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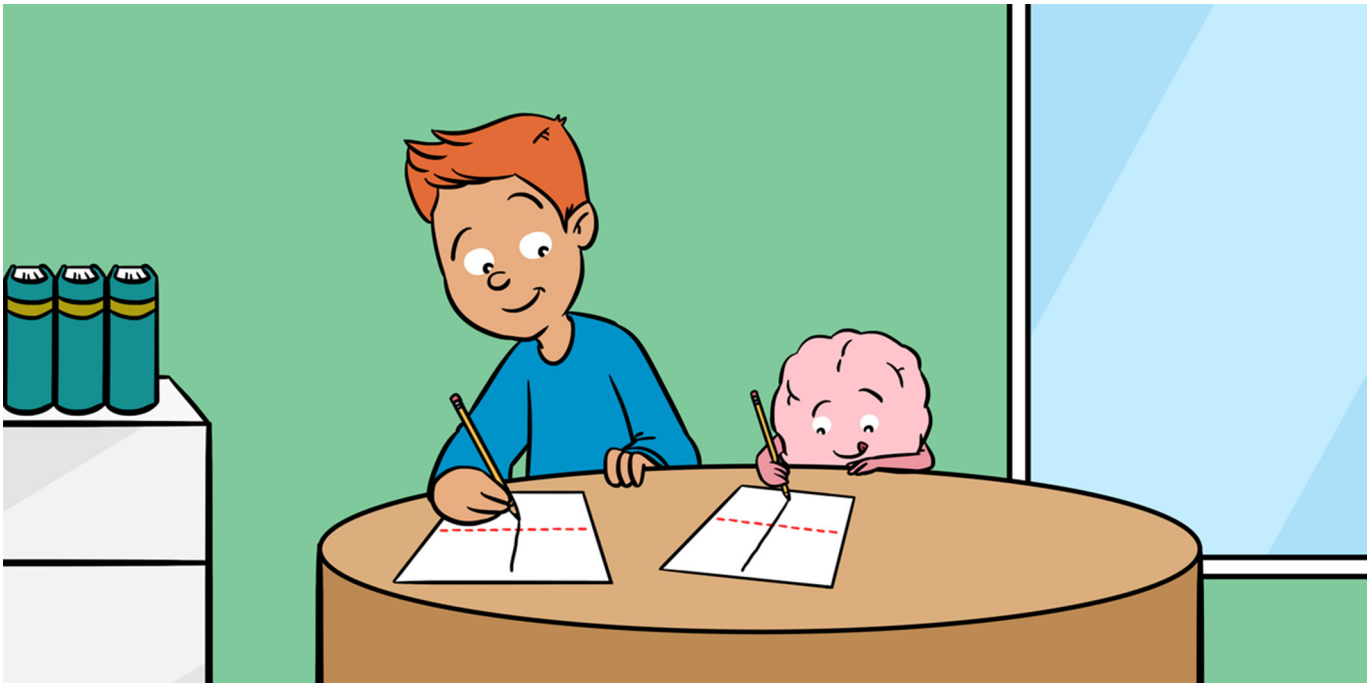

LEFT OR RIGHT? HOW ATTENTION AND READING DEVELOP TOGETHER

Patricia Maria Hoyos[1*], *Na Yeon Kim*[2] *and Sabine Kastner*[1,2]

[1] *Princeton Neuroscience Institute, Princeton University, Princeton, NJ, United States*
[2] *Department of Psychology, Princeton University, Princeton, NJ, United States*

YOUNG REVIEWER:

TRISTAN
AGE: 12

When you are playing catch or I Spy, your brain helps you focus on one location and ignore the rest. Did you know that most people are slightly better at focusing on one side of space, either left or right? This is called a focusing bias. The focusing bias is usually so small that you do not notice it in your daily life. This slight bias can be measured with a simple task: crossing a horizontal line at its center. If you have a slight bias, you will cross the horizontal line a little to the left or right of its actual center. In this article, we will tell you about our recent discovery that children in grades 1–3 have a bias toward the left that gets smaller as they get older. This leftward bias may be related to the development of reading skills.

HOW DOES THE BRAIN PAY ATTENTION TO THINGS IN THE ENVIRONMENT?

