Anticipatory behavior in object manipulation: Learning and alterations following brain damage

Joachim Hermsdörfer

Interacting with objects in our environment would be terribly slow if we solely rely on feedback information about the objects' characteristics. Rather we predict the relevant object properties and scale our motor output according to our prediction. During the manipulation of grasped objects, this anticipatory behavior can inferred from the time course of the grip force increase during the first instances after contact with the object before relevant sensory feedback information is available.

Knowledge about object properties can be acquired by developmental learning, such as knowing that a larger object is heavier than a smaller object of the same material, or can be learned by associative learning, if for example the different colors of two novel objects indicate differences in weight.

We have compared the precision of anticipating objects' weight on the basis of size information with newly learned color information. Both cues effectively modulated the time course of the grip force increase (steeper increase for the larger object or the heavier object according to the color code). Size however induced a stronger effect. Interestingly, when associative learning of the color code was combined with an unrelated working memory task, anticipation developed slower and was less distinct for the two objects.

In a second line of experiments we tested the hypothesis that damage to the motor-dominant brain deteriorates the precision of anticipating object properties. Accordingly we asked patients with stroke of the left or the right hemisphere to grasp und lift objects with different properties using the ipsilesional "non-paretic" hand. When the effect of object size information was tested, most of the patients and control subjects scaled the grip force according to size. Since material information may be less rigidly implemented in the nervous system than size information, we next compared expanded polystyrene and metal-looking objects. Again patients performed largely similar to control subject and scaled their grip force according to the different materials. If however the relevant object properties were only accessible by object identity and not by overt physical characteristics such as size and material, the patients failed to scale the grip force according to weight. Thus patients' grasped a light package of biscuits with the same early grip force rate as a similar-sized but much heavier book. This deficit was more obvious in patients with left brain damage compared to right brain damage.

In conclusion, our results on associative learning of anticipatory grip force control in healthy subject and on the effects of different cues in brain damaged patients indicate that different cues are differently represented in the central nervous system. Physical cues seem to be very rigidly implemented and anatomically distributed, while cues that have to be learned by associations are more vulnerable to resource limitations during learning and to damage of the central nervous system.