Grasping Movement

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English summary

Gasping Movement: What we know and do not know about the control of grasping

Chapter 1 is the introduction to this thesis. In this chapter I describe why grasping is a task that is frequently studied. I outlined the most important theories about the control of grasping and I give a preview of the data that will be presented in the thesis. Skilful interaction with objects in our environment is important ability to get by in daily life. One very common way of interacting with object is to grasp them. This seemingly easy and effortless task is actually is actually quite complex. The fingers have to be brought to the object and place in such a way that the object will not slip as soon as we lift it. The joints in our arm give us more than enough freedom to bring the fingers to the object. In addition, many object have many possible contact point to lift it without dropping it. This is good because it makes the system flexible but it also poses a problem: From all the possibilities, how do we choose one possibility that we are going to execute?

In *Chapter 3* I looked at the posture of the arm (joint angels) at the moment people grasped a sphere. This posture was very predictable, indicating that people don't just randomly pick a posture when executing a movement. The grasping posture depended heavily on the position of the sphere relative to the subject. The starting posture (arm close to the trunk or arm extended) and where the subject had to place the sphere after he grasped it was much less important for the grasping posture.

Another level at which I studied grasping is how the thumb and index finger move from their starting position to the object. The aim was to derive the control mechanism with which the brain plans grasping movements. I will briefly present two theories about the nature of this control mechanism. According to the first theory (Jeannerod, 1984), grasping consists of two independent components; a reach component that brings the hand near the object and a grasp component that moves the thumb and index finger further apart and closer together. According to the second theory (Smeets and Brenner, 1999), grasping consists of to different independent components; a movement of the index finger and a movement of the thumb. According to this theory, the control of separate hitting movements of the thumb and index finger is identical to the movements of the thumb and index finger when they are combined to a grasping movement.

In *Chapter 4* I looked at the trajectories of the thumb and index finger during hitting and grasping movements. Sometimes, the marble subjects had to grasp or hit (see Figure 4.1) moved and sometimes it was stationary. The aim of the experiment was to see to what extent the average paths of the thumb and index finger differed between conditions. In three experiments in which the speed or direction of the sphere varied, the differences between grasping and hitting were never larger than the differences between movements toward moving or stationary objects. This is in line with the theory that grasping is a combination of hitting movements with the thumb and index finger (Smeets and Brenner, 1999). However, this evidence is not conclusive because different control mechanisms in the can sometimes result in the same movements.

The experiment in *Chapter 5* provided a more stringent test for the two theories about the control of grasping. I used a paradigm called prism adaptation that I will briefly outline here. When someone wears prism glasses he sees everything a number of degrees rotated. When asked to point at an object (without vision of the hand) this leads to an error of that same number of degrees. With every attempt the error is reduced. When the prism glasses are removed, the person again makes an error because he automatically applies a correction that is no longer appropriate.

During the experiment described in *Chapter 5* subjects wore prism glasses that rotated everything to the left when they looked with their right eye and to the right when they looked with their left eye. They touched the left side of the cube with their thumb or the right side of the cube with their index finger. Because subjects looked with one eye when they moved their thumb and with the other eye when they moved their index finger, the movements were associated with opposite rotations. In this experiment, the errors reduced with an increasing number of attempts and the subjects made the expected errors when the prism glasses were removed.

But what if the subjects had to grasp rather than touch the cube after the prism glasses were removed? The two theories on grasping predict different outcomes. If grasping is a combination of the two touching movements (Smeets and Brenner, 1999), the distance between the thumb and index finger will be increased or decreased compared to before adaptation depending on which eye was associated with which digit. However, if grasping consists of a reach and a grasp component there should be no effect on the distance between the digits of the adaptation during the touching movements. In this theory, the distance between the digits is determined by the object size and should therefore be independent of the adaptation. The result was that the distance between the digits did depend on the adaptation. This is strong evidence that grasping movements can be considered as a combination of touching movements of the thumb and index finger.

Chapter 2 of this thesis describes a method researchers can use to reliably segment their data. During experiments, data is generally recorded for longer than necessary. For example, in *Chapter 3* I was only interested in the posture of the arm at the time the sphere was grasped (end of the reaching movement). However, the data consists of a series of coordinates that also describe the movements of the arm before and after this moment. In practice, finding the end of a movement can be a difficult and time-consuming task. Oftentimes, subjective corrections are applied when the automatic algorithm fails to detect the endpoint or movements are segmented one by one by hand. The method presented in *Chapter 2* eliminates the need to segment the data by hand or subjectively correct the detected endpoints. It provides an objective way to segment the data.

Chapter 6 is the discussion of the thesis. I discuss the different levels at which grasping is studied and how the theoretical framework the researcher operates in can greatly influence the way experiments are set up and data is interpreted. I argue that a diversity in theoretical frameworks will keep us aware of the framework we are thinking in.