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COUNTERFACTUAL THINKING: THE SCIENCE OF WONDERING "WHAT IF?"

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YOUNG REVIEWERS:

DRUM-MONDVILLE ELEMENTARY SCHOOL
AGES: 10–11

LICEO STATALE M. G. AGNESI
AGES: 14–15

Are you a daydreamer? Where do your daydreams take you? Sometimes you might picture silly things, like your teacher riding on a teeny-tiny tractor (my apologies if you just did). However, some of your daydreams may seem more realistic. Both adults and kids get swept up imagining how things could have turned out differently in their lives. With a little brain power, we invent and investigate new possibilities for what could have been. This type of imagining, called counterfactual thinking, is common and it usually strikes when we are thinking back on our past experiences. Interestingly, applying counterfactual thinking might spur our scientific reasoning skills and help us make smarter decisions. Let us take a look at what we know about counterfactual thinking and why it may be a unique mental superpower!

INTRODUCING COUNTERFACTUAL THINKING!

Do you ever find yourself deep in thought, wondering what life would be like if things had happened differently? Like many people, your mind may have drifted toward interesting or positive experiences that you could have had, if what actually happened to you *did not* happen. Picture this—what if your family had moved to a faraway place many years ago? You would have gone to another school, formed different friendships, and maybe explored fascinating places or tried interesting hobbies. How might those experiences have impacted you today? This is an example of **counterfactual thinking**, which is the natural tendency to dream up alternative ways that the past could have unfolded [1].

COUNTERFACTUAL THINKING

Involves imagining how past events could have happened differently. People do this when reflecting on their experiences, thinking up a change to a scenario and picturing how this change would make things turn out.

When psychologists study counterfactual thinking, they are really trying to answer questions about how and why humans use imagination [2]. Many scientists are intrigued by the idea that imagination does not run totally wild like many people assume, but instead pushes us to picture things that are similar to reality [2]. We do this by mentally deleting or adding details to our everyday experiences. Because the scenes we come up with are usually close to our reality, imagination can give us clues about which choices we should actually make [3]. This connection to real life makes counterfactual thinking an especially important research topic.

WHO USES COUNTERFACTUAL THINKING AND HOW?

We know that adults use counterfactual thinking easily and often. However, researchers once questioned whether kids can also engage in counterfactual thinking. *Why?* Because it requires a lot of the brain's energy and needs skills that get stronger as we grow older. For one thing, counterfactual thinking makes use of the brain's **executive functions**. These skills monitor and control our thoughts and behaviors, to help us reach our goals [4]. When we think counterfactually, executive functions make sure we set aside our ideas of what happened so that we can focus on imagining new possibilities [4]. Since executive functions continue developing until we are adults [4], our counterfactual thinking skills may do the same. Counterfactual thinking also involves **episodic memory** [1], which holds onto memories of events that have happened in our lives. Tapping into episodic memory helps us to recall information about scenarios we have been in and to picture them. Younger kids might have difficulty remembering pieces of the past, meaning it could take time before our memories are vivid enough to build on using imagination. Executive functions and episodic memory are complicated skills for the brain to master and juggle!

EXECUTIVE FUNCTIONS

A set of mental skills that focus our attention and guide our thoughts and actions to help us complete tasks.

EPISODIC MEMORY

The brain's ability to store information about past events, which we use to recall what has happened in our lives.

Research from our laboratory at the University of Toronto has found that kids as young as 4 and 5 years old *are* able to think counterfactually

like adults, if the task is not too complicated [5]. In this study, we showed 3-, 4-, and 5-year-olds a simple machine that lights up when green or blue blocks are placed on top. When red blocks are placed on top, nothing happens. After children learned what each block does, an actor put two blocks on the box at the same time and asked what would have happened if she *did not* put a certain block on top.

TEST YOUR COUNTERFACTUAL THINKING SKILLS

Can you play along like one of our participants by looking at Figure 1? In Figure 1A, the actor put a green block and a blue block on the machine and it lit up. Remember that both green and blue blocks make the machine light up. Now, consider this counterfactual question: what would have happened if the actor *did not* put the green block on the machine? Would it still have lit up?

