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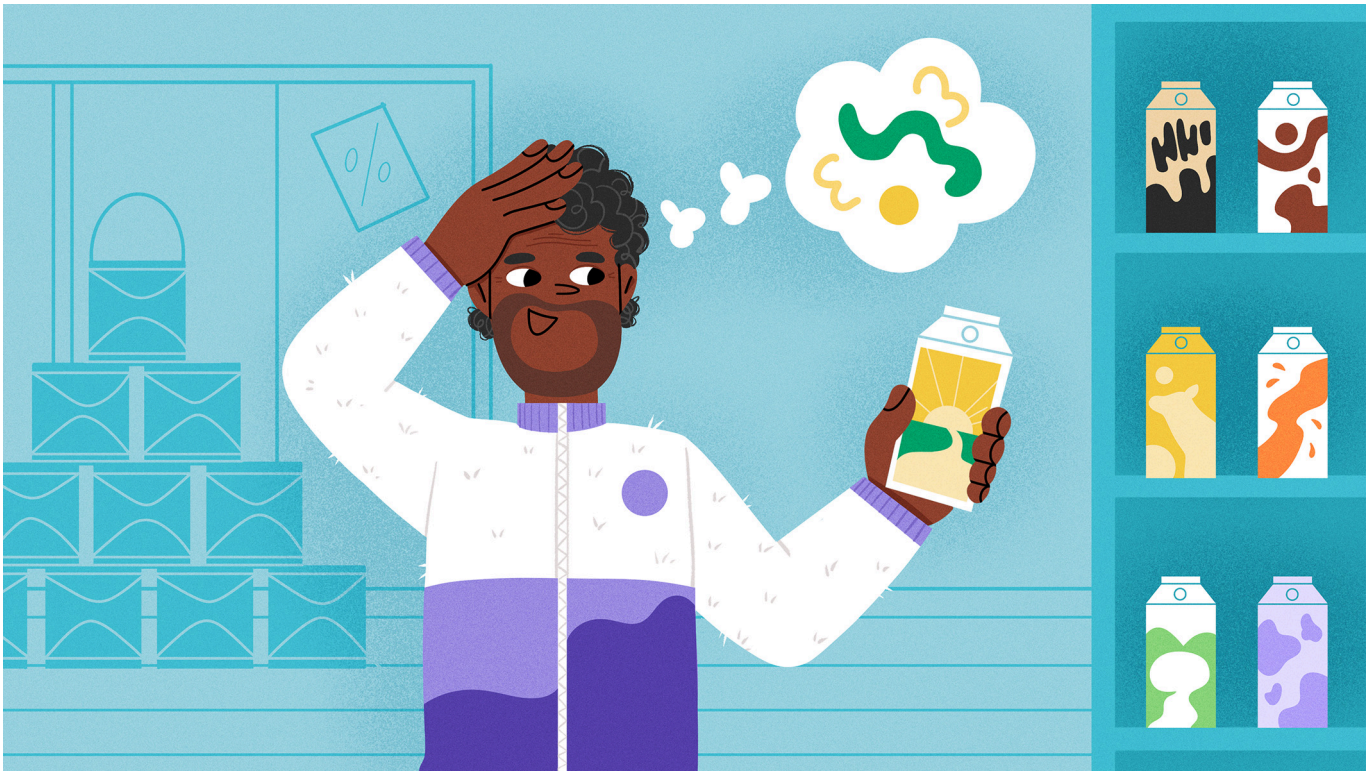

CAN YOU PICTURE IT? PEOPLE VARY IN THEIR ABILITY TO CREATE MENTAL PICTURES

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YOUNG REVIEWERS:

BRAIS
AGE: 15

NOVA
AGE: 13

INTERNATIONAL JOINT LABORATORY OF BEHAVIOR AND COGNITIVE SCIENCE
AGES: 11–13

Mental imagery, or the ability to picture something in your mind, is one of the many ways in which people can be different from each other. While most people can create mental images, a small percentage of people find that they cannot. In fact, individuals like this often find it hard to imagine that others can do this at all! The lack of ability to create mental images is called aphantasia. Scientists sometimes study the effects of aphantasia using visual search and memory tasks. People with aphantasia have a harder time finding objects in a picture, remembering visual details, and imagining the future, but they can use other kinds of memory to help them, such as memory for the locations or names of objects. Aphantasia research is important because it helps us understand how our brains work and how we can support those who see things differently in their minds.

