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Researchers Trace Roots of Vivid Memories

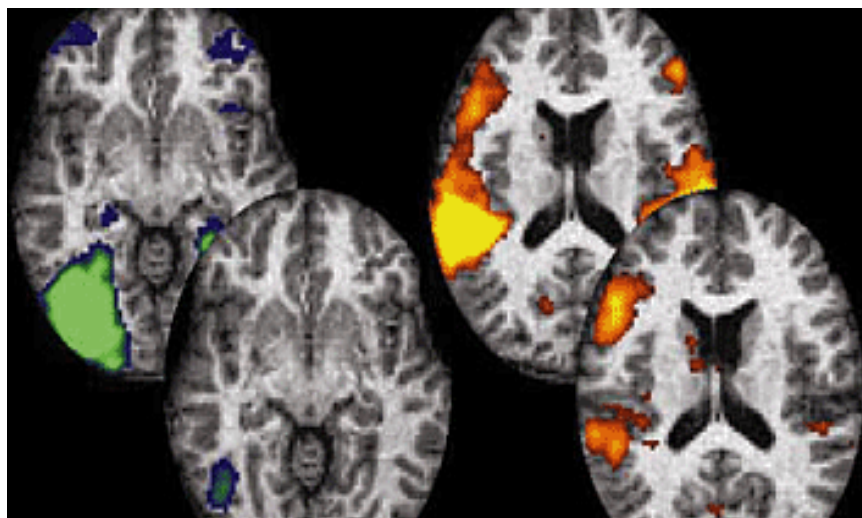


Image Title: Four horizontally-sliced brain images acquired using magnetic resonance imaging show regions of the brain active during perception of environmental pictures (top left) and sounds (top right), and subsequently during retrieval of the same pictures (bottom left) and sounds (bottom right) from long-term memory. These data indicate that regions of sensory cortex are reactivated when remembering sensory-specific information. - Mark Wheeler, Steven E. Petersen, Randy L. Buckner

Researchers have found that calling up vivid memories—the face of a loved one or the chords of a favorite song—activates regions of the brain responsible for processing sensory experiences. When a person recalls a vivid memory, some of the sensory regions of the brain responsible for etching the original memory are reactivated.

In an article published in the September 26, 2000, *Proceedings of the National Academy of Sciences*, Howard Hughes Medical Institute investigator Randy L. Buckner, Mark E. Wheeler and Steven E. Petersen at Washington University in St. Louis describe how they used functional magnetic resonance imaging (fMRI) to probe the roots of a longstanding hypothesis in the field of memory research. According to the reactivation hypothesis, brain regions that

are activated when a person has a sensory-specific experience are reactivated whenever the person remembers that experience.

"The question of how the brain represents memories as we experience them has been debated for more than a century with no clear answers," said Buckner. "We thought that fMRI, with its ability to see changes in brain activity on a moment-to-moment basis, would give us a prime opportunity to gain new insight into this fundamental question."

In fMRI, powerful magnetic fields and radio waves are used to image the brain and other body structures. In brain studies, these images reveal detailed changes in blood flow that occur when specific regions of the brain are activated.

According to Buckner, previous studies by other scientists indicated that stimulation of the brain's visual-processing region evoked visual memories. Likewise, studies showed that asking people to visualize scenes activated visual areas of the brain. But no one had done key experiments to "watch" the brain as sensory-specific memories were evoked in test subjects, said Buckner.

In their first set of experiments, Buckner and his colleagues presented volunteer subjects with a range of pictures of ordinary objects such as a dog, an airplane or a drum; or common sounds such as a dog barking, a plane's roar or a drum's tapping. Labels of descriptive text accompanied the images and sounds. After familiarizing the subjects with the images or sounds, the researchers placed each subject in an MRI scanner and presented them with the labels associated with the pictures or sounds. Each subject was then asked to recall the associated image or sound while the researchers used fMRI to take snapshots of brain activity. Analysis of the results showed that recalling images almost invariably activated the visual cortex while recalling sounds activated the auditory cortex.

"Perhaps we were seeing memory's echo in the brain—activity associated with the stored memory that momentarily bounces back to our awareness when we attempt to remember," said Buckner. While some of the findings were expected—and confirmed the reactivation hypothesis—others were a surprise.

"Given previous research, it was natural to expect that the same brain areas used to perceive visual and auditory information might also be involved in remembering seen and heard items. However, not all the areas involved in perceptions were reactivated during remembering.

"Instead, we found that a subset of these areas representing the highest-level areas in perception were reactivated. While we need to do more work to understand this discovery, it suggests that during remembering the brain areas reactivated do not include those involved with the earliest levels of

perception, but rather selectively rely on high-level brain areas that already contain rather complex representations of sensory information."

Buckner emphasized that the findings confirm and extend the reactivation hypothesis. "For the first time, we have actually seen the brain areas that subserve the reactivation process," he said. "As we learn more about these perceptual areas we will begin to understand how they serve as building blocks for memories. This study gave us some initial insights into which brain areas might represent these building blocks." According to Buckner, an understanding of how the brain represents information during remembering is a resonant mystery for people.

"We have all shared the experience of closing our eyes and remembering what a family member looks like or what a new tune on the radio sounds like. And we are all interested in how our brains help us to do this. These findings that the brain reactivates sensory areas during remembering helps explain how this rich experience of remembering may result in part from the reactivation of multiple sensory areas." According to Buckner, the findings also represent a step along the pathway to understanding and possibly alleviating memory loss associated with various diseases.

"By understanding how such memories can be successfully accessed in healthy subjects, as we did in this study, we begin to build a foundation for exploring why such memories fail in patients with memory difficulties," he said.