Can we play a game of I Spy? I Spy a computer. Name something you see around you.

There are many objects around you, but how did your brain help you focus on just one? The brain's ability to focus on one location in the space around you and ignore the rest is called **visuo-spatial attention**. Think about when you play catch. You can spot and follow the ball with your eyes because of your ability to focus. Visuo-spatial attention allows you to focus on all the space in front of you, so that you can catch a ball flying at you from any direction.

VISUO-SPATIAL ATTENTION

The brain's ability to focus on one location and ignore other locations.

Some people with a certain kind of brain damage can only focus on one side of space. The ability to focus on only one side of space is called **visuo-spatial neglect**. A person with a left-side neglect will only be able to focus on the right side of space (Figure 1). People with visuo-spatial neglect may do things like eat from only half of their plates or wash only half their faces!

VISUO-SPATIAL NEGLECT

The ability to focus on only one side of space.

Although visuo-spatial neglect does not occur in a healthy brain, most people's brains are slightly better at focusing on locations on either the left or the right side of space. In other words, most people have a small **bias** in their visuo-spatial attention capabilities [1]. For most people, the bias is so small that it does not cause any trouble in daily life.

BIAS

A preference. For example, a focusing bias is the ability to focus better on one side of space over the other.

WHY DO PEOPLE HAVE VISUO-SPATIAL ATTENTION BIASES AND HOW CAN WE MEASURE THEM?

Your brain has two halves, or hemispheres—a left hemisphere and a right hemisphere. The parts of your brain that control attention

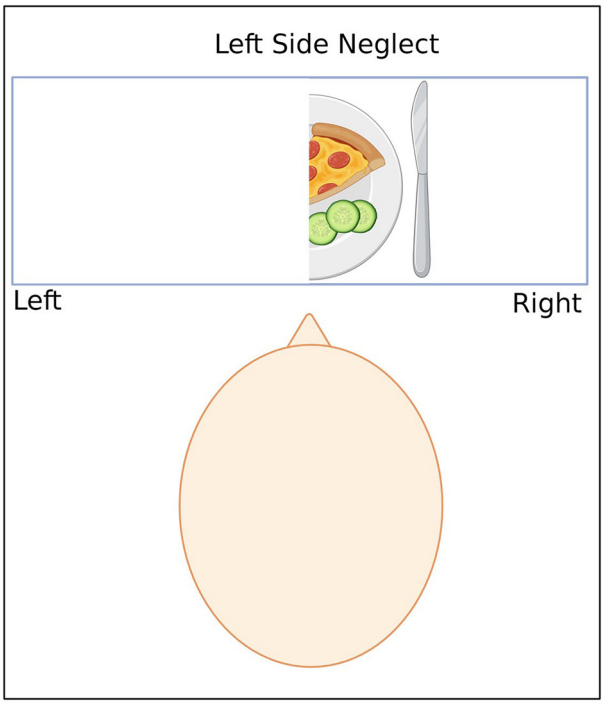

Figure 1

People who suffer from visuo-spatial neglect can focus only on one side of space. In this figure, there is a person with a left side neglect, and they have a plate of food in front of them. Their left side neglect only allows them to focus on the right side of their plate. Because of this, people with visuo-spatial neglect may only eat from half of their plate (figure created with BioRender).

Figure 2

The brain has two halves, called the left and the right hemispheres. The attention parts of the brain are located in both the left and the right hemispheres. The arrows show that the right side of the brain controls attention to the left side of space, and the left side of the brain controls attention to the right side of space (figure created with BioRender).

