Have you ever searched the pages of a *Where’s Waldo®* book and found it difficult to find him? Your eyes jump around the page scanning for his red-and-white striped shirt, but all you seem to find are other funny characters. Maybe you keep getting distracted by a big green monster that does not look anything like Waldo. After you finally find him, you realize that you looked right at Waldo many times without noticing him. Do not worry! In this article, we explain that this is not because you are a bad detective, but because of the way the brain works when we pay attention.

Attention refers to the ability to focus on one thing while ignoring other things [1]. As you read the words on this page, you are shifting your attention from one word to the next, while ignoring all the others. You do the same when you look at a *Where’s Waldo®* book, shifting your attention from one silly character to the next, while trying to ignore all the others. Your search ends when you realize that the character you are currently looking at and paying attention to is Waldo.
Can you find the three apples in this crowded picture? It is difficult because there are many distractors that share features with apples, such as their red color and round shape. You need to move your eyes around to focus your attention on each object until you find an apple.

Attention is like a hidden superpower, but one that you must be careful with. You can control your attention, but you can be distracted and may even miss important things if you are paying attention to other things. In this paper, we will present three important concepts about paying attention and explain how the brain gives you this superpower [2].

**VISUAL SEARCH**
A task requiring attention that involves searching for a target object among other distractors, such as finding a pair of scissors in a messy drawer.

**SPATIAL ATTENTION**
Focusing on a specific location in space, such as only looking for something in the right corner of a messy drawer.

**FEATURE-BASED ATTENTION**
Focusing on certain features of objects, such as the elongated shape or shiny metal color of a pair of scissors.

**NEURONS**
Specialized cells in the brain that send signals to other parts of the brain, allowing us to see, think, and move.

YOU CAN CHOOSE WHAT YOU PAY ATTENTION TO

While some people may think that searching for Waldo is simple, scientists disagree. Many have spent their entire careers studying visual search to better understand how we pay attention. Can you find the three apples in Figure 1? They are hard to find because there are many other objects in the picture, many of which are similar to apples in color, shape, or size. Our brains cannot easily identify an object unless we are looking directly at it. So, you must shift your attention around the picture, focusing on one item at a time, to determine whether it is an apple. Scientists call the strategy of focusing on a specific location spatial attention, because it has to do with locations in the space around us. Without your attention superpower, you could never find the apples. They would simply remain a part of the crowded picture, which is what you experienced when you began your search.

Searching for something in a crowded picture can be easier if you choose to attend to certain features that make up the item you are looking for. For example, apples are small, round, and red. Look again at the images in Figure 1 and try to look only at those items that are red. Did you notice how much easier the search was? Doing so allowed you to ignore all the non-red items, so you did not waste your time on them. Scientists call the strategy of focusing on a specific feature feature-based attention, because it has to do with the features that make up the objects that we see.

How does this superpower work in the brain? Neurons in the visual parts of the brain respond to what the eyes see, using a series of steps.
The first neurons respond to simple features (like red things or round things). Later, other neurons combine these features into whole objects (like an apple). When you choose to attend to a specific feature like “red,” neurons in your brain that detect red things will send stronger signals and neurons that detect blue things send weaker signals. In this way, attention boosts the brain signals related to the features you are interested in. Early signals that receive a boost by attention are more likely to be combined together, which allows you to recognize the object you are focused on. So, attention acts like a glue, binding together the responses of neurons corresponding to the features that make up the object you are looking at.

An important point is that you have some control over all of this. Look at Figure 1 again and try to find the pink pig. As you do this, you could choose to start searching on the right side of the picture, you could choose to look only at pink objects, or you could start at the top and work your way down. Give your superpower a try. But be careful! Many distractors grab your attention because they are similar to what you are looking for. As you search for the pig, you may find yourself looking at many other pink objects, such as the whale on the right side of the picture. This is not surprising, because the pink whale will still cause early neurons that like pink to send along their signals. This explains why the designers of Where’s Waldo® put many similar-looking items on the page that you may mistake for Waldo, like other people wearing red-and-white striped sweaters.

YOUR ATTENTION MAY BE DRAWN TO CERTAIN PLACES OR OBJECTS

Now consider Figure 2A. Can you find the apple? You probably did so very easily. This is because the apple is the only red object in the picture, making it very different from everything else. In the brain, the neurons responding to the red apple produce signals that are very different from the signals produced in response to everything else in the picture. When this happens, your attention is automatically drawn to the apple, strengthening and binding those brain signals and making the apple very easy to see quickly. Scientists who study attention call this effect pop-out. What is important to remember is that pop-out happens automatically, whether you want it to or not.

