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HOW OUR BODILY EXPERIENCES SHAPE OUR THINKING

Venera Gashaj*[*], *Korbinian Moeller and Dragan Trninic

School of Science, Loughborough University, Loughborough, United Kingdom

YOUNG REVIEWERS:

KALLIE
AGE: 14

SHARLYN
AGE: 12

Have you ever wondered how we—as humans—think? Interestingly, while our thinking seems limitless, some scientists argue it relies on something quite ordinary: the human body. This is based on recent research on what is called embodied cognition. This research explores how our thinking is closely tied to our bodily experiences. In this article, we will discuss embodied cognition and how understanding it can transform our approach to learning. Get ready for a fascinating journey that uncovers how your body and mind team up to shape your understanding of the world.

DO OUR BODIES INFLUENCE HOW WE THINK AND LEARN?

Have you noticed how some people feel sad on rainy days? Or how many people, even adults, use their fingers to count? Or maybe you have noticed how we refer to some people as "warm" and others as "cold", and use many other physical and bodily **metaphors** in everyday language, like "feeling down", "stay on top of things", "lend a hand", and so on? Well, such metaphors describe a situation or state by connecting bodily experiences with it. This idea of **embodiment**, or grounding of **cognition** (thinking) in bodily experiences, is fascinating because it provides a new perspective on how the mind works.

In the mid-twentieth century, scientists thought our minds processed information like computers do. They believed we use **abstract** codes in our heads to solve problems, similar to a computer's language of 0 and 1 s. According to this view, the body plays a limited role in thinking. Our brains were seen as computer hardware and our minds as software.

But **embodied cognition** is different. Instead of imagining our minds as software using abstract ideas to reason, embodied cognition argues that cognition is shaped by our bodily experiences and our interactions with the physical world (Figure 1). To break this down with an example, imagine experiencing something new, like learning to play a new sport or a new board game. When this happens, your mind "records" memories about the experience. However, what is recorded includes all sensations you experience in that moment, including **perceptual** (what you see, feel, smell, hear, and taste), motor (how you move), emotional, and **interoceptive** sensations and/or states (such as which body parts were involved, etc.) of how it *felt* to do it. So the "recording" involves your individual, personal sense of performing the activity. Now, when you encounter a similar situation in the future, your brain "replays" parts of the original recordings to help you draw on this experience when dealing with the new situation. This happens without you being aware of it [1]. For example, thinking about using a hammer

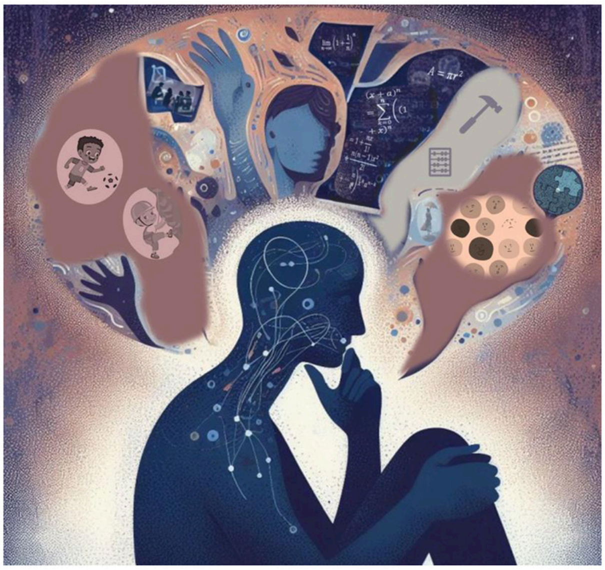

Figure 1

METAPHOR

A word or phrase used to describe something abstract in a vivid way, by relating it to something concrete, creating "a picture in your mind" (that is a metaphor, too).

EMBODIMENT

The idea that cognition is "grounded in" (in other words, cognition is formed and shaped by) bodily experiences.

COGNITION

Various mental activities, such as remembering, reasoning, problem solving, etc.—basically, everything we do to make sense of the world.

ABSTRACT

Not concrete or physical, existing only in thought or as an idea. Something you cannot physically touch or grasp but can think of and understand through thinking.

