How Humans Optimize Their Interaction with the Environment: The Impact of Action Context on Human Perception

Agnieszka Wykowska\textsuperscript{1}, Alexis Maldonado\textsuperscript{2}, Michael Beetz\textsuperscript{2}, and Anna Schubö\textsuperscript{1}

\textsuperscript{1} Department of Experimental Psychology, Ludwig Maximilians Universität, München, Germany
\textsuperscript{2} Computer Science Department, Chair IX, Technische Universität, München, Germany

Abstract. Humans have developed various mechanisms to optimize interaction with the environment. Optimization of action planning requires efficient selection of action-relevant features. Selection might also depend on the environmental context in which an action takes place. The present study investigated how action context influences perceptual processing in action planning. The experimental paradigm comprised two independent tasks: (1) a perceptual visual search task and (2) a grasping or a pointing movement. Reaction times in the visual search task were measured as a function of the movement type (grasping vs. pointing) and context complexity (context varying along one dimension vs. context varying along two dimensions). Results showed that action context influenced reaction times, which suggests a close bidirectional link between action and perception as well as an impact of environmental action context on perceptual selection in the course of action planning. Such findings are discussed in the context of application for robotics.

Keywords: Action Context, Action Planning, Human Perception.

1 Introduction

When humans perform a particular action such as, for example, reaching for a cup in a cupboard, they need not only to specify movement parameters (e.g., the correct width of the grip aperture) but also to select movement-related information from the perceptual environment (e.g., the size and orientation of the cup's handle - but not its color - are relevant for grasping). Moreover, the context in which the grasping action is performed may also have an impact on both the action performance and the prevailing selection processes of the agent. If the cup is placed among other cups of different sizes and handle orientations, selection might be more difficult as compared to when the cup would be placed among plates. In the first case, the context varies along at least two dimensions that are relevant for grasping a cup (size and orientation of handles). In the second case, the cup is embedded in a homogeneous context also consisting of dimensions...
irrelevant for grasping a cup (breadth of plates). Therefore, the two environmental contexts might result in different processing speed of the environmental characteristics.

Several authors have investigated the influence of intended actions on perceptual processes. For example, Craighero and colleagues [2] showed that when agents were asked to grasp a tilted bar, onset latencies of their movement depended on the characteristics of a visually presented stimulus that signaled when the movement should begin (a so-called “go signal”). If the “go signal” shared action-related features with the to-be grasped object (e.g., was of the same orientation), the onset of the movement occurred faster as compared to the condition when the “go signal” differed from the to-be grasped object. These results support a close link between perception and action.

Similar results were reported by Tucker and Ellis [11]. The authors conducted a study in which participants were presented with natural objects (e.g., grape, cucumber) or manufactured objects (e.g., screw, hammer). The objects could be smaller (grape, screw) or larger (cucumber, hammer) implying either precision grip (small objects) or power grip (larger objects). The task was to categorize the objects as natural or manufactured. Half of the participants had to respond with a power grip to natural objects and precision grip to manufactured objects; the other half had opposite instructions. The results showed that although size of the objects was completely orthogonal to the categorization task, it influenced performance: Precision grips were faster to small objects relative to large objects and power grips were faster to large objects compared to small objects. This suggests that size was implicitly processed as an action-related feature of an object and, as such, had an impact on behavior.

More recent studies demonstrated that visual detection processes are highly dependent on intended action types [1] and that the perceptual system can bias action-relevant dimensions if they are congruent with the performed action [3]. Wykowska, Schubö and Hommel [14] conducted a series of experiments in which they observed action-related biases of visual perception already at early stages of processing. Importantly, these studies showed action-perception links in a situation where action and perception were completely unrelated and decoupled but had to be performed in close temporal order. Participants’ task was to detect a visually presented target while they were preparing for a grasping or pointing movement. The target could be an object that deviated in size or in luminance from the other objects. Wykowska and colleagues found that performance in the visual search task was influenced by the intended movement although the movement was not executed but only planned. That is, detection of perceptual dimension (size or luminance) was better when accompanied by the preparation of a congruent movement (e.g., grasping for size and pointing for luminance) as compared to the preparation of an incongruent movement. These results indicate a close link between action and perception that merely coincide in time. Moreover, action preparation affected perceptual processing at the level of early mental representations.