Neuronal filters for broadband information transmission in the brain

21 November 2011

(Medical Xpress) -- As in broadband information technology, the nervous system transmits different messages simultaneously from one brain region to others. But how are messages retrieved at the other end without confusing them? Scientists from the Friedrich Miescher Institute for Biomedical Research (FMI) have discovered neuronal filters between the olfactory bulb and the cortex that can handle this problem. In a study published in *Nature* they show that neuronal filtering in the cortex can extract information about specific odors from the plethora of information that is broadcast by the olfactory bulb. This filtering is likely to be important for the perception and memory of odors, and may also be implemented in other brain areas.

In the age of Morse, information transmission was straightforward: a telegraph operator at one end of a wire encoded a message in a train of clicks that was then received and decoded at the other end. With an ever increasing need for urgent messages, however, more efficient modes of transmission were required. Nowadays, multiple messages are sent through the same wire simultaneously, or even broadcast everywhere in wireless mode. How, then, is a given message extracted from this muddle and correctly decoded? One solution is to encode different messages in different frequency bands and tune the receiver to the desired frequency, as in our radios.

The brain has to deal with similar problems. Nerve cells send all kinds of messages to other nerve cells using a code that resembles the Morse code. At each moment in time, an individual nerve cell in a network has to extract the relevant information from a bombardment of inputs while ignoring irrelevant inputs. Scientists from Rainer Friedrich's group at the Friedrich Miescher Institute for Biomedical Research have now elucidated how this is done as information is transmitted from the olfactory bulb to its cortical target. In a great team effort, they determined how the nerve cells in the cortex process odor information without being lost it in the cacophony of clicks from the olfactory bulb neurons. Their results are published online in the leading journal *Nature*.

The olfactory bulb is the first olfactory processing center in the brain. Upon stimulation of sensory neurons in the nose with an odor, nerve cells in the olfactory bulb produce complex patterns of activity that are transmitted to multiple higher brain regions. Since individual neurons can be activated by several odors, information about each odor is encoded by many nerve cells. Moreover, the pattern of activity encodes different information on different time scales. Fast components of the activity patterns, for example, are informative about broad categories of odors, while the precise identity of a stimulus is encoded efficiently in the slower components. Friedrich's group therefore studied the filters that are used to read out these patterns in the cortex, an area that is believed to form specific olfactory memories. They took advantage of the zebrafish, a small vertebrate model system that allows for the combination of sophisticated optical, genetic and electrophysiological techniques. "To tackle the function of biological systems of such complexity we ultimately need mathematical models. But to construct good models we first need measurements and data from many individual nerve cells" comments Friedrich, "and in the olfactory system of the zebrafish we are able to obtain this data."

Through the development of an ingenious optogenetic tool and pure assiduity, the scientists could explain how information about specific odors is transferred from one area of the brain to the next. They found that neurons in the cortex employ what is called a low pass filter. In other words, nerve cells tune in specifically on those parts of the neuronal conversations that are informative about the precise identity of an odor. "It may appear that some information is lost through this filter", said Friedrich. "However, we know that there are nerve cells in other brain areas that apply other filters. We therefore believe that the brain uses sophisticated arrays of filters to ensure that neurons receive appropriate messages. Neuronal filtering may thus play an important role in the perception and memory of odors and other stimuli."

More information: Blumhagen F, et al. (2011) Neuronal filtering of multiplexed odour representations. *Nature*, Nov 13. doi: 10.1038/nature10633 [Epub ahead of print]

Provided by Friedrich Miescher Institute for Biomedical Research