Visual search is very easy when the thing that grabs your attention and pops out is what you are looking for. However, pop-out can also be distracting and make it harder to find what you are looking for. Try to find the apple in Figure 2B. Did you feel your attention being drawn to the large pink star? Although the apple is still pretty easy to find, it was probably a little harder than it was in Figure 2A, which does not have the star.
Can you find the apple in these pictures? (A) Does the apple “pop out” of this image? Finding the apple is easy when it has unique features, such as its red color, compared to the distractors. (B) Were you distracted by other objects in this image? The bright pink shooting star also pops out and grabs your attention, making the apple harder to find.

The key point to remember is that you will automatically pay attention to any object that looks very different from the things around it. This can happen because the object has a unique color (like the apple) or is very large (like the pink shooting star). Things that are moving are also likely to grab your attention, which is why people often wave their arms in order to get someone to notice them. If you think about your daily life, you can probably come up with many examples of things that grab your attention, even if you do not really want them to.

**ATTENTION CAN BLIND YOU TO OTHER THINGS**

Like any good superpower, it is important to remember that, “With great power comes great responsibility.” You must be careful with your attention superpower. Although it can help you find what you are looking for, it can also make you miss important stuff. Let us think again about searching for an apple. When you try really hard to focus your attention on red things, blue things may go unnoticed, as long as they do not stand out in other ways. If neurons that like blue are being quieted by attention, then their weak signals may not influence other parts of the brain. When you are trying to find a red apple, this is a good thing. But it also means that you may completely miss seeing something important that happens to be blue. Scientists call this **inattentional blindness**.

Researchers Daniel Simons and Christopher Chabris created a famous demonstration of inattentional blindness, in which people watching a short movie clip failed to notice a dramatic surprise that appears in the middle of the clip [4].

In the movie **(Video 1)**, two teams pass basketballs back and forth to each other, with one team wearing white t-shirts and the other wearing black. Simons and Chabris showed the video to research participants and asked them to count passes between players in the white t-shirts. In the middle of the video, while the balls are being passed around, a person dressed in a black gorilla suit walks...
through the group of players. To correctly count the passes, the participants needed to attend to the players wearing white t-shirts, while ignoring all the dark-colored features—so they often did not see the gorilla, even when it turned toward the camera and pounded on its chest! Imagine being a participant in this experiment. You watch a short video and do the pass-counting task. It is all very easy and maybe somewhat boring. When the video ends the scientists ask, “Did you see the gorilla?” You would probably say, “Gorilla?! What gorilla?!?” Inattentional blindness demonstrates an important point about the way our attention superpower works. The more we focus our attention on one thing, the less likely we are to notice other, unexpected things.

WHY ATTENTION MATTERS

After reading this article we hope that you understand three important concepts about paying attention: (1) You can choose what you pay attention to and try to ignore everything else; (2) your attention may be drawn to certain places or objects, even if you do not really want it to be; and (3) if you are attending to one thing, you can be completely unaware of other things, even if you are looking right at them! Understanding how attention works and when it fails is very important because attention is a critical part of many everyday tasks. For example, if you are really interested in the article you are reading, you may not notice your sibling enter the room. But you will probably look up if they stub their toe and cry out in pain. Understanding how our attention works can also help us design safer and more effective environments. For example, fire trucks are brightly colored and have a loud siren to capture your attention, even if you are focusing on something else. Finally, your ability to use and control your attention, like any hero’s superpower, can improve with practice. Simple mindfulness techniques, such as focusing on your breathing for a few minutes each day, can help you have better control of attention, which can improve your overall mental health [5].

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YOUNG REVIEWERS

ALYSSA, AGE: 15
I love math and science, but also love fashion. I am a girl who loves pink but also astrophysics. My hero is Nancy Grace Romanis, who was the first woman to earn an executive position at NASA. I hope to also work for NASA one day.

ANANYA, AGE: 11
Ananya is a curious 11-year old girl who loves everything about nature and science, especially the human body. She has been a very observant child since the beginning and wants answers. She enjoys traveling with her parents to different parts of the world, loves to help her mom in the kitchen, goes on hikes with her father and loves Russian math. She wants to be a physician like her grandparents when she grows up.
OHAD, AGE: 9
Hi, my name is Ohad, I like reading and playing soccer. My favorite food is pasta but I also like pizza. My favorite subjects at school are math, science, and computer. I really like to learn new languages. I do not only know English. I also know and am almost fluent in Hebrew, a language mainly spoken in the country Israel.

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