Getting a grip on grasping

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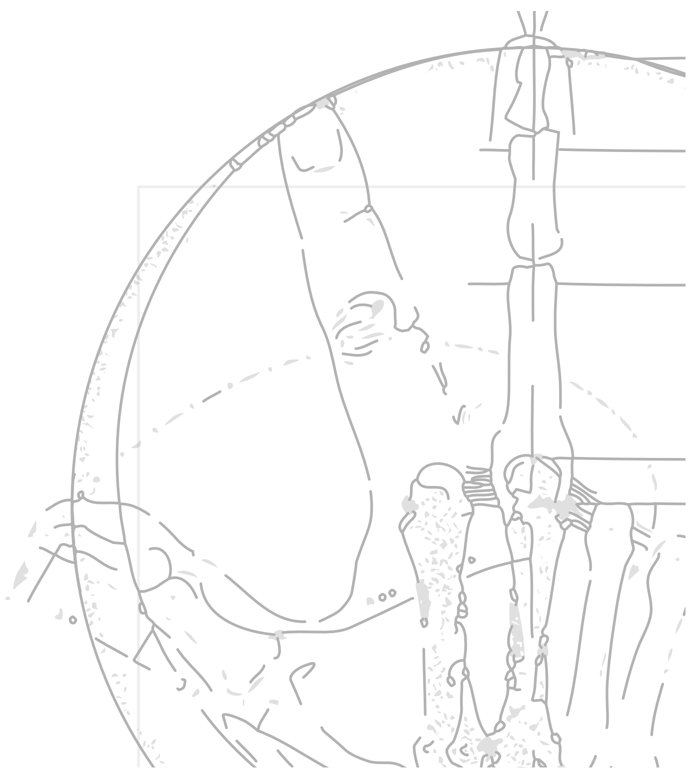
Summary



Getting a grip on grasping

Grasping enables humans to get a grip on a variety of surrounding things. This thesis describes a number of experiments studying grasping behavior. The aim of this thesis is to get a better understanding of how grasping movements are controlled in catching and prehension movements.

Chapter 1, is meant to provide some background on the experimental work reported in this thesis. The framework for the studies presented in this thesis is provided by a vast body of research on the visual guidance of goal-directed movements like hitting, catching, and prehension. A major research question that has been referred to in these studies concerned the timing of these movements. For instance, how do we, before raising our glass, manage to close our grasping hand around it in just the right time and place? In order to answer this question, this thesis focused on 1) the controlled variables, 2) the information, and 3) the control law. Previous studies paved the way in the development of these fundamental underpinnings of motor control. Zaal and colleagues (e.g. Zaal & Bootsma, 2004; Zaal, Bootsma, & Van Wieringen, 1998), for example, provided a model that based on time-to-contact information (tau) predicts the moment of hand closure in prehension. This 'dynamic-tau model', central to this thesis, combines elements of the theories of direct-perception and dynamical systems.

Before focusing on the information and the control law involved in grasping, the question: 'what are the controlled variables in prehension?' is addressed in *Chapter 2*. After 20 years of prehension research that had been based mainly on Jeannerod's (1981, 1984) hypothesis that prehension should be considered as the coordinated act of a reaching and a grasping movement, Smeets & Brenner (1999) proposed 'a new view on grasping'. Their alternative explanation was that prehension might just as well be seen as the simultaneous pointing movements of the thumb and the index finger. Whereas, traditionally, the hand aperture (i.e. the distance between thumb and index finger) had always been considered to be one of the controlled variables in grasping, according to Smeets and Brenner's 'double pointing hypothesis', this hand aperture is really an emergent property related to the time course of the positions of the two digits moving to their respective end points. In *Chapter 2* the latter hypothesis

was tested by perturbing the end position of one of the digits while leaving the end position of the opposing digit unchanged. In the experiment reported in *Chapter 2* participants reached for and grasped an object of which the side surfaces could be made to slide in and out just after the reaching movement had started. In conflict with Smeets and Brenner's double-pointing hypothesis, it was found that in some cases, perturbing the end position of one digit also affected the kinematics of the opposing digit. This finding clearly disagrees with the double-pointing account. Therefore, it was concluded that rejecting the latter hypothesis logically leads to accepting the reaching and grasping hypothesis.

With two components making up one act, reaching and grasping, somehow, need to be coordinated. The traditional view on this issue has been that the grasping is temporally ordered on the time scale provided by reaching. Empirical evidence for a hierarchy of reaching over grasping seemed to come from experiments showing that when object location or size were changed at movement onset, adjustments in the reach component were much faster than adjustments in the grasp component. In *Chapter 3* of this thesis, this account is challenged by the finding that the grasp component can be just as rapid in responding to a change in object size (within 120 ms) as the reach component is reported to respond to a change in object position. These findings imply that the time scale on which an adjustment in the grasp component is ordered is not necessarily provided by reaching. This means that, empirically, the control model of a hierarchy of reaching over grasping lost one of its fundamental underpinnings.

This thesis studies an alternative means to consider the way the grasp component might adjust to size perturbations proposing that the responses to such perturbations result from the online control of the hand aperture. Instead of being ordered in a predefined hierarchical fashion the kinematic details of a grasping movement are believed to be continuously regulated, online, based on time-to-contact information. In *Chapters 4* and *5*, both the control law and the information that might be used for the control of hand closure initiation in grasping have been addressed. The idea tested in these chapters is that grasping behavior is best understood from an approach combining elements of the theories of direct-perception and dynamical systems. In a control scenario that involves first-order time-to-contact information, it does not really matter whether the hand moves toward the object, the object moves towards the hand or a combination of both takes place. This is because the first-order time-to contact information is about the relative hand-object movement. *Chapters 4* and *5* describe a number of experiments that provide evidence for a generic model for understanding the control of hand-closure initiation in both catching and prehension.

Chapter 6 reviews the impact of the results presented in this thesis. In this last chapter the implications, contributions, deficits, and practical application of the knowledge gained by this thesis are being discussed.