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Cognitive neuroscientists shed light on how the brain responds to scenes and their mirror-image reversals

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New research suggests that some parts of the brain perceive a scene and its mirror image as one and the same, meaning those regions are involved in scene categorization rather than navigation.

Picture a penny. You can probably recall its color (copper), which historical figure graces its front (Abraham Lincoln), and even the orientation of the portrait (profile, as opposed to straight on). But can you remember which way Lincoln is facing?

According to MIT research scientist Daniel D. Dilks, only about half of us get this right, meaning we're performing no better than if we had simply guessed. This well-known phenomenon suggests that left-right distinctions are irrelevant to object recognition; in other words, our brains perceive an object and its mirror image as one and the same.

On the other hand, when people look at scenes, it has long been thought that the brain *is* sensitive to left-right orientation, since this information is crucial for navigation. (A road curving to the right must be negotiated differently than one curving to the left.)

However, in a recent study at MIT's McGovern Institute for Brain Research, Dilks and his colleagues identified two parts of the brain that appear to be exceptions to this rule — including one that processes scenes without seeming to distinguish left from right. The results highlight the cognitive differences between perception and action.

The findings were published Aug. 3 in the Journal of Neuroscience; the paper's senior author is Nancy Kanwisher, the Walter A. Rosenblith Professor of Cognitive Neuroscience, and the co-authors are McGovern Institute technical assistant Joshua B. Julian, graduate student Jonas Kubilius of Belgium's Katholieke Universiteit Leuven and Professor Elizabeth Spelke of Harvard University.

On the flip side

The researchers started with "a simple hypothesis," Dilks says: Areas of the brain thought to play a major role in object recognition would be indifferent to right and left, while those that respond to scenes would be sensitive to these distinctions.

To test this idea, the researchers used functional magnetic resonance imaging (fMRI), a technique that measures brain activity associated with perceptual and cognitive tasks. For each trial, participants focused on a pair of images, consisting of two objects or two scenes displayed one after the other. These pairs came in three conditions: two identical images, an image followed by its mirror reversal, or two completely different images.

The researchers predicted that for objects, the brain's response to a pair of mirror images would closely resemble its response to two identical images; that is, brain activity would drop off upon recognition of the second image as the same or virtually the same as the first. On the other hand, for scenes, they expected that mirror-image pairs would be treated as two different images, with the second image provoking a brain response just as intense as the first.

But "we found that it didn't work out that way," Dilks says. Of the two object-selective brain areas they investigated, they found that one was insensitive to left-right reversals, but one, in fact, picked up on these reversals.

More surprising still was the data from the scene-selective regions. Two regions were in line with predictions — that is, they were sensitive to left-right reversals — but one, the parahippocampal place area, or PPA, was not.

Perception versus action

When it comes to processing objects, Dilks says cognitive neuroscientists largely agree that the brain has two separate pathways: one for perception and another for action. When you're looking at a mug, he says, it doesn't much matter if the handle is facing left or right; you still recognize it as a mug. If you're planning to do something with the mug — say, grasp it and bring it to your lips — then "you better [know] left and right, because otherwise you'll be floundering all around trying to pick it up," he says.

According to Dilks, the new results suggest that for scenes, just as for objects, there are separate processing pathways for perception and action — but in the case of scenes, action means navigation, and perception means categorization. The PPA, then, is part of a perception stream,

perhaps helping to categorize environments.

Doris Tsao, an assistant professor of biology at the California Institute of Technology, reaches the same conclusion, saying the new study "challenges the theory that the PPA plays a direct role in navigation, and suggests instead that it may be involved in scene recognition."

This in turn implies that there must be some evolutionary advantage to being able to simply characterize one's surroundings without necessarily needing to navigate them, which makes sense for higher-order social creatures such as humans. Identifying the type of environment you're in, whether it's an office, a playground or a bar, gives you clues as to how you should act.

"You're going to behave very differently at a beach than you would in the city, for example," Dilks says.

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