Research Report

Viewing a Face (Especially One’s Own Face) Being Touched Enhances Tactile Perception on the Face

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ABSTRACT—Observing touch on another person’s body activates brain regions involved in tactile perception, even when the observer’s body is not directly stimulated. Previous work has shown that in some synaesthetes, this effect induces a sensation of being touched. The present study shows that if perceptual thresholds are experimentally manipulated, viewing touch can modulate tactile experience in nonsynaesthetes as well. When observers saw a face being touched by hands, rather than a face being merely approached by hands, they demonstrated enhanced detection of subthreshold tactile stimuli on their own faces. This effect was specific to observing touch on a body part, and was not found for touch on a nonbodily stimulus, namely, a picture of a house. In addition, the effect was stronger when subjects viewed their own faces rather than another person’s face. Thus, observing touch can activate the tactile system, and if perceptual thresholds are manipulated, such activation can result in a behavioral effect in nonsynaesthetes. The effect is maximum if the observed body matches the observer’s body.

Observing touch on another person’s body activates brain regions involved in tactile perception, even when the observer’s body is not directly stimulated (Blakemore, Bristow, Bird, Frith, & Ward, 2005; Bufalari, Aprile, Avenanti, Di Russo, & Aglioti, 2007; Keysers et al., 2004). This finding suggests the existence of a tactile mirror system, analogous to the motor and emotional mirror systems (for reviews, see Gallese, 2007; Iacoboni & Dapretto, 2006; and Rizzolatti & Craighero, 2004). The initial description of a mirror system referred to a network of brain areas, located in the motor system of both monkeys and humans, that respond to both observation and execution of specific actions. Analogously, a number of other brain areas respond to both observation and experience of disgust (Wicker et al., 2003), pain (Avenanti, Bueti, Galati, & Aglioti, 2005; Bufalari et al., 2007; Singer et al., 2004), facial expression (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003), and touch (Blakemore et al., 2005; Bufalari et al., 2007; Keysers et al., 2004). This overlap of brain activity when individuals experience and observe actions, sensations, and emotions suggests that the same mechanisms subserve self-related experience and the perception of other individuals’ experiences (Gallese, Keysers, & Rizzolatti, 2004).

Despite such overlap, brain activity due to observation of other individuals does not normally translate into a self-related experience. For instance, subjects do not usually experience a tactile sensation when they observe other people being touched. An interesting exception is found in some synaesthetic subjects (i.e., visuo-tactile synaesthetes), who experience tactile stimulation when they see other people’s bodies being touched. Banissy and Ward (2007) recently showed that observing touch on another person’s body affected synaesthetes’ processing of tactile stimuli on their own bodies, but did not have this effect in control subjects. The differing effects in synaesthetic and non-synaesthetic subjects might not reflect different mechanisms of visuo-tactile integration, but might instead reflect differing degrees of activation induced in the tactile system by visual information. Indeed, in a recent neuroimaging study, observing
touch activated the tactile mirror system both in nonselected control subjects and in a synaesthetic subject, although the induced activation was lower in the control subjects (Blakemore et al., 2005). This result suggests that in most people, the observation of touch activates the tactile mirror system below a perceptual threshold, such that no conscious tactile perception is experienced, but that in synaesthetes, this brain network is activated above the perceptual threshold, inducing visuo-tactile synaesthesia. If this is the case, a form of visuo-tactile interaction resembling visuo-tactile synaesthesia might be shown in non-synaesthetic subjects when their perceptual thresholds are experimentally manipulated.

The main aim of the present study was to identify in synaesthetes a behavioral consequence of the mirrorlike activity in the somatosensory system due to observation of touch. We also examined whether this effect was specific to observing touch on a part of the human body, as opposed to a nonbody target.

According to the dominant view of the function of a mirror system (Gallese, 2007), resonance of brain activity during observation and experience is essential to binding self-related and other-related experiences. The former might differ from the latter only in the degree of activation of the mirror system (Blakemore et al., 2005). When one observes one’s own body, neural activity due to observation might be strengthened because the body of the observer perfectly matches the observed body. Thus, if this hypothesis is true, visuo-tactile interaction should be stronger when people observe touch directed toward themselves than when they observe touch directed toward other people.

