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Brief article

Seeing the body distorts tactile size perception

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A B S T R A C T

Vision of the body modulates somatosensation, even when entirely non-informative about stimulation. For example, seeing the body increases tactile spatial acuity, but reduces acute pain. While previous results demonstrate that vision of the body modulates somatosensory sensitivity, it is unknown whether vision also affects metric properties of touch, and if so how. This study investigated how non-informative vision of the body modulates tactile size perception. We used the mirror box illusion to induce the illusion that participants were directly seeing their stimulated left hand, though they actually saw their reflected right hand. We manipulated whether participants: (a) had the illusion of directly seeing their stimulated left hand, (b) had the illusion of seeing a non-body object at the same location, or (c) looked directly at their non-stimulated right-hand. Participants made verbal estimates of the perceived distance between two tactile stimuli presented simultaneously to the dorsum of the left hand, either 20, 30, or 40 mm apart. Vision of the body significantly reduced the perceived size of touch, compared to vision of the object or of the contralateral hand. In contrast, no apparent changes of perceived hand size were found. These results show that seeing the body distorts tactile size perception.

1. Introduction

Both vision and somatosensation provide important sources of information about our body. Therefore, combining multisensory inputs is critical to perceiving the properties and current state of the body. Recent results have demonstrated widespread effects of vision of the body on somatosensation, even when entirely non-informative about stimulation, for example by enhancing tactile spatial acuity (Kennett, Taylor-Clarke, & Haggard, 2001) and reducing pain (Longo, Betti, Aglioti, & Haggard, 2009). Such results show that seeing the body can increase the sensitivity of somatosensory processing, or alter perceived intensity of somatosensory stimuli. But does vision also *distort* touch, altering its perceived metric properties? Here, we addressed this question, investigating how vision of the body affects the perceived size of tactile stimuli applied to the seen body part.

How might vision of the body distort tactile size perception? Intriguingly, two sets of considerations lead to opposite predictions. Weber (1834/1996) originally noted that the perceived distance between two tactile stimuli is larger on skin regions with relatively high sensitivity compared to those with lower sensitivity, an effect now known as *Weber's illusion* (Taylor-Clarke, Jacobsen, & Haggard, 2004). Since seeing the body increases tactile sensitivity (Kennett et al., 2001), it is thus natural to hypothesize that this should lead to a corresponding increase in the perceived size of tactile stimuli. Indeed, this was our initial hypothesis. There is, however, another set of considerations which point in the opposite direction, suggesting that reduced tactile sensitivity can be associated with increased perceived size of the body and of touch. For example, cutting off afferent signals from a body part with local anesthesia increases the perceived size of that body part (Gandevia & Phegan, 1999; Türker, Yeo, & Gandevia, 2005) as well as the perceived size of objects held in the

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affected body part (Berryman, Yau, & Hsiao, 2006). Similarly, chronic pain often produces both reduced tactile sensitivity on the affected body part (Moseley, 2008; Pleger et al., 2006), as well as perceived swelling (Moseley, 2005, 2008; Pelz, Seifert, Lanz, Müller, & Maihöfner, 2011). In the case of both anesthesia and pain, *reduced* tactile sensitivity is associated with *increased* perceived body part size. Vision of the body, then, could be expected to produce exactly opposite effects: since seeing the body enhances tactile sensitivity it should reduce the perceived size of the body and also shrink the perceived size of tactile stimuli.

We investigated this question using the mirror box illusion (Ramachandran, Rogers-Ramachandran, & Cobb, 1995) to induce the subjective experience of direct vision of the stimulated left hand, while simultaneously keeping vision non-informative about stimulation. In Experiment 1, participants made verbal judgments of the distance between two touches applied to the dorsum of their left hand, while looking into a mirror aligned with their body midline, with their hands symmetrically on either size of the mirror. The reflection of their right hand, thus appeared to be a direct view of their left hand, yet provided no information about the size of touch. In control conditions, participants looked at the mirror reflection of a non-hand object or at their non-stimulated right hand. To anticipate our results, we found that seeing the body reduces the perceived size of touch. In Experiment 2 we replicated this finding and additionally added a measure of perceived hand size before and after each block, finding no apparent change in any condition.

