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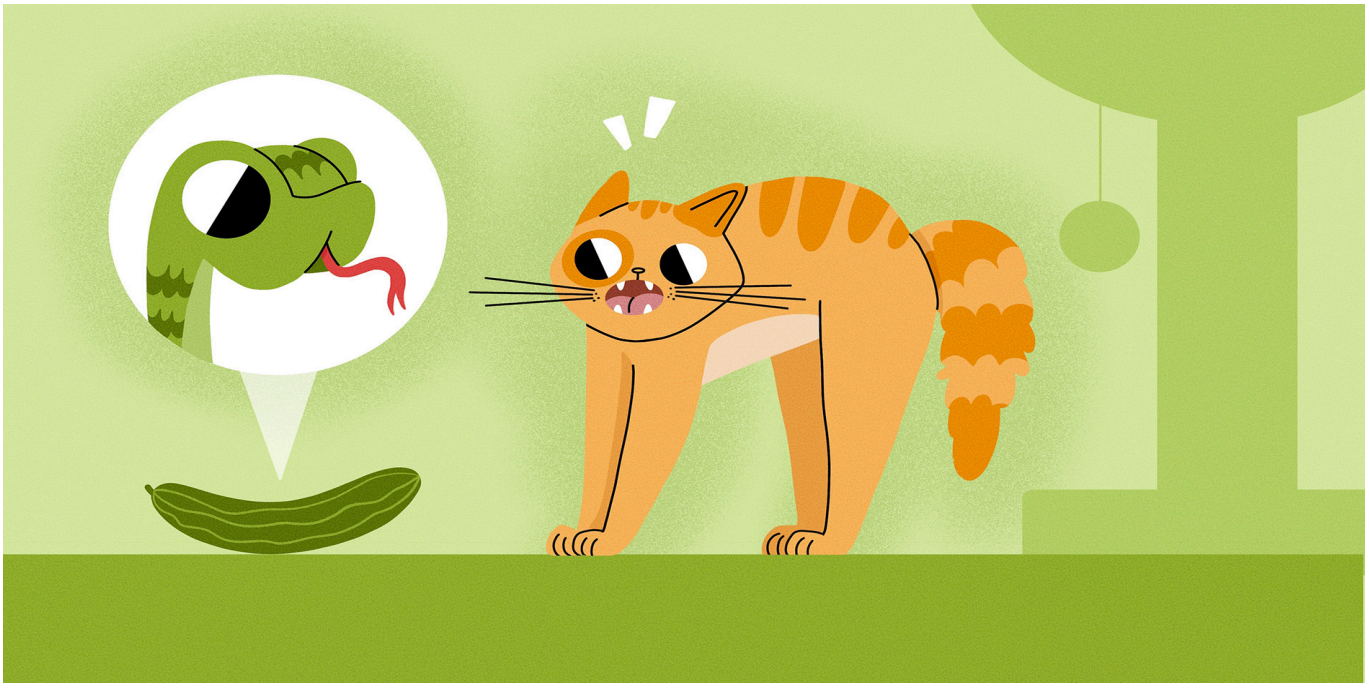

WHAT HAPPENS IN YOUR BRAIN WHEN YOU SPOT SOMETHING SCARY?

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YOUNG REVIEWERS:

AJAY
AGE: 8

DILWORTH MIDDLE SCHOOL
AGES: 12–14

MRITTIKA
AGE: 15

Have you ever noticed that you are good at spotting things in your environment that are potentially dangerous—like a spider crawling on the wall? The brain systems that cause us to notice threatening things are so fundamental that most people are not even aware of them. Brain systems called defensive circuits are tuned to detect threats in our daily lives. These circuits help us to notice the specific features of threatening objects, like the curvy shape of a snake, and they prepare the body to take quick action, like fighting back or running away, therefore increasing our chances of survival. However, sometimes these circuits are overly sensitive, and they sound the alarm too often. These "false alarms" can cause us to see threats in places where there are none. Understanding how threat detection works may help us to understand—and maybe even overcome—our fears!

