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From body shadows to bodily attention: Automatic orienting of tactile attention driven by cast shadows

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ABSTRACT

Body shadows orient attention to the body-part casting the shadow. We have investigated the automaticity of this phenomenon, by addressing its time-course and its resistance to contextual manipulations. When targets were tactile stimuli at the hands (Exp.1) or visual stimuli near the body-shadow (Exp.2), cueing effects emerged regardless of the delay between shadow and target onset (100, 600, 1200, 2400 ms). This suggests a fast and sustained attention orienting to body-shadows, that involves both the space occupied by shadows (extra-personal space) and the space the shadow refers to (own body). When target type became unpredictable (tactile or visual), shadow-cueing effects remained robust only for tactile targets, as visual stimuli showed no overall reliable effects, regardless of whether they occurred near the shadow (Exp.3) or near the body (Exp.4). We conclude that mandatory attention shifts triggered by body-shadows are limited to tactile targets and, instead, are less automatic for visual stimuli.

1. Introduction

Shadows have fascinated philosophers, scientists and novelists for many centuries (for review see Casati, 2003). In recent years, the processing of shadows has also been the target of an increasing number of studies in cognitive science, likely due to the growing body of evidence showing that information carried by shadows can serve a fundamental aid to several tasks performed in daily life. It is now widely acknowledged that shadows can be rapidly processed by our visual system (e.g., Elder, Trithart, Pintilie, & MacLean, 2004; Rensink & Cavanagh, 2004), and they can be efficiently used for object recognition in both humans (Castiello, 2001; Norman, Dawson, & Raines, 2000) and other animal species such as chicks (Mascalzoni, Regolin, & Vallortigara, 2009). In addition, several studies have shown that projected or cast shadows of objects not only greatly assist in defining the spatial arrangement of objects within a scene, in both dynamic and static contexts (e.g., Imura et al., 2006; Kersten, Mamassian, & Knill, 1997; Yonas & Granrud, 2006; see Mamassian, Knill, & Kersten, 1998, for a review), but can also play a role in modulating the dynamics of movement towards the casting objects (Bonfiglioli, Pavani, & Castiello, 2004).

In ecological contexts, shadows are projected not only by objects in the environment, but also by our own body. Converging neuroimaging data (Downing, Jiang, Shuman, & Kanwisher, 2001; Pourtois, Peelen, Spinelli, Seeck, & Vuilleumier, 2007;

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Urgesi, Berlucchi, & Aglioti, 2004) suggest that body parts have dedicated cortical visual processing modules. Consistent with neuroimaging findings, behavioural evidence has also been reported showing that body parts seem to receive privileged processing resources compared to other objects (e.g., Igarashi, Kitagawa, Spence, & Ichihara, 2007; Ro, Friggel, & Lavie, 2007). Pavani and Castiello (2004) combined these two research domains and addressed the issue of whether shadows cast by our own body parts may act as a special category of shadow stimuli, as body shadows are evidence of high priority objects. They reasoned that, unlike object shadows, shadows cast by our own body part have the peculiarity of referring to a location (the body part casting them) for which we have proprioceptive and interoceptive experience, and may also be involved in the construction of the internal representation of body shape (body image) and boundaries (body schema). Pavani and Castiello exploited the visuo-tactile interference paradigm (e.g., Pavani, Spence, & Driver, 2000) and devised an experimental setup in which a task-irrelevant visual stimulus presented far and equidistant from both hands appeared in close proximity to the shadow cast by one of the two hands. The visual stimulus produced interference effects on the tactile localization task, particularly when tactile targets were delivered to the hand casting the shadow compared to when they were presented at the other hand. This exaggerated interference effect was unique to natural body shadows, as it was not modulated by the lateralised shadow when participants wore a shaped glove projecting an unnatural polygonal shadow. Pavani and Castiello interpreted the pattern of increased visuo-tactile interference as reflecting the fact that real body shadows exerted a binding between personal and extra-personal space.

