Imagined Movements May Give People a Leg Up on Actions

By JOHN MONTGOMERY
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Is your mind clear? Good. How many cupboards are there in your kitchen? How many shelves does your refrigerator have?

To answer these questions—or attempt to—most of us need to access visual images of our kitchens and refrigerators and then mentally "scan" those images to try to extract the desired information. We speak of seeing such images in our "mind's eye," and the wording is no coincidence—researchers now know that the visual cortex, the brain region that is employed when we actually see something, is activated in a very similar way during visual imagery.

If you imagine yourself walking through your kitchen, does the thought trigger kinesthetic sensations, as if your arms and legs were actually in motion? For most of us, this rarely happens. Instead, we typically construct a more visual image of our movements, as if we're outside observers watching our own bodies as they move. Yet nearly all of us apparently can become trained to generate "motor images," or mental simulations of movement, without actually moving, and these images also produce activity in nearly identical brain regions to those activated by movement itself.

A number of researchers, particularly Richard Andersen at the California Institute of Technology and Angela Sirigu at the INSERM in Paris, now believe that such motor images may normally be created unconsciously, in a brain region called the posterior parietal cortex, to help plan and fine-tune our movements. And although motor images are mental constructs, they have a remarkable property: They appear to be constrained in much the same way as our physical movements.

Until the last several years, most researchers didn't think the parietal cortex played any role at all in movement. The traditional view is that the parietal cortex forms a mental representation of how the objects we see in the outside world are arranged in three-dimensional space. But Richard Andersen believes that nerve cells, or neurons, in the parietal cortex do much more than respond to and represent visual stimuli. "The idea," Andersen says, "is that when you get to the parietal cortex, you're not simply dealing with sensory information, but you actually have neural activity related to intentions and plans to do things."

Andersen and his colleagues recently identified a group of neurons in the parietal cortex of the macaque monkey that become active just before the monkey makes specific movements. The neurons, however, aren't involved in the act of movement itself. Instead, they appear to become active, or "fire," when the monkey has made a decision to move. If neurons in an "eye movement" region of the parietal cortex begin to fire, the monkey's eyes will move less than a second later. Shortly after neurons in a neighboring "arm movement" region fire, the monkey will move its arm.

By studying the electrical activity of these two sets of neurons, Andersen's group can predict, before the monkey has moved at all, whether it will move its eyes or its arm. Monitoring the activity of these neurons, Andersen says, "allows us to sort of read the monkey's thoughts or intentions about his plans for movement."

Although this exercise in mind-reading is too fine-scale and invasive to be ethically performed in humans, the human parietal cortex may also contain neurons that are involved in planning movements. One advantage of doing comparable studies in people is that the experimental subjects can communicate their thoughts and emotions while they're being experimented on. As Angela Sirigu notes, "we shouldn't underestimate the capacity of monkeys for introspection, but we haven't found a way yet of obtaining reliable reports of their inner experiences."

In a series of experiments on motor imagery, Sirigu and her colleagues carefully trained a group of people to imagine repeatedly touching their thumb to their other fingers in sequence, beginning with the little finger, and to do so in rhythm with the beat of a metronome. Many of the subjects were at first skeptical that they could form discrete motor images, Sirigu says, but soon they were nearly all reporting "vivid kinesthetic sensations" during the imagery task, even though their hands and fingers were motionless.

Sirigu then increased the speed of the metronome until the subjects could no longer imagine moving their fingers fast enough to keep up with the metronome's ticks. After their motor imagery speed was recorded, the same subjects were told to actually perform the finger movements, and Sirigu measured this speed as well. When she compared the subjects' actual finger-movement speed with their imagined speed, Sirigu found that, for each person, the values were nearly identical.

Sirigu then used this same motor imagery experiment to test patients who had suffered damage to their parietal cortex. Parietal-lesioned patients usually have little difficulty making simple movements with their arms and legs. But they often have "apraxia," a disorder that inhibits their ability to execute intricate sequences of movements. They frequently have trouble with tasks such as combing their hair or brushing their teeth. When Sirigu ran these patients through her finger movement test, she found their maximum imagined speed was often dramatically different from their actual speed.

