's use of glucose, and curbs non-essential functions in a fight-or-flight situation.

MiND YOUR

Adrenaline

1 When it's Released

Adrenaline is released during the "fight-or-flight" response to immediate physical or mental stress.

2 Triggers

Sudden stress, danger, excitement, physical exertion.

3 Functions

Increases heart rate, elevates blood pressure, boosts energy supplies, dilates airways.

MiND YOUR

Noradrenaline

1 When it's Released

Noradrenaline also plays a role in the body's "fight-or-flight" response, similar to adrenaline, but it also helps maintain regular bodily functions.

2 Triggers

Stress, low blood pressure, physical activity.

3 Functions

Increases heart rate, triggers the release of glucose from energy stores, increases blood flow to muscles.

HORMONE	HEALTHY LEVELS	UNHEALTHY LEVELS
Cortisol	• Helps maintain homeostasis. • Increases blood sugar for energy. • Reduces inflammation. • Aids in metabolism.	• Chronic elevation can lead to weight gain, especially around the abdomen. • Can weaken the immune system over time. • May cause high blood pressure and heart disease. • Can lead to anxiety, depression, and other mental health issues.
Adrenaline	• Provides a quick energy boost. • Increases alertness and focus. • Enhances physical performance. • Helps the body respond to immediate danger.	• Chronic overproduction can lead to high blood pressure. • May cause anxiety and restlessness. • Can result in heart palpitations or arrhythmias. • Prolonged high levels can contribute to heart disease.
Noradrenaline	• Supports focus and attention. • Helps the body respond to stress. • Regulates blood pressure. • Increases blood flow to muscles.	• Chronic high levels can lead to chronic stress. • Can cause high blood pressure. • May contribute to anxiety and insomnia. • Can negatively affect cardiovascular health over time.

HOW DOES OUR BODY RESPOND TO STRESS?

The easiest way to understand our stress response is to break it down in different stages, and how our body reacts at each stage. According to the General Adaptation Syndrome (GAS), as this phenomenon called, we respond to stress in 3 stages:

- **Alarm**, which prepares the body to deal with a threat;
- **Resistance**, which allows the body to recover;
- **Exhaustion**, which occurs in response to prolonged or chronic stress;

Now, let's take a closer look at each stage.

Alarm Stage

This is the first stage, where a distress signal has been sent to the brain – specifically the part of the brain called the hypothalamus. The brain responds by sending a message to release 'stress hormones' like epinephrine (adrenaline), cortisol, and norepinephrine.

As the body is preparing to respond to the stressor they are experiencing by 'fight or flight', blood pressure and heart rate are elevated resulting in:

- Dilated pupils – more aware of its surroundings.
- Pale or flushed skin – blood flow to legs, arms increases.
- Rapid breathing – more oxygen is needed.
- Trembling – over-activation of muscles.

Resistance Stage

During this stage, the body tries to recover from the initial elevated response. In the resistance stage, the body lowers blood pressure and heart rate, and the amount of 'stress hormones' released. However, it remains alert and can easily switch back to the previous stage when a stressor persists.

Exhaustion Stage

The exhaustion stage occurs after prolonged stress where your body is too depleted and out of energy to continue combating a recurrent stressor and recover. If the person does not find ways to manage stress levels at this stage, they place themselves at serious risk of developing stress-related health conditions.

Did you know?

During the stress response, some of your other body systems are less active. This includes your **immune system** and your **digestive system**. This is why you don't feel hungry during a stressful situation.