PICTURE THIS...

If you close your eyes, can you picture your best friend's face? Can you imagine the scenery in your local park, or what your homeroom classroom looks like? Using your brain to "see" things you are not actually looking at is called **mental imagery**. Mental imagery does not only mean visual imagery; you can also imagine with your other senses: the smell of freshly cut grass, the sound of children's laughter, the taste of a PB&J sandwich, and the feeling of your toes in sand. But most current psychology research is focused on visual images (and is therefore called visual imagery). This research shows that people differ in their mental imagery abilities. Some people can see very clear pictures in their heads, while others see only fuzzy images, bits and pieces, or nothing at all. Sometimes people can "see" in their dreams (*involuntary* imagery), but not when they try to imagine something on purpose (*voluntary* imagery).

MENTAL IMAGERY

Using your brain to see or experience things that are not present.

When people can remember objects but cannot see them in their minds it is called **aphantasia**. About 10%—11% of people have been been found to have very dim or fuzzy imagery, and 2% of people have no mental imagery at all [1]. Sometimes people develop aphantasia after an injury, but usually it is a condition they experience since birth. Experts do not consider aphantasia a disability or a medical condition, however, as it is just like being left-handed or having green eyes—it is simply one of the many ways in which people can differ from one another.

APHANTASIA

The inability to produce voluntary visual imagery.

It is important to study the effects of aphantasia because understanding how our brains work can help us find the best strategies for learning and remembering things. It is also beneficial to know that not everyone experiences the world the same way, as this helps us understand each other better.

HOW DO WE STUDY APHANTASIA?

For a long time, people have known that such differences in imagery exist, but it was hard to imagine the inner worlds of other people (and even harder to study them!), so there has not been a great deal of research on aphantasia yet. Scientists have begun to conduct experiments to understand aphantasia. The first step is to test visual imagery abilities. The most commonly used test is called the Vividness of Visual Imagery Questionnaire (VVIQ) [2]. The VVIQ asks you to imagine a few particular scenes and rate how clearly you can picture them on a scale from one to five (Figure 1).

It is fascinating that people imagine things differently, of course, but do these differences affect a person's ability to find or remember things? To study the effects of aphantasia on real world behaviors like performing memory tasks or completing a visual search task, scientists

Figure 1

Figure 1

Visual imagery is rated on a scale from 1–5. The images in the figure depict the type and amount of information that might be represented in each level of the rating scale. Image created with the help of Hotpot.ai.

often divide people into groups based on their VVIQ scores. This allows researchers to compare the performance of people with aphantasia to people with strong visual imagery. **Cognitive psychologists** design tasks to measure specific mental processes that may be affected by visual imagery. One example is a visual search task in which participants are presented with a visual display of objects and are asked to locate a specific object in the display. As you can see in Figure 2, visual search can be very simple or extremely challenging.

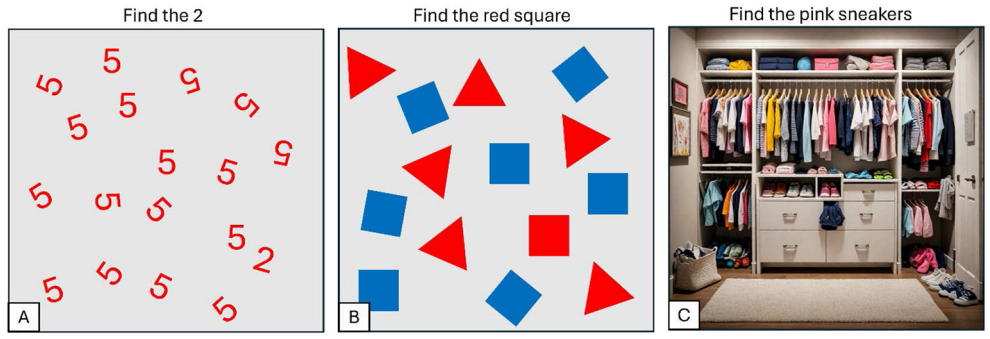

Figure 2

Figure 2

Different kinds of visual search tasks, in which a research participant is asked to look for something specific among sets of distractors. **(A)** Participants are asked to find the 2 among the distractors, which are the 5s. **(B)** Distractors are triangles and blue items in a task where participants try to find the red square. **(C)** This cluttered scene contains varied sneakers as distractors. Image created with the help of Hotpot.ai.

