TURNAROUND FOR CHILDREN

Stress and the Brain

OBJECTIVE: Educators will understand the impact of stress on the developing brain.

PURPOSE: A deep understanding of how adversity and stress can affect the brain creates the foundation for supporting healthy, whole-child development.

SCIENCE SIGNALS

The brain's malleability is both an opportunity and a vulnerability, depending on the context.

A shared understanding of how stress can affect the brain allows a school community to lay the foundation for healthy, whole child development with a trauma-sensitive lens.

Relationships buffer the negative impacts of chronic stress.

Similarly, knowing how positive relationships and environments can buffer the impact of chronic stress empowers a school community to prioritize these supports for all students.

TURNAROUND FOR CHILDREN

Table of Contents

Science Grounding

The brain is a dynamic, living structure, made up of tissue that is the *most* susceptible to change from experience of *any* tissue in the human body (Cantor, Osher, Berg, Steyer, & Rose, 2018). As Fischer and Biddell (2006) state, “There is no separation of nature and nurture, biology and environment, or brain and behavior, but only a collaborative coordination between them” (p. 383). This idea can be seen in the way babies interact with and change in response to world around them, all the way down to the way our genes adapt to experience.

Although our DNA is composed of more than 20,000 genes, fewer than 10% are ever expressed (Gissis & Jablonka, 2011; Jablonka & Lamb, 2005; Rands, Meader, Ponting, & Lunter, 2014). Cues from our social and physical world signal a chemical process in our bodies, which determines which genes are expressed, along with how and when (Keating, 2016; Moore, 2015; Slavich & Cole, 2013; as cited in Cantor et al., 2018). This astounding malleability means that both negative and positive experiences play a key role in determining how our brains and bodies are shaped. There is no such thing as a developing child independent of context.

The most common naturally occurring example of negative context is the experience of trauma and stress. Positive stress activates the healthy production of adrenaline and cortisol – but chronic, unbuffered stress, sometimes called toxic stress, can create an *overproduction* of these hormones. Because development is malleable, a consistent and overwhelming presence of these hormones can fundamentally change the way a child’s body and brain develops (Shonkoff et al., 2012). In the body, chronic, unbuffered stress leads to increased inflammation and poorer health outcomes (e.g., Felitti et al., 1998), and in the brain, key structures adapt to function in negative environments, leading to challenges for learning and behavior in other environments.

For example, stress hormones like cortisol can influence the structure and function of key brain areas for learning, like the amygdala, the hippocampus, and the prefrontal cortex – all part of the brain’s limbic system (Shonkoff et al., 2012). These structures become primed to be on high alert for danger, and to react quickly. These changes affect a child’s ability to regulate emotion, attention, and behavior, and to learn and remember – all key components of academic success.

However, positive environments and relationships can buffer the potentially damaging effects of stress and catalyze learning and development (Osher, Cantor, Berg, Steyer, & Rose, 2018). Trusting relationships, like those between teachers and students, produce another type of hormone – oxytocin. Sometimes called the “love hormone,” oxytocin can counterbalance the effects of the stress hormone, cortisol. Additionally, school environments that feel physically and emotionally safe by being calm, predictable and consistent are less likely to activate a hyper-alert stress response system. By creating a safe and supportive environment, and by being attuned and responsive to each student’s holistic needs, educators play a critical role in students’ healthy development and learning.

In fact, we can use this understanding of science to disrupt the assumptions we have about children and what they are capable of. We can use this science to design schools and classrooms that truly nurture the development of the whole child. We can design to develop the learner from any developmental starting point. By doing this, we can unleash the potential in each and every child.

Context-Setting

Skill 1: Understand the Brain's Learning Centers

You may have heard the many myths about the brain – that some people are "left-brained" while others are "right-brained," that we only use 10% of our brains, or that having babies listen to classical music will guarantee academic genius. While all of those statements have been debunked, one idea that still lingers in education is that students have a fixed IQ, and our level of intelligence and ability to learn won't change. This too, is a myth!

