Why the middle finger has such a slow connection

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Each part of the body has its own nerve cell area in the brain -- we therefore have a map of our bodies in our heads. The functional significance of these maps is largely unclear. What effects they can have is now shown by Ruhr-University Bochum (Germany) neuroscientists through reaction time measurements combined with learning experiments and "computational modeling." They have been able to demonstrate that inhibitory influences of neighboring "finger nerve cells" affect the reaction time of a finger.

The fingers on the outside – i.e. the thumb and little finger - therefore react faster than the middle finger, which is exposed to the "cross fire" of two neighbours on each side. Through targeted learning, this speed handicap can be compensated. The working group led by PD Dr. Hubert Dinse (Neural Plasticity Lab at the Institute for Neuroral Computation) report in the current issue of *PNAS*.

The researchers set subjects a simple task to measure the speed of decision: they showed them an image on a monitor that represented all ten fingers. If one of the fingers was marked, the subjects were to press a corresponding key as quickly as possible with that finger. The thumb and little finger were the fastest. The middle finger brought up the rear. "You might think that this has anatomical reasons or depends on the exercise" said Dr Dinse, "but we were able to rule that out through further tests. In principle, each finger is able to react equally quickly. Only in the selection task, the middle finger is at a distinct disadvantage."

To explain their observations, the researchers used computer simulations based on a so-called mean-field model. It is especially suited for modelling large neuronal networks in the brain. For these simulations, each individual finger is represented by a group of nerve cells, which are arranged in the form of a topographic map of the fingers based on the actual conditions in the somatosensory cortex of the brain. "Adjacent fingers are adjacent in the brain too, and thus also in the simulation", explained Dr. Dinse. The communication of the nerve cells amongst themselves is organised so that the nerve cells interact through mutual excitation and inhibition.

The computer simulations showed that the longer reaction time of the middle finger in a multiple choice task is a consequence of the fact that the middle finger is within the inhibition range of the two adjacent fingers. The thumb and little finger on the other hand only receive an inhibitory effect of comparable strength from one adjacent finger each. "In other words, the high level of inhibition received by the nerve cells of the middle fingers mean that it takes longer for the excitement to build up – they therefore react more slowly" said Dr. Dinse.

From the results of the computer simulation it can be concluded that weaker inhibition from the neighbouring fingers would shorten the reaction time of the middle finger. This would require a so-termed plastic change in the brain – a specialty of the Neural Plasticity Lab, which has been studying the development of learning protocols that induce such changes for years. One such protocol is the repeated stimulation of certain nerve cell groups, which the laboratory has already used in many experiments. "If, for example, you stimulate one finger electrically or by means of vibration for two to three hours, then its representation in the brain changes" explained Dr. Dinse. The result is an improvement in the sense of touch and a measurable reduction of the inhibitory processes in this brain area. This also results in the enlargement of the representation of the finger stimulated.

The Bochum researchers then conducted a second experiment in which the middle finger of the right hand was subjected to such stimulation. The result was a significant shortening of the reaction time of this finger in the selection task. "This finding confirms our prediction" Dr. Dinse summed up. Thus, for the first time, Bochum's researchers have established a direct link between the so-called lateral inhibitory processes and decision making processes. They have shown that learning processes that change the cortical maps can have far-reaching implications not only for simple discrimination tasks, but also for decision processes that were previously attributed to the so-called "higher" cortical areas.

More information: Claudia Wilimzig, Patrick Ragert, and Hubert R. Dinse. Cortical topography of intracortical inhibition influences the speed of decision making, *PNAS* (2012), doi/10.1073/pnas.1114250109

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