cortex xxx (2017) 1–6

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Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

# Dissociable effects of stimulus range on perception and action

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ARTICLE INFO

Article history:
Received 20 October 2016
Reviewed 9 December 2016
Revised 18 December 2016
Accepted 20 December 2016
Published online xxx

Keywords:
Perception and action
Grasping
Effects of context
Relative processing
Psychophysics

ABSTRACT

We have recently reported the discovery that the ability to detect a minimum increment to a stimulus depends on the spread of the other stimuli for which this just noticeable difference (JND) is being measured (Namdar, Ganel, & Algom, 2016). In particular, the JND around a standard stimulus was larger when the other standards tested within the same experimental session spread a larger range. In this study we show that this range of standards effect (RSE) is limited to perceptual estimations and does not extend to action. The JND remained invariant when the participants grasped the objects rather than perceptually estimated their size. This difference supports the hypothesis that visual perception, on the one hand, and visually controlled action, on the other hand, are governed by separate rules and mediated by different mechanisms.





## 1. Introduction

Perceptual resolution with respect to a given stimulus is contingent upon the context in which the stimulus is presented (Namdar et al., 2016; see also, Hellström, 2000). In particular, perceptual sensitivity with respect to the same stimulus is greater [i.e., the just noticeable difference (JND) or the difference threshold or limen, DL, is smaller] when the other stimuli tested are of similar magnitudes than when they are spread over a larger range of magnitudes. For example, the JND for a stimulus with a weight of 400 g was found smaller when the other standards tested within the same condition were 350 and 450 g than when they were 200 and 600 g. In other words, the perceptual resolution for a single stimulus is contingent upon the resolution of the context, or stimulus set, in which it is embedded. Coarse resolution of the set (e.g., wider spacing between stimuli) leads to a decrease in the resolution of each stimulus within that set. Alternatively, it was also suggested that the range of standards effect (RSE) could have stemmed from adaptation effects to stimulus range, which result in an increased sensitivity to stimuli in a narrow compared to a wide range (Namdar et al., 2016).

The RSE has been established across different perceptual modalities, including visual size discrimination and tactile weight perception. However, it is still unclear whether the RSE applies solely to the perceptual system. Does it also constrain performance in the domain of visuomotor control of action?

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http://dx.doi.org/10.1016/j.cortex.2016.12.017
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Are grasping trajectories immune to the range of the stimuli being grasped? This seems plausible given evidence that grasping is less susceptible to influences of context than perception (e.g., Ganel & Goodale, 2003, 2014; Goodale & Westwood, 2004). We note though that a number of recent studies reported short-term contextual modulation of grasping, too (e.g., Dixon & Glover, 2009; LeBlanc & Westwood, 2015). However, if the RSE is found limited to visual perception so that it does not affect visually-controlled action, then a powerful diagnostic to dissociate perception and action at the level of a single stimulus becomes available.

According to Goodale and Milner's influential account, vision for action and vision for perception are subserved by distinct (yet interactive) neuroanatomical streams (Goodale & Milner, 1992; Mishkin, Ungerleider, & Macko, 1983; but see; Franz, Gegenfurtner, Bülthoff, & Fahle, 2000). Goodale and Milner suggested that the *dorsal* pathway in the primate visual system, which includes parietal regions, enables flexible control of actions directed at objects in the environment. The *ventral* pathway, by contrast, provides a rich and detailed representation of the environment sustaining visual perception (Goodale & Milner, 1992). Research within this framework suggests that the visuomotor system processes information in a selective manner more than does the visual perceptual system (Ganel & Goodale, 2003, 2014; Goodale & Westwood, 2004). This property often insulates grasping from the unwanted influence of task-irrelevant contextual information (Aglioti, DeSouza, & Goodale, 1995; Doherty, Campbell, Tsuji, & Phillips, 2010; Ganel, Chajut, & Algom, 2008; Ganel, Tanzer, & Goodale, 2008, but see; Franz et al., 2000; Utz, Hesse, Aschenneller, & Schenk, 2015).

