COMMENTARIES

Motor Control, 1999, 3, 272-275

On Achieving Strong Inference in Prehension Research

Ronald G. Marteniuk and Christopher P. Bertram

Smeets and Brenner have suggested that it may be time to abandon Jeannerod's "classical approach" to studying human prehension, and have presented a mathematical model as an alternative. We argue that this model provides insufficient grounds for widespread acceptance, and question whether or not such an approach furthers the science of motor control.

***Key Words*:** grasping, motor control, visuomotor channels, reaching, transport

> The Question . . . consists of asking in your mind, in hearing any scientific explanation or theory put forward, "But sir, what experiment could disprove your hypothesis?" . . . This goes straight to the heart of the matter. It forces everyone to refocus on the central question of whether there is or is not a testable step forward. (Platt, 1964, p. 352)

In 1981, Marc Jeannerod proposed a theory to explain the tendencies he observed in human prehensile behavior. His theory postulated the existence of functional ensembles—the visuomotor channels—that are characterized by specific input/output relationships, and specialized for independently generating the transport and grasp phases of prehension. In the 18 years since Jeannerod's original work, the concept of visuomotor channels has stood as a theoretical backdrop for the vast majority of research relating to the grasping hand. In that time a wealth of information has been brought forth in support of Jeannerod's claims (see Jeannerod, 1986, for review). However, there are also those studies that oppose the notion of independent visuomotor channels controlling transport and grasp (e.g., Lemon et al., 1995). To state the situation more plainly, it can be said that although there are many studies supporting Jeannerod's theory, there are also studies that fail to support it.

The apparent contradictions in the empirical data have led several scientists to question whether or not independent visuomotor channels for transport and grasp exist. Smeets and Brenner, in their paper "A new view on grasping," have suggested that there is enough evidence currently available to abandon Jeannerod's "classical approach" and to begin a new search for the underlying mechanisms of prehension. They have proposed a novel description for reaching and grasping,

---

The authors are with the Human Motor Systems Laboratory, Simon Fraser University, Burnaby, BC, Canada V5A 1S6.

based on determining optimal positions on an object for finger placement, and then independently moving the thumb and fingers to that position. The description was then modeled using a minimum-jerk approach, and the results were compared to empirical data. For example, the model predicted the linear relationship between object size and maximum grip size to have a slope with an average value of 0.81.

The same empirical data were obtained from 35 separate studies in current literature, and the average slope was calculated to be 0.82. A *t*-test was then used to show that the two slopes were not significantly different. Because it appears that the model has predicted events that have been empirically measured, the finding is viewed as evidence for the validity of the model. Based on this, and on other similarities between the predictions of the model and the trends seen in the literature, Smeets and Brenner deemed the model a success. So the question now becomes: Should we accept this new view of prehension, thereby rejecting Jeannerod's classical approach?

The dismissal of a longstanding theory is an issue that must be weighed carefully. If we are to accept this new view, we must first be satisfied that two conditions have been met: (a) we accept the conclusions generated by the model, and hence the methodology involved, and (b) we are satisfied that the grounds for rejecting the classical approach are valid. In other words, Smeets and Brenner must show adequate proof for their claims and adequate disproof of current presumptions.

In order to evaluate the conclusions generated by the Smeets and Brenner model, it must first be determined whether the methodology was sound. Recall that the view they proposed states that prehension is guided by independently moving the thumb and fingers to an optimal target position on the to-be-grasped object. In certain instances, the accuracy of this new description was based on how well the predictions of the model correspond to empirical data found in motor control research. Therefore, if the success or failure of a mathematical model is to be determined by its correspondence to reality, one must first ensure that the picture being painted of reality is a precise one.

One way the authors have chosen to present reality is to condense the results of a number of studies onto a single graph. For example, Figure 6B of the Smeets and Brenner article shows the relationship between object size and time to maximum grip. It is apparent from the figure that although there is a general trend of increase from left to right, there is also a great deal of variability in the experimental data. Considering the fact that these studies differed in experimental design, object characteristics, and so on, this variability is not surprising. What is surprising, however, is Smeets and Brenner's apparent assumption that averaging the slopes of the individual data plots somehow captures an *average motor behavior* that represents performance in each of the 32 separate experiments. Yet these are not the plots of an individual subject over a group of trials, nor are they the results of different subjects plotted for the same task. Rather, the individual plots represent completely different experiments, and in most cases different tasks.

