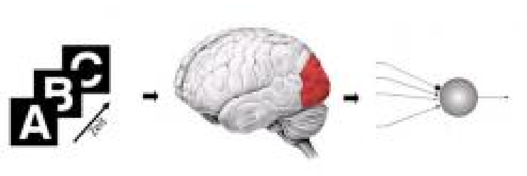
Researchers crack part of the neuronal code

22 December 2009



The scientists were able to predict the letters shown to the test animals based on their brain activity. To this end, they created a computer simulation of simple neurons (shown schematically on the right) and fed them with the data they had measured in the animals' brains in response to a visual stimulus. Image: Max Planck Institute for Brain Research

(PhysOrg.com) -- Prostheses for paralysed patients, communication with patients who have lost all capacity for normal communication - the hopes for modern brain research are high. However, such brain-machine interfaces (cyborgs) require a complete dictionary, with the help of which the activities of the brain can be translated successfully into desires, ideas and movement plans.

Together with colleagues from the Graz University of Technology, scientists from the Max Planck Institute for Brain Research in Frankfurt have succeeded in taking a step towards achieving this. They have shown that early processing stages in the brain gather information over an extended period.

How does the brain store detailed information from sensory stimuli? How much can researchers read from the activity of certain regions of the brain? Current findings confirm a new theory. Up to now, scientists had assumed that the early stages of information processing in the brain took place gradually, that is that one stimulus was processed after another in a conveyor-belt-like sequence. This idea must now be revised. As Danko Nikoli? from the Max Planck Institute for Brain Research and his Austrian colleagues Wolfgang Maass and Stefan Häusler have shown, the activity in early brain areas depends on stimuli that arose some time ago. "The brain functions like a jug of water into which stones are thrown and, as a result, generate waves," explains Nikoli?. "The waves overlap but the information as to how many stones were thrown into the jug and when they were thrown in is retained in the resulting complex activity patterns of the fluid."

The brain is clearly able to render this information usable and, for example, to superimpose images seen in succession. The duration and intensity of the continuing effect of images that have just been seen corresponds to a very detailed visual memory also known as iconic memory. If you see an image and close your eyes immediately afterwards it remains visible for a short while. It may be located in the primary visual cortex.

Researchers 'read' brain activity

The scientists showed letters to cats while electrodes recorded the activity of up to 100 cells in the animals' primary visual cortex. The team from Graz created computer-simulated neurons for the interpretation of these signals. Based on the activity of the neurons, the scientists were able to conclude which letter the cat had just seen. Following a brief training period, the simulated cells were able to provide very reliable indications of the visual stimuli processed. The researchers then changed the letters, altered the duration of their presentation or that of the pauses between them. They then tried to predict again which letters the cats were shown and the letters they had seen shortly before. The results obtained support the "wave" theory: apart from information about the image just seen, the neurons also transmitted information about the previously viewed images.

Having established this much, the researchers wanted to identify the aspects of brain activity that involve most information. In the same way as tone, cadence or a word itself carries meaning in different languages, the language of the brain could be based, for example, on the intensity or precise timing of the response. To establish this, the scientists blurred the temporal precision and observed how the predictive power of the simulated cells changed. Without the temporal information, there was a sustained diminution of this power. Hence, the brain clearly codes the information about a stimulus in terms of both the intensity and the precise temporal structure of the neuronal responses.

The researchers particularly welcomed the fact that the simulated cell was relatively simple in its structure but nonetheless provided good results. "When we created a more complex design for the evaluation program, the quality of the readout only changed marginally. This facilitates the task of developing artificial prostheses enormously," says Nikoli?.

More information: Danko Nikoli?, Stefan Häusler, Wolf Singer and Wolfgang Maass, Distributed fading memory for stimulus properties in the primary visual cortex, *PLoS Biology*, December 22nd, 2009

Provided by Max-Planck-Gesellschaft