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EXPLORE MORE! HOW NEW ENVIRONMENTS MAY BOOST YOUR MEMORY

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YOUNG REVIEWERS:

AURELIA
AGE: 11

MAYUKHA
AGE: 14

Previous scientific studies have suggested that being in new places or situations can boost memory in young adults! We wanted to find out if this effect is also present in younger children and older adults. Our results showed that children, adolescents, and young adults who spent time exploring a new environment could remember more information than people who spent time exploring a familiar environment. This means that in younger people, but not older people, memory was boosted after exploring a new place. We also discovered that these memory benefits apply to learning movement skills. In the future, we hope to understand the brain's role in these memory benefits.

CAN NEW PLACES HELP YOU REMEMBER BETTER?

We use the ability to remember every day. Memory allows us to recognize friends and family, do well on tests, tie our shoelaces, and so much more! Sometimes we forget things, and that is normal too.

Do you remember what you had for dinner when you were on holiday in a country you had not visited before? And do you remember what you had for dinner the day after you returned home from that holiday? You might notice that you remember your holiday dinner much better than the dinner you had at home. This may be because, throughout human history, it has been important to pay attention to things that are new or different. The same applies to exploring unfamiliar situations. To survive, our ancestors had to quickly learn whether and to what extent new environments were dangerous or rewarding, so that similar situations could be explored safely, and rewards such as food and shelter could be found in the future [1]. Were there dangerous animals threatening to eat them alive, or perhaps tasty fruits that kept their hunger at bay? This tells us *why* we might remember better after being in unfamiliar situations... but *how* does unfamiliarity, also known as **novelty**, actually boost memory?

NOVELTY

An event or experience that is new or unfamiliar.

HOW DO YOU LEARN AND REMEMBER?

Imagine your brain as a forest. Any two parts of the forest could become connected by a path if the same route is taken often enough. The more often a traveler chooses the same path, the more visible the path becomes. In the study of brains, this is called **long-term potentiation**. Like a forest has paths between separate regions, the brain has connections between cells called **neurons**, which are the brain's "communicators". Neurons use electrical and chemical signals to communicate with each other, transmitting important information throughout the brain. The more often a connection is activated, the stronger that connection becomes—just like paths in a forest. In the brain, these connections might represent things like memories or learned information. When these connections are activated, we can recall that information.

LONG-TERM POTENTIATION

The strengthening of a connection between neurons as a result of the connection being activated time after time.

NEURONS

The brain's "communicators", which use electrical and chemical signals to communicate with each other, transmitting important information throughout the brain.

Previous studies suggest that being immersed in or witnessing anything novel activates brain areas important in the production of **dopamine**. Dopamine is one of the chemical messengers that neurons use to talk to one another. The main task of dopamine is to anticipate the value of things in our environment. For example, dopamine helps us to evaluate how rewarding certain objects, people, or experiences are, and helps us better remember the things that are important or rewarding. You could picture dopamine as a ranger deciding which paths in the forest (memories) are especially important and then making these paths more walkable (easier to remember). The brain areas responsible for producing dopamine mature throughout childhood and adolescence, leading to more dopamine rangers working in our brain during that time in our lives. In contrast, as we become older, these areas begin to retire and—just like humans do—lose some of their productivity, resulting in less dopamine in the brain [2].

DOPAMINE

One of the chemical messengers that neurons use to transmit information. The main task of dopamine is to evaluate the value of things in our environment.

DECLARATIVE MEMORY

The conscious memory of information, such as lists of words or the names of the world's capital cities.

SEMANTIC MEMORY

A sub-category of declarative memory, namely the memory of facts and concepts.

EPISODIC MEMORY

A sub-category of declarative memory, namely the memory of personal experiences.

PROCEDURAL MEMORY

Memory of information that we can use to perform actions, such as how to ride a bike or throw a ball.

People can store several types of memories. We can store information from the past, such as lists of words or the names of the world's capital cities. The ability to consciously remember such information is called **declarative memory**. There are two types of declarative memory: **semantic memory** and **episodic memory**. Semantic memory is the memory of facts, which you use to know the correct answers during a test at school. Episodic memory is the memory of things that have happened in your life, such as the holiday dinner we mentioned earlier. A brain area called the hippocampus is especially important in creating and storing declarative memories. It is also a popular "travel destination" for dopamine. The hippocampus receives information from all over the brain and bundles up that information to be stored long term, as a memory.

In addition to declarative memory, we also store information that we can use to perform actions but that we are relatively unconscious of, such as how to ride a bike or throw a ball. The type of memory that is responsible for knowing how to do such things is called **procedural memory**. Procedural memory can help you do well in your sports and playground games, and it is dependent on other brain regions, such as the basal ganglia and the cerebellum (Figure 1). While the positive effects of novelty have been repeatedly shown for information stored in declarative memory [3], it is unclear if these effects are also true for procedural memory.