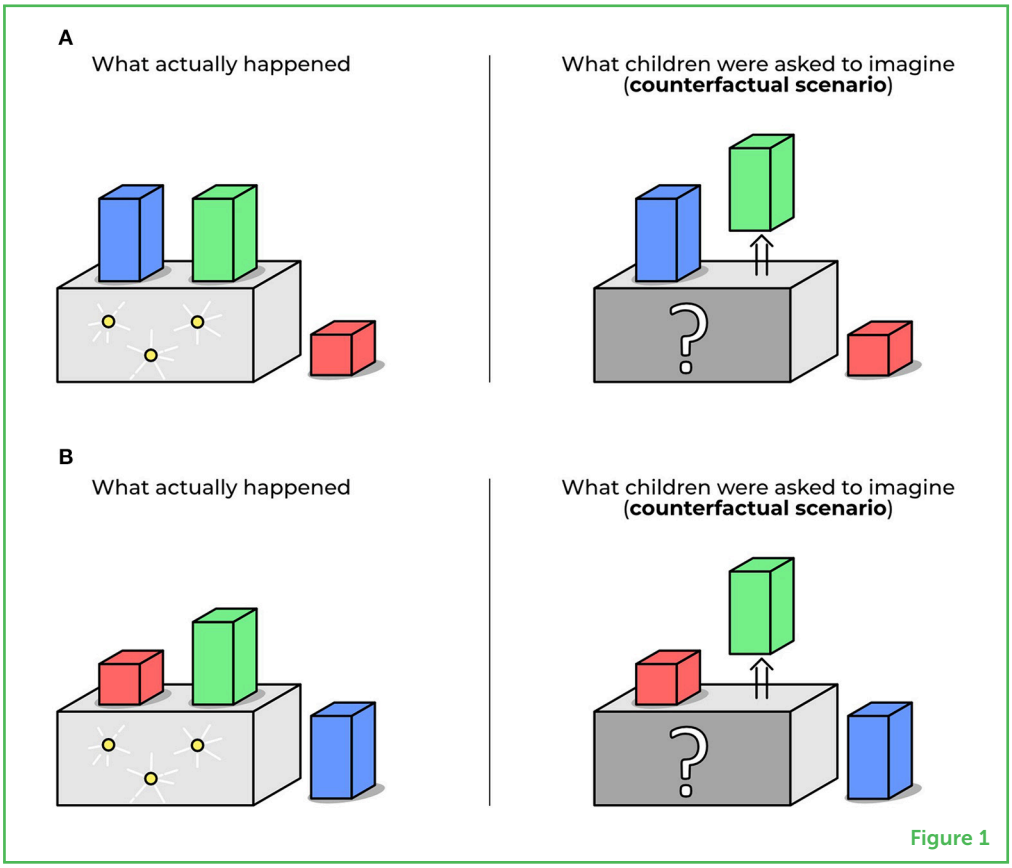

Figure 1

In our study, children first saw a pair of blocks added to a machine that lights up. In one example, children saw the blue and green blocks placed on the machine [as in **(A)**], while in another example, they saw the red and green blocks placed on the machine [as in **(B)**]. The blue and green blocks cause the machine to light up, but the red block does not. In both cases, children were asked what would have happened if the green block was not placed on the machine.

Let us try Figure 1B next, in which the actor put a green block and a red block on the machine. Remember that green blocks make the machine light up, but red blocks do not. Now think about the same counterfactual question again: what would have happened if the actor *did not* put the green block on the machine? Would it still have lit up?

In Figure 1A (green + blue), you probably said the machine would still have lit up, while in Figure 1B (green + red), you probably said the machine would not have lit up if the actor did not put the green block on it. In our study, we found that 4- and 5-year-olds answered these questions correctly, but 3-year-olds did not. This task might seem easy to you, but it is trickier for younger kids. They must *remember* what happened (using episodic memory) but *set aside* their knowledge of the green block (using executive functions) to arrive at an answer. The fact that 4-year-olds can answer these questions shows that they can think about simple counterfactual scenarios. These abilities continue to grow as children get older and can think about increasingly complex events related to reality—like what life would be like if you had moved somewhere new!

WHEN DO WE USE COUNTERFACTUAL THINKING AND WHY?

Psychologists are still learning about and debating why humans engage in counterfactual thinking. Sometimes we use counterfactual thinking simply to satisfy our curiosity, imagining "what if?" as a mini mental experiment [2]. We might picture ourselves getting a surprise blueberry pancake breakfast in the morning instead of our usual oatmeal, or we might imagine our reaction if we spotted a spider on our spoon before taking a bite! Other times, we might use counterfactual thinking in a way that helps us identify the **cause and effect** of events [5], like scientists do when thinking up hypotheses and designing experiments. We could imagine how the sight of a spider on our spoon would *cause* us to drop food onto the floor, with the *effect* of creating a mess! Picturing this counterfactual scenario could then spark our **scientific reasoning** skills [2], leading us to hypothesize that spiders on spoons always give people a fright, which can result in a food-spattered floor. (We would not recommend testing this out on your friends, by the way!) These examples make it clear that we do not think counterfactually just to escape reality. It is an incredible tool that we use to make connections in our own lives and to better understand the world around us.

CAUSE AND EFFECT

The relationship between events when one event is the result of another.

SCIENTIFIC REASONING

Using logical thinking and problem-solving skills to devise and test scientific questions/theories.

