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Do “traffic lights” in the brain direct our actions?

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In every waking minute, we have to make decisions – sometimes within a split second. Neuroscientists at the Bernstein Center Freiburg have now discovered a possible explanation how the brain chooses between alternative options. The key lies in extremely fast changes in the communication between single nerve cells.

The traffic light changes from green to orange – should I push down the accelerator a little bit further or rather hit the brakes? Our daily lives present a long series of decisions we have to make, and sometimes we only have a split second at our disposal. Often the problem of decision-making entails the selection of one set of brain processes over multiple others seeking access to same resources. Several mechanisms have been suggested how the brain might solve this problem. However, up to now, it is a mystery what exactly happens when during a rapid choice between two options. In the current issue of the “Journal of Neuroscience”, Jens Kremkow, Arvind Kumar, and Ad Aertsen from the Bernstein Center Freiburg propose a mechanism how the brain can choose between possible actions – already at the level of single nerve cells.

As the structure and activity of the brain are just too complex to answer this question through a simple biological experiment, the scientists constructed a network of neurons in the computer. An important aspect of the model in this context is the property of nerve cells to influence the activity of other nerve cells, either in an excitatory or inhibitory manner. In the constructed network, two groups of neurons acted as the senders of two different signals. Further downstream in the network, another group of neurons, the “gate” neurons, were to control which of the signals would be transmitted onward.

As the cells within the network were connected both with exciting and inhibiting neurons, the signals reached the gate as excitatory and, after a short delay, inhibitory activity. In their simulations, the scientists found that the key for the gate neurons’ “decision” in favour of one signal over the other was the time delay of the inhibitory signal relative to the excitatory signal. If the delay was set to be very small, the activity of the cells in the gate was quenched too quickly for the signal to be propagated. Conversely, a larger delay caused the gate to open for the signal. Results from neurophysiological experiments have already shown that a change in delay properties is possible in real neurons. These findings therefore support the hypothesis of Kremkow and colleagues that such temporal gating can form the basis for selecting one of several alternative options in our brain.

Kremkow J, Aertsen A & Kumar A (2010) Gating of signal propagation in spiking neural networks by balanced and correlated excitation and inhibition. Journal of Neuroscience 30(47) 15760-15768

Attached files

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  Image caption: The timing of exciting (red curve) and inhibiting (blue curve) signals could be a way to control the “traffic flow” of activity in the brain. (Illustration: Bernstein Center Freiburg)

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