Several recent studies have suggested that there are some situations in which grasping trajectories can be modulated by short-term contextual information. For example, it has been reported that the trajectory of grip aperture is affected, at least to some extent, by the aperture of the immediate preceding trial (Dixon & Glover, 2009, see also; LeBlanc & Westwood, 2015). Additionally, recent evidence suggests that grasping, similarly to visual perception, can be affected by contextual information, such as that entailed in the Ebbinghaus illusion (Kopiske, Bruno, Hesse, Schenk, & Franz, 2016; but see; Ganel & Goodale, 2014; Haffenden & Goodale, 1998; Whitwell & Goodale, 2016). A different line of evidence suggests though, that unlike perceptual estimations, which are affected by irrelevant variations in stimulus shape, grasping is immune to the same effects (Ganel & Goodale, 2003, 2014). It is therefore an open question whether the RSE, an effect which has been only demonstrated in the perceptual domain, would extend to affect online control of actions.

### 1.1. *The present study*

Our goal in this study was twofold. First, we wished to replicate the RSE so that it rests on an even firmer empirical basis. In the previous study (Namdar et al., 2016), we used the psychophysical method of Constant Stimuli. In this study, we made use of the Method of Adjustment (Baird & Noma, 1978; Gescheider, 1976; Marks & Algom, 1998). In this method, the JND is given by the standard deviation of the reproductions of the stimulus tested for resolution. An advantage of the method is that the JND or DL derived can be easily compared between perception and grasping (Ganel, Chajut, & Algom, 2008; Ganel, Chajut, Tanzer, & Algom, 2008; Ganel, Freud, & Meiran, 2014). We expected that the JND for the same 40 mm stimulus would be larger when the other stimuli tested simultaneously are 20 and 60 mm than when the other stimuli are 35 and 45 mm. Secondly and more important, we expected that this effect would be limited to perception: grasping the same stimuli would not result in modification of the JND for the common 40 mm stimulus. Therefore, in the perceptual condition, the participants were asked to make perceptual estimations of size, whereas in the grasping condition they were asked to perform visually-guided grasping movements toward the same objects. In a control experiment we also tested whether the hypothesized insensitivity of the grasping trajectories to the measuring context can possibly be confounded by on-line corrections based on visual feedback from the fingers and the target object (Glover & Dixon, 2002). Such online corrections could mask contextual effects on grip apertures. To address this concern, grasping movements in the control experiment were performed in an open-loop design, for which visual feedback was prevented during grasp.

## 2. Methods

### 2.1. *Participants*

A group of 14 right-handed students from Ben-Gurion University of the Negev, who gave their informed consent, participated in the main experiment (3 males, mean age of 23.35, SD = 1.59 years). A separate group of 14 right-handed participants (8 males, mean age of 23.57, SD = 2.65 years) participated in the control, open-loop grasping experiment. All participants signed a consent form and the experimental protocol was approved by the departmental ethics committee in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

### 2.2. *Apparatus and stimuli*

The stimuli were five plastic rods of a constant width and height of 5 mm. The values of length were 20, 35, 40, 45, and 60 mm. The participants set in front of a black tabletop with the tips of the index finger and thumb (right hand) resting on a small starting button fixed to the center of the tabletop. The participants wore a set of LCD glasses (Translucent Technologies, Toronto, ON) with liquid-crystal shutter lenses used to control stimulus exposure time. The experimenter manually switched between the rods prior to each trial in a pseudo-randomized order. Each rod was placed 30 cm from the participant, in the center of the table, along the midline of the participant. Rods were placed on the table perpendicularly to the participant's viewing plane (Fig. 1).

### 2.3. *Design*

The main experiment consisted of two separate, closed-loop tasks, a grasping task and a manual estimation task. In the grasping task, the participants were asked to grasp the rod



Please cite this article in press as: Namdar, G., et al., Dissociable effects of stimulus range on perception and action, Cortex (2017), http://dx.doi.org/10.1016/j.cortex.2016.12.017