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Seeing the Body Modulates Skin Temperature

Seeing the Body Produces Limb-Specific Modulation of Skin Temperature

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Vision of the body, even when non-informative about stimulation, affects somatosensory processing. We investigated whether seeing the body also modulates autonomic control in the periphery by measuring skin temperature while manipulating vision. Using a mirror-box, the skin temperature was measured from left hand dorsum while participants: (a) had the illusion of seeing their left hand, (b) had the illusion of seeing an object at the same location, or (c) looked directly at their contralateral right hand. Skin temperature of the left hand increased when participants had the illusion of directly seeing that hand but not in the other two view conditions. In experiment 2, participants viewed directly their left or right hand, or the box while we recorded both hand dorsum temperatures. Temperature increased in the viewed hand but not the contralateral hand. These results show that seeing the body produces limb-specific modulation of thermal regulation.

**Keywords:** Body Representation, Thermal Regulation, Autonomic Control, Mirror Box
1. INTRODUCTION

Vision of the body, even when entirely non-informative about stimulation, has widespread effects on somatosensation, enhancing tactile spatial acuity [1, 2], reducing acute pain [3, 4], increasing somatosensory intracortical inhibition [5], and reducing perceived tactile distance [6]. While such effects are diverse, they are consistent with effects limited to the central nervous system, for example by visual modulation of GABAergic inhibition in somatosensory cortex [3, 5, 7]. It is unknown how widespread the effects of seeing the body are and whether they might extend beyond somatosensory processes in the CNS.

We investigated whether seeing a limb modulates temperature regulation in that limb. In Experiment 1 we used the mirror box illusion [8], asking participants to look into a mirror aligned with their body midline and view the reflected image of their right hand, which appeared to be a direct view of their left hand behind the mirror. We measured skin temperature from the left hand dorsum while participants: (a) had the illusion of directly seeing their left hand, (b) had the illusion of seeing a non-body object at the same location, or (c) looked directly at their contralateral right hand. In Experiment 2, we measured skin temperature from both hands while participants looked directly at either one.

2. MATERIALS AND METHODS

(a) Participants

Sixty predominantly right-handed individuals participated, thirty in experiment 1, (23 female; age: M = 32 years, SD = 7), and thirty in experiment 2 (14 female; age: M = 32 years, SD = 13).

(b) Procedure

Both experiments used a non-contact infrared thermometer (Precision Gold N85FR, Maplin Electronics, South Yorkshire) and a box (13x7x7 cm). Both experiments involved three conditions,
each repeated twice. The first three blocks included one of each condition, counterbalanced across participants according to a Latin square. The last three blocks were performed in the reverse order.

In Experiment 1, participants sat at a table with their index fingers on Velcro discs 20 cm on either side of a mirror aligned along their midline and facing their right hand. Across conditions, participants saw: the mirror reflection of their right hand which appeared to be a direct view of their left hand (View Hand condition), a non-hand object reflected at the same location (View Object condition), or a direct view of their right hand (View Other Hand condition).

Following baseline temperature measurement, the mirror (or right hand) was uncovered for two minutes and temperature was recorded from the left hand dorsum every 10 seconds. Participants’ subjective experience of the mirror illusion was assessed with a short questionnaire [3, 6] after each block. Because it was unclear how long any effect might take to emerge, we classified the first minute as an induction period, analogous to the period of stimulation used to induce the rubber hand illusion [9, 10], and excluded it from analyses. Our analyses accordingly focused on the 2nd minute (test period).

In Experiment 2, participants directly viewed their right hand, left hand, or the object for three minutes while temperature was recorded from both hands in alternation. Participants placed their hands with palms down 60 cm apart on marked positions across the table. Two occluders (50x30 cm) blocked vision of the right and left hand. After a baseline temperature measurement, the appropriate occluder was removed to allow vision of the right or left hand, or the object was placed directly in front of the participant. Skin temperature was recorded every 10 seconds, alternating between the right and left hand. As in Experiment 1, the first minute was treated as an induction period and excluded from analyses.

