Acta Psychologica 180 (2017) 160–168

Contents lists available at ScienceDirect

Acta Psychologica

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

When perception trips action! The increase in the perceived size of both hand and target matters in reaching and grasping movements

Elisabetta Ambron[a,*], Luis F. Schettino[b], Marlee Coyle[a], Steven Jax[c], H. Branch Coslett[a]

[a] Laboratory for Cognition and Neural Stimulation, Dept. of Neurology, Perelman School of Medicine at the University of Pennsylvania, United States
[b] Neuroscience Program, Lafayette College, United States
[c] Perceptual-Motor Control Laboratory, Moss Rehabilitation Research Institute (MRRI), United States

ARTICLE INFO

Keywords:
Reaching
Grasping
Vision
Body representation
Multisensory integration

ABSTRACT

Reaching and grasping movements rely on visual information regarding the target characteristics (e.g. size) and the hand position during the action execution. Changes in the visual representation of the body (e.g. increase in the perceived size of the hand) can modify action performance, but it is still unclear how these modifications interact with changes in the external environment. We investigated this topic by manipulating the perceived size of both hand and target objects and the degree of visual feedback available during the movement execution. Ten young adults were asked to reach and grasp geometrical objects in four different conditions: (i) with normal vision with the light on, (ii) with normal vision in the dark, (iii) using magnifying lenses in the light and (iv) using magnifying lenses in the dark. In contrast with previous works, our results show that movement execution is longer in magnified vision compared to normal when the action is executed in the light, but the grasping component was not affected by changes in size in this condition. On the contrary, when the visual feedback of the hand was removed and participants performed the action in the dark, movements were faster and the distances across fingers larger in the magnified than normal vision. This pattern of data suggests that grasping movements adapt rapidly and compensate for changes in vision when this process depends on the degree of visual feedback and/or environmental cues available. In the debate regarding the dissociation between action and perception, our data suggest that action may overcome changes in perception when visual feedback is available, but perception may trick action in situations of reduced visual information.

1. Introduction

The motor system adapts rapidly to the constraints of the visual environment (Rossetti & Pisella, 2002). Reach-to-grasp movements change to accommodate the characteristics (e.g. size or orientation) of target stimuli (Castiello, 2005; Jeannerod, 1999; Schettino, Adamovich, & Poizner, 2003) or cues from the visual environment (Churchill, Hopkins, Rönnqvist, & Vogt, 2000; Schettino et al., 2003). When more visual information is available and the action is executed with full vision rather than in the dark, reaching and grasping movements are generally more precise (Berthier, Clifton, Gullapalli, McCall, & Robin, 1996; Jakobson & Goodale, 1991; Jeannerod, 1984). However, these observations are not conclusive For instance, Winges, Weber, and Santello (2003) showed that blocking vision at different points of movement execution increased the timing of the reach, but did not affect the grasping components of the action.

In this context, vision of the hand plays an important role in action performance (Churchill et al., 2000). Access to visual feedback of the hand results in shorter movement times relative to conditions without visual feedback (Jeannerod, 1984), but it has also an effect on grasping parameters. For example, maximum grip aperture (MGA) decreases (Jakobson & Goodale, 1991) and occurs earlier in the movement (Connolly & Goodale, 1999) with visual feedback. Interestingly, a beneficial effect of vision of the hand in action performance has been noted not only when the hand is visible during the execution of the movement (Saunders & Knill, 2003), but also prior to movement onset (Desmurget, Rossetti, Jordan, Meckler, & Prablanc, 1997; Rossetti, Stelmach, Desmurget, Prablanc, & Jeannerod, 1994) and at the end of the action (Carlton, 1981).

Interestingly, changes in the perceived size of the hand also affect movement execution. This line of research took inspiration from studies on tactile and pain perception which demonstrated that changes in the apparent size of a body part with magnifying or minimizing lenses have an effect on tactile acuity (Kennett, Taylor-Clarke, & Haggard, 2001),

* Corresponding author at: Laboratory for Cognition and Neural Stimulation, Dept. of Neurology, Perelman School of Medicine at the University of Pennsylvania, Goddard Laboratory, 3710 Hamilton Walk, Philadelphia, PA 19104, United States.
E-mail addresses: eli.ambron@gmail.com, eambron@mail.med.upenn.edu (E. Ambron).

http://dx.doi.org/10.1016/j.actpsy.2017.09.011
Received 7 May 2017; Received in revised form 22 August 2017; Accepted 20 September 2017
Available online 26 September 2017
0001-6918/

tactile distance judgments (Taylor-Clarke, Jacobsen, & Haggard, 2004), and pain-perception (Moseley, Parsons, & Spence, 2008; Longo, Betti, Aglioti, & Haggard, 2009; Mancini, Longo, Kammers, & Haggard, 2011). In particular, the magnification of a body part through vision improves tactile discrimination (Haggard, Taylor-Clarke, & Kennett, 2003; Kennett et al., 2001) and has an analgesic effect on pain perception (Moseley et al., 2008).