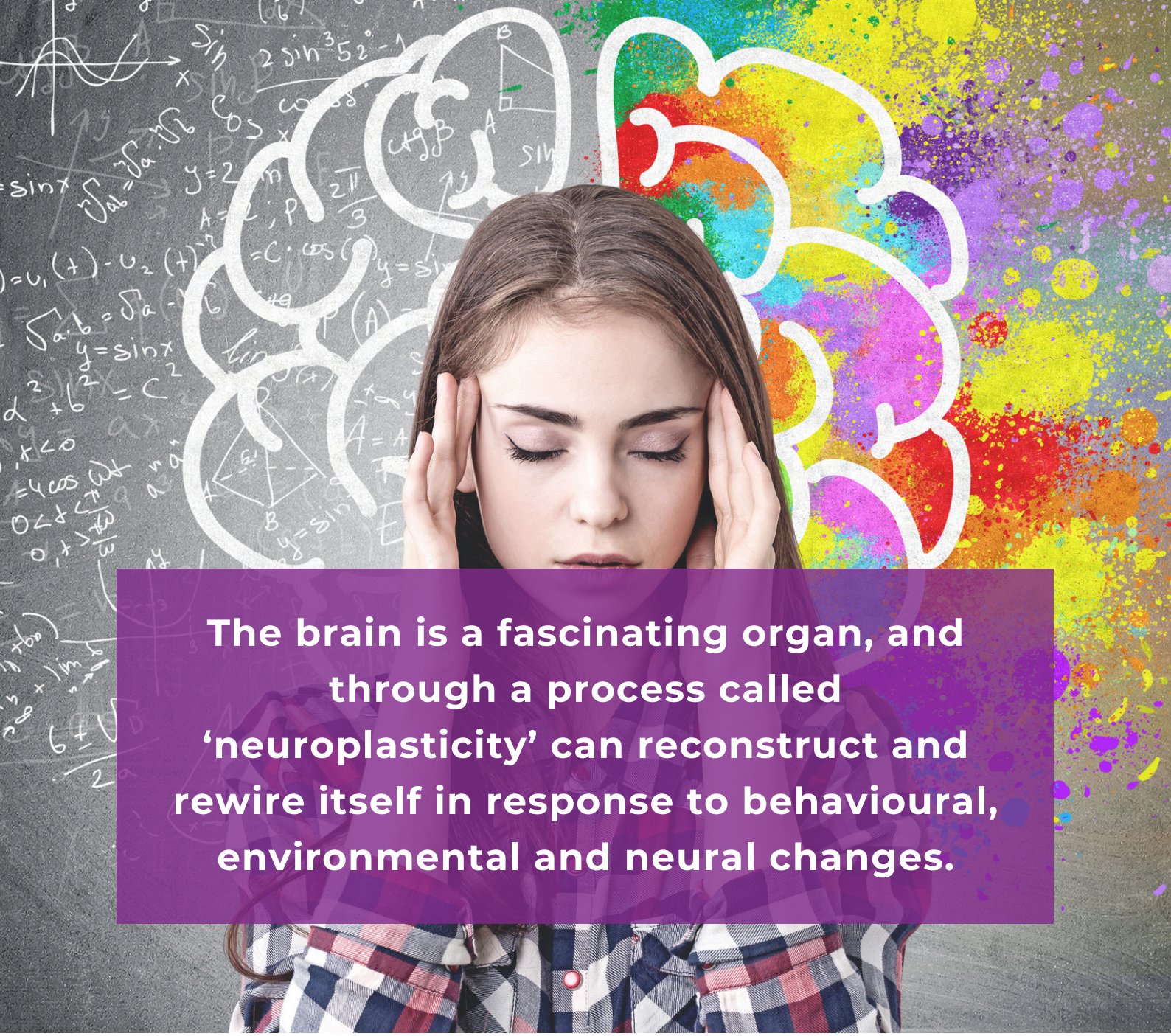
GENERAL ADAPTATION SYNDROME IN PRACTICE

Let’s see every stage in practice through the following hypothetical scenario:

An employee is suddenly assigned to a high-priority project with an extremely tight deadline. The project requires the employee to work long hours, including nights and weekends. In the *alarm stage,* the body perceives the increased workload as a threat. The employee experiences a surge in stress hormones (e.g., cortisol and adrenaline). Physiological responses may include heightened alertness, increased heart rate, and a state of hyperarousal as the body prepares to deal with the stressor.

The employee, recognizing the prolonged nature of the project, adapts to the continuous high workload. They start working overtime consistently, sacrificing personal time and rest to meet the demands of the project. In the *resistance stage*, the body attempts to cope with the ongoing stressor. Stress hormone levels remain elevated, but the body starts to adapt to the demands. The employee might develop coping mechanisms, such as time management strategies or increased reliance on caffeine to sustain energy levels.

As weeks pass, the employee continues to work long hours without adequate rest. The demands of the project persist, and the employee finds it increasingly challenging to maintain the same level of performance and enthusiasm. In the *exhaustion stage,* the body's resources are depleted. Despite the initial adaptation, the prolonged stress takes a toll on the employee's physical and mental well-being. Burnout becomes a risk, and the individual may experience fatigue, reduced immunity, cognitive decline, and increased susceptibility to illness.



How chronic stress can rewire the brain?

