One brain area, two planning strategies

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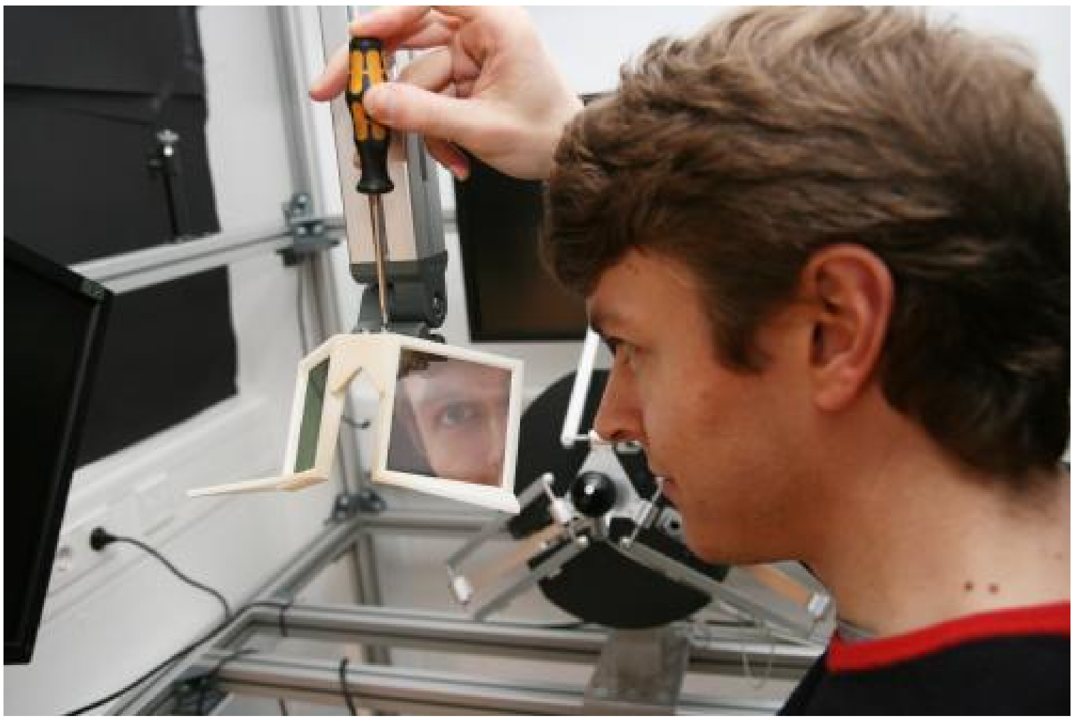

Dr. Pierre Morel adjusts an experimental setup with mirrors similar to the one used in the motor planning study. Credit: Deutsches Primatenzentrum/Christian Kiel

Ready to strike, the spear fisherman holds his spear above the water surface. He aims at the fish. But he is misled by the view: Due to the refraction of light on the surface, he does not see the actual location of the fish. How must his brain now plan the arm movement? Do the brain cells (neurons) reflect the position where the fish was spotted, in other words, the visual target? Or do they plan the physical target, which is the actual direction in which the arm and spear should move in order to hit the fish?

In their research, Shenbing Kuang, Pierre Morel and Alexander Gail of the Sensorimotor Group within the Cognitive Neuroscience Laboratory at the German Primate Center (DPZ) tried to answer this question on the different aspects of planning a limb movement. It was clear that certain neurons in the posterior parietal cortex are responsible for the planning of arm movements. But it was unknown whether neurons take over both described aspects of motor planning and whether one of the two planning functions is more dominant, should they both exist. The results of the Göttingen neuroscientists show: Most neurons are responsible for the encoding of the physical goal, the actual and thus the felt movement of the arm. Regardless of this, some neurons plan the visual goal in the same area of the brain, that is the visualized movement (*Cerebral Cortex* 2015).

To answer their question about the planning of limb movements, the researchers conducted an experiment in which the physical movement of the arm and the visual information about this movement could be separated. Other than for the spear fisherman, these signals are congruent in the everyday life of most humans: If you want to grasp a glass on a table, there is no refraction of light through the water to be taken into account. To find out if neurons indicate the planning of the future visualized movement or the physical movement, the neuroscientist worked with rhesus monkeys which were shown mirrored images of their hand movements during parts of the experiment.

The rhesus monkeys were trained to move their hands to a light cue on a touch screen (for example from the center of the screen to the left), while at the same time the activity of neurons in their posterior parietal cortex was recorded. In some cases they performed the movement under normal vision, but in other cases the monkey saw the exact opposite hand movement produced by a reversing prism: When it reached to the right, it saw a reach movement to the left.

The result: In the planning phase of the movement, the activity of most neurons did not differ between the normal and the reversed-view hand movement. However, some neurons in the same area of the brain responded exactly the opposite in the mirrored situation. The researchers concluded that these neurons were responsible for the planning of the visual hand movement goal, as this goal changed its position when the monkeys saw the reversed hand movement. So Shenbing Kuang and his colleagues were able to prove the coexistence of neurons for these two different planning goals in the posterior parietal cortex. The frequency distribution of these neurons suggests that the planning of the physical goal is the dominant function: In both monkeys the neuroscientists found about three to four times as many neurons for the physical goal of the movement than for the visual goal.

"These results shed light on how the brain plans the various aspects of a movement simultaneously" says Shenbing Kuang, "and it becomes apparent that in the planning of a movement, we include the different sensory consequences of our movements." Sensorimotor Group leader Alexander Gail adds: "The interplay of visual and physical movements plays a central role in the learning of movements. In order to develop adaptive neural prostheses we would like to have a better understanding of this basic ability."

More information: Kuang, S., Morel P. and Gail, A. (2015): "Planning Movements in Visual and Physical Space in Monkey Posterior Parietal Cortex." *Cerebral Cortex*, Jan 9 (Epub ahead of print). DOI: 10.1093/cercor/bhu312

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