Counterfactual thinking may also help us to learn from our past mistakes. Psychologists have found that counterfactual thoughts mostly pop up when we people remember something negative that happened to them, especially if they feel emotions like regret or guilt about what they did to get into that situation [3]. Try remembering a negative experience you have had. Maybe you accidentally hurt a friend's feelings or did not do your best on a test at school (like in Figure 2). You might even feel regretful thinking about that moment...kicking your counterfactual thinking into gear! You are likely to think of what you could have said or done instead, to avoid the negative outcome.

Figure 2

An example of adaptive counterfactual thinking in action! A girl is thinking about a time that she was unprepared for a test. She then thinks about what she could have done differently to pass the test, and she makes plans to change her behavior in the future. Have you ever thought about something in the past that you wish had happened differently and then changed your plans for the future?

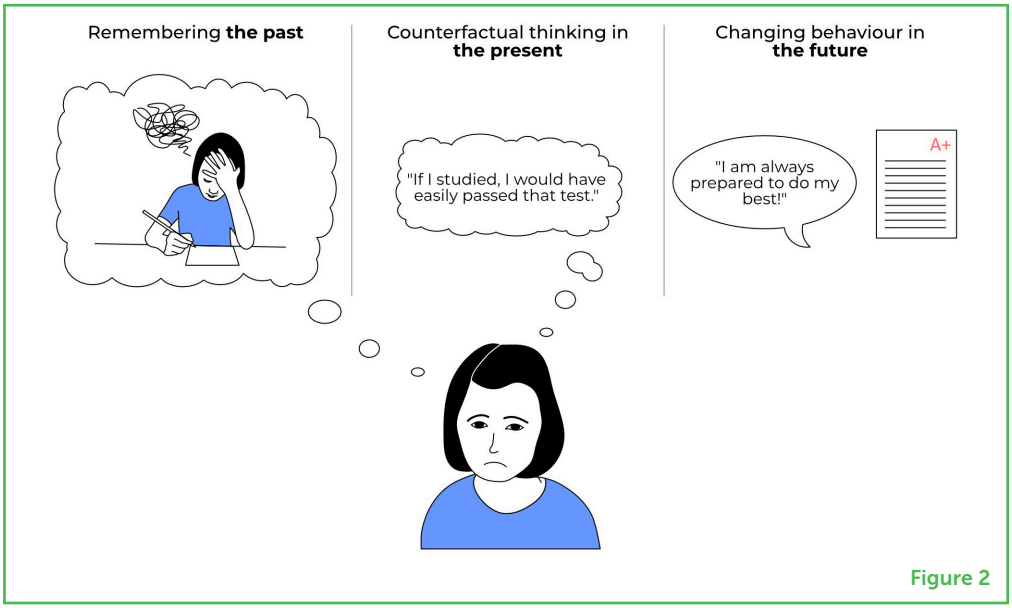

Figure 2

ADAPTIVE

Supporting the wellbeing and functioning of a creature, whether animal or human.

So, visualizing ways to reach outcomes that are more positive really could be helping humans stay happier and healthier [3]. This means that counterfactual thinking might be an **adaptive** trait, allowing us to thrive in our environments. Can you even imagine what life would be like if humans had never developed counterfactual thinking? Inventing counterfactual possibilities is not only a way to explore exciting alternate realities, but also a mental superpower that makes for a brighter future in the real world. So, keep on dreaming! Your daydreams might be teaching you important lessons and pushing you to act in more adaptive ways. That is, if you are not too busy picturing completely silly things or the pancakes in your counterfactual dreams!

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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

DRUMMONDVILLE ELEMENTARY SCHOOL, AGES: 10–11
Hello! We are a group of Grade 5 students from Drummondville Elementary School in Central Quebec. We love math and science and especially learning new things. We are responsible and energetic. We are so "close knit" that we will be moving to a new school soon!

LICEO STATALE M. G. AGNESI, AGES: 14–15
We are a class of lively and intelligent students, we face various difficulties due to our differences but thanks to our knowledge we like working in groups and confronting each other. We always try to brighten up the moment with funny jokes and answers. Thanks to this activity, we could bring together our different ideas to write a final answer. This experience has helped us to understand the ideas of others and have an equal and inclusive type of communication with everyone.

AUTHORS

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Emily Veall recently completed her master's in developmental psychology and

education at the Ontario Institute for Studies in Education, University of Toronto. She keeps busy by researching how children use imagination and reasoning skills, and by working on creative writing projects. Emily finds children hilarious and highly insightful, and she wants to help all kids feel capable of doing amazing things (in big or small ways). In her spare time, Emily loves cycling around the city, collecting old trinkets, and cuddling her cat, Scout. *emily.veall@mail.utoronto.ca

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Angela Nyhout is a developmental psychologist at the University of Kent in Canterbury, England, where she teaches university students and conducts research. In her research studies, she is interested in learning about the human mind at its most fascinating point: childhood! She is especially interested in how children use their imaginations to discover new possibilities and learn about the world around them. Angela loves visiting the seaside and exploring English castles with her two young children. *a.nyhout@kent.ac.uk