Grasping Neurones

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We agree with Robertson that our new view on grasping is a description of motor behavior rather than an exploration into the nature of the neural proccssing underlying this behavior. However, neurophysiologists might be inspired by our new view to ask other questions, perform other experiments, and analyze these differently. In this way, they could generate new insights about the neural control of grasping.

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In our target article (Smeets & Brenner, 1999a), we introduced a new behavioral view on grasping. We argued that the classical description of grasping as a combination of transport and grip does not give much insight into the reach-tograsp movement. We proposed an alternative: Grasping is a combination of movements of the individual digits. We formalized this view using a modified oneparameter model for pointing. This model could predict various commonly observed characteristics of grasping behavior. The peculiar finding was that our completely different view yielded predictions, which corresponded with the experimental results that were thought to support the classical view.

We agree with Robertson's remark that neither our model nor our more general view gives any insight into how the nervous system generates this behavior. Moreover, we argued in our target article that it is very dangerous to draw conclusions about control mechanisms based on correspondence between model predictions and experimental results. Our view explicitly states that the grasping behavior will be the same, independent of whether the grasping is done with digits of one hand or digits of both hands. We even argued that the movements of the endeffectors relative to the object should be the same in grasping, eating, and catching (Smeets & Brenner, 1999b). It is clear that not all of these tasks are controlled by the same neurones.

Relating Neurophysiology to Behavior

Predicting which neurones will be active during a certain task is extremely difficult. To do so, one must know what constitutes the task and how this information is coded. Even at the level closest to behavior (the motoncurone), these issues are

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not straightforward. One might assume that the task for motoneurones is to control force and that this is coded using a fixed combination of firing frequency increase and recruitment of larger neurones (the "size principle", DeLuca & Erim, 1994). However, reality is a bit more complex. For instance, Tax et al. (1990a, 1990b) studied the activity in motoneurones of elbow flexors in two tasks that were mechanically indistinguishable. In one task, their apparatus moved the arm at a constant speed while subjects were asked to generate a flexion torque; in the other task, the apparatus controlled the torque while the subject was instructed to keep the speed constant. Although the behavior was the same, the relative contribution of the three major elbow flexor muscles and the frequency at which motor-units fired when they were recruited differed for the two tasks (Tax et al., 1990a, 1990b). We thus agree with Robertson that the same behavior does not imply that the control is the same.

A clear example in the field of grasping is the study by Wing and Fraser (1983). They compared the grasping behavior of a patient with a thumb prosthesis with that of normal subjects. Although the control of the prosthesis is quite different from a normal thumb (it is controlled by movements of the contralateral shoulder), the behavior was remarkably similar. One can conclude from this experiment that although certain structures in the brain are active in normal grasping, their activity is not necessary to generate normal grasping behavior. On the other hand, there are neurones in the premotor cortex of which the activity is closely related to grasping behavior, without a clear contribution in its control, as their firing is modulated in the same way when someone else performs the grasp (di Pellegrino et al., 1992). For modeling grasping *behavior*, it is therefore not useful to build one's model on the activity of brain structures.

What is the relation between our new behavioral view on grasping and the neurophysiological question? Our view cannot help to find out how the nervous system codes a certain task. But it does make predictions on which variables are important in defining tasks. The definition of tasks for experiments has been guided until now by the classical view, according to which the important parameters are the position of the wrist and the size of the grip. In experiments, the comparison is made between neural activity in grasping and in pointing, taking care that the accuracy for the wrist is the same in both tasks. According to our alternative view, this is an irrelevant parameter. We have argued that the movement of the tip of a digit is the important parameter in both tasks. Therefore, one should design experiments in which the accuracy for the digits is the same if one wants to compare grasping with pointing.

As an example, we discuss the study by Van Kan et al. (1994), a study cited in Robertson's commentary. They studied the activity in monkey cerebellum during reaching and grasping. They found that the activity of the interpositus nucleus was modulated to a much greater extent when the monkey grasped a raisin (requiring an accuracy of a few millimeters) than when it moved a lever (requiring an accuracy of a few centimeters) to the same position. They conclude that the activity of this nucleus differs between grasping and pointing. Our description of their results would be that the activity of the interpositus nucleus was much more modulated when the monkey performed an accurate task (grasping a raisin) then when performing a task with less spatial constraints. From our point of view, one could conclude from their data that the activity of this nucleus depends on the required accuracy. However, the data of Van Kan et al. could also be interpreted differently within the context of our view. One could argue that the interpositus nucleus is involved in the temporal coordination of the two digits. Thus, although our view does not tell us directly how pointing and grasping are controlled, it does suggest new experiments that could help reveal the role of neural structures in such behavior.

Conclusion

We conclude that the classical view of grasping influenced experiments and their interpretation not only in the behavioral domain, but also in the neurophysiological domain. In both domains, experiments are generally based on the classical distinction between transport and grip. Therefore, it is not surprising that it is easy to interpret the results in the classical framework. However, our approach to grasping provides different interpretations for both domains. These interpretations urge for neurophysiological experiments that will shed new light on the similarity between the neural control of pointing and grasping.

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