

Is It Pointing to Grasping or Grasping Pointing?

Geert J.P. Savelsbergh and John Van der Kamp

The Smeets and Brenner view on grasping is simple: grasping is in fact pointing. In our comments we examine the model beyond the reach-to-grasp task, namely, by grasping (without reaching) of moving objects and eating. The model fits the data of both tasks. Although generalization of a model to different tasks usually strengthens its acceptance, in the present case it reveals its shortcomings, namely, both tasks include a clear grasping component that is hard to accept as pointing.

Key Words: hand aperture, catching, eating

Smeets and Brenner's new view of grasping is a plea for considering the grasping movement of the thumb and index finger as two independent pointing movements of the two digits. According to these researchers, the individual movement trajectories of the two digits are primarily constrained by the position and orientation of contact with the object. A minimum-jerk model for pointing was applied to both digits to describe the grasping movement. Hence, what is regulated are two independent pointing movements from which the time-evolution of hand aperture should be understood as an emergent property. Thus, aperture is not controlled as such.

If anything, Smeets and Brenner's viewpoint is an original one and every attempt to question the status quo is welcomed. For the last two decades the understanding of prehension has mainly been based on a distinction, which can be traced back to Woodworth (1899), between a reach (proximal muscles) and grasp (distal muscles) phase. Jeannerod (e.g., 1981) connected these two movement phases to two independent visuomotor channels, which is supported by neurophysiological evidence (Brinkman & Kuypers, 1973). In the first channel, so-called extrinsic properties of the object (e.g., position and orientation) are processed to regulate the transport of the hand toward the object, whereas the second channel processes the intrinsic properties of the object (size, mass, shape, fragility) which influence the digits' movements. This connection between visual channels and the transport and grasp components inspired Jeannerod (1981) to state that they are regulated independently.

We agree with Smeets and Brenner's analysis that there are serious shortcomings with the conceptual division between extrinsic and intrinsic properties.

The authors are with the Institute for Fundamental and Clinical Human Movement Sciences, Vrije Universiteit, Van der Boechorststraat 9, 1081 BT, Amsterdam, The Netherlands.

This distinction appears to be rather artificial: for instance, increasing the size of an object necessarily goes along with changing the position and orientation. Although it has often been interpreted as supporting the traditional distinction between transport and grasp component, there is a bulk of kinematic evidence to show that the manipulation of either extrinsic or intrinsic properties may affect both components (e.g., Paulignan et al., 1991a, 1991b; Savelsbergh et al., 1996), underlining the need to rethink Jeannerod's hypothesis.

The new perspective presented by Smeets and Brenner is reminiscent of an earlier suggestion of Wing and co-workers (Haggard & Wing 1997; Wing & Fraser, 1983). These researchers argued that it is not the wrist but the positioning of the thumb that is regulated in reaching. This makes the wrist position kinematically redundant. Supposedly, the index finger is either (independently) pointed to an opposing position on the target, a position advanced by Smeets and Brenner, or used to adjust the hand aperture to the requirements of the object.

A big advantage of the Smeets and Brenner model (S-B model) is that it provides quantitative predictions of the kinematics of hand aperture. Their predictions of, for instance, the maximal hand aperture and its timing appear to fit the data reported in the literature quite well. However, showing that a model fits the data is only a first step. To really establish a new view of grasping, efforts should be directed beyond simply proving the model. The S-B model should also improve the understanding of different grasp movements, such as grasping an approaching object, and most important, it should withstand empirical testing to falsify the model. The remainder of our commentary will focus on these two aspects.

Can the new view on grasping be generalized to different tasks?

Because we are interested in the information-based regulation of interceptive timing, we have extensively used a paradigm in which subjects had to catch moving balls projected into the stationary hand (Savelsbergh et al., 1991; Van der Kamp & Savelsbergh, 1998; Van der Kamp et al., 1997). To succeed at this task, subjects needed only to open and close their hand in time. No reaching or pointing was required. The S-B model predicts larger maximal hand aperture and later occurrence of maximal hand aperture for larger objects. Increasing the diameter of the approaching ball (4, 6, 8, and 10 cm; Van der Kamp et al., 1997, Experiment 2) resulted in larger hand aperture (9.9, 10.0, 11.0, and 11.6 cm) and a proportionally later occurrence of the moment of maximal aperture for larger balls (60, 59, 63, and 67%). Further, the S-B model predicts larger maximal hand aperture and earlier occurrence of maximal hand aperture when timing constraints are increased. An increase in speed of the approaching balls (0.5, 1.0, 1.5, 2.0, and 2.5 m/s; Van der Kamp & Savelsbergh, 1998, Experiment 1) led to larger maximal hand aperture (11.8, 12.3, 12.2, 12.5, and 12.7 cm) that occurred proportionally earlier (76, 74, 73, 72, and 68%). In short, the observed effects seem qualitatively consistent with the predictions made by the S-B model. However, hand aperture kinematics are difficult to understand as emerging from two independent pointing trajectories, since the hand was at a fixed location and no reaching movements were made.

To make our case even stronger, consider the coordination between hand and mouth during eating. In Castiello's experiment (1997; cf. Bermejo et al., 1989) subjects ate different size pieces of cheese, i.e., 0.5- and 2.0-cm cubes. The pattern of the arm movement in bringing the cheese to the mouth was examined, as was mouth aperture. The mouth was considered to reflect the grasp component. In

agreement with the predictions made by the S-B model for reach-to-grasp movements, an increase in food size resulted in an increased maximal mouth aperture, i.e., 2.0 and 3.2 cm, and a proportionally later occurrence of maximal mouth aperture, i.e., 55 and 61%. But can we really understand mouth movements as pointing trajectories?