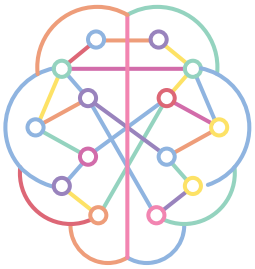
Many people are unable to find a way to put the brakes on stress, however, chronic activation of this survival mechanism can lead to exhaustion and burnout or worse to change how the brain functions. The brain is a fascinating organ, and through a process called *‘neuroplasticity’* can reconstruct and rewire itself in response to behavioural, environmental and neural changes (**Puderbaugh and Emmandy, 2023**). During chronic stress, as we saw earlier, the fear centre of the brain is constantly activated and this leads to the under-engagement of other parts of the brain. In short, the part that gets more activation will become stronger, whereas other parts will become weaker. Hence, brain functions such as memory or decision-making are taking a back seat, giving priority to the part of the brain which handles threads, making us for example more forgetful.

NEUROPLASTICITY

Neuroplasticity is the brain's extraordinary ability to change and adapt throughout life. Unlike the outdated notion that the brain is fixed after a certain age, research shows that it remains malleable, constantly reorganizing itself in response to experiences, learning, and even external environments. This process involves forming new neural connections and strengthening or weakening existing ones based on how we use different parts of our brain.

For example, when you practice a new skill—like learning a language or playing a musical instrument—your brain creates and reinforces pathways that make this task easier over time. Similarly, the brain adapts to stressors, either in harmful ways, such as reinforcing negative thought loops, or in beneficial ways, like building resilience and emotional regulation through conscious practice. Neuroplasticity is both the brain's greatest strength and a double-edged sword, as it can be shaped positively or negatively depending on our habits and mindset.

At its core, neuroplasticity works through two main mechanisms:



Structural Plasticity:

Changes in the physical structure of the brain occur when you engage in new activities or learn something novel. For example, studies have shown that the hippocampus of London taxi drivers is larger than average because of their need to memorize complex maps and routes (**Maguire et al., 2000**).

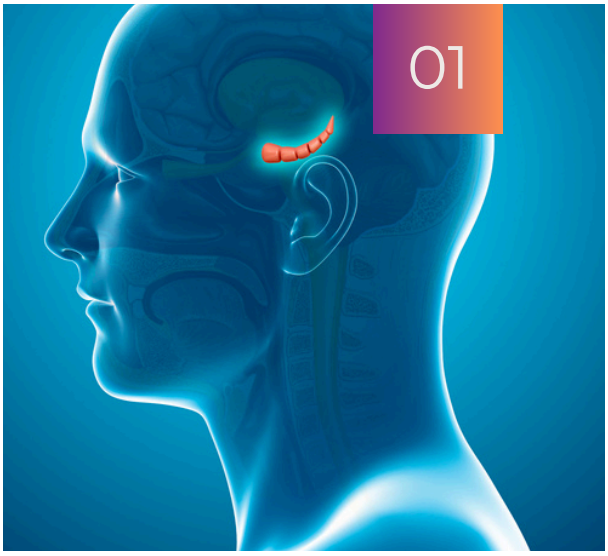
Functional Plasticity:

The brain's ability to shift functions from damaged areas to undamaged ones. This is often observed in stroke survivors who regain motor or language skills through targeted therapy and rehabilitation.

How Stress Impacts Neuroplasticity

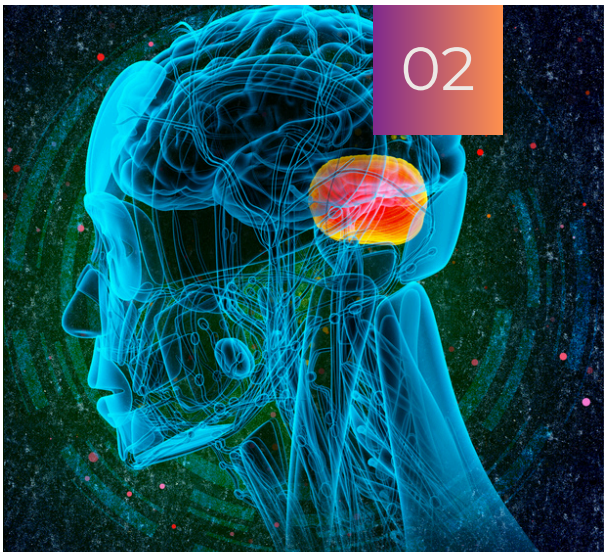
At a cellular level, neuroplasticity is driven by changes in synapses—the connections between neurons. When you repeatedly perform a specific task or think a certain way, your brain strengthens the synaptic connections related to that behavior. This process, called long-term potentiation (LTP), increases the efficiency of neural communication. Conversely, unused connections may weaken through synaptic pruning, which helps the brain eliminate redundant pathways and optimize efficiency.

Stress significantly affects neuroplasticity, both positively and negatively, depending on its duration and intensity. While short-term stress can enhance focus and learning by triggering a mild release of cortisol, chronic stress disrupts the brain's ability to adapt, leading to detrimental changes.