To study these issues, we measured how tactile perception on the face is affected by observation of touch on one’s own face, on another person’s face, and on a nonbody stimulus (a picture of a house). We took advantage of a classic experimental paradigm used in brain-damaged patients: the tactile confrontation task. In this task, subjects are touched on either side of their body or on both sides and must report the location of the touch. Patients with extinction usually fail to report the contralesional stimulus in conditions of double stimulation, because of competition for attentional resources between the two hemispaces (Bender, 1952; Làdavas, 2002). In the present study, we applied this paradigm to healthy subjects by electrically stimulating them on the right, the left, or both cheeks. To simulate extinction, we set stimulus intensity such that the tactile stimulus was stronger on one cheek than on the other: We predicted that in dual-stimulation trials, the stronger stimulus would occasionally extinguish the weaker one. During this task, subjects watched a movie showing their own face (self condition), another person’s face (other condition), or a house (house condition), centered on a computer screen. Human fingers either touched (touch condition) or simply approached (no-touch condition) the image, on the right, the left, or both sides. Therefore, the side of visual information could be congruent or incongruent with the side of tactile stimulation. Subjects were instructed to press a button with the hand corresponding to the side where they felt the tactile stimulus on their face (and to press the button with both hands in the case of double stimulation), ignoring the visual stimulation.

A modulation of tactile performance by visual information was taken as an index of visuo-tactile interaction. If such interaction depends on a mirrorlike mechanism, the effect of visual stimuli on tactile responses would be expected to be stronger in the touch than in the no-touch condition. Moreover, if this effect is specific to viewing the body, visuo-tactile interaction would be expected to be stronger when the fingers touched a face rather than the house. Finally, if the effect is sensitive to the identity of the observed body, a stronger visual modulation of perception of touch would be expected when subjects viewed their own face rather than another person’s face.

METHOD

A total of 16 healthy subjects (all students at the University of Bologna; mean age = 23 years) participated in the study.

Tactile stimuli were delivered via a pair of miniaturized electrodes placed on each subject’s right and left cheeks. Participants were randomly divided into two groups. In Group 1, the tactile stimulus on the left cheek was calibrated to be more intense than that on the right cheek, and in Group 2, the relative strengths of the stimuli were reversed. Prior to the experiment, the intensity of the electrical stimuli was titrated for each subject in the absence of visual information. Using a staircase procedure, we set detection thresholds to 90% for the stronger stimulus and 70% for the weaker stimulus. Thresholds were recalibrated before each experimental block.

Visual stimuli were presented on a 17-in. computer screen placed approximately 60 cm in front of the subject and covered an area of about 10 × 20 cm on the screen. These stimuli consisted of three sets of movies, one depicting the subject’s own face, the second depicting the face of another person (of the same age and gender as the subject), and the third depicting a house (see Fig. 1). The house was chosen as the third image because it has a perceptual configuration similar to that of a face, but is automatically categorized as a nonbody stimulus (Kanwisher & Yovel, 2006). In each trial, two fingers were initially positioned on the lower part of the screen, one on the right and on the left; the finger on the right, the finger on the left, or both fingers moved in toward the centrally presented target and then retreated back to the starting position. The motion followed one of two trajectories: In the touch condition, the finger (or fingers) actually touched the central target, whereas in the no-touch condition, the finger (or fingers) stopped about 5 cm away from the target. A tactile stimulus was delivered to the subject precisely when the finger (or fingers) reached the visual target and the direction of movement reversed (see Fig. 1).

The experiment comprised three counterbalanced experimental blocks of the tactile confrontation task; in each block, a different image (self, other, or house) was the visual target. Each block presented 18 unique stimuli, representing all combina-
tions of side of tactile stimulation (left, right, bilateral), side of visual stimulation (left, right, bilateral), and finger-movement trajectory (touch, no-touch). Each unique stimulus was repeated six times, for a total of 108 trials per block, presented in random order. Each trial lasted about 3 s.

