UCLA Neuroscientists Reveal The Symphony Of Memory Formation; **Advanced Imaging Shows Crescendo, Diminuendo Of Brain Circuitry**

University Of California - Los Angeles

Using newly developed imaging techniques, UCLA neuroscientists for the first time have "unfolded" the brain's sea-horse-shaped hippocampus to reveal how dynamic activity within the brain structure's complex architecture orchestrates memory formation. Details appear in the Jan. 24 edition of the peer-reviewed journal Science.

The researchers used extremely high-resolution functional magnetic resonance imaging (fMRI) and software developed at UCLA's Ahmanson-Lovelace Brain Mapping Center to study blood flow within the hippocampus as 10 human volunteers learned to associate names with faces.

The study identified areas within the hippocampus -- the cornu ammonis and the dentate gyrus -- as highly active only during encoding of the face-name pairs. This activity decreased as associations were learned. The subiculum, another area of the hippocampus, was active primarily during the retrieval of the face-name associations. Activity in the subiculum also decreased as retrieval became more practiced.

Previous studies have demonstrated the importance of the hippocampus in forming memories. However, no studies until now have directly examined how activity patterns within specific substructures change during learning.

"Our findings demonstrate that memory formation is a dynamic process, with subdivisions within the hippocampus making distinct but changing contributions as learning takes place," said lead author Michael M. Zeineh, a Brain Mapping Center researcher and student in the David Geffen School of Medicine's Medical Scientist Training Program. "Brain activity increases as information is introduced, then diminishes as the new information becomes better learned.

"As knowledge about the brain's complex circuitry grows, neuroscientists will be better able to understand and address a host of debilitating neurological disorders, from Alzheimer's disease to epilepsy to damage caused by head injuries," Zeineh said.

The brain's hippocampus is located on the floor of each lateral ventricle. The debilitating effects of damage to the hippocampus were highlighted in the 2001 feature film "Memento," which told the story of a man who struggles to track his wife's killer despite a head injury that destroys his ability to form short-term memories.

The UCLA study used fMRI to scan the brains of volunteers as they viewed information using goggles with a TV display. Researchers first introduced pairs of names and faces in sequence and instructed volunteers to learn which face corresponded to which name. In order to distract the subject to prevent rote rehearsal, researchers then asked the volunteers to focus on a crosshair on the screen and report any change. Finally, the researchers showed the volunteers the earlier faces at random, asking them to recall the name associated with each. The process was repeated five times over eight minutes.

Researchers used the scans to evaluate blood-oxygen level dependent signals. When the brain becomes active, blood flow increases. The magnetic properties of hemoglobin, a protein in red blood cells that carries oxygen to body tissues, vary depending on the level of oxygenation. These differences can be detected by fMRI.

Other UCLA researchers on the team were Stephen A. Engel of the Department of Psychology; Paul M. Thompson of the Laboratory of Neuroimaging and Department of Neurology; and Susan Y. Bookheimer of the Ahmanson-Lovelace Brain Mapping Center and Department of Psychiatry and Biobehavioral Sciences, Division of Brain Mapping.

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The Ahmanson-Lovelace Brain Mapping Center at UCLA seeks to improve understanding of the brain in health and disease, through the comprehensive and quantitative study of its structure and function.