Acta Psychologica 156 (2015) 22–31

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Impact of action planning on spatial perception: Attention matters☆

Wladimir Kirsch *

Department of Psychology, University of Würzburg, Germany

ARTICLE INFO

Article history:
Received 11 October 2013
Received in revised form 11 December 2014
Accepted 6 January 2015
Available online xxxx

PsycINFO classification:
2323
2330
2346

Keywords:
Spatial perception
Motor planning
Attention
Perception–action coupling

ABSTRACT

Previous research suggested that perception of spatial location is biased towards spatial goals of planned hand movements. In the present study I show that an analogous perceptual distortion can be observed if attention is paid to a spatial location in the absence of planning a hand movement. Participants judged the position of a target during preparation of a mouse movement, the end point of which could deviate from the target by a varying degree in Exp. 1. Judgments of target position were systematically affected by movement characteristics consistent with perceptual assimilation between the target and the planned movement goal. This effect was neither due to an impact of motor execution on judgments (Exp. 2) nor due to characteristics of the movement cues or of certain target positions (Exp. 3, Exp. 5A). When the task included deployment of attention to spatial positions (former movement goals) in preparation for a secondary perceptual task, an effect emerged that was comparable with the bias associated with movement planning (Exp. 4, Exp. 5B). These results indicate that visual distortions accompanying manipulations of variables related to action could be mediated by attentional mechanisms.

1. Introduction

How observers judge spatial aspects of their environment depends on the observers' current potentials and intentions to act (see e.g., Delevoye-Turrell, Bartolo, & Coello, 2010; Làdavas & Serino, 2008; Proffitt, 2008; Proffitt & Linkenauger, 2013; Witt, 2011; for reviews). For example, using tools that extend reaching range decreases the apparent distance to distant objects (e.g., Berti & Frassinetti, 2000; Farnè & Làdavas, 2000; Longo & Lourenco, 2006; Witt & Proffitt, 2008; Witt, Proffitt, & Epstein, 2005), wearing a heavy backpack increases the apparent slope of a hill (Bhalla & Proffitt, 1999), and objects seem farther away when they are difficult rather than easy to grasp (Linkenauger, Witt, Stefanucci, Bakdash, & Proffitt, 2009). These and similar effects are often explained by the old idea that motor variables serve as a reference (or "ruler") for early sensory information and thus, provide a basis for subjectively experienced perceptual events (cf. e.g., Proffitt & Linkenauger, 2013; Van der Heijden, Müsseler, & Bridgeman, 1999; Witt, 2011; see also Scheerer, 1984 and Viviani, 2002 for historical reviews). How such a "scaling" of sensory stimulation takes place however, is not well understood.

In the present paper, I explore the idea that visual attention contributes to the perceptual distortions that follow manipulations of action plans. It is known for long that planning a goal oriented movement incorporates the direction of visual attention to the endpoint of the movement. This has been inferred from facilitated processing of visual stimuli at target locations of planned hand or eye movements (see e.g., Deubel, Schneider, & Paprotta, 1998; Baldauf & Deubel, 2010 for a review). Planning to grasp rather than to reach an object enhances processing of object's orientation (Bekkering & Neggers, 2002; Gutteling, Kenemans, & Neggers, 2011). Also, planning a grasping movement facilitates perception of object's size, while planning of pointing movements facilitates perception of luminance (Wykowska & Schubö, 2012; Wykowska, Schubö, & Hommel, 2009). Obviously, thus, action planning processes are tightly coupled to visual attention. Perhaps, orienting attention is nothing else but the activity of sensorimotor circuits, in other words, it is a consequence of motor processes as suggested in premotor theory of attention (Rizzolatti, Riggio, & Sheliga, 1994).

Preliminary hints for a role of visual attention in action dependent plasticity comes from own previous work. The experimental task we used resembled those used in the research of attentional mechanisms (e.g., Deubel et al., 1998). Participants saw a cue that informed them about certain characteristics of an upcoming movement. Before movement execution they were asked to estimate certain distances. The larger the amplitude or force of the planned movement, the larger were judgments of the visual distance (Kirsch, Herbort, Butz, & Kunde, 2012; Kirsch & Kunde, 2013a). While these results suggested that

☆ This research was supported by grant KI 1620/1-1 awarded to W. Kirsch by the German Research Council (DFG).

* Corresponding author at: Institut für Psychologie III der Universität Würzburg, Röntgenring 11, D-97070 Würzburg, Germany. Tel.: +49 931 31 82191; fax: +49 931 831 2815.
E-mail address: kirsch@psychologie.uni-wuerzburg.de.

http://dx.doi.org/10.1016/j.actpsy.2015.01.002
0001-6918/

motor planning affects visual perception, it was left unclear, which specific aspect of movement planning can be held responsible for these effects. In an attempt to isolate one of these variables we manipulated end locations of aiming movements with otherwise constant amplitudes (Kirsch & Kunde, 2013b). This did in fact affect distance judgments, suggesting that the anticipated movement goal distorts somehow the perceived location of objects that are part of the judged distance.