Most current research on aphantasia uses cluttered displays, such as *Where's Waldo* scenes. Visual search tasks help researchers determine whether mental imagery abilities are important for finding things. For example, if you have a hard time imagining what your dog looks like, will that make him harder to find at a crowded dog park? Scientists also study whether visual imagery affects **working memory**, which is the ability to temporarily store and manipulate information in our minds when that information is no longer available to our senses. We use working memory for solving problems, making plans, and following directions. Scientists sometimes give people working memory tasks to see how well they can remember details without being able to picture them.

COGNITIVE PSYCHOLOGISTS

Scientists who study how people think, learn, pay attention, remember things, and solve problems.

WORKING MEMORY

The ability to temporarily store and manipulate information in our minds when that information is no longer available to our senses.

WHAT DO WE KNOW ABOUT APHANTASIA?

One group of researchers wanted to know if people with aphantasia would be able to find Waldo in their *Where's Waldo* task [3]. They discovered that aphantasic individuals could find Waldo, but they did

so more slowly than people without aphantasia. This could mean that people with aphantasia are unable to use a mental image of Waldo to guide their attention when searching. Alternatively, it could mean that, without a mental image, they struggle to decide if they have found Waldo when they look at each new person in the scene. Studies currently being conducted in our lab use tools like **eye trackers** to learn more about these questions by studying the eye movements of research participants (you can read more about eye movements in this Frontiers for Young Minds article). This new work will tell us how long it takes someone's eyes to find the target of a search and how long it takes them to respond (*"that's him!"*) once they have found it.

EYE TRACKER

A device that uses infrared light and a special camera to record a person's eye movements to see where they are looking.

Interestingly, researchers report that people with aphantasia may have a harder time remembering previous events from their lives, as well as imagining future scenarios [4]. These results should not be a cause for concern, however, because it also appears that people with aphantasia can use other kinds of memory to help them with remembering or finding things. One study asked participants to draw a scene from memory and again from a photo to see whether participants could remember the details of a scene without visual imagery [5].

Figure 3 shows an example from that study of how memories of a scene differ between people with aphantasia and people without. Notice that the person with aphantasia recalled fewer details about the scene than the person with visual imagery. Luckily, the aphantasic person could use other strategies to help with their recollection. While they could not visualize the objects precisely, the person with aphantasia used the names of the objects to help them remember parts of the scene. Because they could also correctly represent the locations of objects, scientists inferred that their **spatial memory** is unaffected. Other research has supported this view [6]. Further comparing the picture drawn from memory to the one drawn from looking at the target scene shows that the lack of detail in the drawing from memory is unrelated to the individual's artistic ability.

SPATIAL MEMORY

The type of memory that involves the locations of objects and places.

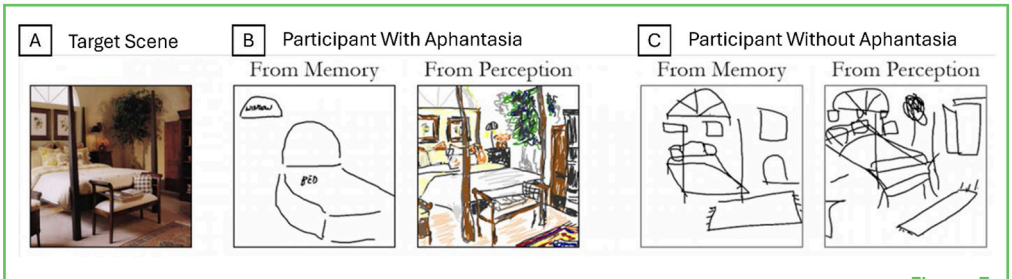

Figure 3

Figure 3

Drawings produced by participants with and without aphantasia. **(A)** The target scene. Pictures drawn from memory were performed without looking at the target scene, and those drawn from perception were completed while being able to look at the target scene. **(B)** Aphantasic participants' drawings from memory were less detailed than controls'. **(C)** Control participants remembered several more objects from the target scene. Figure modified from [5] with permission.