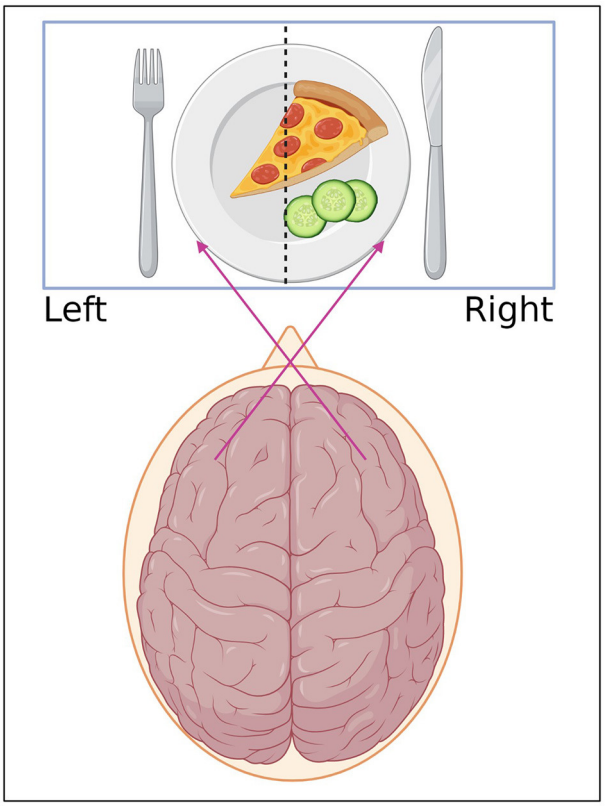

Figure 2

are located across both hemispheres, and each hemisphere controls the opposite side of space (Figure 2). The right hemisphere controls attention to the left side of space, and the left hemisphere controls attention to the right side of space. The focusing strength of each hemisphere competes with the other hemisphere to direct attention to either the left or right side of space. This is called **interhemispheric competition**. Usually, the focusing strengths of the two hemispheres are not perfectly balanced, and one hemisphere is a bit stronger than the other. This leads to a bias in visuo-spatial attention [1].

Scientists can directly compare the attention strength of each hemisphere using brain imaging techniques such as **magnetic resonance imaging** (MRI; For more information about MRI, read this Frontiers for Young Minds article [2]). There is a much simpler way to measure biases in visuo-spatial attention. We show participants a horizontal line and ask them to cross it with a vertical line at its center. While a robot would be able to cross the horizontal line perfectly at the center, most people cross the line slightly to the left or right. This task, shown in Figure 3, is called the **line bisection task**. It helps us learn which brain hemisphere is stronger in the interhemispheric competition.

INTERHEMISPHERIC COMPETITION

The competition between the brain's hemispheres to focus on each side of space. When one side is stronger than the other, a bias to focusing on one side forms.

MAGNETIC RESONANCE IMAGING

A scientific technique that uses a strong magnet to take pictures of the brain and measure its activity in a safe and reliable way.

LINE BISECTION TASK

A task in which the participant is asked to cross a horizontal line with a vertical line at its center.

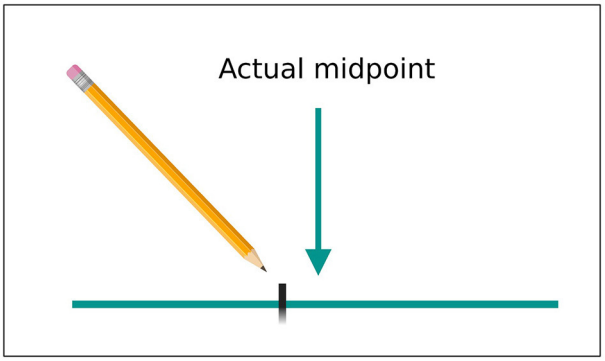

Figure 3

In the line bisection task, we show participants a horizontal line and ask them to cross it with a vertical line at its center. While a robot would be able to cross the horizontal line perfectly at the center, most people cross the line slightly to the left or right. In this example, the participant crossed the line a bit to the left of the actual midpoint. This means that they have a slight leftward visuo-spatial attention bias (figure created with BioRender).

HOW DOES SPATIAL BIAS CHANGE AS YOU GROW UP?

Although scientists knew that attention regions of the brain change a lot as children get older, they did not know how these changes affect visuo-spatial attention bias. In a recent study, we used the line bisection task to measure the visuo-spatial biases of 459 children from grades 1–8 and 61 adults [3]. We found that, overall, children in grades 1–3 have a visuo-spatial attention bias to the left. This means that, in the line bisection task, younger children are more likely to cross the horizontal line slightly to the left of its actual center (as in Figure 3). It also suggests that the right hemisphere is stronger than the left hemisphere in focusing attention to the left side of space in grades 1–3.