Averaging independent data sets simply on the grounds that they share a common dependent variable seems a questionable leap in logic. Figure 6B illustrates this point. Comparing only the data from Carnahan et al. (1996) and Berthier et al. (1996), it is clear that the two studies show different patterns of increase in terms of relative time to maximum grip (slopes of approximately 0.2 and 5.6%/

cm, respectively). Individually, in fact, both studies appear quite different from the predictions of the model (1.2%/cm). However, if we combine the slopes in Carnahan et al. (1996) and Berthier et al. (1996), the averages begin to look more like the model predictions. Mathematically, that may seem reasonable, but practically speaking, averaging independent data sets is meaningless. Thus it would appear that the logic of how the model is validated (in this instance) is fundamentally flawed.

We are thereby forced to question the extent to which the model speaks to human behavior. Again, in the words of Platt (1964), "The mathematical box is a beautiful way of wrapping up a problem, but it will not hold the phenomena unless they were caught in a logical box to begin with" (p. 352). Considering that the model's success hinges on its likeness to empirical data, the strategy of averaging across a series of uncorrelated data points seems somewhat casual. We would advise that before any firm conclusions be drawn from this model, Smeets and Brenner seek out an appropriate quantitative method (e.g., meta-anaylsis) to synthesize the experimental data.

The second condition we said had to be met in order to accept the Smeets and Brenner view of prehension was that we be satisfied with their grounds for rejecting Jeannerod's classical approach. Traditional thought holds that the transport and grasp components are independently controlled throughout the prehensile movement (Jeannerod, 1981). To dispute this, Smeets and Brenner cite studies from both anatomical and informational perspectives. For example, from an anatomical standpoint there is evidence that hand movements are aided by proximal lower arm muscles (Lemon et al., 1995), which is contrary to the view that the grasp component is controlled solely by the distal musculature. From an informational standpoint, the classical view holds that transport of the arm is specified by extrinsic object properties (e.g., position and orientation) whereas grasp characteristics are specified by intrinsic object properties (e.g., size and shape). Smeets and Brenner point out, however, that orientation, which was originally considered an extrinsic property, can also play a role in grasp formation (Jeannerod et al., 1995).

Smeets and Brenner suggest that this dual classification of orientation serves as the critical blow to the belief that transport and grasp are controlled independently. We would argue, however, that dismissing a well-founded theory on the basis of an inconsistency in the literature would be throwing the baby out with the bath water. Perhaps modification of the theory would be more prudent, and in fact Jeannerod himself has acknowledged this (Jeannerod et al., 1995). Smeets and Brenner's point is well-taken: if a theory can no longer serve the purpose of explaining experimental findings, then it should be abandoned. But is their model grounds for rejecting the Jeannerod theory?

The weakness of their model is that even if all the claims put forth are valid—which we suggest they are not—the model itself is still far from perfect. Smeets and Brenner acknowledge this fact several times throughout the paper. Its ability to account for phenomena is limited, and even where results are possible, they are not always consistent with actual data. Moreover, it is not clear what the implications of the model are for future experimentation. If we abandon an imperfect theory, but one that suggests critical tests, and accept an alternative, relatively limited model, have we truly taken science a step forward? Have we added a brick to the wall of understanding, or have we merely added "chaos to the brickyard" (Forscher, 1963)?

References

Berthier, N.E., Clifton, R.K., Gullipalli, V., McCall, D., & Robin, D. (1996). Visual information and object size in the control of reaching. *Journal of Motor Behavior*, **28**, 187-197.

Carnahan, H., McFayden, B.J., Cockell, D.L., & Halverson, A.H. (1996). The combined control of locomotion and prehension. *Neuroscience Research Communications*, **19**(2), 91-100.

Forscher, B.K. (1963). Chaos in the brickyard. *Science*, **142**, 339.

Jeannerod, M. (1981). Intersegmental coordination during reaching at natural visual objects. In J. Long & A. Baddeley (Eds.), *Attention and performance IX* (pp. 153-169). Hillsdale, NJ: Erlbaum.

Jeannerod, M. (1986). Mechanisms of visuomotor coordination: A study in normal and brain damaged subjects. *NeuroPsychologia*, **24**, 41-78.

Jeannerod, M., Arbib, M.A., Rizzolatti, G., & Sakata, H. (1995). Grasping objects: The cortical mechanisms of visuomotor transformation. *Trends in Neuroscience*, **18**, 314-320.

Lemon, R.N., Johansson, R.S., & Westling, G. (1995). Corticospinal control during reach, grasp, and precision lift in man. *Journal of Neuroscience*, **15**, 6145-6156.

Platt, J.R. (1964). Strong inference. *Science*, **146**, 347-353.

Accepted for publication: November 16, 1998.