In conclusion, the effects predicted by the S-B model are observed beyond the reach-to-grasp task. Although generalization of a model to different tasks usually strengthens its acceptance, in the present case it reveals its shortcomings. Unless one is prepared to regard the catching of approaching balls with a stationary hand and the mouth movements during eating as pointing movements, one is apt to conclude that another more general view on grasping needs to be developed.

A proposal to test the new view on grasping

Although the S-B model fits the findings in the literature rather well, acceptance of the model is only warranted after it is put to the test. In this respect, one defining characteristic of their new view is that the adjustments in hand aperture arise from two separately controlled digits. Therefore, an important test would be to examine the effects of perturbing either the index finger or the thumb. The design of such an experiment would be not unlike that of Polman et al. (1996), who had subjects grasp approaching balls while their fingers and thumb were perturbed by spring loads. However, instead of perturbing the thumb and fingers at the same time, either the thumb or the fingers should be perturbed. The individual kinematic trajectories of the perturbed thumb and the index finger should be compared to the unperturbed baseline situation. Only if solely the perturbed digit in question adjusts its movement trajectory can Smeets and Brenner's view be upheld. However, if the unperturbed digit appears to make compensatory movements in response to spring loads, the S-B model fails. Another model is needed that would contain parameters that reflect the regulation of hand aperture per se.

The experiments conducted by Cole and colleagues (Cole et al., 1984; Cole & Abbs, 1986) may provide some clues to the outcome of the proposed experiment. Cole et al. (1984) applied loads to oppose thumb flexion movements when subjects were flexing thumb and index finger in order to make contact. The desired force was achieved by compensatory adjustments of *both* the thumb and index finger flexor muscles. Loads applied to the thumb during a task in which no finger-thumb coordination was required did not result in compensatory index finger movements. For unperturbed rapid pinch movements, Cole and Abbs (1986) reported that the finger-path trial-to-trial variation covaried with the variation in the path of the thumb. From these studies one is tempted to conclude that, in contrast to the arguments of Smeets and Brenner, the thumb and index finger are tightly coupled during grasping movements.

Of course, the observations concern relatively unrestrained movements without a target, which makes any firm conclusions with respect to natural prehension hazardous. However, it suggests that an extension of Wing's model (Haggard & Wing, 1997; Wing & Fraser, 1983) may be a more fruitful approach. That is, during prehension the thumb is used to position the hand, whereas the index finger primarily functions to adjust hand aperture to the size of the object. In the experiment proposed, this should be reflected in differential compensatory movements for thumb and finger perturbation. However, the final judgment of the proposal of the S-B model should be postponed until the experimental results speak for themselves.

In conclusion, we think that the new view is an original one, but it fits too much data. Normally this would have been a strong point of a model, however, in this case we see it as a rather weak point. Maybe the S-B model points not to grasping but to grasping pointing by curve fitting.

References

- Bermejo, R., Allan, R.W., Houben, D., Deich, J.D., & Zeigler, H.P. (1989). Prehension in the pigeon: I. Descriptive analysis. *Experimental Brain Research*, **75**, 568-576.
- Brinkman, J., & Kuypers, H. (1973). Cerebral control of contralateral and ipsilateral arm, hand, and finger movements in the split brain rhesus monkey. *Brain*, **96**, 653-674.
- Castiello, U. (1997). Arm and mouth coordination during the eating action in humans: A kinematic analysis. *Experimental Brain Research*, **115**, 552-556.
- Cole, K., & Abbs, J.H. (1986). Coordination of three-joint digit movements for rapid finger-thumb grasps. *Journal of Neurophysiology*, **55**, 1407-1423.
- Cole, K., Gracco, V.L., & Abbs, J.H. (1984). Autogenic and nonautogenic sensorimotor actions in the control of multiarticulate hand movements. *Experimental Brain Research*, **56**, 582-585.
- Haggard, P., & Wing, A. (1997). On the hand transport component of prehensile movements. *Journal of Motor Behavior*, **29**, 282-287.
- 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.
- Paulignan, Y., Jeannerod, M., MacKenzie, C., & Marteniuk, R. (1991a). Selective perturbation of visual input during prehension movements: II. The effects of changing object size. *Experimental Brain Research*, **83**, 407-420.
- Paulignan, Y., MacKenzie, C., Marteniuk, R., & Jeannerod, M. (1991b). Selective perturbation of visual input during prehension movements: I. The effects of changing object position. *Experimental Brain Research*, **83**, 502-512.
- Polman, R.C.J., Whiting, H.T.A., & Savelsbergh, G.J.P. (1996). The spatio-temporal structure of control variables during catching in different load conditions. *Experimental Brain Research*, **109**, 483-494.
- Savelsbergh, G.J.P., Steenbergen, B., & Van der Kamp, J. (1996). The role of fragility information in the guidance of the precision grip. *Human Movement Sciences*, **15**, 115-127.
- Savelsbergh, G.J.P., Whiting, H.T.A., & Bootsma, R.J. (1991). 'Grasping' Tau. *Journal of Experimental Psychology: Human Perception and Performance*, **19**, 315-322.
- Van der Kamp, J., & Savelsbergh, G.J.P. (1998). Interceptive timing is based on the relative rate of gap constriction. (Submitted)
- Van der Kamp, J., Savelsbergh, G.J.P., & Smeets, J.B. (1997). Multiple information sources in interceptive timing. *Human Movement Sciences*, **16**, 787-821.
- Wing, A.M., & Fraser, C. (1983). The contribution of the thumb to reaching movements. *Quarterly Journal of Experimental Psychology*, **35**, 297-309.
- Woodworth, R.S. (1899). *Le Mouvement*. Paris: Octave Doin.

Accepted for publication: November 24, 1998