Because cast shadows can be interpreted as evidence of things but they can hardly be defined as things in themselves, the findings of Pavani and Castiello (2004) raised the possibility that body shadows may also act as a visual cue that favours orienting of attention towards the body itself. This issue was addressed by Galfano and Pavani (2005), who devised a variant of the exogenous spatial cueing paradigm (see, e.g., Posner & Cohen, 1984) using hand shadows as spatially uninformative visual cues combined with a tactile localization task. Participants received tactile targets, unpredictably to the thumb or index finger of either hand, and were required to indicate whether the target was given on the thumb or index finger, regardless of the stimulated hand. At the same time they viewed the shadow of either the touched or the untouched hand, cast in front of them by a lateral light source. The shadow was entirely irrelevant to the task, because it indicated the actual stimulated hand on half of the trials only. Furthermore, participants were explicitly informed that the shadow conveyed no useful information for carrying out the task. Nonetheless, tactile localization performance was significantly better at the hand casting the shadow compared to the other hand. This result was taken as evidence that cast shadows of the body can elicit an involuntary orienting response towards the body parts casting them. Critically, when the cast shadow of the hand was replaced by the cast shadow of an object, shadow-driven orienting of attention became unreliable. Pavani and Galfano (2007) qualified this result further by showing that shadow-driven orienting was reliable for tactile targets presented at the hands, but did not emerge for visual targets presented near the hand or near the shadow. Thus, body shadows appear to specifically draw attention to tactile stimuli at the body part they refer to, rather than to the portion of space they cover.

These findings indicate that our cognitive system treats self-attributed body-shadows as a powerful attention cue, which orients resources to personal (body) space rather than external space. However, it remains unclear to what extent these mechanisms of attentional orienting triggered by body-shadows are truly mandatory. In the present research, we addressed this hypothesized automaticity of orienting of attention driven by body shadows in personal and extra-personal space, for tactile as well as visual stimuli. To this purpose, we focused on two important features considered critical when addressing automaticity in attention shifting over space. First, we wanted to establish whether the cueing effects reported previously (Galfano & Pavani, 2005; Pavani & Galfano, 2007) arose early in processing. As briefly anticipated earlier, one of the most striking aspects of the orienting of attention by body shadows is related to the fact that this phenomenon takes place despite the fact that the spatially non-predictive shadow cue is presented long in advance of the target. In all the experiments reported by both Galfano and Pavani (2005) and Pavani and Galfano (2007), the Stimulus Onset Asynchrony (SOA) separating shadow onset and target onset was 2750 milliseconds (ms). Importantly, cognitive phenomena are considered to be automatic to the extent that they arise early in processing. It is well known that orienting of visual attention in response to uninformative peripheral cues emerges rapidly after cue onset – with a cue-target SOA as short as 100 ms (e.g., Cheal, Lyon, & Gottlob, 1994; Müller & Rabbitt, 1989). Similar results have been reported for another type of spatial cue that is considered to induce automatic attention shifts, that is eye gaze (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Galfano et al., 2011). Hence, if shadow-driven orienting reflects automatic attention shifts, then our first general prediction was to observe such effect with a very short SOA.

A second important feature often considered for addressing automatic processes is resistance to contextual modulations (e.g., Bargh & Ferguson, 2000; Moors & De Houwer, 2006; Pasqualotto, Finucane, & Newell, 2013; Ristic & Kingstone, 2005; Zbrodoff & Logan, 1986). That is, orienting of attention can be said to occur in a strongly automatic fashion if and only if it proves largely insensitive to manipulations of experimental setting.

To test these predictions, we ran four experiments in which we used the same paradigm employed by Pavani and Galfano (2007), but we included a range of different SOAs to assess the time course of shadow-driven orienting. SOAs values were 100, 600, 1200, and 2400 ms and were adopted from the literature on gaze-driven orienting (e.g., Friesen & Kingstone, 1998; Frischen & Tipper, 2004; Galfano et al., 2012). In Experiment 1, we aimed to assess the time course of shadow-driven orienting to tactile targets on the body. Participants were asked to discriminate whether the target was presented at the thumb or index finger of either hand. Participants were fully informed that the target was equally likely to be presented to the hand casting the shadow and the other hand, which rendered the shadow cue uninformative. In Experiment 2, we addressed the time course of shadow-driven orienting in extra-personal space, by using visual targets presented near the