RESULTS

Subjects’ accuracy in responding to the tactile stimuli was studied by means of a mixed analysis of variance with the within-subjects factors of type of image (self, other, or house), finger-movement trajectory (touch or no-touch), side of tactile stimulation (left, right, or bilateral), and side of visual stimulation (left, right, or bilateral) and the between-subjects factor of group (Group 1 or 2). We performed Duncan post hoc comparisons, when necessary, to study single effects.

The results showed that performance in this paradigm does mimic the performance of patients with extinction. The effect of side of tactile stimulation was significant, $F(2, 28) = 3.40, p < .05, \eta^2 = .78$; accuracy was lower in response to bilateral stimuli (66% correct responses) than in response to left (79%; $p < .04$) or right (80%; $p < .04$) stimuli. Incorrect responses to bilateral stimuli consisted mostly of reporting the side of stronger stimulation: The probability of erroneously responding “left” to bilateral stimuli was 83% in Group 1 and 4% in Group 2, whereas the probability of erroneously responding “right” was 4% in Group 1 and 79% in Group 2. Thus, when there was competition between differing-intensity signals from the two hemifaces, the weaker stimulus was much more frequently extinguished than the stronger stimulus.

Visual information modulated subjects’ detection of tactile events. The critical three-way interaction of side of tactile stimulation, finger-movement trajectory, and type of image was significant, $F(4, 56) = 2.55, p < .05, \eta^2 = .18$. Post hoc comparisons revealed that accuracy in responding to bilateral stimuli was higher when subjects viewed a face being touched rather than approached, both when subjects viewed their own face (touch: 72%, no-touch: 67%, $p < .05$) and when subjects viewed another person’s face (touch: 66%, no-touch: 62%; $p < .05$, one-tailed; see Fig. 2). When subjects viewed a house, however, the pattern of response reversed (touch: 61%, no-touch: 67%; $p < .05$). Finally, the effect of viewing touch was maximized when subjects viewed their own face; subjects detected bilateral tactile stimuli more accurately in that condition than in any other condition (all

Fig. 1. Visual stimuli used in the tactile confrontation task. In blocked trials, subjects viewed an image of their own face, another person’s face, or a house. In each trial, the finger on the bottom left, the finger on the bottom right, or both fingers moved toward the target; in the touch condition, the finger (or fingers) actually touched the target, and in the no-touch condition, the finger (or fingers) reached a position 5 cm away from the target.
general attentional effect of spatial compatibility. In another condition, the trajectory of finger movements, and is likely a result of visuo-tactile events (see Table 1). This effect was independent of the type of stimulation.

The interaction between side of tactile stimulation and side of visual stimulation was also significant, $F(4, 56) = 2.55, p < .05$, $\eta^2 = .09$; subjects were more accurate in trials with congruent visuo-tactile events than in trials with incongruent visuo-tactile events (see Table 1). This effect was independent of the type of image and the trajectory of finger movements, and is likely a general attentional effect of spatial compatibility.

DISCUSSION

The present study utilized competition between tactile signals from the two hemispaces in order to manipulate subjective perceptual thresholds. This manipulation enabled us to study how visual information related to touch modulates tactile processing. Observing a face being touched, compared with observing a face being simply approached, reduced the extinction of a weak tactile stimulus during bilateral stimulation. This finding reveals a mirrorlike modulation of tactile perception by the observation of touch. That effect might resemble a form of visuo-tactile synaesthesia previously shown only in visuo-tactile synaesthetes. In nonsynaesthetes, observation of touch typically evokes subthreshold brain activity in somatosensory areas and in the mirror system (Blakemore et al., 2005); this activity does not normally have a perceptual counterpart, as subjects do not report tactile perception when observing touch (Banissy & Ward, 2007). The present results show for the first time that this brain activity can be revealed in behavior if subjective perceptual thresholds are experimentally manipulated. Thus, the same mechanism underlies the effect of observation of touch on tactile processing in synaesthetes and nonsynaesthetes; the difference between these groups might be only that sensitivity to the effect is stronger in synaesthetes.

