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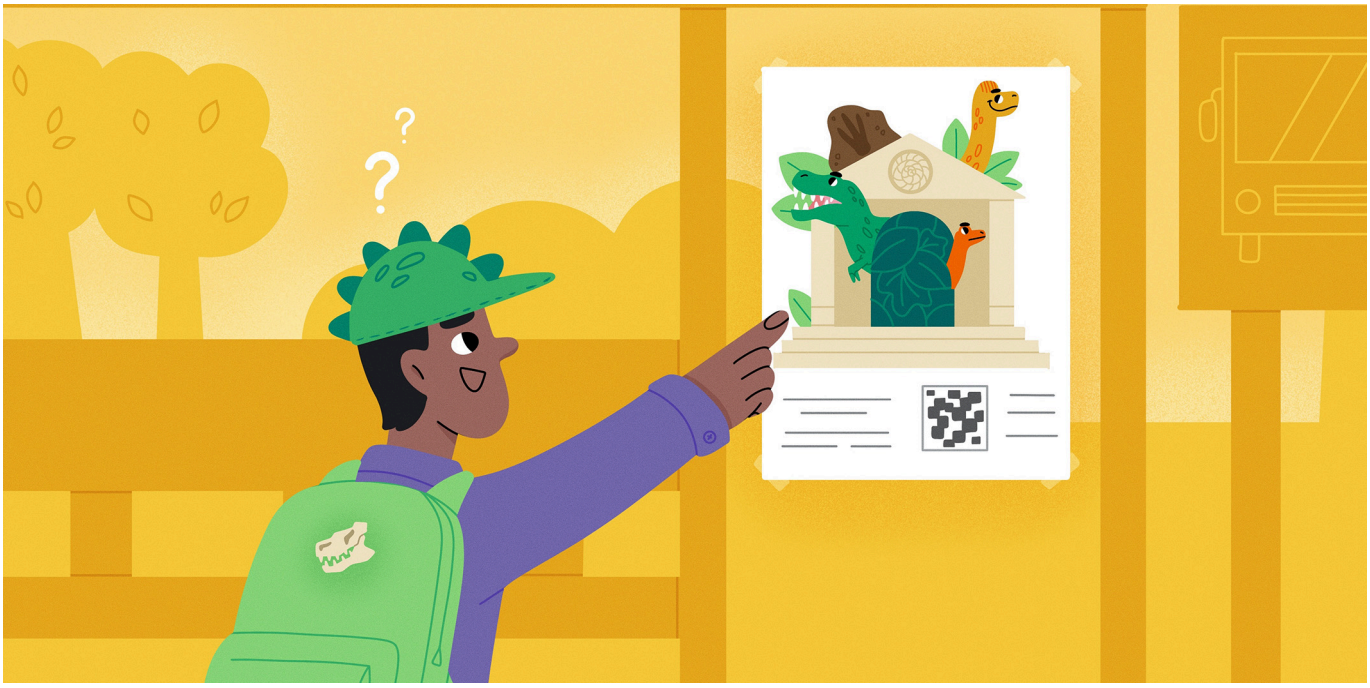

ARE YOU CURIOUS ABOUT CURIOSITY?

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YOUNG REVIEWERS:


ERIC
AGE: 11


JADEN
AGE: 13


KAI
AGE: 10


ROBIN
AGE: 9


ZHUOHUA
AGE: 8

Kids (and adults) are often curious. Maybe you are curious about dinosaurs, giant squids, or rollercoaster rides. But have you ever been curious about *why* you are curious about some things but not about other things? In the last 10 years, scientists have asked similar questions about curiosity. In this article, we will share some of the answers. We explain how scientists across the world study curiosity. We also explain that people become curious to seek out specific information or to explore new things. Based on research on curiosity and the brain, scientists think that curiosity is a signal that it is valuable (or rewarding) to learn something or figure something out. Curiosity can even make you remember information better. After reading this article, we hope that your curiosity is satisfied!

ARE YOU CURIOUS ABOUT CURIOSITY?

Have you ever desperately wanted to know what gift you would get for your birthday, or what your score was on a school test? Have you

ever lifted a stone to see whether any creepy crawlies lived under it? Have you ever wanted to touch something just to experience what it felt like? These are examples of what we call curiosity. Curiosity makes people want to explore things, to seek out new information.

