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Too much anticipation? Large anticipatory adjustments of grasping movements to minimal object manipulations



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ABSTRACT

When humans grasp objects, the grasps foreshadow the intended object manipulation. It has been suggested that grasps are selected that lead to medial arm postures, which facilitate movement speed and precision, during critical phases of the object manipulation. In Experiment 1, it has been tested whether grasp selections lead to medial postures during rotations of a dial. Participants twisted their arms considerably before grasping the dial, even when the upcoming dial rotation was minimal (5°). Participants neither assumed a medial posture at any point during a short rotation, nor did they assume any of the postures involved in short rotations in the opposite direction. Thus, grasp selections did not necessarily lead to specific postures at any point of the object manipulation. Experiment 2 examined the effect of various grasps on the speed of dial rotations. A medial initial grasp resulted in the fastest dial rotations for most rotation angles. Spontaneously selected grasps were more excused than necessary to maximize dial rotation speed. This apparent overshoot might be explained by participants' sensitive to the variability of their grasps and is in line with the assumption that grasps facilitate control over the grasped object.

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1. Introduction

Most objects can be grasped in different ways. This allows humans to choose grasps that facilitate the subsequent interaction with an object (for recent reviews see [Herbolt, 2013](#); [Rosenbaum, Chapman, Weigelt, Weiss, & van der Wel, 2012](#); [Wunsch, Henning, Aschersleben, & Weigelt, 2013](#)). However, the selection of a suitable grasp is not trivial. It requires – among other things – the integration of information about the object, about the constraints and properties of the human body, and the relationship between object and body movements. Grasp selection for the interaction with objects is often studied with the bar transport task and its variations. These tasks require participants to grasp an object and rotate it in different directions. Thereby, participants usually twist the arm before grasping the object, which then leads to a medial arm posture (i.e. a posture in the middle of the arm's range of motion, [Fig. 1](#)) at the end of the object rotation. As medial postures are perceived as more comfortable, this finding has been termed “end-state comfort effect” ([Rosenbaum et al., 1990](#)).

A medial end posture characterizes object manipulations even in the presence of otherwise strong constraints on human movement. For example, when two objects have to be handled, medial end postures are assumed even if this requires executing asymmetric arm movements ([Weigelt, Kunde, & Prinz, 2006](#)). Likewise, participants prefer handling an object with the non-dominant hand when this leads to a medial end posture over handling an object with the dominant hand when this entails a non-medial end posture ([Coelho, Studenka, & Rosenbaum, 2013](#); [Johnson, 2000](#)). Additionally, other factors (e.g. habitual grasps, task framing) studied so far affected the grasp only slightly or when the grasp selection had little influence on the postures assumed during the object manipulation (e.g. [Herbolt & Butz, 2011, 2012](#); [Herbolt, Butz, & Kunde, 2014](#); [Hughes, Haddad, Franz, Zelaznik, & Ryu, 2011](#); [Künzell et al., 2013](#); [Rosenbaum, Vaughan, Barnes, & Jorgensen, 1992](#); [Seegelke, Hughes, & Schack, 2011](#)).

The reason for the finding that object manipulations usually involve and often end in medial arm postures has been explained by the combination of two hypotheses ([Künzell et al., 2013](#); [Rosenbaum, van Heugten, & Caldwell, 1996](#); [Rosenbaum et al., 2012](#); [Short & Cauraugh, 1999](#)). First, it was assumed that participants select grasps that maximize control over the object. That is, being able to move the object as quickly ([Rosenbaum et al., 1996](#)) and precisely ([Short & Cauraugh, 1999](#)) as possible. Depending on the task, the need for precise control may be highest at the beginning of the rotation, during the rotation, or at its end ([Hughes, Seegelke, & Schack, 2012](#); [Künzell et al., 2013](#); [Rosenbaum et al., 1996](#)). This hypotheses is supported by several experiments. For example, participants who should rotate a handle adjusted the grasp more strongly in anticipation of the upcoming rotation when precision requirements were high ([Rosenbaum et al., 1996](#)). Likewise, when the need for precision was highest during early phases of the movement, participants tended to grasp the object initially with a medial grasp ([Hughes et al., 2012](#); [Künzell et al., 2013](#)).

Whereas the first hypothesis suggests that grasps are selected that maximize the control over the object, the second hypothesis addresses how grasp selection could contribute to the maximization of control. It was assumed that movements can be controlled best with medial arm postures. Thus, grasp selection should ensure that the arm is in a medial posture when the precision demands are highest. This hypotheses has been addressed less frequently, but it also found empirical support. When participants were asked to oscillate a bar in a medial posture, they were quicker than when oscillating the bar in supine or prone postures ([Rosenbaum et al., 1996](#)).¹ Likewise, participants placed objects more precisely when holding them with a medial arm posture than with an uncomfortable arm posture ([Short & Cauraugh, 1999](#)).

In sum, the postures assumed during an object manipulation are thought to determine the grasp, because postures determine how fast and precise a movement can be controlled. In the remainder, the hypothesis that grasps are selected that lead to specific arm postures at some point during the object manipulation – either to maximize control or for other reasons – will be referred to as *posture-determined grasp selection*.

¹ Please note that the present nomenclature for arm posture deviates from [Rosenbaum et al.'s \(1996\)](#). Their ‘medial’, ‘central’, and ‘lateral’, corresponds to the terms ‘prone’, ‘medial’, and ‘supine’, respectively, in the present article.

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