SFN 2003 - Day 1 -

Report:
Seeing double: a tale of two pathways
Investigators: Melvyn Goodale, Karl Gegenfurtner and David Milner

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by Rabiya S. Tuma

You see a screwdriver, identify the handle, reach out, and grasp it. Sounds simple enough, but two distinct visual pathways are involved, say neuroscientists - one that perceives an object and another that guides you to it, according to the latest functional imaging studies.

Although the perception and the action both rely on sight, there are two visual pathways involved, say neuroscientists, and these are largely independent of one another. After accidental exposure to carbon monoxide, a patient known as DF lost the ability to recognize objects. She can, however, judge their distance and grasp them appropriately, says Melvin Goodale of the University of Western Ontario in London, Ontario.

She can't tell you what a pencil is when she sees it or which end of it is the top or the bottom, but when she reaches out to take hold of one, she naturally orients her hand so that the lead tip is pointing down and the eraser is pointing up, he says. This dissconnect between identification- and motion-related vision led Goodale and his colleagues to propose that there are two distinct pathways. But without functional data this was largely conjecture, he says.

As early as 1989, Goodale could tell from structural magnetic resonance imaging (MRI) studies that DF had suffered damage to the ventral occipital region. Now she has been tested with functional MRI (fMRI), which measures blood flow in the brain and indicates which regions are activate during a task. And, it turns out, there are different regions responsible for perception-vision and for motion-vision, he says.

When DF was shown line drawings of objects versus scrambled drawings during fMRI testing, there was no difference in the neural activity in the lateral occipital cortex (LO), whereas this region in healthy controls showed strong reactions to the line drawings but not to the scrambled ones. This confirms the researchers' earlier conclusion that DF suffered severe damage to the ventral occipital region.

However, when DF reached for and grasped objects placed in front of her during an fMRI session, there was significantly more activity in the anterior intraparietal sulcus than when she simply touched the objects with the back of her hand. These patterns of brain activity in DF were similar to those seen in control subjects.

Together these data support the team's conclusion that there are different pathways supporting the visual-perception and visual-motor systems.

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During the time that the team has been working with DF, she has become quite well-known, and other researchers and clinicians have been referring similar patients or ones with related disorders to Goodale. In particular, there is a group of patients who have essentially the opposite perturbation to DF.

These patients can identify objects but cannot use visual cues to direct appropriate motion. For example, they can describe how a slot in a box or wall is oriented, but cannot orient their hand appropriately and have trouble putting a card through it.

In collaboration with David Milner, Goodale's group is now looking at these patients. "If these patients work offline, that is they are not reacting in real-time but work from their short-term memory, they improve significantly," said Goodale. DF, by contrast, performs significantly worse when she tries to reconstruct the situation based on past perception, he says.

Clearly the two visual pathways are related, concludes Goodale. The perceptual-vision system responds to the richness of the world, but is weak in its ability to measure the size and distance and angle of things. The motion-vision system, by contrast, is good at the metrics, but weak on identification.

He likens the situation to a robot sent off to Mars. If left by itself, there is no way such a robot could be programmed to respond to all possible situations that it might encounter. If, however, it had a camera attached, and a human controller at home telling it to go get the rock on the right, it could accurately accomplish the task using appropriate grip and movement.

The team is planning a program to test these new patients with fMRI in the near future to see if their lesions are the inverse of DF's, as their visual skills predict.

Sensory and motor systems were traditionally dealt with as different systems in the brain, but that approach needs to change as Goodale's work with DF clearly demonstrates, says Karl Gegenfurtner from Giessen University in Germany who chaired today's session. "We cannot simply look at sensory-motor interactions as simply having sensory then motor analyses, because the motor output itself changes the sensory inputs," he said.

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