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Mirror-touch synesthesia is linked with empathy

Michael J Banissy & Jamie Ward

Watching another person being touched activates a similar neural circuit to actual touch and, for some people with 'mirror-touch' synesthesia, can produce a felt tactile sensation on their own body. In this study, we provide evidence for the existence of this type of synesthesia and show that it correlates with heightened empathic ability. This is consistent with the notion that we empathize with others through a process of simulation.

Recent research indicates that people's ability to empathize with others relies on shared affective neural systems in which common brain areas are activated during both experience and passive observation. Moreover, building on the discovery of mirror neurons in the monkey brain[1], functional imaging has suggested the existence of mirror systems in humans not only for actions, but also for sensations and emotions[2–6]. For example, watching another human being touched (relative to an object being touched) activates the primary and secondary somatosensory cortex along with premotor and superior temporal regions. These systems may be crucial for empathy because they enable the observer to simulate another's experience by activating the same brain areas that are active when the observer experiences the same emotion or state[7]. Consistent with this, a recent study provides evidence that increased activations in the auditory mirror system are correlated with improved perspective-taking abilities[8]. Moreover, this correlation not only included premotor areas, but also extended to somatosensory cortices, indicating that individuals may start to mirror the tactile consequences of heard actions[8]. Furthermore, there is a growing body of evidence suggesting that individuals with autistic spectrum disorder (ASD) have impaired activity in the action mirror system[9,10], which may lead to the deficits in imitation and empathy observed in ASD[11].

One recent study reported a single case of vision-touch or mirror-touch synesthesia in which the observation of touch on other humans results in tactile sensations on her own body. Functional magnetic resonance imaging showed that these conscious tactile experiences are associated with hyperactivity in the same mirror-touch network that is evoked by observed touch in nonsynesthete controls in which no overt tactile experience is elicited[3]. As such, mirror-touch synesthesia offers a unique opportunity to explore the role that the tactile mirror system has in empathy.

We developed a new behavioral protocol to provide evidence for the authenticity of this form of synesthesia (see **Supplementary Methods** online). If synesthetic touch uses the same neural circuit as actual touch and is phenomenologically similar to actual touch, then participants should have difficulty in discriminating between actual and synesthetic touch. We designed two experiments, with participants being required to report the location of actual touch (left, right, both, none) applied to the facial cheeks in one, and the location of actual touch applied to the back of the hands (left or right hand) in the other. During the task they also observed another person being touched, but were asked to ignore this. All participants gave informed written consent to the experiments. For synesthetes, but not for controls, the observed touch elicited a tactile sensation, whose location was either in the same spatial location as the actual touch (congruent condition) or in a different spatial location (incongruent condition). For example, in an incongruent trial they might receive an actual touch on the left cheek (and are thus required to give the response 'left'), but a synesthetic touch on the right cheek. Reporting in the incongruent condition was expected to be slower and more error prone. In particular, we were interested in errors in which the participant treated the synesthetic touch as if it were an actual touch (that is, giving the response 'both' in the example above): a mirror-touch error (**Fig. 1**).

For some synesthetes an observed touch on the left cheek triggered a synesthetic sensation on their left cheek (anatomical correspondence), but for others the synesthetic sensation was felt on the right cheek (as if they had been looking in a mirror, a specular correspondence). As such, congruency was determined according to each synesthete's self report (see **Supplementary Methods** and **Supplementary Table 1**).

On both the faces and hands experiment, synesthetes ($n = 10$) produced a higher percentage of mirror-touch errors than did controls ($n = 20$). This pattern of errors implies that synesthetic touch feels like real touch. Synesthetes were significantly faster at identifying a site

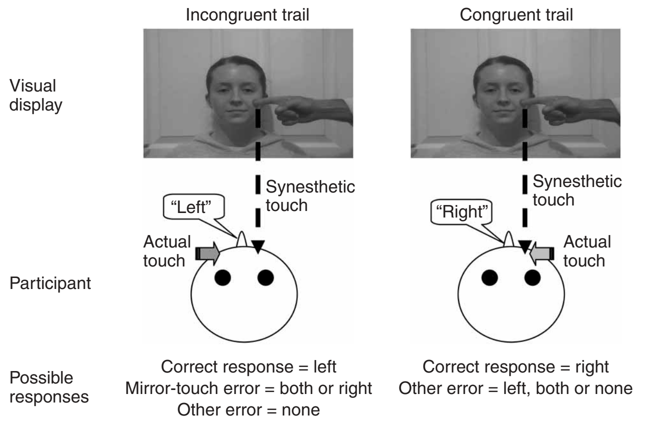

Figure 1 Participants were required to report the site on which they were actually touched (that is, left cheek, right cheek, both cheeks or no touch) while ignoring observed touch (and the synesthetic touch induced by it). Hands and faces were presented in two separate blocks. In the hands experiment, the perspective from which touch was observed was manipulated so that touch was shown from either one's own or from another's perspective.

Department of Psychology, University College London, 26 Bedford Way, London, WC1H OAP, UK. Correspondence should be addressed to M.J.B. (m.banissy@ucl.ac.uk).

