Consciousness and Cognition 18 (2009) 223–228

Contents lists available at ScienceDirect

Consciousness and Cognition

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

Grasping the diagonal: Controlling attention to illusory stimuli for action and perception

Elisabeth Stöttinger *, Stefan Aigner, Klara Hanstein, Josef Perner

Department of Psychology, University of Salzburg, Hellbrunnerstrasse 34, A-5020 Salzburg, Austria

ARTICLE INFO

Article history:
Received 18 February 2008
Available online 27 May 2008

Keywords:
Visual illusions
Perceptual judgement
Knowledge for action
Implicit knowledge
Conscious perception
Obstacles avoidance

ABSTRACT

Since the pioneering work of [Aglioti, S., DeSouza, J. F., & Goodale, M. A. (1995). Size-contrast illusions deceive the eye but not the hand. *Current Biology, 5*(6), 679–685] visual illusions have been used to provide evidence for the functional division of labour within the visual system—one system for conscious perception and the other system for unconscious guidance of action. However, these studies were criticised for attentional mismatch between action and perception conditions and for the fact that grip size is not determined by the size of an object but also by surrounding obstacles. Stoettinger and Perner [Stoettinger, E., & Perner, J., (2006). Dissociating size representations for action and for conscious judgment: Grasping visual illusions without apparent obstacles. *Consciousness and Cognition, 15*, 269–284] used the diagonal illusion controlling for the influence of surrounding features on grip size and bimanual grasping to rule out attentional mismatch. Unfortunately, the latter objective was not fully achieved. In the present study, attentional mismatch was avoided by using only the dominant hand for action and for indicating perceived size. Results support the division of labour: Grip aperture follows actual size independent of illusory effects, while finger-thumb span indications of perceived length are clearly influenced by the illusion.

1. Introduction

More than 10 years ago Aglioti, DeSouza, and Goodale (1995) published an experiment (later replicated by Haffenden & Goodale, 1998) which demonstrated a functional division of labour within the visual system. They used the well known Ebbinghaus Illusion with two identical discs—one surrounded by smaller rings the other surrounded by larger rings. Participants were asked to pick up the larger/smaller disc in the middle. In keeping with the well known effect of the illusion the disc surrounded by smaller rings was judged larger than the one surrounded by larger rings. However, grip size scaling (thumb finger opening on the way grasping a disc) was about the same for both discs. This was taken as evidence for two different pathways within the visual system—one for action and one for perception which have to fulfil different requirements: According to Goodale and Milner (1992; Milner & Goodale, 1995) computations for perception should primarily be "object-centred" with a focus on the relationship between an object and its surrounding objects (and should therefore be distorted by the illusion), whereas the computations for action requires a focus on the object with respect to the observer. Egocentric coordinates and the actual size of the object are computed each time an action occurs which leads to an immunity to the illusion.

This interpretation of the original finding by Aglioti et al. (1995) has, however, come in for much criticism. For an overview see Smeets and Brenner (2006). One criticism was voiced by Pavani, Boscagli, Benvenuti, Rabuffetti, and Farnè (1999)

* Corresponding author. Fax: +43 0 662 8044 5124.
E-mail address: elisabeth.stoettinger@sbg.ac.at (E. Stöttinger).

1053-8100/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.concog.2008.04.003

and by Franz, Gegenfurtner, Bülthoff, and Fahle (2000) who claimed that task demands are not matched appropriately in most experiments. Size-contrast illusions like the Ebbinghaus Illusion usually depend upon contrasting two complementary elements. As Franz et al. (2000) showed the size of the illusory effect is much stronger when the two discs in each display of the Ebbinghaus Illusion are directly compared than when a disc in one of these displays is compared to a plain disc (without any surrounding rings). They argued that participants in Aglioti's experiment had to process the entire illusion display in the perceptual task ("which is larger"), whereas in the motor task (picking up the disc) they may only look at or attend to the target itself to be grasped. This might have restricted their attention to only that particular disc, attenuating the illusory effect and, consequently, resulting in seemingly more accurate grip size differences. Therefore, it has been argued that observed differences between perception and action are in fact an experimental artefact caused by an attentional mismatch of conditions (Bruno, 2001; Franz, 2001; Franz, Fahle, Bülthoff, & Gegenfurtner, 2001; Franz et al., 2000; Pavani et al., 1999).