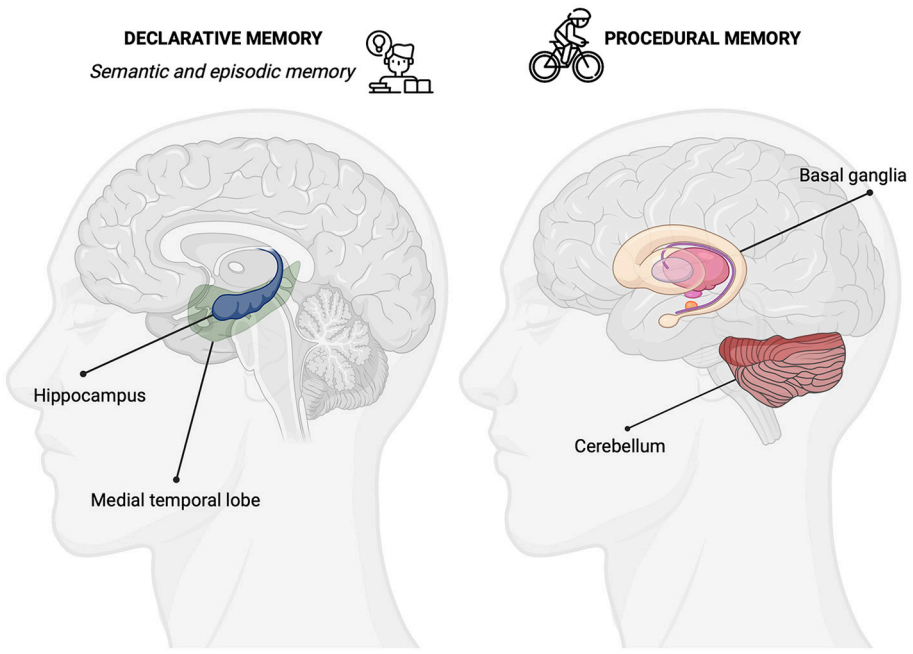

Figure 1

Declarative memory, which is the memory of the things we know, involves areas of the brain called the hippocampus and the medial temporal lobe. Procedural memory, which is the memory of how we do things, involves different brain areas—namely, the basal ganglia and the cerebellum. Figures created with BioRender.com.

WHAT DID WE INVESTIGATE?

So, we knew that a novel environment could boost memory through dopamine, which strengthens the connections between neurons in the brain. We also knew that the brain areas responsible for producing dopamine first become stronger and then weaker as we age. This means that the positive effects of novelty on memory may vary in individuals of different ages. We wanted to investigate whether the novelty-related boost in memory affects people of all ages, and whether it is true for procedural memory in addition to declarative memory.

To explore these questions, we asked a total of 439 individuals visiting a science museum to participate in our experiment. They were divided into four groups based on their ages: children (8–11 years), adolescents (12–17 years), younger adults (18–44 years), and older adults (45 years and older). During the experiment, each participant explored two virtual environments (Figure 2). For some participants both environments were identical, meaning that the second environment they explored was already familiar to them. For the remaining participants, the environments were different, meaning that the second environment they explored was novel. After exploring the environments, all participants were presented with a list of words, and we later tested their memory of these words. In addition, all participants completed a task in which they learned to perform a series of movements. In this task, they had to move a joystick to hit a target presented on the computer screen.

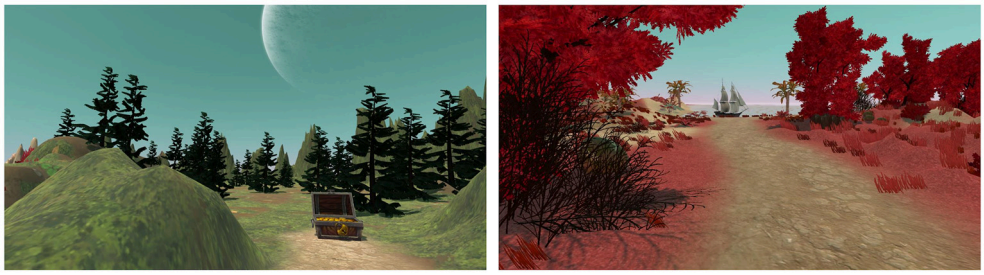

Figure 2

Figure 2

In our experiment, we asked participants to explore two virtual environments before completing word list and movement tasks. These images show screenshots from the two virtual environments that participants explored. Participants in the "familiar" group explored the same environment twice, whereas participants in the "novel" group explored two different virtual environments.

WHAT DID WE FIND?

We found that age affected whether novelty boosted memory! Adolescents and young adults remembered more words overall compared to children and older adults. More interestingly, we also found that children, adolescents, and young adults remembered *more* words after exploring a novel environment as compared to a familiar environment. In contrast, older adults remembered *fewer* words after exploring a novel environment as opposed to a familiar environment. Do you remember how dopamine levels in the brain rise and fall as we

go through life? The beneficial effect of novelty that we observed in our study—with benefits for younger but not older people—follows the same pattern (Figure 3). We also found that people who explored more in the virtual environments remembered more words. Perhaps people who are more open to exploration have better memory? Or maybe exploration improves memory? We cannot answer those questions with the current study's results, but these would be fascinating topics for future research.