Our ability to learn in any given moment depends on what is happening inside our brains, which is shaped over time by the dynamic interaction between our genetic makeup and our experiences.

The Malleable Brain

MAKING MEANING OF KEY CONCEPTS

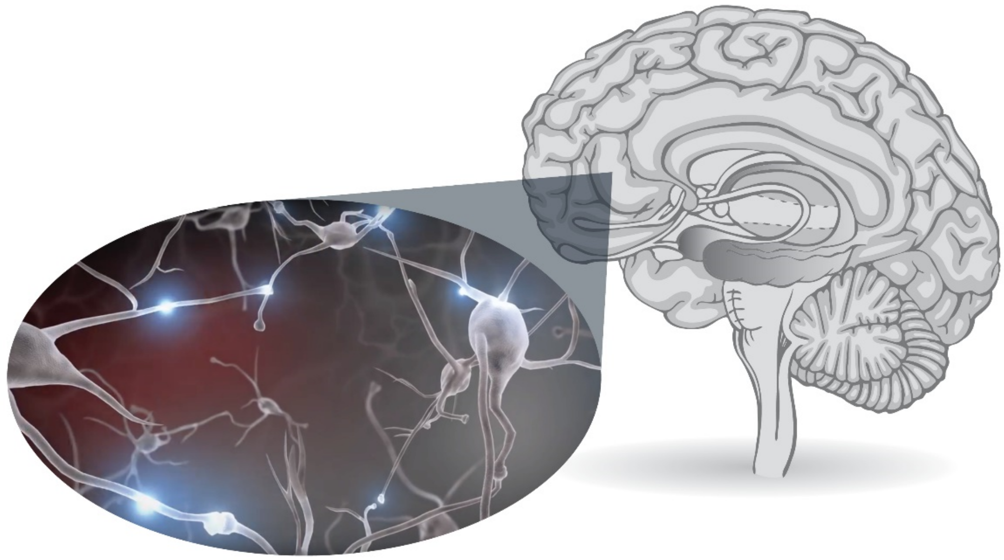
First, let's look under the microscope, zooming all the way down to our DNA. Although our DNA is composed of more than 20,000 genes, fewer than 10% are ever expressed (Gissis & Jablonka, 2011; Jablonka & Lamb, 2005; Rands, Meader, Ponting, & Lunter, 2014).

Circle 10% of the 20 genes below (each image represents over 1,000 genes in our DNA):

Cues from our social and physical world (our environments, relationships, etc.) signal a chemical process in our bodies, which determines which genes are expressed, along with how and when (Keating, 2016; Moore, 2015; Slavich & Cole, 2013; as cited in Cantor et al., 2018). This process, known as epigenetic adaptation, means that both positive and negative experiences play a key role in determining how our brains and bodies are shaped.

Neurons That Fire Together, Wire Together

Zooming out to the cellular level, we see that experiences create, strengthen and reorganize connections between neurons (or nerve cells in the brain), and eliminate unused neural pathways. Called neuroplasticity or neural malleability, this process allows the human brain to be shaped and changed during development and throughout a lifetime (Hebb, 1949; Cantor et al., 2018).



These connections between neurons create increasingly integrated and specialized networks. One network in the brain, known as the limbic system, is incredibly important for our ability to learn.

