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Research report

Influence of the body schema on mirror-touch synesthesia

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ABSTRACT

Individuals with mirror-touch synesthesia (MTS) report feeling touch on their own body when seeing someone else being touched. We examined how the body schema – an on-line representation of body position in space – is involved in mapping touch from a viewed body to one's own body. We showed 45 mirror-touch synesthetes videos of a hand being touched, varying the location of the viewed touch by hand (left, right), skin surface (palmar, dorsal) and finger (index, ring). Participant hand posture was either congruent or incongruent with the posture of the viewed hand. After seeing the video, participants were asked to report whether they felt touch on their own body and, if so, the intensity and location of their percepts. We found that participants reported more frequent and more veridical (i.e., felt at the same somatotopic location as the viewed touch) mirror-touch percepts on posturally congruent versus posturally incongruent trials. Furthermore, participant response patterns varied as a function of postural congruence. Some participants consistently felt sensations on the hand surface that was stimulated in the video – even if their hands were in the opposite posture. Other participants' responses were modulated based on their own hand position, such that percepts were more likely to be felt on the upright, plausible hand surface in the posturally incongruent condition. These results provide evidence that mapping viewed touch to one's own body involves an on-line representation of body position in space.

1. Introduction

The majority of individuals do not experience tactile sensations while observing touch on someone else's body. However, those with mirror-touch synesthesia (MTS) do report feeling tactile sensations on their own body when seeing someone else being touched. In the first reported case of mirror-touch (or vision-touch) synesthesia, Blakemore, Bristow, Bird, Frith, and Ward (2005) imaged a mirror-touch synesthete (C) and twelve non-synesthetes while viewing videos of individuals or inanimate objects being touched. When comparing activity for viewing a person versus an object being touched, they found greater activity in primary and secondary somatosensory cortex for C compared to all controls. In non-mirror-touch synesthetes, regions such as secondary somatosensory cortex and parts of primary

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somatosensory cortex (e.g., area 2) are active when viewing another person being touched (Blakemore et al., 2005; Bufalari, Aprile, Avenanti, Di Russo, & Aglioti, 2007; Ebisch et al., 2008; Keysers et al., 2004). Holle, Banissy, and Ward (2013) examined an additional ten mirror-touch synesthetes, finding that posterior secondary somatosensory cortex differed in response to viewed touch compared to controls, showing overactivity when watching a face being touched and hypo-activity when watching a dummy being touched. From these results, it has been hypothesized that mirror-touch percepts are caused by the same mechanisms that lead to activation in somatosensory regions after viewed touch in non-synesthetes. However, mirror-touch synesthetes are thought to have an overactive “mirror-touch” system, resulting in suprathreshold sensations after viewing touch on an individual – known as the “Threshold Theory” of MTS.

In understanding the mechanisms of the mirror-touch system, one question of interest is the relationship between the location of the viewed touch and the mirror-touch percept on the synesthete's own body. Previous studies have identified two major subtypes of MTS, in which the spatial mapping between the viewed touch and synesthetic percept is based on different frames of reference. In a somatotopic representation, touch is represented based on its position on the skin surface, irrespective of its position in external space. Whereas in an egocentric, external representation, locations are encoded based on the position of the stimulus in external space (Medina, McCloskey, Coslett, & Rapp, 2014). Banissy and Ward (2007) presented 10 mirror-touch synesthetes videos of a person, facing the synesthete, being touched on either their left or right cheek. Four mirror-touch synesthetes reported sensation on the same skin surface that was touched in the video – such that seeing someone touched on their anatomically-defined left cheek would result in a percept on the mirror-touch synesthete's left cheek. In this *anatomical* subtype of MTS, the synesthete experiences a mirror-touch percept in the same location of the viewed touch in a somatotopic frame of reference. However, six other participants, when viewing someone touched on their anatomically-defined left cheek, perceived touch on their own right cheek. For these individuals with *specular* (or mirrored) MTS, the viewed touch and mirror-touch percept are on the same side in an external reference frame.

To do these mappings, one needs to have a representation of one's own body and the body of the touched individual. A number of studies have provided evidence for an on-line representation of body position in space – often called the body schema or postural schema (Head & Holmes, 1911; Medina & Coslett, 2010). In mirror touch synesthesia, one study examined the relationship between body position and mirror touch synesthesia, finding no effect of viewed face position or hand crossing on synesthetic percept intensity (Holle, Banissy, Wright, Bowling, & Ward, 2011). However, no studies have examined how the synesthete's body schema influences the mapping process from viewed touch to synesthetic percept. In this study, we manipulated the position of the synesthete's body and the viewed body to examine whether and how the body schema influences MTS. More specifically, we examined whether the body schema influenced the frequency and location of mirror-touch percepts, and whether the processes utilized in mapping viewed touch onto one's own body differed across individuals in specific manners.

First, the relationship between the location of the viewed touch and the participant's own body position could influence how *frequently* mirror-touch percepts are experienced. Consider a trial in which the participant views a hand touched on the dorsal surface (palm down) of the index finger of the right hand, with the synesthete's hands positioned palms up (see Fig. 1). In this trial, the posture of the viewed hand is incongruent with the posture of the participant's own hands. If participants are referencing an on-line representation of their body for mapping mirror-touch percepts, one possibility is that this postural incongruency could lead to a decrease in mirror-touch percepts. However, if this mapping is not influenced by the synesthete's own body position, then incongruencies in body posture should have no effect on mirror-touch percept frequency.

Second, changes in body position may also influence, not only the perceived frequency, but the perceived *location* of mirror-touch percepts. Consider the trial previously

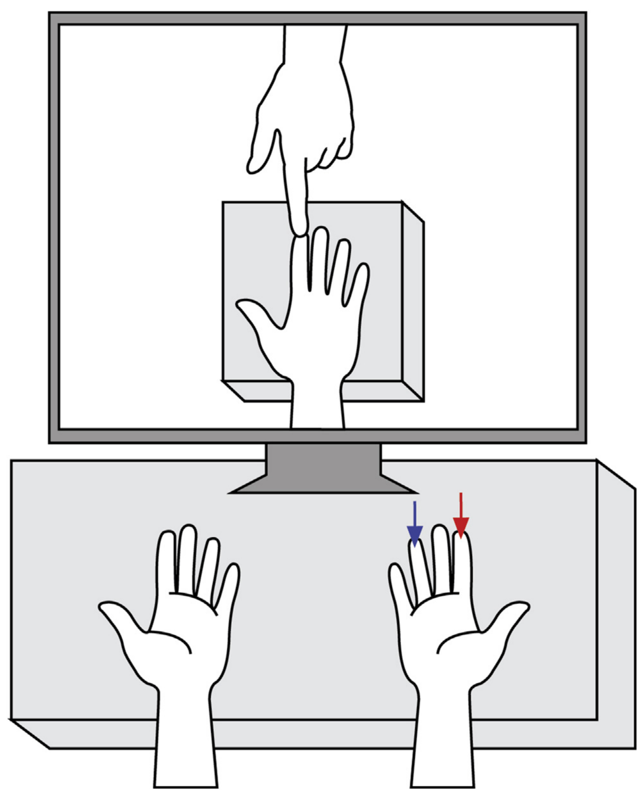

Fig. 1 – Diagram showing participant hand posture on an incongruent trial, in which the participant's hands (bottom) are positioned palms up on a table and the viewed hand (top) is palms down. In the video, the hand is stimulated on the dorsal surface of the index finger of the right hand. The red arrow points to the finger corresponding to the viewed touch. The blue arrow points to a potential response if the location of the viewed touch were encoded in an external, hand-centered representation.