Hippocampus Shrinkage

Chronic stress damages the hippocampus, which plays a critical role in learning and memory. Research by **McEwen and Sapolsky (1995)** showed that prolonged exposure to cortisol leads to the atrophy of hippocampal neurons, impairing the ability to form new memories and regulate emotions. It also leads to impaired memory, reduced learning capacity, and difficulty in managing emotions.



Overactivation of the Amygdala

The amygdala, responsible for processing emotions like fear and anxiety, becomes hyperactive under chronic stress. This overactivation enhances negative emotional responses and impairs the brain's ability to engage in rational thinking and decision-making. As a result, we experience heightened anxiety, increased emotional reactivity, and difficulty calming down.

Weakened Prefrontal Cortex

The prefrontal cortex, which governs executive functions such as planning, focus, and impulse control, is compromised under prolonged stress. Studies show that chronic stress reduces the volume of gray matter in this region, further exacerbating difficulties in emotional regulation and cognitive control (Arnsten, 2009). As a result, we can experience poor decision-making, lack of focus, impulsivity, and difficulty planning or solving problems.

Reversing damages caused by stress

The good news is that neuroplasticity also works in reverse. Through intentional behaviors and practices, you can counteract these negative effects and rebuild healthier neural pathways.

When referring to the damage related to neuroplasticity, it primarily involves the negative impacts of chronic stress on the brain's structure and function.

As you've learned, while neuroplasticity allows the brain to adapt and change positively, it can also work in harmful ways under sustained stress. Despite these negative effects, the brain's neuroplasticity offers a way to reverse this damage via a process known as *Neurogenesis*: the growth of new neurons. In the hippocampus, neurogenesis is stimulated by activities like exercise, meditation, and engaging in creative pursuits.

Another way is *Rewiring Neural Circuits* and that happens via consistent practice of positive habits —such as mindfulness, gratitude, and goal setting—which can strengthen neural pathways that promote resilience and reduce stress-related responses.

See Units 4 & 5 of this training course to explore these useful techniques based on these two processes.

Bottomline is, your brain is not fixed —it's constantly evolving. Now that you understand neuroplasticity, you have the power to rewire your mind to thrive in high-pressure environments and navigate stress with greater confidence and resilience.

GOOD PRACTICES & TIPS

Recognize your triggers

Be aware of your triggers that provoke the fight or flight response. These can be physical, emotional, or psychological stressors.

Be mindful!

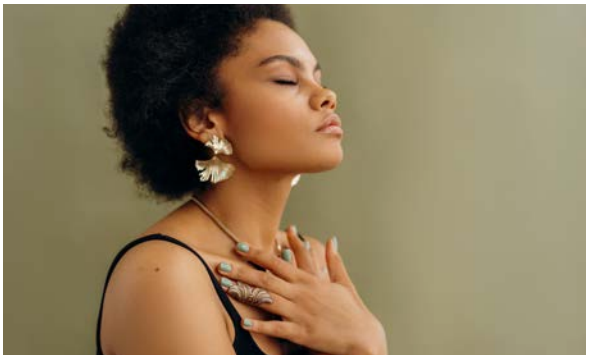
It teaches you to observe your thoughts and sensations without reacting to them impulsively.

Explore coping strategies

Identify healthy coping strategies that work for you, such as journaling, engaging in hobbies, or spending time with loved ones.

Deep breathing!

Deep breaths help activate the parasympathetic nervous system, which counteracts the stress response.



PRACTICAL ACTIVITY

FIGHT OR FLIGHT SIMULATION

Objective:
To provide learners with a hands-on experience of the fight or flight response

FOLLOW THESE STEPS:

- Imagine you are standing on a stage to talk about an important project that you have preparing for weeks to a packed audience.
- Pay attention to your physical and emotional reactions - how do you feel?
- How the general adaptation syndrome theory can be used to explain your reactions to this situation?

PRACTICAL ACTIVITY

THE STRESS BALLOON

Objective:

It demonstrates the concept of stress hormones using readily available materials, providing a tangible way for participants to understand how stress affects the body at a physiological level.

FOLLOW THE STEPS:

- Pour Baking Soda into a balloon, filling the balloon halfway.
- Use the funnel to pour vinegar into the water bottle, filling about ⅓ of the bottle.
- Cover the top of the bottle with the bottom of the balloon.
- When ready, lift the balloon and let the baking soda fall into the vinegar.
- Watch what happens!