The Brain's Learning Centers

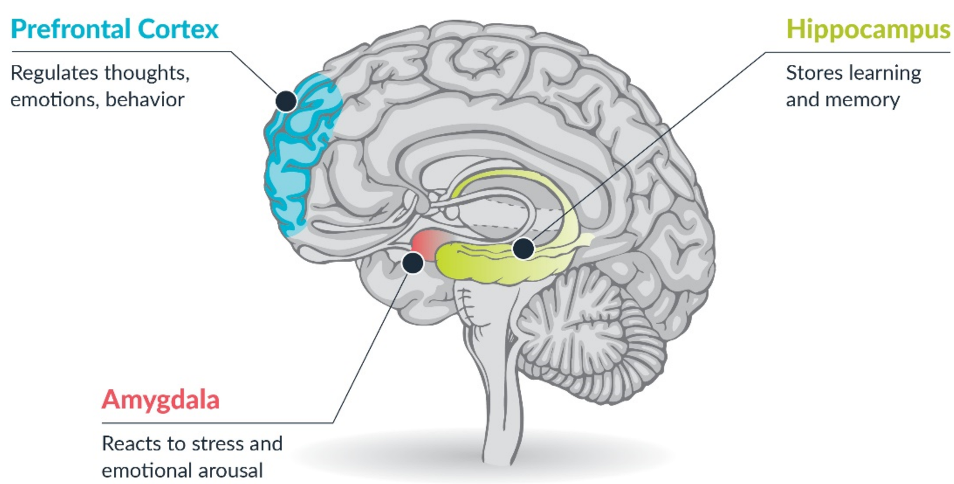
While the entire brain is implicated in the learning process, several key structures in the brain's limbic system – the prefrontal cortex, the amygdala, and the hippocampus – must work together seamlessly to facilitate effective learning, and in turn are shaped by our learning.

The **prefrontal cortex**, located just behind our forehead in the brain's frontal lobe, helps to regulate thoughts, emotions and behavior. For example, it is critical for carrying out a specific set of skills called executive functions, which include working memory, cognitive flexibility, inhibitory control, complex problem-solving, planning, etc.

The **amygdala**, two small, almond-shaped structures located in either side of the brain's temporal lobe, reacts to stress and emotional arousal. This means the amygdala facilitates emotional reactions, including responding to stress, fear and danger by cueing the body's "fight, flight or freeze" response. The amygdala also plays an important role in modulating emotional memories.

The **hippocampus**, two symmetrical seahorse-shaped structures located on either side of the brain's medial temporal lobe, are one part of the brain responsible for housing our learning and memory.

These three interconnected regions of the brain's limbic system communicate with one another during the learning process.



Skill 2: Identify Types and Causes of Stress

The incredible malleability of the human brain, including the brain's learning centers, is both an opportunity and a vulnerability, depending on the context. One of the most commonly occurring examples of negative context is stress – but did you know that not that not *all* stress is bad?

Types of Stress

The amount of stress we experience, in combination with the supports we have available to help us cope, determine how that stress might affect our brains and bodies (National Scientific Council on the Developing Child, 2014).

- **Positive Stress** is characterized by a mild stress response, including brief increases in heart rate and mild elevations in stress hormone levels. This type of stress alerts and prepares us – it can benefit us in situations where we need to be focused and energized. This type of stress actually builds healthy response systems to cope with future stress.
- **Tolerable Stress** is characterized by a more serious but temporary physical stress response, consistently buffered by supportive relationships. These experiences would have the potential to negatively affect development, but with support from trusting relationships, they do not have long-term impact on the brain and body.
- **Toxic Stress** is characterized by an intense, frequent, or chronic activation of the stress response system, in the absence of protective relationships. It is this type of stress that can change the way a child's brain and body develops.

For all children, positive relationships and environments buffer the effects of stress and catalyze healthy development.

The Adverse Childhood Experiences (ACEs) Study

In 1998, a public health study was published in the American Journal of Preventative Medicine reporting on the relationship between childhood abuse and household dysfunction to many of the leading causes of poor health in adults (Felitti et al., 1998). The study's authors, including Dr. Vincent Felitti of Kaiser Permanente's Department of Preventative Medicine and Dr. Robert Anda of the Centers for Disease Control, correlated the number of adverse childhood experiences (ACEs) of more than 17,000 adults with their long-term health outcomes. The original ACEs surveyed included childhood experiences such as abuse and neglect, drug or alcohol abuse by someone in the home, seeing domestic violence, etc. In subsequent research conducted on ACEs, other experiences have been acknowledged and studied, such as experiences of systemic oppression, witnessing community violence, and more.