Figure 1

The mind works through embodied cognition, which means that our thoughts are shaped by physical experiences and interactions, highlighting the connection between body and mind. Experiences can include social interactions, physical activities, emotions, logic, memories, tools, and hand use. Created by AI, retouched by Mango Creativo ©.

or even just seeing it activates the same parts of your brain that are active when you actually use a hammer. This means that your mental image of a hammer includes a simulation of previous experiences of using it.

EMBODIED COGNITION

A theory of cognition that states that cognition is embodied, or deeply dependent upon features of the physical body and, by extension, the environment.

PERCEPTION

Use of the senses, like sight or hearing, to interact with the world around you at a given moment.

INTEROCEPTION

Feeling and sensing things inside yourself, like being aware of your heartbeat, feelings of hunger, or any internal sensations.

MAKING SENSE OF ABSTRACT IDEAS

We use all our perceptual, motor, and interoceptive sensations to make sense of the world. Such connections may be clearer for concrete ideas like using a hammer, in which everyday experiences help shape our understanding. However, the way we use these sensations may be less clear for abstract ideas like justice or mathematical ideas like numbers. Unlike a hammer, which we can directly observe in use or even use ourselves, abstract ideas are more difficult to observe or experience in everyday life (for example, it is difficult to point at "justice"), and some abstract ideas are impossible to observe with our senses (for example, we cannot see "infinity"). So, how do we make sense of abstract ideas? This question is a big challenge for every theory of cognition, but there is a possible answer. Embodied cognition suggests that, to grasp abstract ideas, we connect them to our previous experiences [2]. For example, to understand "justice", we might recall situations in which we have experienced fairness or unfairness and their consequences (such as characteristics of a situation that felt unfair). Try it: think about your idea of justice, about something that was unfair. What do you remember?

For example, when someone cheats in a game, several things might happen at the same time. You see the unfair move, which is a perceptual experience. At the same time, you might have a motor experience, like sitting still in your chair and feeling tense, while the cheating player moves around confidently. Emotionally, you might feel frustrated or angry about what is happening. Simultaneously, you could notice an interoceptive sensation, like your heart racing or your stomach tightening in response to the unfairness. All these experiences can occur together, shaping how you react to the situation.

This way, even abstract ideas can be grounded in perceptual, motor, emotional, and interoceptive experiences. Our bodies and real-life experiences of interactions with the physical world help us make sense of both concrete and abstract ideas.

LEARNING NEW IDEAS

What does embodied cognition mean for learning new ideas, for instance, at school? Think about learning abstract ideas, like in mathematics. Mathematics is often seen as abstract, but embodied cognition implies that real-life bodily experiences help us to master not only basic mathematical ideas (e.g., numbers), but also more advanced mathematical ideas. For the basics, brain research tells us that when we are handling numbers and doing simple arithmetic, there is an overlap in the parts of the brain that are also active when we move our fingers (Figure 2) [3].