WANTING TO KNOW SOMETHING

People become curious when they know that there is something that they do not know. Often, this is something specific. Imagine, for example, that you read online that scientists have discovered the true color of the Tyrannosaurus rex. On the website is a link that you can click to see a drawing of the T-Rex made by the scientists. Do you want to know whether it is green, brown, purple, or bright orange? Would you click the link? This is an example of curiosity that is driven by **uncertainty**. Uncertainty is high when you are aware that there is a piece of information that is important to you, but you do not know what it is. In our example, you know that scientists discovered the color of the T-Rex, but you do not know what the color is. You are uncertain about the color. In such situations, people become curious, and this curiosity leads them to try to find the missing information. For example, they may click on the link with the picture of the T-Rex. We call this type of curiosity **specific curiosity**.

UNCERTAINTY

When a person is unsure about something or a person does not know a particular thing.

SPECIFIC CURIOSITY

Curiosity about a specific piece of information. In specific curiosity, people know that there is something that they do not know and try to find the missing information.

But people are not only curious in situations in which a specific piece of information is missing. People can also be curious because they want to discover something new [1]. We call this type of curiosity **general curiosity**. Imagine that you find out there is a dinosaur exhibit in a nearby museum. This exhibit may pique your curiosity. Will there be new facts to discover about dinosaurs? Will there be massive, fossilized bones that you have not seen before? In this example, curiosity may encourage you to ask your parents to visit the exhibit. Here, curiosity may be less about finding a specific piece of missing information, and more about discovering all sorts of new things. People may be curious about experiences or situations in which they can learn or explore (for example about dinosaurs). By following your curiosity, you may even learn something that you never knew you did not know!

GENERAL CURIOSITY

Curiosity about discovering new things. In general curiosity, people seek out new experiences or situations in which they can learn or explore.

WHAT ARE PEOPLE CURIOUS ABOUT?

In the last 10 years, scientists have made progress studying curiosity. Some scientists have focused on identifying people who are generally curious vs. people who are generally not that curious. People are all different, and individuals who are very curious may behave in different ways than people who are not so curious. In addition to studying curiosity as an aspect of an individual's character, scientists also investigate curiosity as an experience in response to specific things. For example, some scientists presented participants with a lottery, to test whether participants were curious about whether they had won

or lost money. One of the most common ways to study curiosity is by presenting so-called trivia questions [2]. Trivia questions ask about relatively obscure facts, such as "How big is the giant squid that lives in the deep sea?". Scientists can ask participants these questions and also ask them how curious they are about the answers. Researchers can also measure curiosity by looking at certain behaviors, such as how long participants are willing to wait for the answers.

Interestingly, people are not only curious about things that make them feel good. Some scientists have used nasty images to test whether participants are curious about negative things, and they found that bad things can also make people curious. Maybe you have experienced this yourself when you see a fire truck rush by, and you wonder what has happened. Or maybe you have been curious about a scary part in a movie. A nice example of curiosity about negative things is a famous study with joke pens that give a harmless electric shock when clicked [3]. In this study, people were sitting in a waiting room where pens with colored stickers were lying on a table. The green pens never gave a shock, the red pens always gave a shock, and the yellow pens sometimes gave a shock. Which pen would you click? The scientists found that participants wanted to click the yellow pens the most—the pens that may, or may not, give a shock. You might be asking, "why do people want to click a pen to find out if it will shock them, when shocks hurt?". Well, people find it important to reduce uncertainty ("Will this pen shock me?") and are willing to accept the consequences while finding out.

One important aspect of curiosity is that people are often curious about information that is not directly useful. Why would you want to know whether a pen lying on the table next to you gives you a shock? Why would you want to know how big a giant squid is that lives in the deep sea? You will probably never encounter a giant squid, so the information has no direct purpose. But maybe you still want to know... (it is 13 m long!). Scientists think that you may want to know these things because information itself is valuable or rewarding. Reward is a term often used in psychology and **neuroscience**. It means that something is worthwhile or valuable to someone. Scientists have studied rewards such as money and food for decades. These types of rewards, called **extrinsic rewards**, are directly useful to people—you can buy things with money and food gives you energy. But people can also be curious about information or experiences that are rewarding just for the sake of knowing them. These are called **intrinsic rewards**. Just as you often do something just for the sake of doing it (for example playing with Lego), you may also want to know a piece of information just for the sake of knowing it (for example the answer to the question about the giant squid). In these cases, the reward does not come from money or food, but from the experience or information itself.

NEUROSCIENCE

The scientific study of the brain. Neuroscientists try to understand how the brain works.

EXTRINSIC REWARD

Things that are valuable because they are directly useful, such as money or food.

INTRINSIC REWARD

Things that are valuable just for the sake of knowing them or doing them.