With the purpose of investigating whether alterations in perceived hand size affect motor control, Marino, Stucchi, Nava, Haggard, and Maravita (2010) asked participants to grasp a cylinder without visual feedback, with a normal view of the hand, or viewing their hand enlarged or shrunken. In their paradigm the vision of the object was kept consistent, while the perceived hand size varied. Interestingly, the results showed that grasping movements adapted automatically to the changes in body representation. In particular, when participants perceived their hand magnified, MGA was smaller than in the real-size and no-vision hand conditions. However, this effect was not observed with the shrinkage of the hand. These results were replicated in a study by Bernardi et al. (2013), which confirmed a reduction of grip aperture when the hand was perceived larger, while no effect was observed on movement time. In an additional experiment, these authors manipulated the size of the object keeping constant the size of the hand and confirmed a reduction of grip aperture with the smaller object, but also showed that the size of the object had an effect on the reaching component with an increase of movement time with smaller objects. Similarly, Karok and Newport (2010) examined changes in reaching and grasping parameters in response to changes in object or hand size. In their set up based on a virtual-reality system, participants were asked to reach and grasp a wooden block, presented among other two distractors. Immediately after the movement onset, the hand, the target object, or the distractor, progressively increased in size (up to 100% lateral increase). This hand size perturbation induced a progressive reduction of grip aperture in approaching the object, whereas the opposite pattern was observed when the target object increased in size: here MGA progressively increased and was reached later than in normal viewing conditions. Furthermore, modifications of the reaching component were observed only with changes in perceived hand size, as participants exhibited shorter movement times when the hand was enlarged. These changes occurred despite participants being unaware of the modifications in the visual perception of the hand. In fact, participants were informed only at the end of the experiment that a perturbation of hand size occurred during the task as most of them did not note such manipulation during task execution.

Taken together, this evidence suggests that the motor system rapidly adapts to meet the changes of visual information available, in particular if these changes involve effector (Bernardi et al., 2013; Karok & Newport, 2010; Marino et al., 2010) or target size (Gentilucci, 2002; Karok & Newport, 2010). However, the evidence that the perceived target's size affects action performance is equivocal, as studies on visual illusions have suggested that the motor system is resistant to visual illusions and adjusts to meet the requirement of real rather than the perceived size of objects (Aglioti, DeSouza, & Goodale, 1995; Ganel, Freud, Chajut, & Algom, 2012; Ganel, Tanzer, & Goodale, 2008). Nevertheless, as in most of these paradigms the action was executed in closed loop conditions, the vision of the hand may have a significant influence in determining these null effects. In support of this view, Heath, Rival, Westwood, and Neely (2005) reported the effect of an illusion in open loop conditions and demonstrated that when visual feedback of the hand is removed, action relies more on visual perception. Franz, Hesse, and Kollath (2009) replicated and extended these results. They tested the effect of the Muller-Lyer illusion on reaching and grasping while modulating movement onset and the level of visual feedback across conditions. The authors reasoned that the inconsistency in replicating the effects of visual illusions during grasping could be dependent on the level of visual feedback available during action performance. In line with this interpretation, the authors found that the effect of the visual illusion on grasping increases if the response onset is delayed, but that this effect is not simply due to the memory demands of the task. Their results showed that manipulating the availability of visual feedback at different time frames after movement onset, decreases the effect of the illusion as a function of the amount of visual feedback available.

Similarly, Franz, Gegenfurtner, Bülthoff, and Fahle (2000) showed that the incongruence across studies is often due to a mismatch between the task demands in perception and in action (see also Franz & Gegenfurtner, 2008 for a critical review on this topic). For example, these authors showed that the effect of the Ebbinghaus illusion observed in perception (participants judge the central circle surrounded by smaller circles bigger than the same circle when surrounded by larger circles) can be equally observed in grasping when the task demands are matched (i.e. only one stimulus is presented rather than two; or the perceptual comparison is carried out with respect to a target circle not part of the Ebbinghaus figure). This evidence suggests that perception and action may not be as independent as originally claimed (Milner & Goodale, 1995) and that visual illusions may equally affect the perceptual and motor domains.

Indeed, a recent multicentre study conducted on a large sample of participants (Kopiske, Bruno, Hesse, Schenk, & Franz, 2016) asked whether the vision-for-action system is as sensitive to visual illusions as the vision-for-perception system, or even whether these systems can be dissociated. Through of series of perceptual and motor tasks, the authors manipulated the physical or perceptual size of the Ebbinghaus illusion stimuli to test for a possible dissociation between the vision-for-perception and vision-for-action systems. Their results showed that participants exhibited a consistent effect of the visual illusion on the scaling of maximum grip aperture accordingly to the perceived size of the objects, providing strong evidence that action is as affected by the Ebbinghaus illusion as perception.

In the present study, we investigated how changes in the perceived size of the effector and/or of the target influence reaching and grasping movements. Specifically, we explored whether or not the motor system is (i) affected by changes in perceived size of the hand, as shown in previous work (Bernardi et al., 2013; Karok & Newport, 2010; Marino et al., 2010), or whether this effect disappears when the target object is also magnified; and if it is (ii) resistant to changes in the perceived size of an object, also in conditions in which the visual feedback of the hand is not available (the action is performed in the dark). To investigate this topic we manipulated the level of visual feedback, (actions were performed in dark or in the light) and the level of vision, which was either normal or magnified. Therefore, participants reached and grasped geometrical objects employing a full hand precision grip under four possible conditions: (i) with normal vision in the light; (ii) with normal vision in the dark; (iii) with magnified vision in the light and (iiii) with magnified vision in the dark. In the light, both hand and objects were visible in either normal size (NORMAL LIGHT condition) or enlarged (MAGNIFIED LIGHT condition). In the dark condition, the hand was not visible, but the fluorescent glow of the objects was visible in normal size (NORMAL DARK condition) or in larger size (MAGNIFIED DARK condition).

These manipulations allowed us to investigate whether changes in the perceived size of the body influence action performance even in conditions where the overall vision is magnified. In the light condition we predicted three possible outcomes. First, if changes in the perceived size of the hand have a primary role in action performance despite changes in the perceived size of the target, action performance should change with magnification of the hand with a reduction of movement execution time and of grip aperture with magnification (cf., Bernardi et al., 2013; Karok & Newport, 2010; Marino et al., 2010). In contrast, if the size of the object overrides changes in body representation, participants' performance should follow the perceived size of the object across conditions, showing a larger grip aperture when the object is perceived larger. A third possibility is that as both hand and target are