While most research has focused on the lack of voluntary *visual* imagery, some researchers have wondered whether other forms of sensory (what you see, hear, smell, taste, and feel) imagery are involved as well. If so, that would mean that a person with aphantasia may not be able to imagine the taste or smell of their favorite food or the sound

of their favorite song. The general conclusion scientists have reached is that around half of people with aphantasia have reduced imagery for all their senses, and about a quarter of them have no sensory imagery at all [6]. Scientists have also discovered that many people with aphantasia can experience some involuntary imagery, such as in their dreams. However, they typically report having fewer and less detailed dreams. For example, they may recall what happened in their dream, but not what things looked like.

HOW DO WE EXPLAIN APHANTASIA?

The strongest theory we currently have focuses on how memories and imagination are produced in the brain [6]. This is an updated version of a theory called the **constructive episodic simulation hypothesis** (CESH+). This theory states that memories or imagined things are assembled (constructed) out of many independent elements. When we imagine our best friend playing at the park, there are several things to remember. We can remember what our friend looks like, what the park smells like, how it feels to play at the park, and where the swings and slides are located. All these different bits of memories are stored in different locations in the brain. We rely on a kind of map of these pieces stored in the **hippocampus** to help us retrieve each one. CESH+ says that all the different types of information have their own retrieval processes. This includes sensory information as well as emotions, meanings, and where things are. The brain combines all these pieces of information into one complete memory.

CONSTRUCTIVE EPISODIC SIMULATION HYPOTHESIS

Theory proposing that elements of memories are stored throughout the brain and are retrieved and recombined to construct both memories and imagination of future events.

HIPPOCAMPUS

A small region in the brain thought to be heavily involved with memory formation.

We can think of CESH+ like building a model out of LEGO® bricks. The set comes with instructions indicating which plastic bag has which bricks and how to put them together. If the instructions are wrong, if a piece is missing, or if pieces do not fit together like we expected, we might still be able to build the model, but it will not be entirely complete. This could mean that aphantasia might be caused by a problem with the brain's memory "map" (or instructions), but scientists think it is more likely that, for certain types of information, the brain can find the right piece but cannot access it properly. Another idea is that aphantasia happens because the brain cannot put all the parts of the memory together correctly. Scientists hope this theory can help explain why some kinds of sensory imagery are affected while others are intact. It may also help us understand why people with aphantasia can use other strategies (like the names or locations of objects) to help their memory. Finally, it may explain why some people with aphantasia can still experience involuntary imagery, such as dreams. Building a dream might be more like building a model with whatever bricks are available.

FUTURE RESEARCH

The more we know about individual differences in how our brains work, the better we can understand ourselves and each other. Aphantasia can make it harder to remember things that have happened or to imagine future events. It can also make someone slower at searching a scene for a hidden object. Fortunately, people with aphantasia can use other kinds of strategies to help them. Typically, people with aphantasia still can use words instead of pictures to remember things. Most people with aphantasia can also remember the locations of objects even if they cannot remember details about the objects themselves. Future research will continue to teach us more about the ways aphantasia can affect people, as well as ways that people with aphantasia can overcome these difficulties.

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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

BRAIS, AGE: 15

Brais is 15 years old. He is in 10th grade and lives in Brooklyn, NY. He loves participating in math competitions, learning mathemagic tricks (magic tricks based on math), and solving puzzles. He also plays violin and piano and volunteers at his local library.

NOVA, AGE: 13

Nova is 13 years old and an 8th grade student. She lives in New York City with her parents, her two older brothers, and her four guinea pigs. Her favorite subjects are English and theater. In her spare time, she likes to play her violin, sing, write poems, and ride horses.

INTERNATIONAL JOINT LABORATORY OF BEHAVIOR AND COGNITIVE SCIENCE, AGES: 11–13

Hi! We are a group of kids from the International Joint Laboratory of Behavior and Cognitive Science Youth Science Camp. We really like psychology and brain science. We love to think, explore, play sports, and make cool stuff!

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Ashley P. Mathis is a PhD student at New Mexico State University. Her current research focuses on the relationship between mental imagery and visual search performance. Outside of graduate school, she spends her time with her husband, two busy kids, and two dogs.

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