One of the most important ways for humans and other animals to stay alive is to avoid harm and steer clear of potential threats. To do this, our brains must be constantly alert, so they can quickly detect and identify

threats in the environment. Over the time that humans have existed, our brains have evolved special systems that help us to stay alive [1]. The **defensive circuits** are one of these brain systems. But what are the signs that our defensive circuits are on the lookout for, to warn us that something might be threatening?

DEFENSIVE CIRCUITS

A broad term for the networks of brain areas related to detecting and responding to challenges and opportunities in daily life. Their purpose is to increase the probability of survival.

WHAT DO OUR BRAINS FIND THREATENING?

Our defensive circuits are constantly on the lookout for things that might affect our survival—in other words, our brains are constantly working to keep us safe. The defensive circuits look for specific features of objects that make those objects stand out from the other things around them. These features could include visual properties, like certain shapes or colors, or they could elicit emotions, like an object being dangerous or scary. Objects with these features are given priority in our brains; that is, we pay attention to them before (or instead of) other things. For instance, in a previous study, people were asked to search for different shapes hidden among a bunch of straight lines. The shapes were either curvy, like the letter *S*, or consisted of straight lines, like the letter *W* [2]. Participants were faster at finding the curvy shapes, and if they saw a scary video before the search (which may activate their defensive circuits), they found the curvy shapes even faster! This might happen because curved lines can tell the brain that we are looking at a snake!

Over the many years of human evolution, our defensive circuits evolved to detect features that are common to many threats in general, instead of evolving to detect specific animals or objects that might be dangerous [3]. This is because the brain likes to solve problems using the least possible energy. Additionally, since there are many objects and situations that might be dangerous for us, a flexible and general detection system is better at responding to new threats quickly. So how exactly does this quick threat detection work?

GRAB, HOLD, AVOID!

ATTENTIONAL BIASES

Our tendency to focus our attention on certain things while ignoring others.

AMYGDALA

An almond-shaped structure deep in the brain. It has a crucial role in identifying and understanding objects that elicit an emotional response.

When we detect a threat, our attention works differently than it does when we see non-threatening objects. These differences in the way we pay attention are called **attentional biases**, and there are three of them: grab, hold, and avoid [4].

First, the presence of even a single feature that could indicate a threat (like a curvy shape) *grabs* our attention very quickly. This happens so fast that it does not even require a conscious effort—it is an automatic process, like a reflex (Figure 1). An almond-shaped structure deep inside the brain, called the **amygdala,** is responsible for monitoring the emotions (like fear) associated with things we see and hear. (For more information about why emotional things catch our attention, see this

CORTEX

The outer, wrinkly layer of the brain. It plays a key role in various "higher" brain processes such as attention, memory, and language.

Frontiers for Young Minds article). Threat detection happens so quickly because the threat information does not have to go all the way around the **cortex** (the outer layer of the brain), which is what happens when our brains see other, non-threatening things. You can think of this kind of like a shortcut through the brain! This shortcut is very advantageous because processing information quickly gives us more time to avoid the thing that might be threatening us.