3. RESULTS

Experiment 1

The questionnaire data are shown in Table 1 and suggest that the mirror box created a compelling illusion of seeing the left hand in the View Hand condition.
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### Table 1: The illusion questionnaire responses. Items 1 and 2 used a Likert scale with +3 being “Strongly Agree” and -3 being “Strongly Disagree”. Item 3 used a 0-100 scale with 0 being “Strongly Left Hand” and 100 being “Strongly Right Hand”.

<table>
<thead>
<tr>
<th>Questionnaire item</th>
<th>View Hand Mean (S.E.M.)</th>
<th>View Object Mean (S.E.M.)</th>
<th>View Other Hand Mean (S.E.M.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“It felt that I was directly looking at my hand rather than at mirrored image.”</td>
<td>1.64** (.31)</td>
<td>-2.55** (.20)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>“It felt like the hand I was looking at was my hand.”</td>
<td>2.23** (.25)</td>
<td>-</td>
<td>2.93** (.03)</td>
</tr>
<tr>
<td>“Did it feel like the hand you were looking at was right or left hand?”</td>
<td>24.40** (4.89)</td>
<td>-</td>
<td>100 (0)</td>
</tr>
</tbody>
</table>

** p < .001

** Figure 1: Changes in the left hand dorsum skin temperatures (Experiment 1). **Left panel:** The time course of temperature change compared to the baseline measure taken at the start of each
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The analysis focused on test period (light grey). Right panel: Mean temperature increase in test period across experimental conditions. Error bars are one S.E.M.

The temperature data are shown in Figure 1. Skin temperature of the left hand (compared to baseline) differed significantly across the three conditions, $F(2,58) = 3.43, p = .04, \eta^2 = .11$. There was a clear increase from baseline in the View Hand condition (0.139°C), $t(29) = 2.97, p = .01, d_z = .54$, but not in the View Object (0.022°C), $t(29) = .66, n.s.$, or View Other Hand (0.041°C), $t(29) = 1.06, n.s.$, conditions. The increase in the View Hand condition was significantly larger than that in the View Object, $t(29) = 2.56, p = .02, d_z = .47$, and View Other Hand, $t(29) = 2.05, p = .0495, d_z = .37$, conditions. We found no correlation between the temperature increase in View Hand condition and self-rated experience of seeing the left hand in mirror (Table 1, Question 1), $r(30) = -.06, n.s.$

The baseline temperature showed a slight decrease across successive blocks in a regression analysis (mean $\beta = -.046^\circ$C), though this did not reach significance, $t(29) = .84, n.s.$

**Experiment 2**

Table 2 suggests that the left and right hand temperatures (relative to baseline) were higher when participants viewed that hand compared to looking in a direction of their other hand or box. This is supported by a significant interaction between the visual condition and location of temperature recordings, $F(2,58) = 5.40, p = .01, \eta^2 = .16$ There was no main effect visual condition, $F(2,58) = 1.10, n.s.$, nor a difference in temperatures recorded from the right and left hand, $F(2,58) = .14, n.s.$

<table>
<thead>
<tr>
<th>experimental condition</th>
<th>measured right hand mean (s.e.m.)</th>
<th>measured left hand mean (s.e.m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>view of the right hand</td>
<td>0.17 (0.05)</td>
<td>0.05 (0.04)</td>
</tr>
<tr>
<td>view of the left hand</td>
<td>0.05 (0.08)</td>
<td>0.08 (0.05)</td>
</tr>
</tbody>
</table>
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| view of the non-hand object (box) | -0.01 (0.06) | 0.06 (0.05) |

Table 2: Changes in hand dorsum skin temperature. Temperature was recorded from both hands in each experimental condition (Experiment 2).