Children in grades 1–3 are special because although the older children (grades 6–8) and adults also have a bias, it is much smaller. This does not actually mean that children in grades 1–3 will have trouble playing catch or I Spy in comparison to people of other ages. The bias to the left is so small that it goes unnoticed in daily life. However, as we will discuss next, the subtle bias may change how the brain learns new things, such as reading.

HOW DOES SPATIAL BIAS RELATE TO READING?

If it is so small, why would the brain create a bias to the left that occurs specifically during early elementary school? We thought that this bias might be the brain's way of giving children in grades 1–3 an advantage in learning to read. The ability to read like you are reading this article is like a superpower. Think about it—humans are the only animals that can read! This means that the human brain must make special changes to help you develop the skill of reading (to learn more about the brain's ability to read, check out this Frontiers for Young Minds article [4]).

To test this idea, we gave children in grades 1–3 a short task that measures reading fluency. The task involves naming a series of letters or numbers on a sheet as quickly as possible from left to right, similar to reading English. We found that the children who had more of a leftward bias were better at the reading task. This means that the leftward bias gives children an advantage in the reading task. How does a leftward bias help you learn to read? Consider how your eyes are moving as you read this article. When a person reads English, their eyes shift from left to right. So, although the bias is so small that it is unnoticeable in daily life, it gives your brain a greater advantage in shifting your eyes from left to right when you are learning to read.

CONCLUSION

In conclusion, we discovered that visuo-spatial attention bias changes as children develop and that the leftward bias in younger children may give them an advantage in learning to read. This means that the right hemisphere is stronger than the left hemisphere in focusing attention to the left side of space during grades 1–3. While the spatial bias is very small, it gives younger children an advantage during the same time that they are learning to read in school. Understanding how spatial bias develops may help teachers improve how children learn in school. If focusing on the left side of space gives children an advantage in learning to read, teachers may seat younger children having difficulty learning to read on the right side of the classroom. This way, the information on the blackboard will be to their left, and their leftward spatial bias may give them an advantage in learning to read.

The development of visuo-spatial attention is yet another example of how the brain adapts and changes to help you learn new skills as you get older. One question you may have is whether children learning to read languages like Hebrew, which is read from right to left, would have a rightward spatial bias. Another question is how the development of visuo-spatial attention biases would be different in children that have a hard time reading or paying attention. Those are only a few of the many interesting questions about visuo-spatial attention that scientists will study in the future.

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Hoyos, P. M., Kim, N. Y., Cheng, D., Finkelston, A., and Kastner, S. 2020. Development of spatial biases in school-aged children. *Dev. Sci.* 24:e13053. doi: 10.1111/desc.13053

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YOUNG REVIEWER

TRISTAN, AGE: 12
My name is Tristan, I have a younger brother, I am in year 7 and I am quite interested in neuroscience. My favorite sports are swimming and climbing. I can speak English, Dutch, and Turkish, and at school I am learning Chinese and Spanish (and Latin). My favorite subjects are English, Spanish, Science, Maths, and Geography. My favorite foods are pizza and sushi, and my current favorite novel is The Maze runner/The Hunger games/Percy Jackson.

AUTHORS

PATRICIA MARIA HOYOS

I am a cognitive neuroscientist at Princeton University. I study how the brain develops in children. As children get older, they are exposed to new challenges, such as reading and learning how to swim. I am interested in studying how the brain changes as children meet new cognitive challenges as they grow up. Outside of the lab, I enjoy dancing, drawing, and playing with my dog. *phoyos@princeton.edu

NA YEON KIM

I am a cognitive neuroscientist at the California Institute of Technology. I study how we pay attention to specific things—how do our brains help us find a friend in a crowd, play jigsaw puzzles, and notice interesting things from the world? I am particularly interested in how such capabilities change as children grow. Outside the lab, I enjoy playing tennis, running, and traveling to new places.

SABINE KASTNER

I am a scientist and professor at Princeton University who studies how people use their brains to pay attention to specific activities (e.g., how can it be that you do not hear your parents calling for dinner when you are playing a video game or reading a book?). I also enjoy spending time with my two kids and love the Beatles.