Medical Xpress

Neuroscientists discover long-term potentiation in the olfactory bulb

May 3 2009

Ben W. Strowbridge, Ph.D, associate professor of Neuroscience and Physiology/Biophysics, and Yuan Gao, a Ph.D. student in the neurosciences program at Case Western Reserve University School of Medicine, are the first to discover a form of synaptic memory in the olfactory bulb, the part of the brain that processes the sense of smell.

Their study, entitled "Long-term plasticity of excitatory inputs to granule cells in the rat olfactory bulb" will be published in the June 2009 issue of Nature Neuroscience and is currently available online.

In the 1970s, scientists discovered that elemental connections between brain cells, called synapses, could change their strength following brief periods of activity. This process, called long-term potentiation (LTP), is the leading candidate to explain how we store information about specific places, names and events. While laboratories around the world have found LTP in nearly every part of the mammalian brain there was one glaring exception: the part of the brain that first processes the sense of smell, the olfactory bulb.

Gao, a fourth-year graduate student, had learned that damaging olfactory sensory pathways prevents sheep from forming selective bonds with her own lambs, causing them to adopt lambs from other mothers. This cued her curiosity as to how a mother ewe forms such a selective bond with her lamb within several hours of parturition, a bond that is primarily dependent on olfactory sensory recognition.

Using an innovative home-built laser microscope, Strowbridge and Gao were able to determine that the olfactory bulb does in fact have LTP. This specialized microscope used an advanced imaging technique called "2-photon excitation" which enabled the researchers to see entire brain cells and then test whether different types of inputs to the cell could mediate olfactory memory.

"The real surprise in the study was the specific brain connection that changed following experience. It was a rarely-studied brain projection from the cortex back to the olfactory bulb" said Strowbridge.

Neuroscientists commonly believe that the way the brain processes information is similar to climbing a pyramid—starting from the bottom and working up to the top. All of the sensory systems have a large number of low-level cells that do very simple things (forming the base of the pyramid), and then they feed their results to brain areas higher up the pyramid. The brain cells in these "higher" regions begin to reflect abstract concepts, such as the shape of human faces, in the visual system or melodies in the auditory system. The brain areas related to our conscious perception of the world are presumably at the top of pyramid.

However, the Case Western Reserve University researchers found that the brain circuit had the ability to change with experience was unexpectedly a connection from high in the pyramid (the olfactory cortex) back to a lower level (the olfactory bulb).

One of the implications of Strowbridge and Gao's work is that the brain may learn about different smells by having higher brain areas first make a prediction about which scent it might be, and then test that prediction against the actual sensory data coming into the brain.

"Our work suggests that there is much more talking back-and-forth between higher and lower brain areas during olfactory learning," continued Strowbridge. "We are just beginning to explore the function of the feedback circuits that inform low-level parts of the brain, like the olfactory bulb, about predictions made by higher-order brain regions. The 2-photon microscope used in this study is an ideal tool to ask what these different brain circuits are actually doing."

Previous studies had suggested that the circuit changes associated with olfactory learning, such as sheep learning to recognize their own lambs though their characteristic scents, involved changes in the olfactory bulb. Strowbridge and Gao discovered that certain olfactory brain circuits can change with experience. This discovery provides a possible explanation for how animals can form memories of particular scents.

In 2006, Strowbridge's grouped discovered a new type of brain cell, the Blanes cell, in the olfactory bulb, also using the same home-built 2-photon microscope. Ramón y Cajal, an important Spanish anatomist, had drawn pictures of these cells and named them for one of his medical students in the late 1800s. They stayed a curiosity item in very old textbooks until Strowbridge's laboratory found that they represented a very important cell type in the brain. Using 2-photon imaging, the CWRU group showed that Blanes cells have unusual properties that may help the brain maintain memories of smells and also opened a new approach to understanding the basis of memory impairment in Alzheimer's disease. That study was published in the March 16, 2006 issue of the journal Neuron.

This study was funded by the National Institutes of Health. The 2-photon laser microscope used in the study was constructed with support from the Mount Sinai Health Care Foundation.

Source: Case Western Reserve University (news : web)