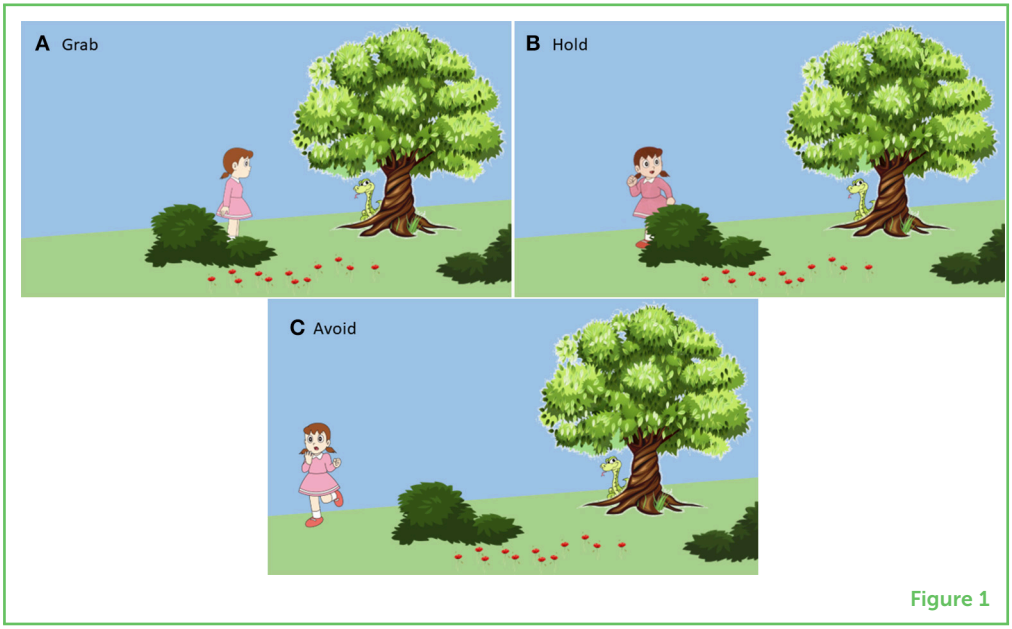

Figure 1

The three attentional biases. **(A)** Kiara quickly detects a scary snake, even though it blends into the background—it *grabs* her attention. **(B)** Then, the snake *holds* her attention—she is momentarily unable to look away from it. **(C)** Finally, she *avoids* looking at the snake again and instead looks for a way to run away.

Once we look at something that might be a threat, we often find looking away to be very difficult—the threatening object *holds* our attention. This is the second attentional bias. This aspect of attention is controlled by the parts of the brain that are involved in "higher" functions like thinking, and conscious, and purposeful actions. The hold bias is also automatic, and the advantage of this bias is that it gives us more time to collect additional details about the potential threat. Those details are crucial for understanding whether we are facing a real threat (like a snake vs. a curvy branch, for example) and for determining how to best deal with the situation.

After we have identified the potential threat, our brains must often make up for the time we spent examining it—we need to *avoid* paying attention to the threat so that we can look around and process the rest of the environment, too. This is the third attentional bias. This is also a largely unconscious process. It is a useful bias because processing the rest of the environment can help us detect additional threats, or find a way out of the situation we are currently in.

RUN!... BUT FROM WHAT?

Once you detect a threat, the defensive circuit prepares your body to take action [1]. We each have behavioral patterns that we are

born with, and you may have heard them called fight, flight, or freeze. Our bodies are prepared to quickly initiate one of these patterns by making changes to our emotions (for example, feeling fear) and body functions (such as speeding up our heartbeat and breathing). Together, these changes allow us to respond appropriately to threatening situations, increasing the likelihood that we will get away without harm.

The activation of our defensive circuits is so fast that we often do not know what made us afraid until a couple of seconds have passed. Remember, signs of a potential threat quickly grab our attention and more detailed information about the environment catches up some time after that. This makes it possible for us to evaluate the situation and decide how to act (Figure 2). For example, in Figure 1, Kiara suddenly stops when she sees the snake, and feels the urge to run away. But if, after closer inspection, she realizes that what she saw really was just a branch that *looked* like a snake, she would feel relief. Being alert and detecting threats can make us scared, and sometimes we run from things that are not harmful—but when these "false alarms" happen, we should remember that being scared by a stick is probably better than not seeing a dangerous snake, and accidentally getting too close to it!

