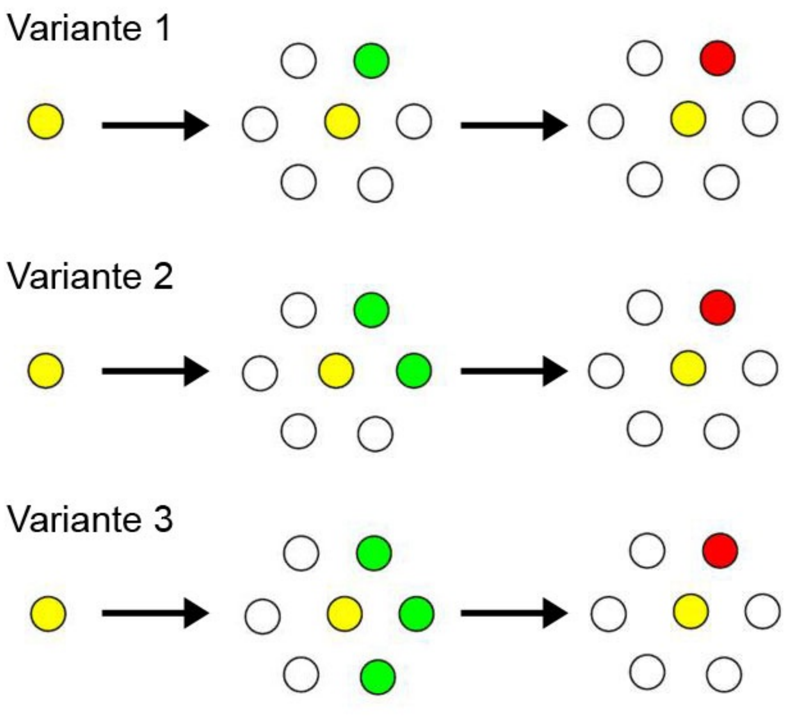
The brain plans in advance – if it can

It depends very much on the concrete circumstances as to how much effort the human brain puts into the planning and preparation of movements. When reaching for an object on a table in front of us we make use of previously stored information to prepare the movement in advance. When we try to catch a falling object, we have to react quickly and there is no time to prepare the movement. Movement is processed mainly in the motor cortex of the brain. Researchers led by Jörn Rickert at the Bernstein Centre for Computational Neuroscience and the University of Freiburg have now discovered that completely different neural activities in the motor cortex can lead to identical movements, depending on how well the movement is planned in advance.

In order to investigate how the brain controls voluntary movements in advance, the scientists took a close look at the brain activity of rhesus monkeys. The tests were carried out at the Centre National de la Recherche Scientifique in Marseille. The monkeys sat in front of a screen with six push buttons arranged in a circle, and were trained to touch a particular button in a particular situation. In one experimental set-up, the monkeys had to push a specific button that lit up green one second prior to reaching out for the button. The light then changed from green to red, indicating that the monkeys had to touch the button. In another experimental set-up, the monkeys were trained to follow an approximate direction of movement. This was achieved by a green signal given by two or three adjacent push buttons. After one second, one of the push buttons would turn red and the monkeys were required to touch the red button. This process led to the monkeys experiencing a second of uncertainty about what exactly they needed to do. The activity of individual nerve cells in the monkeys' motor cortex was measured throughout the entire experiment.



Experiments carried out with rhesus monkeys.
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Using quantitative-statistical methods, the scientists investigated how well the direction of movement in different phases of the experiments could be deduced from the measured activity of the nerve cells. They found that the neural encoding of movement depended strongly on the amount of information available. If the target of the movement was precisely known prior to having to reach for it, the brain is able to precisely plan the movement. The direction of movement can in this case be deduced from the activity of the neurons prior to reaching for the object, i.e. during the planning phase. If the target is not precisely known, it goes without saying that the movement cannot be planned as well as in the first case. However, this lack of planning led to a more accurate neuron activity at the precise moment that the monkeys were reaching out for a particular object. "The motor cortex plans movements as early as possible, i.e. as soon as the necessary information is available," said Rickert explaining their findings. Planning insecurity is later compensated by the neurons allocating their computational resources to meet the demands defined by the movement task and context.

The results obtained by the Freiburg researchers will contribute to the further development of brain computer interfaces (BCIs). Using BCIs, information on movements can be read from the brain, enabling severely paralysed patients to control prostheses by thought. "Our results, coupled with the results of other groups of researchers, show that there is no clear relationship between neural activity and movement," explained Rickert. Both planning security, and attention or motivation may have a considerable effect on the encoding of movement. "Such factors need to be taken into account when decoding movement parameters from the brain and applying them to brain computer interfaces," said Rickert.

The results were recently published in the "Journal of Neuroscience" and, amongst other things, are of importance for the development of brain-controlled prostheses used by severely paralysed patients.

Original publication:
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Contact:
Dr. Jörn Rickert
Institute of Biology I
University of Freiburg
Tel.: +49-761-203-2543
E-mail: rickert(at)biologie.uni-freiburg.de