2. Methods

2.1. Participants

Fifty-eight individuals (37 females) between 18 and 72 years of age participated, 30 in Experiment 1 and 28 in Experiment 2. Participants were right-handed as assessed by the Edinburgh Inventory (Oldfield, 1971; *M*: 91.3).

2.2. Materials and procedure

Participants sat at a table in front of a mirror aligned with their body midline (see Fig. 1). Velcro disks on the table (20 cm on either side of the mirror) indicated where the index finger of each hand should be placed. There were three visual contexts: (1) in the *View Stimulated Hand* condition, participants looked into the mirror at the reflection of their right hand, which appeared to be a direct view of their stimulated left hand; (2) in the *View Object* condition, participants looked into the mirror at the reflection of a black box (13 × 7 × 7 cm) appearing at the same location; and (3) in the *View Other Hand* conditions, participants looked directly at their right hand. Participants wore a black smock preventing peripheral vision of their left arm. A black board across the table from the participant occluded their view of the experimenter's movements.

Tactile stimuli were pairs of wooden posts mounted in foamboard, separated by 20, 30, or 40 mm, as in our previous study (Longo & Haggard, 2011). Each post tapered to a blunt point (∼1 mm width). Stimuli were applied to the dorsum of the left hand for approximately 1 s. Participants made verbal estimates (in mm) of the perceived distance between the two touches. Participants were told that they were free to give a response of 0 mm if they perceived only one touch. Seven participants (two in Exp. 1, five in Exp. 2) preferred to respond in inches, which were converted to mm offline. Stimuli were oriented either medio-laterally (*across* the hand) or proximo-distally (*along* the hand). There were six experimental blocks. The first three blocks included one block of each context, counterbalanced according to a Latin square. The last three blocks were performed in the reverse order. Each block consisted of six repetitions of each combination of size (20, 30, 40 mm) and orientation (along, across) in random order, yielding 36 trials per block and 216 overall. Z-scores were calculated for each trial, separately for each of the three stimulus sizes. Trials with Z-scores greater than ±3 were excluded as outliers (0.39% and 0.30% of trials in the two experiments).

Because participants felt the stimuli, but did not see them applied to the left hand, this could produce perceptual conflict in the View Stimulated Hand condition. To avoid this, a white cube (13 × 5 × 5 cm) was applied by the experimenter to the dorsum of the right hand (in the View Stimulated Hand and View Other Hand conditions) or object (in the View Object) condition, approximately time-locked to the application of the task-relevant stimulus on the left hand. Though the bottom of the cube was

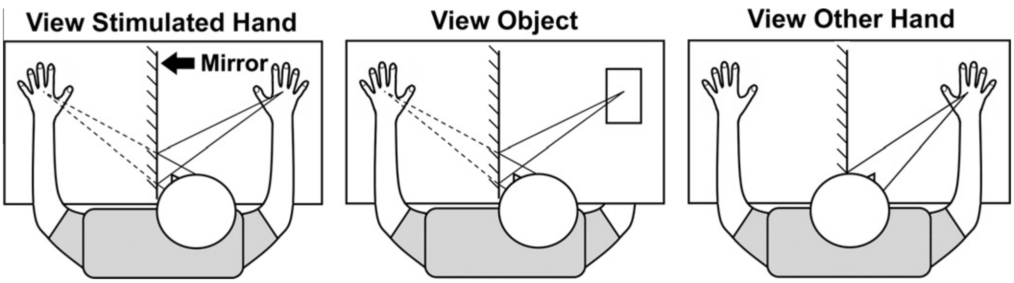

Fig. 1. Schematic depictions of the three experimental conditions. The task-relevant tactile stimuli were always delivered to the left hand behind the mirror. In the View Stimulated Hand and View Object conditions, participants looked into the mirror, seeing the reflection of their right hand or a non-hand object. In the View Other Hand condition, participants looked directly at their right hand.