CURIOSITY AND THE BRAIN

Neuroscientists have a pretty good idea about how the brain responds to rewards. They found that brain regions associated with a chemical messenger called dopamine are sensitive to rewarding things, such as money and food. An example of a reward brain region is the **nucleus accumbens**, hidden deep in the lower part of the brain (see Figure 1). Recent research has shown that reward brain regions also respond when people are curious about the answers to trivia questions [2]. For example, when participants read a trivia question such as, "what does the term dinosaur actually mean?". Researchers found

NUCLEUS ACCUMBENS

A region in the brain that is active when people are about to get a reward.

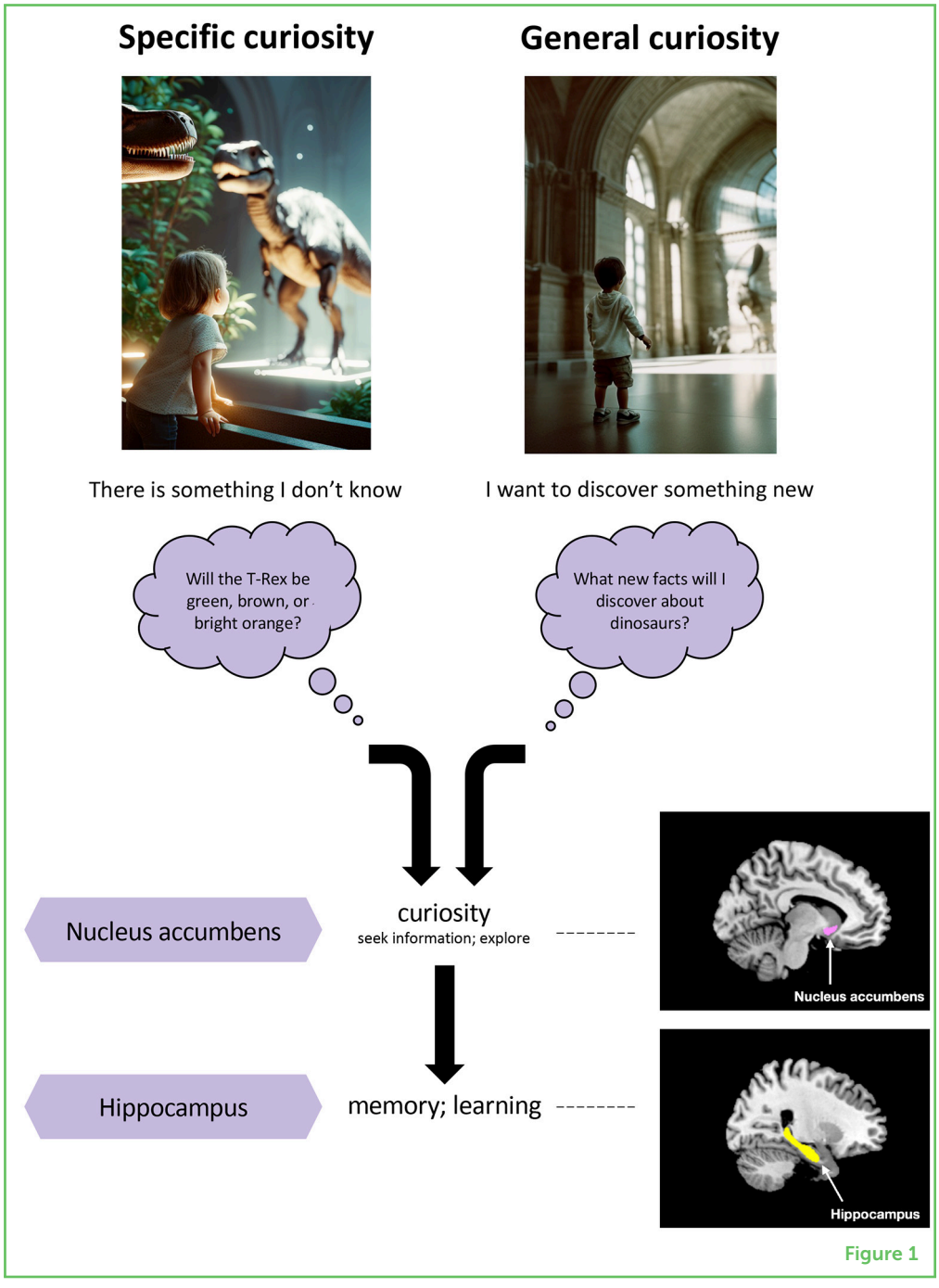

Figure 1

In specific curiosity people are curious about a specific piece of information that is missing. In general curiosity people are curious about discovering new things. Curiosity activates the nucleus accumbens (a brain region that is active when we are about to get a reward) and the hippocampus (a brain region that helps us learn and remember things). When we are curious, we learn things better because our hippocampus is more active than when we are not curious. The figure shows where in the brain the nucleus accumbens and hippocampus are located (figure partly created with Playground AI and MRIcron and MNI-atlas).

activity in the nucleus accumbens—the same brain region that is also active when you see a waiter in a restaurant bringing your dessert, or when your parent is about to give you your weekly pocket money. These brain findings show a link between curiosity and reward [4]. People are curious because it is rewarding to learn something or figure something out.