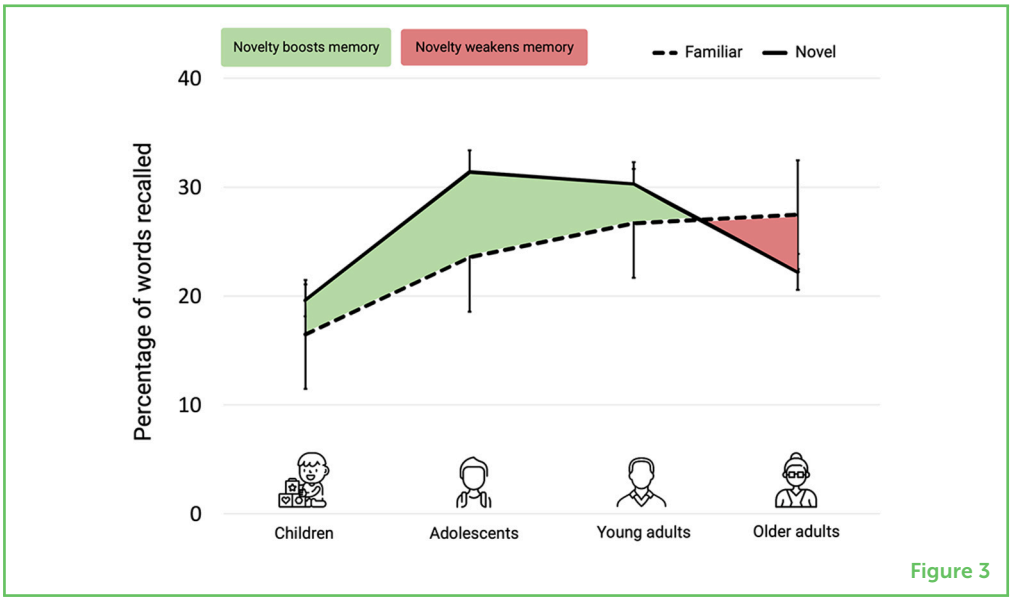

Figure 3

We calculated the percentage of words participants remembered from the studied word list. Memory performance is shown for each age group. The solid line shows the percentage of words recalled by participants in the *novel* group, who saw two different virtual environments, and the dashed line shows the percentage of words recalled by participants in the *familiar* group, who saw the same virtual environment twice. You can see that novelty boosted memory in children, adolescents, and young adults (green), while novelty weakened memory in older adults (red). Figures created with BioRender.com.

Finally, we found that the beneficial effects of novelty also extend to the memory of movements. Specifically, we found that participants remembered the learned joystick movements better after exploring a novel environment as compared to a familiar environment [4]. This suggests that the memory of learned movement skills becomes more durable after people explore novel environments.

SHOULD YOU STAY HOME OR EXPLORE NEW PLACES?

To conclude, in our experiment we found that exploring a novel environment led to a boost in declarative as well as procedural memory in children, adolescents, and younger adults, but not in older adults. This means that exploring may especially help younger people to improve their memory. This includes you, so go out and explore (safely, and after getting permission from an adult)! Our findings are important because they suggest that by exposing younger people who have memory problems to novelty, we may be able to help them improve their memory. Future research could help us to identify which memory problems specifically benefit from novel situations. Maybe someday, doctors will give people with memory issues a "prescription" to explore new places!

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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

AURELIA, AGE: 11

My name is Aurelia. I am an 11-year-old girl who enjoys fashion, sewing, playing with my four cats and bearded dragon, and hanging out with my friends. My favorite subjects at school are math and English. I am a Girl Scout Cadette, enjoy running 5K runs, and am also very active in my church.

MAYUKHA, AGE: 14

I dream of a world without conflicts, clean surroundings and lots of flowers around.

AUTHORS

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Kreeta is a double graduate student of clinical neuropsychology and cognitive neuroscience at Leiden University. She is originally from Finland but has completed her higher education in the Netherlands. Her academic interests lie within the neuropsychological basis of pain, fear, and learning, with an added interest in the effects of novelty on behavior and cognition. In her free time, she is an avid equestrian and a photographer.

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Marit is an assistant professor at the Health, Medical and Neuropsychology section at Leiden University, the Netherlands. Her research focuses on how the brain controls movement, and how such control changes due to aging or disorders such as Parkinson's disease, Alzheimer's disease, or depression. In her spare time, she loves to go on runs to explore her city looking for novel places.

JUDITH SCHOMAKER

Since 2019, Judith has been an assistant professor at the Health, Medical and Neuropsychology section at Leiden University, the Netherlands. Her research has revolved around the topic of novelty, that is, new and unknown things. How do we perceive novelty? What does encountering novelty do within the brain? And what about behavior? In her research, she has found that novelty has many effects on the brain, behavior, and memory. She has a passion for rare (novel) plants and loves to explore virtual environments in (classic) adventure video games.
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