The original study found that individuals who experienced four or more ACEs were at 2–3x greater risk for developing heart disease and cancer, 10–12x greater risk for intravenous drug use and attempted suicide, and 32x more likely to experience learning and behavioral challenges at school. In fact, individuals with six or more ACEs, on average, had a life expectancy that was shortened by nearly 20 years (Felitti et al., 1998).

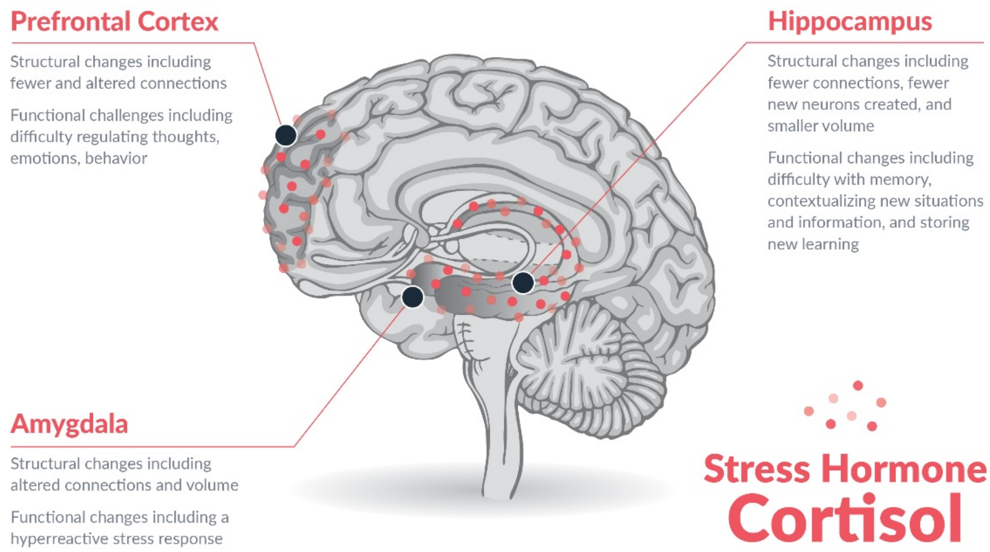
Why did this pattern occur? The connection is explained when we understand that adversity doesn't just happen to children, it happens inside their brains and bodies through the biological mechanism of stress.

Skill 3: Explain How Stress Affects the Brain

As we know, *not all stress is created equal*. The body's stress response (driven by the HPA, or hypothamic-pituitary-adrenocortical axis) activates the healthy production of adrenaline and cortisol, triggering the body's "fight or flight" response, but toxic (or, chronic and unbuffered) stress can create an *overproduction* of these hormones. Because development is malleable, a consistent and overwhelming presence of these hormones can fundamentally change the way a child's brain and body develop. In the body, stress leads to increased inflammation, which leads to negative health outcomes; in the brain, key structures adapt, leading to challenges for learning and behavior in other environments.

This Is Your Brain on Stress

The neural architecture most vulnerable to the impact of the stress hormone cortisol – the prefrontal cortex, the hippocampus, and the amygdala – is also critical for learning. When the brain is experiencing too much stress in the moment, these structures have difficulty working together to effectively facilitate the learning process. Under conditions of toxic (chronic, unbuffered) stress, these structures become primed to be on high alert for danger, and to react quickly.



Under conditions of toxic stress, the **amygdala** becomes hyperreactive, with some research indicating that the amygdala may also change in size (e.g., Luby et al., 2013). This hyperactivity can mean that a child is in a constant state of high alert, becoming extremely sensitive to potential triggers.