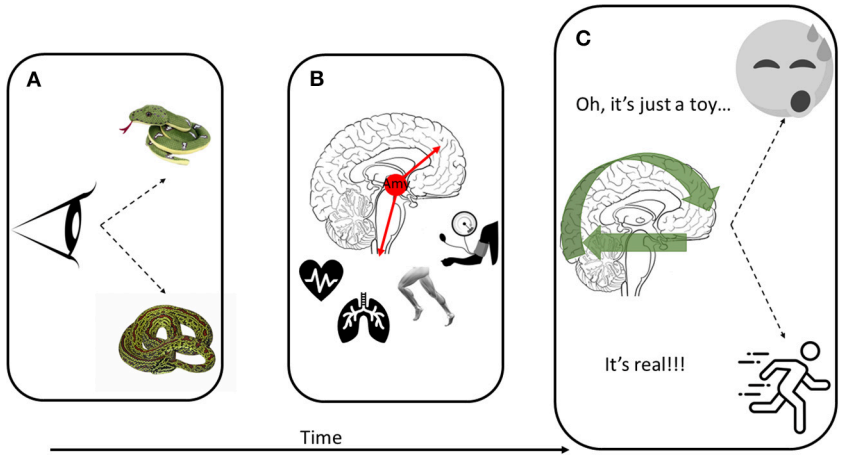

Figure 2

Figure 2

(A) Your eyes detect something that might be a threat and that visual information is sent to the brain. **(B)** The amygdala (Amy) immediately prepares your body for action by speeding up your heartbeat and breathing, increasing muscle tension in your legs, and increasing your blood pressure. This happens quickly because the information follows a "shortcut" in the brain. **(C)** Then, more detailed information about the threat catches up through the normal, slower route through the cortex, and you can decide how to act.

SCARED EASILY? SCIENCE CAN HELP

Some of us are scared more easily than others; for these people, it takes less to trigger their defensive circuits [4]. If a person's defensive circuits are triggered easily, that might mean they are generally more alert, but also that they are more likely to have false alarms in response to non-threats. While such people will probably detect things that might cause them harm, overly sensitive defensive circuits might eventually stop working as they should because they are being overused. Overly active defensive circuits can also lead to

PHOBIA

An intense and specific fear when facing (or thinking of) a particular object or situation. Fear that is out of proportion with the actual threat posed by the object or situation.

excessive and irrational fears known as **phobias**. Four main categories of phobias are: animals (for example: snakes, spiders), medical-related experiences (for example: injections, going to the doctor), things in the environment (for example: rivers, storms), and particular situations (for example: heights, elevators). In the long term, phobias can cause serious health issues, so it is important to help people talk about their fears, and to find ways to help people with phobias. Treatments often involve changing people's behavior or exposing them to the things they are afraid of in a safe and controllable environment. Some treatments are designed to lessen the attention-grabbing effect of threats over time, and to make people able to look away when they see something that they think is a threat but really is not—these treatments involve trying to overcome the "grab" and "hold" biases. These types of treatments are still in an early phase of research, and future studies should explore ways to make them more effective, such as by using virtual reality, for example.

SO WHAT DO YOU KNOW NOW?

To sum up, our brains are wired to pick up signs from the environment that might signal that something harmful is nearby. The brain is tuned to react quickly and efficiently to such signals. Doing so allows us to quickly select the behavior that gives us the best chance of escaping harm. Sometimes, however, this system is triggered by things that are not truly harmful. There are also differences between people in regard to how easily the defensive system is activated. This can be problematic for those of us whose defensive systems are activated too easily, leading to phobias. While therapists develop the most efficient treatments, it is also important for scientists to keep studying how the brain responds to threats, to gain a better understanding of how they work and how and why phobias develop in the first place.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

AJAY, AGE: 8

Eight-year old Ajay studies in the third grade and likes to write screenplays, put together storyboard for comics, make paper crafts, and lego models. He likes playing with friends and watches Arthur episodes. Ajay's favorite time during vacation trips is in the pool. Ajay is a voracious reader.

DILWORTH MIDDLE SCHOOL, AGES: 12–14

This article was reviewed by Mrs. Ellis and her wonderful eighth grade science students at Dilworth Middle School in Sparks, Nevada. The students were really excited to learn about phobias, as many of them either had their own, or knew someone who had one. They were also happy to review this article so other kids around the world could enjoy reading about Neuroscience as much as they did.

MRITTIKA, AGE: 15

15-year old Mrittika loves hanging out with friends and family. Her interests include: playing the viola, dancing, singing, reading, calligraphy, and she is a voracious reader. Math, Social Studies, and Music are her favorite subjects. Mrittika's favorite accomplishments are becoming a senior editor on her yearbook editing team and being a publicist for her school's Drama Department. She received an award for being the best foreign language student of the year in middle school and is a finalist in a nationwide computer science competition. Mrittika aspires to be a more open-minded and knowledgeable person.

AUTHORS

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