In this activity, the vinegar represents a stressor, the balloons represent the body's cells and baking soda the stress hormones released. Stress hormones prepare the body for action in response to a perceived threat, but chronic stress can have negative effects on health and well-being.

EXPERIENTAL ACTIVITIES

SELF REFLECTION ACTIVITY

Find a quiet and comfortable space without distractions. Reflect on past experiences when you felt stressed, anxious, or threatened in some way. These experiences could be related to work, relationships, or other aspects of your life. In your notebook or journal, write down the details of each stressful experience, including the triggering event, your thoughts and emotions at the time, and any physical sensations you noticed.

HERE ARE SOME QUESTIONS YOU CAN USE AS REFLECTION POINTS:

- Write down you observations and reflections on the experience, focusing on how your body and mind responded to the perceived threat.
- How your thoughts and emotions influence your physical reactions and vice versa?
- Are there any patterns or recurring themes in your stress responses across different situations?

KEY TAKEAWAYS

01

A stressful situation — whether something environmental, such as a tight work deadline or psychological such as constant worry about losing a job – can trigger our fight or flight response

02

According to the General Adaptation Syndrome (GAS), we respond to stress in 3 stages: the alarm stage, resistance and exhaustion.

03

The brain responds to stress by sending a message to release ‘stress hormones’ like epinephrine (adrenaline), cortisol, and norepinephrine.

04

Exposure to chronic stress can rewire and affect how the brain’s functioning.

ASSESSMENT

01.

What is the primary purpose of the fight-or-flight response?

A- To improve digestion

B- To prepare the body to face or escape danger

C- To regulate body temperature

02.

Which hormones are released by the adrenal glands during the fight-or-flight response?

A- Dopamine and serotonin

B- Adrenaline and noradrenaline

C- Oxytocin and vasopressin

03.

What is a common physical change that occurs during the fight-or-flight response?

A- Dilated pupils

B- Increased digestive activity

C- Decreased heart rate

04.

The fight-or-flight response is part of which system of the body?

A- Circulatory system

B- Autonomic nervous system

C- Endocrine system

ASSESSMENT

05.

Which of the following is a potential long-term effect of chronic activation of the fight-or-flight response?

- A- Improve digestion
- B- Memory loss
- C- Enhanced immune function

06.

The second stage of the General Adaptation Syndrome is?

- A- Exhaustion
- B- Alarm
- C- Resistance

ASSESSMENT ANSWERS

1-B	2-B	3-A
4-B	5-B	6-C

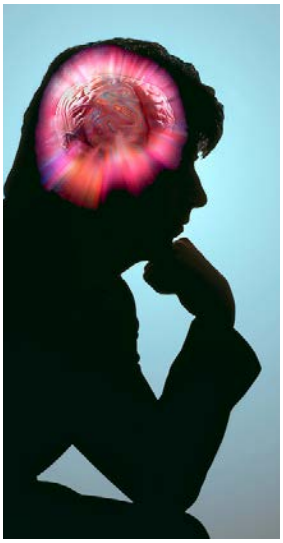
RESOURCE LIBRARY

We've compiled some other interesting resources which can help you explore further the processes which happen in you brain in times of stress.

HOW STRESS AFFECTS YOUR BRAIN

In this TED-Ed Animations video, Madhumita Murgia shows how chronic stress can affect brain size, its structure, and how it functions, right down to the level of your genes. After watching the video, we suggest you take advantage of the "Think", "Dig deeper" and "Discuss" sections to increase your understanding on this topic.

WATCH ON TEDEd



HOW TO PROTECT YOUR BRAIN FROM STRESS

Due to chronic stress, the brain areas that help execute functions like memory, your attention and concentration literally deteriorate. Luckily, brain science has revealed many ways to prevent or counteract this. In this TEDx talk, Niki Korteweg shares the four most important things you can do to keep your brain healthy and working at its very best.

WATCH ON YOUTUBE

RESOURCE LIBRARY

We've compiled some other interesting resources which can help you explore further the processes which happen in you brain in times of stress.

EFFECTS OF STRESS ON DIGESTION

Did you know that when a person is in stress, their body tries to cope up with it. Stress burns your calories, making you feel tired. The brain, in return, signals the liver to produce more and more glucose to give energy to the body to overcome the tiredness. Watch this video to find out more interesting facts about how stress influences your digestions system.

WATCH ON YOUTUBE

HOW STRESS AFFECTS YOUR BODY

Our hard-wired stress response is designed to gives us the quick burst of heightened alertness and energy needed to perform our best. In this TED talk, Sharon Horesh Bergquist gives us a look at what goes on inside our body when we are chronically stressed.

WATCH ON YOUTUBE

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