Movement and prediction: neurophysiological relations
[dt.: Zum neurophysiologischen Zusammenhang von Bewegung und Vorhersage]

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Background: Forward models in motor control

Recent psychological models suggest that to plan an action is to predict its outcomes in terms of perception and proprioception. To anticipate how it will feel to move in a certain way, and how things will look, feel, smell, taste and sound in a few seconds, is at the basis of our ability to make the next step in an action. The algorithms and processes describing the computations which are required in this context are often framed in terms of "forward models". It is suggested that the "motor system" of our brain is continuously setting up these forward models in order to exert motor control. Forward models entail a prognosis of how it is like to feel moving in a certain way, e.g. when reaching out and grasping a cup of coffee: expecting a nearly empty cup leads to lower forces than expecting a full cup; expecting a hot surface leads to a different grip type than a cold surface; and so on.

Prediction activates the "motor system"

Strikingly, the so-called "motor system" of our brain has been found to be active not only when we prepare or execute an action but also during tasks which do not require to move or act in any way. One kind of task requires subjects to process stimuli which are reminiscent of action, e.g. photographs showing movements, or tools which are related to highly over-learned movement stereotypes. However, another kind of task can be described as requiring the subject to predict perceptual events. How can this latter phenomenon be explained?

Experiments on event prediction

In order to investigate this question, a series of experiments has been conducted using functional Magnetic Resonance Imaging (fMRI). This non-invasive method allows to measure local metabolic change in the brain while subjects perform a task, and therewith the contribution of certain brain areas to a given task. Typically, fMRI is used in order to investigate how the average young healthy brain is activated during a specific task, whereas inter-individual differences are of minor interest.

Experiments on prediction in the absence of motor planning or execution yielded that the motor system is engaged during prediction of perceptual events in a systematic manner that can be related to the role of the motor system in body control. The term "events" used here refers to temporally structured perceptions in the several-seconds range; events involve change, have clear beginnings and endings, and are exemplifications of dynamic properties. Roughly one may say that we predict external events using the same system which is made for predictions while we act and move. But how can we think of the motor system to be exploited for the prediction of something that is not an action?

The mode: Prediction of external events with our motor system

We cannot re-enact but anticipate inanimate or even non-human animate events, and our motor system becomes involved while doing so. The framework which is presented here accounts for this finding by generalizing a predictive account of the motor system from action to event perception. According to this framework, we predict events we cannot reproduce by exploiting an audio/visuomotor representation that never amounts to a real action because it lacks interoceptive information. The motor system provides a multi-purpose platform for many kinds of prediction, i.e., a repertoire of styles of transformation that can be used for both, perception as well as action.