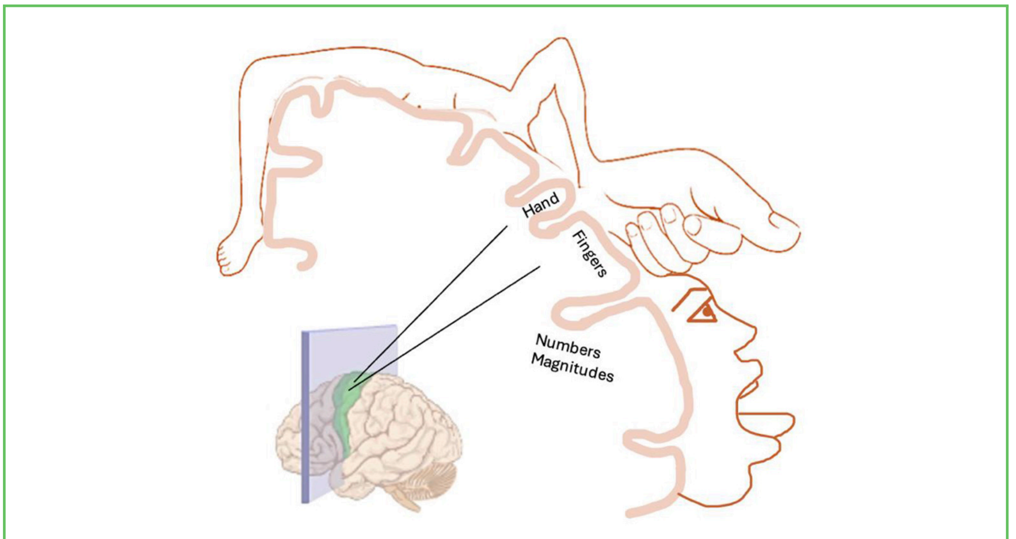

Figure 2

Figure 2

The green area of the brain is involved in motor (movement) and sensory processes. The zoomed-out slice that looks like a stretched-out person is called the motor homunculus, and it shows which parts of the brain control which body parts. Note that the brain part that controls fingers is next to parts of the brain that help us understand numbers and magnitudes. These brain areas are partly overlapping, which could explain why they seem to work together and why fingers are a helpful tool in learning numbers [3]. Brain image from: https://nba.uth.tmc.edu/neuroscience/m/s3/chapter03.html, homunculus drawn by authors.

Ever noticed how younger kids naturally start using their fingers for counting and calculations? Well, it turns out, they naturally establish that connection, because it helps them learn numbers and calculate (Figure 3). You can read more about what movements can teach us about brain function here. Using fingers seems to associate mathematical ideas with bodily experiences and thus things we see and do, making basic mathematics easier to grasp and understand [4].

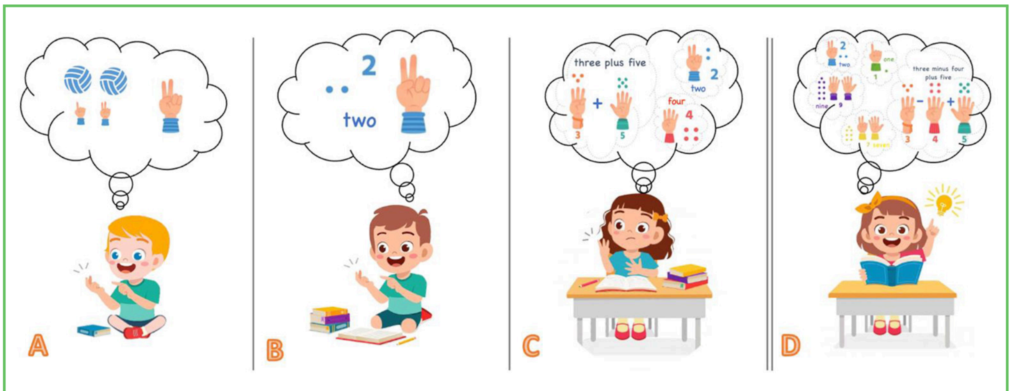

Figure 3

Figure 3

(A) Each finger raised corresponds to a counted item, helping to form unique associations between finger patterns and numbers. **(B)** Different ways to represent the number two, reinforcing the connection between physical actions and understanding number magnitude. **(C)** Fingers aid arithmetic by allowing us to add and break down numbers: for example, three extended fingers plus five equals eight fingers. Eight can be broken down into fours and twos. **(D)** Even when we count in our heads, our brains may still simulate the finger-counting process internally as we

Can we also understand advanced mathematics by moving our bodies? Yes [5]! This might be difficult to believe, especially because a math class usually involves sitting quietly. Nevertheless, there is a story about Terrence Tao, one of the leading mathematicians of today, transition to more abstract reasoning. Individual icons of children designed by Freepik, icons edited and put together by the first author.

that illustrates this point. Terrence is a professor of mathematics at the University of California Los Angeles and a winner of the Fields Medal, the highest prize in mathematics. When discussing one of his mathematical discoveries, Prof. Tao mentioned that to grasp a particularly difficult mathematical idea, it helped him to lay down on the floor and roll around! Why did he do this? Well, he was trying to invent something like a mathematical description of waves rotating on top of one another. He tried pretending to be the thing he was aiming to mathematically describe, and rolling around helped his thinking. In other words, the act of rolling around was similar enough to the mathematical problem he was working on that rolling in a particular way helped him "see" things in a new way. Of course, this does not mean that all students should roll around to learn math. Not everyone will have the same experiential and mathematical background that made this movement meaningful to Prof. Tao. Instead, the story shows that bodily actions can help us make sense of even highly advanced mathematics. And, more generally, although students in classrooms are expected to sit down and work quietly, this restrictive behavior is not the norm for mathematicians, who often walk around, change positions, and gesture (read more here) while trying to understand mathematics.

