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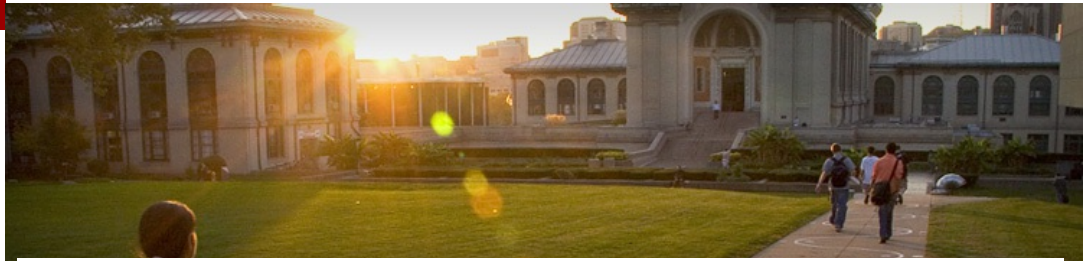
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Carnegie Mellon Study Identifies Where Thoughts Of Familiar Objects Occur Inside the Human Brain

Experts Trained Algorithm To Extract Patterns From Participants' Brain Activation Scans

PITTSBURGH — A team of Carnegie Mellon University computer scientists and cognitive neuroscientists, combining methods of machine learning and brain imaging, have found a way to identify where people's thoughts and perceptions of familiar objects originate in the brain by identifying the patterns of brain activity associated with the objects. An article in the Jan. 2 issue of PLoS One discusses this new method, which was developed over two years under the leadership of neuroscientist Professor Marcel Just and Computer Science Professor Tom M. Mitchell.

A dozen study participants enveloped in an MRI scanner were shown line drawings of 10 different objects - five tools and five dwellings - one at a time and asked to think about their properties. Just and Mitchell's method was able to accurately determine which of the 10 drawings a participant was viewing based on their characteristic whole-brain neural activation patterns. To make the task more challenging for themselves, the researchers excluded information in the brain's visual cortex, where raw visual information is available, and focused more on the "thinking" parts of the brain.

The scientists found that the activation pattern evoked by an object wasn't located in just one place in the brain. For instance, thinking about a hammer activated many locations. How you swing a hammer activated the motor area, while what a hammer is used for, and the shape of a hammer activated other areas.

According to Just and Mitchell, this is the first study to report the ability to identify the thought process associated with a single object. While earlier work showed it is possible to distinguish broad categories of objects such as "tools" versus "buildings," this new research shows that it is possible to distinguish between items with very similar meanings, like two different tools. The machine-learning method involves training a computer algorithm (a set of mathematical rules) to extract the patterns from a participant's brain activation, using data collected in one part of the study, and then testing the algorithm on data in an independent part of the same study. In this way, the algorithm is never previously exposed to the patterns on which it is tested.

Another important question addressed by the study was whether different brains exhibit the same or different activity patterns to encode these individual objects. To answer this question, the researchers tried identifying objects represented in one participant's brain after training their algorithms using data collected from other participants. They found that the algorithm was indeed able to identify a participant's thoughts based on the patterns extracted from the other participants.

"This part of the study establishes, as never before, that there is a commonality in how different people's brains represent the same object," said Mitchell, head of the [Machine Learning Department](#) in Carnegie Mellon's [School of Computer Science](#) and a pioneer in applying machine learning methods to the study of brain activity. "There has always been a philosophical conundrum as to whether one person's perception of the color blue is the same as another person's. Now we see that there is a great deal of commonality across different people's brain activity corresponding to familiar tools and dwellings."

"This first step using computer algorithms to identify thoughts of individual objects from brain activity can open new scientific paths, and eventually roads and highways," added Svetlana Shinkareva, an assistant professor of psychology at the University of South Carolina who is the study's lead author. "We hope to progress to identifying the thoughts associated not just with pictures, but also with words, and eventually sentences."

Just, who directs the [Center for Cognitive Brain Imaging](#) at Carnegie Mellon, noted that one application the team is excited about is comparing the activation patterns of people with neurological disorders, such as autism. "We are looking forward to determining how people with autism neurally represent social concepts such as friend and happy," he said. Just also is developing a brain-based theory of autism. "People with autism perceive others in a distinctive way that has been difficult to characterize," he explained. "This machine learning approach offers a way to discover that characterization."

The project applying machine learning to brain patterns was funded by the W.M. Keck Foundation and the National Science Foundation.

For more information on the article contact Marcel Just, at 412-268-2791.

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Top photo: Marcel Just; Bottom photo: Tom Mitchell