Connections within the **prefrontal cortex**, as well as connections between the prefrontal cortex and other regions, deteriorate under conditions of toxic stress (Shonkoff et al., 2012). This makes it difficult for this region to carry out its typical cognitive control functions and to down-regulate arousal from the amygdala. Deficits in these executive functions can result in "impulsivity, poor performance monitoring, reduced ability to regulate performance, impaired planning, reduced reasoning ability, difficulty generating strategies, inflexibility, inability to use feedback, and reduced working memory" (Carlson, Zelazo, & Faja, 2013, p. 715).

Toxic stress may also result in reduced **hippocampal** volume on both the left and right sides (Luby et al., 2013). Additionally, although the hippocampus is one of the few regions of the brain known to continuously generate new neurons, elevated levels of cortisol have been shown to inhibit this neurogenesis, again diminishing its functional capacity (Shonkoff et al., 2012). Impairment of the hippocampus damages the ability to create, store and retrieve memories. This also means that children who have experienced toxic stress may have difficulty contextualizing new information and assessing new situations.

Not only do structural and functional changes occur within each structure, but the necessary balance between regions – the up-regulation from the amygdala and the down-regulation from the prefrontal cortex and hippocampus – can be interfered with. As the amygdala frequently or consistently sounds the alarm, the prefrontal cortex and hippocampus are effectively turning down its response (Shonkoff & Garner, 2012).

The impact of stress on the brain implicates the same skills that serve as foundational building blocks to healthy development and learning, as shown on the Building Blocks for Learning framework below. For example, changes to the amygdala, prefrontal cortex and hippocampus influence a child's ability to manage stress and develop strong self-regulation skills. Additionally, relationships with primary caregivers and other caring adults can serve to buffer stress – which is related to attachment.

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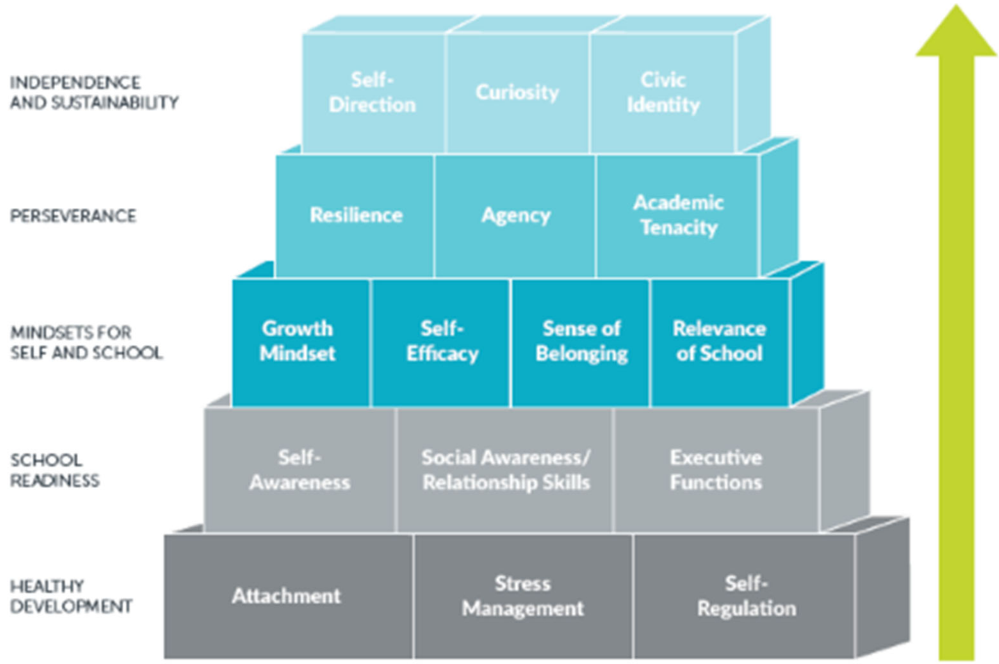

The Power of Relationships

As we now know, the deciding factor for whether a stress experience is tolerable or toxic **is the presence of caring and supportive relationships.**

This buffering relationship can be seen on both the behavioral and biological level. On the surface, we may see an adult comforting a child during a stressful experience, or actively teaching them coping skills.