Based on her experiments, Sirigu has hypothesized that, in generating motor images, the parietal cortex may function to set up "an internal model of projected movements, which allows us to make predictions about how the movement will unfold." People with parietal cortex lesions may develop apraxia, Sirigu believes, because they have lost the ability to perform accurate mental simulations of movement—they can no longer produce faithful motor images.

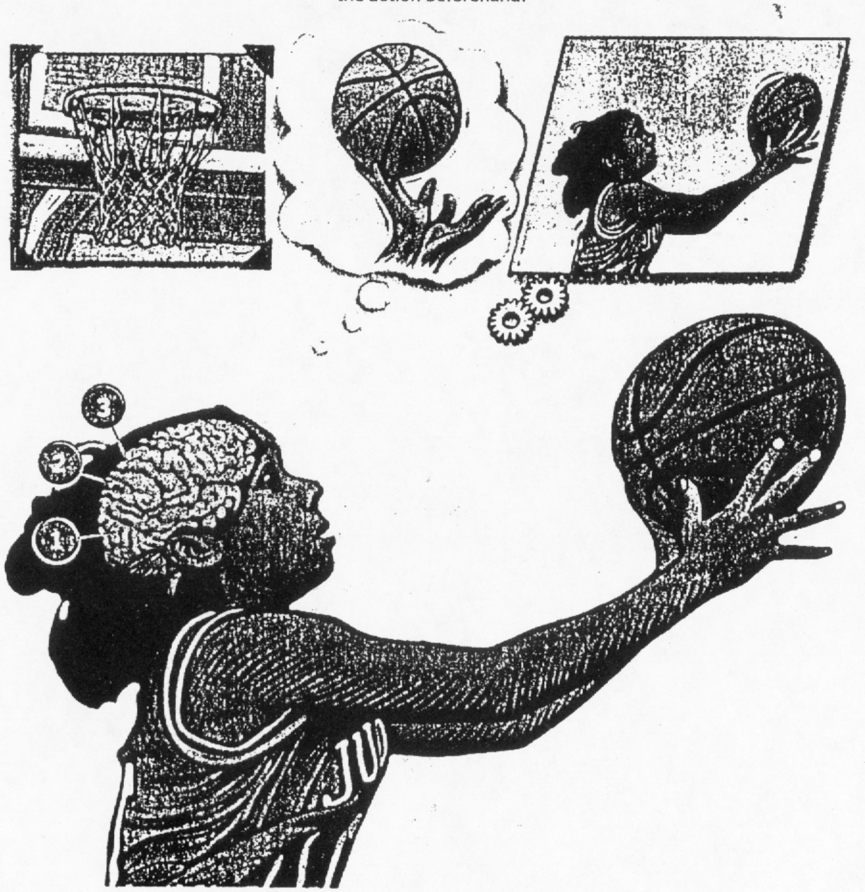
Sirigu's experiments suggest that the motor images we can access are to a great extent limited by the movements we can actually make. People who, for example, are only capable of moving very slowly, can only conjure motor images of equivalent slowness. So learning how to access our motor images apparently won't unleash, or even give the illusion of unleashing, previously unreachable levels of hand and foot speed.

Motor imagery may have evolved this way, Sirigu speculates, because "when you're doing something risky or potentially harmful—like jumping over an obstacle—rehearsing the action in your mind allows you to try out different possibilities when you can't afford to go by trial and error." And if the motor imagination were allowed to run wild, perhaps it would be too easy for us to deceive ourselves about our physical capacities.

In the ancestral savannas and forests, where the human motor system largely evolved, having motor images that were not firmly rooted in reality could have been particularly disastrous. A mental simulation that overestimated running speed, for instance, could have sent one of our ancestors on a confident sprint near a hungry saber-toothed tiger.

Seeing, visualizing, taking action

1. **The visual cortex** is the part of the brain employed when we actually see something with our eyes.
2. **The parietal cortex** is the part of the brain neuroscientists now believe helps plan and fine-tune our physical movements by creating mental images of the action beforehand.
3. **The motor cortex** is the part of the brain involved in the actual movement.



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