Moreover, this mirrorlike effect is specific to viewing a part of the body being touched. When subjects viewed an image of a house, performance was better in the no-touch condition than in the touch condition. These opposing effects obtained in the face (self, other) and house conditions may reflect two different forms of visuo-tactile interaction. The effect of viewing touch in the face conditions may have been due to a mirrorlike mechanism, whereas the facilitation in the no-touch, house condition might have been an effect of visuospatial attention. Indeed, the fingers reached more eccentric portions of space in the no-touch condition than in the touch condition, and this might have enlarged the attentional field by cuing more lateralized positions of the two hemispaces. As a result, the detection of concurrent lateralized tactile events might have been enhanced.

In addition, we found a general effect of spatial congruency between the side of tactile stimulation and the side of visual stimulation. Accuracy was higher when visual and tactile stimuli were presented in the same side of space. In other words, the congruency effect was based on a specular reflection, rather than an anatomical remapping: For instance, a tactile stimulus on the observer’s right cheek was enhanced by viewing a finger movement on the right side of space (of the screen), which corresponded to the left side of the shown image. The congruency effect was independent of whether the subject viewed a face or a house and of whether the image was touched or just approached; this suggests that the effect was linked to a spatial compatibility effect and was not due to the mirrorlike remapping of touch.

Another new finding from this study is that visuo-tactile integration is maximized when subjects see their own faces touched. A right fronto-parietal network is specifically activated when subjects view images of their own faces, rather than the

TABLE 1

<table>
<thead>
<tr>
<th>Side of tactile stimulation</th>
<th>Side of visual stimulation</th>
<th>Bilateral</th>
<th>Left</th>
<th>Right</th>
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<td>78</td>
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<tr>
<td>Right</td>
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<td>63</td>
<td>79</td>
<td>83</td>
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1This suggestion is supported by results of a control condition. In order to study whether the spatial extent of the fingers’ movements affected the detection of bilateral stimuli independently of the displayed image, we asked 6 subjects from the total sample to perform an additional experimental block. This block was identical to the others, except that the fingers moved on a black background, without a visual target. As in the house condition, perception of bilateral stimulation was higher in the no-touch condition (67%) than in the touch condition (54%; Wilcoxon test: $z = 2.20, p < .03$). This suggests that when subjects did not view a part of the body being touched, visual stimuli cuing more lateralized spatial positions of the visual field enhanced the processing of tactile bilateral stimuli.
faces of other people (Platek et al., 2006; Sugiura et al., 2006; Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005). This brain network includes areas that have demonstrated mirrorlike activation properties (see Uddin, Iacoboni, Lange, & Keenan, 2007). Results from the present study suggest that such enhanced activity due to self-related visual information might cross-modally modulate the processing of tactile information: Tactile accuracy was higher when subjects viewed their own faces than when they viewed other people's faces. This suggests that when the match between the observer and the observed body is stronger, the visuo-tactile resonance is greater. This conclusion supports the intriguing speculation that perceptual sensations related to the self and perceptual sensations related to others at least partially rely on a continuous distribution of neural activity within the same brain areas; the level of activation of these areas shifts as a function of attributing an experience to the self or to the other.

To conclude, the present results show that observation of touch affects tactile processing in nonsynaesthetic subjects; the effect is maximized when subjects observe touch directed toward themselves. This form of visuo-tactile interaction can be measured behaviorally, with a simple experimental paradigm that can be further exploited to investigate several open issues in the field.

Acknowledgments—The authors thank Alessandro Farnè for his collaboration, Aikaterini Fotopoulou and Manos Tsakiris for their precious comments, and Ashish Ranpura for his help in editing the manuscript.

REFERENCES


(RECEIVED 9/4/07; REVISION ACCEPTED 12/17/07)