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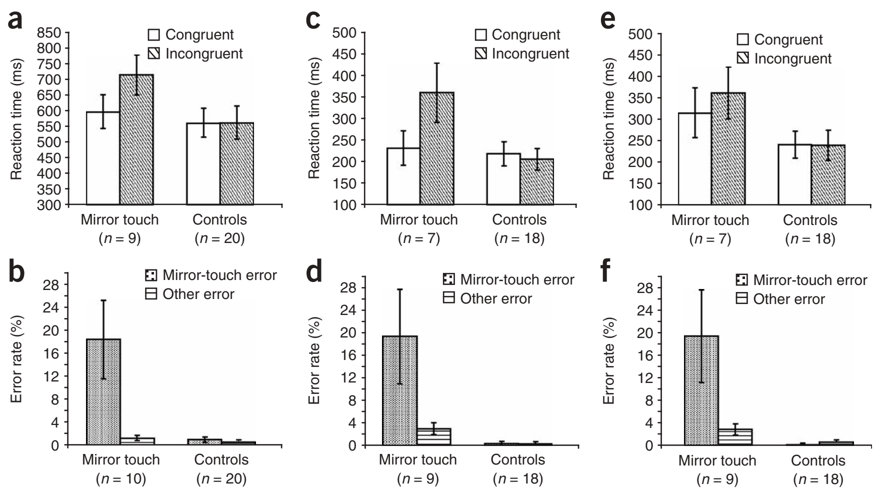

Figure 2 Behavioral correlates of mirror-touch synesthesia. (**a**,**b**) Faces experiment. Reaction-time performance was compared using 2 (congruency) × 2 (group) mixed ANOVA. Participants performed faster overall on congruent than on incongruent trials ($F = 10.69$, $P = 0.003$). A significant interaction was observed ($F = 10.37$, $P = 0.003$), and this was a result of synesthetes performing slower on incongruent trials ($t = -2.69$, $P = 0.028$). Mirror-touch synesthetes had a higher percentage of mirror-touch errors compared with controls ($t = 2.54$, $P = 0.032$), but showed no differences in other error types. (**c**–**f**) Hands experiment. A 2 (congruency) × 2 (group) × 2 (perspective) mixed ANOVA conducted on reaction times revealed a significant congruency × group interaction ($F = 18.93$, $P < 0.001$), which was a result of synesthetes performing slower on incongruent trials ($t = -3.08$, $P = 0.022$). Analysis of errors revealed a significant main effect of error type ($F = 9.91$, $P = 0.004$) and of group ($F = 12.42$, $P = 0.002$), with participants producing more mirror-touch errors than other errors and synesthetes being more error prone overall. Notably, there was a significant group × error type interaction ($F = 10.02$, $P = 0.004$) showing that synesthetes produced particularly more mirror-touch errors than controls on trials shown from either perspective (own perspective: $F = 10.91$, $P = 0.003$, **c** and **d**; another's perspective: $F = 11.62$, $P = 0.002$, **e** and **f**). For details of other effects see **Supplementary Results**. Error bars are ± s.e.m.

touched on their face or hands when actual touch was congruent with their synesthesia compared with incongruent trials (**Fig. 2**). This pattern was not found when participants observed touch to objects (see **Supplementary Results** online).

The empathic ability of mirror-touch synesthetes ($n = 10$) was compared with those of nonsynesthetic control participants ($n = 20$) and of controls ($n = 25$) who reported other types of synesthesia (minimally, grapheme-color) but not mirror-touch synesthesia. The empathy quotient (EQ) has three main subscales: (i) cognitive empathy, (ii) emotional reactivity and (iii) social skills[12,13]. Mirror-touch synesthetes showed significantly higher scores on the emotional reactivity subscale of the EQ relative to controls (**Table 1**), but not on the other subscales. It has been suggested that the experiencing aspects of affective empathy may particularly depend on shared interpersonal representations[14]. This supports the notion that empathy is multifaceted and that the tactile mirror system may modulate some, but not all, aspects of this ability.

Given the neural mechanisms thought to be involved in mirror-touch synesthesia, the differences in empathic ability reported here appear consistent with the hypothesis that we understand and empathize with others by a process of simulation[7].

Table 1 EQ scores

Group	EQ score	Cognitive empathy	Emotional reactivity	Social skills
Mirror-touch ($n = 10$)	51.30 ± 3.20	19.30 ± 1.27	17.20 ± 1.41	9.70 ± 1.04
Controls ($n = 45$)	46.20 ± 1.82	15.51 ± 0.86	13.56 ± 0.74	8.47 ± 0.42
Significance	N.S.	N.S.	$P = 0.036$	N.S.

Results from nonsynesthetic controls ($n = 20$) and synesthetes lacking mirror touch ($n = 25$) did not differ and were combined. N.S. = not significant. Data shown as mean ± s.e.m.

Note: Supplementary information is available on the Nature Neuroscience website.

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AUTHOR CONTRIBUTIONS
M.J.B. conducted the experiments. J.W. devised the concept. The authors contributed equally in all other respects.

COMPETING INTERESTS STATEMENT
The authors declare no competing financial interests.

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