What we may not see on the surface is the *biological impact* of a buffering relationship. Trusting relationships, like those between parents and children, or teachers and students, produce another type of hormone – oxytocin. Sometimes called the "love hormone," oxytocin can counterbalance the effects of the stress hormone, cortisol. By being attuned and responsive to each individual and supporting them to become independent and autonomous, adults, including educators, play a critical role in students' healthy development and learning. Similarly, environments that feel physically and emotionally safe by being calm, predictable and consistent are less likely to activate a hyper-alert stress response system.

Together, these changes from the experience of chronic, unbuffered stress may affect a child's ability to regulate emotion, attention and behavior, and to learn and remember. **However, the most critical takeaway from this research is that the presence of a buffering relationships – like that of a caring parent or other adult – can not only mitigate the effects of stress, but promote lifelong healthy development.**

Educator Tool: Stress Thermometer

PURPOSE

The purpose of this activity is to reflect on how stress affects the brain and body, to build awareness of your own stress response, along with that of students.

DIRECTIONS:

Using the guiding questions below, consider how your body reacts to stress. Record your thinking in the My Body's Stress Response column. Then, reflect on what you notice.

Guiding Questions:

When you feel stress, what is your body's response? Consider what happens to your ...

- Heart rate
- Breathing
- Muscles
- Stomach
- Hands and feet
- Hunger level
- Energy level
- Thoughts
- Other feelings or sensations in your body

My Stress Level:		My Body's Stress Response:
HIGH		
MEDIUM		
LOW		

Reflect:

What happens inside your body when you feel stress? What happens when you feel that stress over time? When do you see these physical stress responses in students?

TURNAROUND
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Student Tool: Stress Thermometer

DIRECTIONS:
How does your body feel when you are a little bit stressed? What about when you are VERY stressed? Write your answers in the column labeled My Body's Stress Response. Then, talk to a partner or adult about what you notice on your thermometer.

When you feel stress, what happens to your ... ?

- Heart rate
- Breathing
- Muscles
- Stomach
- Hands and feet
- Hunger level
- Energy level
- Thoughts
- Other feelings or sensations in your body

My Stress Level:		My Body's Stress Response:
HIGH		
MEDIUM		
LOW		

Talk to a partner about:

How do you know you are stressed? What happens to your body?

Summary of Understandings

Understand the Brain's Learning Centers

- The brain is malleable, shaped by both our genes and our experiences.
- The brain creates increasingly integrated networks by creating, strengthening, and reorganizing connections between neurons.
- The structures in the brain called the prefrontal cortex, hippocampus, and amygdala (the "learning centers") are part of a particularly important network needed for the learning process, known as the limbic system.

Identify Types and Causes of Stress

- Not all stress is bad – in fact, some stress can alert and prepare us, and build healthy brain architecture to cope with future stress.
- Unlike positive or tolerable stress, toxic stress in the absence of protective relationships can have a negative effect on development.
- Research on adverse childhood experiences shows that toxic stress can lead to increased risk of negative health outcomes, as well as learning and behavioral challenges at school.

Explain How Stress Affects the Brain

- Adversity does not just happen <u>to</u> children, but <u>inside</u> their brains and bodies through the biological mechanism of stress.
- The stress hormone cortisol can influence the structure and function of key brain areas for learning, like the amygdala, the hippocampus, and the prefrontal cortex.
- These changes affect a child's ability to regulate emotion, attention and behavior, and to learn and remember (the foundational building blocks) – all key components of academic success.
- Positive environments and relationships buffer stress and catalyze learning and development.

TURNAROUND FOR CHILDREN

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