In the present study I went one step further, and tested whether shifts of spatial attention on their own are sufficient for perceptual distortions to occur. This is suggested by a couple of observations. For instance, the lines of Vernier stimuli are perceived as displaced after brief peripheral cues, which corresponds to a repulsion of the lines away from the attention-grabbing cues (Pratt & Turk-Browne, 2003; Suzuki & Cavanagh, 1997). Also, oval stimuli appear more or less stretched out depending on attentional cues (Fortenbaugh, Prinzmetal, & Robertson, 2011). Thus, there is good reason to speculate that attentional mechanisms involved in planning an action cause perceptual distortions.

Experiments 1–3 establish an experimental procedure to demonstrate robust influences of planned movement endpoints on the perceived position of movement-unrelated objects. Experiment 4 will then demonstrate that with essentially the same task perceptual perturbations emerge from orienting of attention alone without (obvious) necessity for planning a movement. Finally, Experiment 5 refutes a possible objection that the main findings are due to certain stimulus characteristics.

2. Experiment 1

The goal of Experiment 1 was to show that the anticipated endpoint of the planned movement biases perception of object's locations in an assimilation-like manner (end-point hypothesis, cf. Kirsch & Kunde, 2013b). That is, planning a movement to the left of a current target location should bias the perceived location of an object to the left. And conversely, the apparent target location should shift to the right when the endpoint of the planned movement deviates to the right of it. Also, the magnitude of the perceptual bias should increase with an increase in deviation between the target and the anticipated end position of the movement.

I combined a version of previously used planning-perception-execution paradigm (e.g., Kirsch & Kunde, 2013b) with a “position naming task” (Van der Heijden, Van der Geest, De Leeuw, Krikke, & Müsseler, 1999). In each trial participants judged the position of a target line shortly presented during preparation of a mouse movement (cf. Fig. 1). The planned end point of the movement could horizontally deviate from the position of the target line to the left and to the right by a varying degree. The main question of interest was whether and how target judgments are affected by the concurrently planned movements.

2.1. Methods

2.1.1. Participants

Twelve participants volunteered and provided written informed consent. They received payment for their participation. The sample included 9 females and 3 males with normal or corrected to normal vision. The mean age was 25 years ranging from 22 to 30 ($SD = 3$). All participants reported to be right handers.

2.1.2. Apparatus

Participants sat in front of a standard 19″ CRT monitor that was positioned approximately at eye-level at a viewing distance of about 65 cm. The monitor stood on a wooden superstructure that was positioned on a table. The participant's head was supported by a chin rest. The display had a resolution of 1024 (H) × 768 (V) pixels and a refresh rate of appr. 100 Hz. The background was white, the stimuli were black or colored (see below). A keyboard was placed at the left side in front of the participant on the table so that she could use it with the left hand. A computer mouse was placed at the right side of the participant so that she could use it with the right hand. The experiment was carried out in a low-illuminated room: only a faint

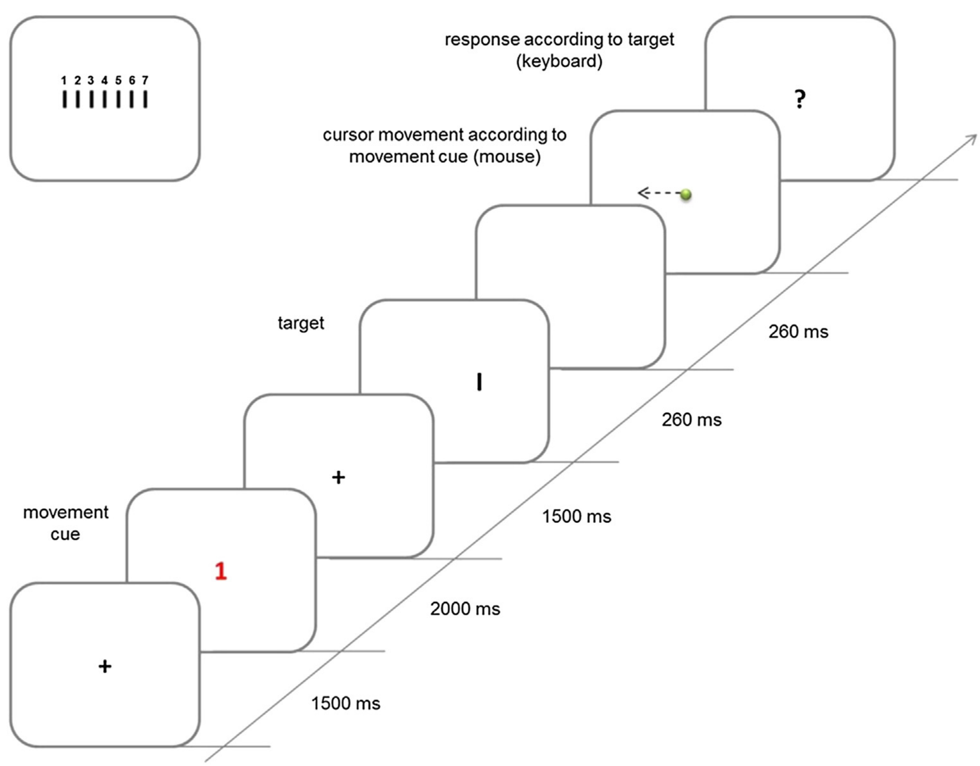

Fig. 1. Schematic illustration of the main trial events in Experiment 1. The assignment of numerical cues to the positions of the target line is shown in the left upper corner. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)