Figure 2: Changes in skin temperature of the right and left hand dorsum (Experiment 2). Left panel: The time course of temperature change of the seen same hand, other hand, and object conditions compared to the baseline. The analysis focused on test period (light grey). Right panel: Mean increase in temperature of measured hand in the seen hand and other hand conditions. Error bars are one S.E.M.

To follow up this significant interaction we ran a 2x2 ANOVA on the hand-view conditions including factors ‘viewed hand’ (right, left) and ‘measured hand’ (seen hand, other hand). Skin temperature was increased for the seen hand compared to the other hand (Figure 2), \( F(2,58) = 6.34, p = .02, \eta^2 = .18 \). Critically, there was no main effect of right vs. left hand, \( F(2,58) = 1.85, n.s. \), nor an interaction, \( F(2,58) = .62, n.s. \), suggesting no laterality in the observed effect. The temperature
increase was statistically significant in the seen hand condition, $t(29) = 2.87, p = .01, d_z = .52$, but not when the other hand or box were viewed, $t(29) = .99, n.s.,$ and $t(29) = .53, n.s.$, respectively.

4. DISCUSSION

Looking at your hand increases its temperature, but does not affect the contralateral hand. Moreover, viewing a non-hand object, even if in the exact location of the hand, does not result in temperature increase. These findings demonstrate that vision of the body produces limb-specific modulation of thermal regulation and thus they add to a growing literature reporting the widespread effects of vision on bodily stimuli processing [1-6].

Our findings have intriguing similarities with recent results showing temperature modulation in the rubber hand illusion. In this illusion, touch applied synchronously both to a prosthetic hand and one’s own hidden hand produces the compelling feeling that the rubber hand actually is one’s hand [9-11]. The experience of ownership over the rubber hand produces a limb-specific temperature drop in the hidden hand [12, 13]. Moseley and colleagues [12, 14] suggest that the experience of ownership over the rubber hand displaces the actual hand, resulting in ‘disownership’ and reducing homeostatic control in the limb. Our results can be interpreted as reflecting the opposite process, an enhanced ownership over the seen limb resulting in increased homeostatic control and temperature.

Several psychiatric and neurological conditions involving disruptions of body representation have also been found to feature disordered thermoregulation, including complex regional pain syndrome (CRPS) [15, 16], schizophrenia [17], phantom limb pain [18], and self-injurious behaviour [19]. CRPS, for example, is associated with increased pain, decreased tactile sensitivity on the affected limb [20, 21], somatosensory disinhibition [22], and reduced temperature on the affected limb [15, 16]. Intriguingly, vision of the body has the opposite effects in healthy participants, reducing pain [3, 4], enhancing tactile sensitivity [1, 2], enhancing somatosensory inhibition [5], and increasing limb temperature (this study).
Thus, vision of the body appears to produce real-time enhancement of a coherent constellation of characteristics, which appear to be impaired in CRPS, suggesting that these characteristics may arise from a single cortical network. Moseley and colleagues [14] recently presented the idea of a ‘body matrix’, a putative cortical network integrating multisensory and homeostatic functions to represent the body and the space immediately surrounding it. The diverse effects produced by vision of the body could result from limb specific modulation of body matrix activity. Consistent with this proposal, in a recent fMRI study we found that seeing the body while receiving painful stimuli increased functional connectivity between visual and posterior parietal areas and both somatosensory cortices (SI and SII) as well as areas known to be involved in homeostatic control, including the insula and anterior cingulate cortex [23].

The causal mechanism underlying our findings remains uncertain. One possibility is that in addition to modulating somatosensory processing, vision of the body also modulates the autonomic nervous system directly, analogous to the effect reported above in CRPS. Alternatively, seeing the body may modulate activity in motor cortical areas. While seeing the body does not induce obvious movement of the hand, it could produce sub-threshold muscular activation which could drive the effect we report. Future research should investigate this issue.
References


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