EMBODIMENT SHAPES OUR THINKING

The idea of embodied cognition invites us to reevaluate how we see the impact of our senses, movements, and feelings while interacting with the world. When we realize just how much our bodies shape our thinking, we gain valuable insights into how we learn and make sense of the world. In school, this perspective emphasizes how hands-on activities and learning through acting out can be effective components of learning even abstract subjects like mathematics.

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REFERENCES

1. Barsalou, L. W. 2008. Grounded cognition. *Ann. Rev. Psychol*. 59:617–45. doi: 10.1146/annurev.psych.59.103006.093639
2. Fischer, M. H., Glenberg, A. M., Moeller, K., and Shaki, S. 2021. Grounding (fairly) complex numerical knowledge: an educational example. *Psychol. Res*. 86:2389–97. doi: 10.1007/s00426-021-01577-4
3. Penner-Wilger, M. M., and Anderson, M. L. 2008. "An alternative view of the relation between finger gnosis and math ability: redeployment of finger representations for the representation of number", in *Proceedings of the 30th*

Annual Meeting of the Cognitive Science Society, Austin, TX, July 23–26, 2008, eds B. C. Love, K. McRae and V. M. Sloutsky (Austin, TX: Cognitive Science Society), 1647–52.

4. Barrocas, R., Roesch, S., Gawrilow, C., and Moeller, K. 2020. Putting a finger on numerical development–reviewing the contributions of kindergarten finger gnosis and fine motor skills to numerical abilities. *Front. Psychol.* 11:1012. doi: 10.3389/fpsyg.2020.01012
5. Nathan, M. J., Schenk, K. E., Vinsonhaler, R., Michaelis, J. E., Swart, M. I., and Walkington, C. 2021. Embodied geometric reasoning: dynamic gestures during intuition, insight, and proof. *J. Educ. Psychol.* 113:929–48. doi: 10.1037/edu0000638

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YOUNG REVIEWERS

KALLIE, AGE: 14

I enjoy learning about neuroscience because of the intriguing brain functions and neurosurgery. Participating in leadership, collaborative events with other youth and community members is one of my passions! I participated in School Council as a representative and Student Government as the co-president. I won the Mayor's Leadership Award for being an active member in those activities! I also play lacrosse, read, crochet multitudes of things, and create digital art! I am fascinated by butterflies, and cats big and small.

SHARLYN, AGE: 12
I am Sharlyn from Sias International School, and I am 12 years old. I enjoy drawing, reading, and making up characters. My favorite animals include cats, butterflies, and whales. My favorite book is The Secret Garden by Frances Hodgson Burnett.

AUTHORS

VENERA GASHAJ
I hold a Ph.D. in developmental psychology and am currently a postdoc at Loughborough University, UK. My research explores how physical movements contribute to understanding math ideas. I focus on the impact of hands-on learning experiences, the influence of the home learning environment, and the role of math anxiety in learning. I use various methods such as long-term observations, experiments, and interviews to uncover insights into these aspects of learning. *v.gashaj@lboro.ac.uk; venera.gashaj@hfh.ch

KORBINIAN MOELLER
I am a professor of mathematical cognition at Loughborough University, United Kingdom. I study how we learn and understand math, using various methods like eye-tracking and brain imaging (e.g., fMRI/DTI and computational modeling). I am particularly interested in how we develop math skills, exploring this through games and hands-on experiences. My goal is to understand how early math skills contribute to later success in math and to promote the development of these skills.

DRAGAN TRNINIC
I earned a Ph.D. in science and mathematics education, and I study how physical and social surroundings shape learning. I see knowledge as a means for engagement. Specifically, I investigate how people grasp mathematics, and how repeated practice leads to exploration and learning. My research methods vary from observing everyday situations to conducting structured experiments.