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What memories are made of

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Why is it that amnesia patients can't remember their names or addresses, but they do remember how to hold a fork? It's because memories come in many flavors, says Fred Helmstetter, professor of psychology at the University of Wisconsin–Milwaukee (UWM). Remembering what is not the same as remembering how.

"Different circuits in the brain are activated when you remember what you had for breakfast this morning versus when you fell off a bicycle in second grade," says Helmstetter, who researches the brain's regulation of memories, emotions and learning.

And it's those distinctive connections in the brain's communication network that differentiate between the "aware," or conscious, memories and the unconscious ones, some of which Helmstetter calls "emotional memories."

Selectivity is one of the many aspects of memory that intrigues him, and it's key to his research into the specific brain process that is responsible for making you aware of what you've learned or remembered.

Dissecting the mechanisms behind emotional memory is important because the region of the brain that governs this also controls fear and anxiety. That is why an emotional memory, such as a traumatic car accident, can activate the autonomic nervous system, causing bodily responses like an increase in heart rate, sweating and blood pressure – even if you don't realize it.

So the research has implications for a variety of illnesses, from Alzheimer's disease to anxiety disorders.

Unraveling the differences between kinds of memories, Helmstetter believes, depends on understanding the chemical changes that happen in the brain at the molecular level.

Helmstetter's work has already shown how memories are stored in certain neurons. Now he wants to know more about the molecular players that make the brain's whole network of constantly changing memory connections possible. His extramural funding has come from sources such as the National Science Foundation and the National Institute of Mental Health.

Once thought to be static, the adult brain is now known to be the opposite – constantly forming or breaking neural connections and growing new cells.

It happens automatically when you exercise, take drugs or recover from certain illnesses. But it also occurs by simply thinking: The brain reroutes its communication pathways and its genetic instructions in response to experience.

"When you first learn something, such as how to ride a bike, there is an actual physical change in the brain – the cells make proteins they didn't make before," Helmstetter says.

The brain's capacity for dynamic states, called neuroplasticity, or just plasticity, makes tracking the circuitry behind memories a task of near-epic proportions. Hundreds of variables come into play.

Consider, for example, that a lot of memory formation and storage goes on simultaneously, some of it consciously and some of it unconsciously.

And, in the time it takes to commit something to memory, hundreds of other experiences are being sorted and perhaps stored.

A message passed between two neurons is like person-to-person e-mail rather than a listserv. It does not trigger a global response in the brain's processing network.

Sound complicated? "That's right," says Helmstetter. "Plasticity is functionally infinite."

So how can scientists investigate under such a tempest of changing circumstances? It would be impossible to track all the neural adjustments marking every new condition, Helmstetter concedes. So he uses a mix of approaches.

One weapon in his investigative arsenal is an imaging technique that produces a 3-D picture of the parts of the human brain that are active during memory formation or recall. Using functional magnetic resonance imaging (fMRI), Helmstetter can "map" the anatomy of plasticity because it allows him to actually see, in real time, where cells are more active and use more energy.

But since it isn't yet possible to observe which genes turn on and off while humans call up their memories, he does the next best thing: He studies what happens in rats. He further simplifies the experiments by modifying the expression of whole families of genes at once.

"Our initial approach has been to use broad strokes," he says. "We suppress the whole compliment of genes involved in memory formation rather than chasing each individual gene and its expression."

The rat results are then compared with the information gleaned from the memory imaging in humans to see if there's a correlation. The memory circuitry is the same in both organisms, he says.

But of potentially more value is finding the exact role that genes and proteins play in the brain in response to stimuli, he says, because genes also are affected by environment.

What he's discovered suggests he is on the right track. Storage of a memory is a time-dependent endeavor. The process of making a memory involves a set of genes that are expressed or come "on" right away, he says.

"We now look at time versus structure," he says. "And we're focused on a set of proteins that appear to be required in several parts of your brain right after something important happens to you."

Source: University of Wisconsin - Milwaukee

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