Curiosity can give you a mental "push" to seek out information, but curiosity may also be important for remembering that information once you have sought it out. Because you experienced curiosity, you created a new memory or learned something that you did not know before. Scientists have found that if you are curious about a piece of information, you remember this piece of information better. When looking at the brain, scientists found that the **hippocampus**—an important region for learning and memory—gets activated when people are curious (see Figure 1). It is as if the learning and memory system in the brain is "warming up" to learn the information that you are curious about [4]. Curiosity can thus be a good thing, because it may help you to learn and remember things better.

HIPPOCAMPUS

A region in the brain that helps people to learn and remember things.

A SUMMARY TO HELP YOU REMEMBER

Curiosity stimulates people to seek information, to explore, and to find answers. Although scientists are still very busy figuring out how curiosity exactly works, here are four important things we know about curiosity:

- People can be curious when they know there is something specific that they do not yet know (specific curiosity), or when they want to discover something new (general curiosity).
- People can be curious about all sorts of things, including seemingly useless pieces of information or negative information.
- Curiosity is a sign that it is rewarding to know or experience something.
- Curiosity can make you remember a piece of information better.

So, the next time you wonder whether any creepy crawlies live under a stone, and you lift it, you may learn something new (a millipede!) and your brain may store this information, because it is a valuable thing to learn about the world.

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YOUNG REVIEWERS

ERIC, AGE: 11
Eric loves animals. He visited the zoo in every city he traveled to. He is very curious about animals and wants to know everything about them. He enjoys playing video games and tennis. He lives in the USA.

JADEN, AGE: 13

Jaden enjoys swimming, hockey, and playing video games. He is very athletic and good at math. He is very curious about history and asks many questions. Jaden's favorite food is sushi. He is very open to learning and loves going to school. He lives in the United States with his mom, dad, and little brother.

KAI, AGE: 10

Kai is a very athletic person. He loves sports such as hockey, baseball, and swimming. He is very energetic and active. During his free time, he likes to make origami and read. He is always enthusiastic at school and willing to learn. He has always dreamed about playing in the NHL. His favorite food is ramen. He lives in the USA.

ROBIN, AGE: 9

I am from Beihang primary school. I like swimming, building Lego, mechanisms, and brain computer interfaces. The brain has many cool functions which I want to explore. I would like to be an astronaut in the future. It is fascinating to know the frontiers of science.

ZHUOHUA, AGE: 8

I am an 8-year-old girl with enormous energy. I like swimming, dancing, and playing the piano. But what I like most is reading fairy tales. Besides this, I am also fascinated by science especially space science. I know a lot of stuff about space such as spacecraft, asteroids, and black holes. In the future, I would like to become a scientist who is also a good piano player.

AUTHORS

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Suzanne Oosterwijk works as an associate professor at the Department of Social Psychology at the University of Amsterdam in The Netherlands. She is interested in emotions and curiosity. She has studied how emotions are produced by the brain. She is also interested in the connection between emotions and the body, and how people understand the emotions of other people. In the last few years, her research has focused on curiosity. For example, she performs experiments to study why people are curious about negative things, such as news about bad things that happen in the world. *s.oosterwijk@uva.nl

MARRET K. NOORDEWIER

Marret Noordewier works as an assistant professor of Social, Economic and Organisational Psychology at Leiden University in The Netherlands. She is interested in how people feel when information is new, unexpected, or unknown. For example, she studies when curiosity, confusion, or surprise feel good (e.g., because it can be nice to discover new things) or bad (e.g., because it can be uncertain not to know it all). Marret is also head of research at the Knowledge Centre Psychology and Economic Behaviour, which aims bridge the gap between science and practice with research, advice, training, and events.

MATTHIAS J. GRUBER

Matthias Gruber works as an associate professor at the Cardiff University Brain Research Imaging Centre (CUBRIC) in Cardiff, Wales, United Kingdom. His research focuses on how the brain supports curiosity and curiosity-based learning. In particular, his research group studies how curiosity affects learning of facts, and how networks in the brain support curiosity-based learning. His group also develops experiments in which curiosity is measured in virtual environments and in video games, to better understand how curiosity affects exploration and thereby further exploration-based learning. Matthias is also interested in promoting research on curiosity via public talks and projects in schools.