To undermine the critique of attentional mismatch Dewar and Carey (2006) used bimanual grasping and matching. They could show that grasping the shaft of the Mueller Lyer illusion[1] in contrast to matching the length of the shafts was not significantly influenced by the illusion. This was taken as evidence for the perception-action dissociation within the visual system. Unfortunately the study of Dewar and Carey (2006) failed to rule out all arguments against the functional division of labour interpretation: extraneous reasons could have influenced grasping (Jacob & Jeannerod, 2003; Smeets & Brenner, 1999). In case of the Ebbinghaus Illusion the actual size of the disc is one factor. Another plausible factor determining grip size is the space between the disc and surrounding obstacles. As Haffenden and Goodale (2000) and Haffenden, Schiff, and Goodale (2001) found, grip aperture was significantly greater when the gap between the target disc and the surrounding annulus was shorter (big target surrounded by small circles) than for the other arrangement. Maybe participants open their hand wider as if to grasp the entire display which could lead to the erroneous impression that grasping is influenced by the illusion (for influence of surrounding annuli see also De Grave, Biegstraaten, Smeets, & Brenner, 2005).

Franz, Bülthoff, & Fahle, 2003 did a similar experiment with seemingly contradicting results. They found a systematically increasing grip aperture with perceived size independent of the gap between target and context circles. However, participants had to grasp the stimuli blindfolded without any kind of visual feedback throughout the entire movement because as soon as participants started their grasping movements, shutter glasses suppressed their vision. Participants had four seconds to carry out this movement, which creates a problem of interpretation: the unconscious representation for guiding movements does not persist for longer than two seconds. If the delay between seeing an object and movement execution toward this object is longer than two seconds, movements are based on the longer lasting conscious perceptual representation (see for example Goodale, Jakobson, & Keillor, 1994; Goodale, Westwood, & Milner, 2004; Milner & Goodale, 1995). In fact, it has also been reported that visuomotor "representations" for actions do not bridge delays at all—and operate only in real-time (e.g., Westwood & Goodale, 2002). Hence, if participants in the experiment by Franz et al. (2003) did take close to 2 s for their blindfolded movement, it is fairly likely that these authors found an influence of the illusion on grasping because a transition from real-time to memory driven control had occurred which forced participants to base their grasping on the illusory perceptual representation (see also Goodale et al., 1994, 2004 for differences between pantomimed—memory driven—and real actions).

Beside the commonly used Ebbinghaus Illusion the Mueller Lyer illusion (for example used by Daprati & Gentilucci, 1997; Dewar & Carey, 2006; Otto-de Haart, Carey, & Milne, 1999; VanDoorn, Van der Kamp, & Savelsbergh, 2007) suffers from similar problems: The lines between the different orientated arrows (pointed inside or outside which causes the impression that one line looks longer than the other) had to be grasped by participants. One side effect of these background markings is that the wings of the background arrows may have unexpected effects on the visuo-motor system. On the one hand the wings could act as obstacles which make participants try to place the fingers cautiously within the V-shaped wings at the end. This may reduce the maximum grip size and give the impression that grasping is based on a more accurate representation. On the other hand the wings could also have the opposite effect. Maybe participants try to grasp "the whole object" (not only the stick itself but the entire object of stick and wings). This may increase grip size and would give us the impression that grasping is influenced by the illusion (for a detailed discussion of the potential influences of obstacles see Stoettinger & Perner, 2006).

In order to avoid the problems outlined above Stoettinger and Perner (2006) used new material and procedures. To counter the critique of attentional mismatch (Bruno, 2001; Franz et al., 2000; Pavani et al., 1999), bimanual actions (like Dewar & Carey, 2006) were used: participants had not only to compare the length of the two displays for their conscious judgment but also had to grasp both stimuli simultaneously. To avoid (at least minimize) the interference of extraneous reasons for adjusting action parameters the diagonal illusion (experiment 1) and an adjusted illusion were used, in which any potential obstacle in the trajectory of the approaching hand was identical for each display (experiment 2). In ruling out all plausible methodological arguments discussed above Stoettinger and Perner (2006) found evidence for the functional division of labour within the visual system: grip size scaling follows actual size independent of illusory effects. In contrast, conscious size judgments, i.e., direct comparisons of lengths (experiment 1) and finger-thumb span indications of perceived length (experiment 2) were clearly biased by the illusion.

[1] In the Mueller-Lyer illusions two lines with different arrows at the end are used – one arrows whose ends pointed outwards, which causes the impression that this line is longer than the other line where arrow ends pointed inwards).