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Research report

A *sensational* illusion: Vision-touch synaesthesia and the rubber hand paradigm

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ABSTRACT

For individuals with vision-touch synaesthesia, the sight of touch on another person elicits synaesthetic tactile sensation on the observer's own body. Here we used the traditional rubber hand paradigm (Botvinick and Cohen, 1998) and a no-touch rubber hand paradigm to investigate and to authenticate synaesthetic tactile sensation. In the traditional rubber hand paradigm, the participant views a prosthetic hand being touched by the Examiner while the participant's hand – hidden from view – is also touched by the Examiner. Synchronous stimulation of the prosthetic hand and the participant's hidden hand elicits the rubber hand illusion. It may seem to the participant that she is feeling touch at the location of the viewed prosthetic hand – visual capture of touch, and that the prosthetic hand is the participant's own hand – illusion of ownership. Thus, for participants who experience the traditional rubber hand illusion, tactile sensation on the participant's hidden hand is referred to the prosthetic hand. In our no-touch rubber hand paradigm, the participant views a prosthetic hand being touched by the Examiner but the participant's hand – hidden from view – is not touched by the Examiner. Questionnaire ratings indicated that only individuals with vision-touch synaesthesia experienced the no-touch rubber hand illusion. Thus, synaesthetic tactile sensation on the (untouched) hidden hand was referred to the prosthetic hand. These individuals also demonstrated proprioceptive drift (a change, from baseline, in proprioceptively perceived position) of the hidden hand towards the location of the prosthetic hand, and a pattern of increased proprioceptive drift with increased trial duration (60 sec, 180 sec, 300 sec). The no-touch rubber hand paradigm was an excellent method to authenticate vision-touch synaesthesia because participants were naïve about the rubber hand illusion, and they could not have known how they were expected to perform on either the traditional or the no-touch rubber hand paradigm.

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1. Introduction

Synaesthetic tactile sensation can be so compelling that an individual may mistake synaesthetic sensation for physical touch. In auditory-touch synaesthesia, sound elicits tactile sensation (Beauchamp and Ro, 2008; Ro et al., 2007); in smell-touch synaesthesia, odour elicits tactile sensation (Cytowic, 2002); in taste-touch synaesthesia, flavour elicits tactile sensation (Cytowic); and, in vision-touch synaesthesia, the sight of touch on another person elicits tactile sensation on the observer's own body (Blakemore et al., 2005). This paper is concerned with vision-touch synaesthesia, which is also referred to as mirror-touch synaesthesia (Ward et al., 2008, p. 259).

Patient studies (e.g., Bradshaw and Mattingley, 2001; Ramachandran and Rogers-Ramachandran, 1996) provide some of the earliest examples of how visual information can trigger tactile sensation. Bradshaw and Mattingley presented information about a man with severe health problems (including extensive metastatic carcinomatosis), who was so sensitive to touch that even slight contact with his skin was experienced as "sharp fingernails" (p. 136). In describing how this man responded to observed touch, his wife said "If I slightly knocked my finger, spontaneously showing him, he would immediately grasp his own finger and say 'don't do that' (meaning not to show him suddenly); he actually felt it. If I merely commented (that I had knocked my finger), there was no such reaction" (p. 136 and p. 821). More recent studies document vision-touch synaesthesia in healthy individuals (see Banissy and Ward, 2007; Banissy et al., 2009a, 2009b, 2011; Blakemore et al., 2005; Holle et al., 2011, and for an overview, see Ward et al., 2008). Banissy et al. (2009a) have estimated the prevalence rate for vision-touch synaesthesia to be as high as 1.6 in 100, which makes it one of the most common forms of synaesthesia; the prevalence rate for colour-grapheme synaesthesia is approximately 1.4 in 100 (Simner et al., 2006).

Blakemore et al. (2005) provided the first investigation of vision-touch synaesthesia in a neurologically healthy individual. Participant C (41-year-old female) claimed that she had always "perceived observed touch on other people as touch to her own body" (p. 1573), and she was surprised to learn that this experience was atypical. In a functional magnetic resonance imaging (fMRI) study, Participant C and control participants without vision-touch synaesthesia demonstrated activation in the primary and secondary somatosensory cortices, and the motor and premotor regions, when they were touched. More interestingly, the primary and secondary somatosensory cortices "were activated by the mere observation of touch to a human" (Blakemore et al., p. 1579). Related fMRI studies support these findings for control participants without vision-touch synaesthesia: McCabe et al. (2008) found activation in the primary somatosensory cortex when control participants observed touch (with a finger) to a human arm, and Keysers et al. (2004) found activation in the secondary somatosensory cortex when control participants observed touch (with an object) to a human leg. In the Blakemore et al. study, Participant C (when compared to control participants without vision-touch synaesthesia) exhibited significantly more activation bilaterally in the primary and secondary somatosensory cortices and in the left premotor cortex when she observed touch (with a finger) to a human face or neck relative to touch to a similarly-shaped object with face- and neck-like properties (e.g., a lamp). Participant C also exhibited bilateral activation in the anterior insula, but there was no evidence of insula cortex activation in control participants. Blakemore et al. suggested that in most people "it is possible that the somatosensory mirror system, which matches observed and felt touch, is involved in understanding the effect of tactile stimulation on others" (p. 1581). The authors concluded that what distinguished Participant C from control participants who did not feel observed touch was over-activation in the mirror system along with activation in the anterior insula, which contains tactile receptive fields and has been shown to play a role in self-attribution.

Banissy and Ward (2007) hypothesised that the somatosensory mirror system may have an important role in empathy. Consistent with this, they found that individuals with vision-touch synaesthesia scored significantly higher on the emotional reactivity subscale of the Empathy Quotient, when compared to control participants without synaesthesia and control participants with other forms of synaesthesia. Banissy et al. (2011) have since demonstrated a link between vision-touch synaesthesia and another aspect of emotion. Participants with and without vision-touch synaesthesia were presented with an adjective describing an emotional state, and the task was to identify which of three faces best depicted this emotional state. Individuals with vision-touch synaesthesia demonstrated superior performance on this expression-recognition task whereas their performance was identical to control participants on non-emotive tasks, such as tasks investigating memory for faces. Taken side-by-side, these studies suggest that vision-touch synaesthesia may be linked to "general enhancements in emotion processing" (Banissy et al., p. 1823).

Researchers who investigate synaesthesia emphasise how important it is to *authenticate* the individual's experience (see Gheri et al., 2008; Simner et al., 2006). For example, in the study by Blakemore et al. (2005), fMRI was used to authenticate Participant C's report that she experienced observed touch on another person as if it were touch on her own body. Banissy and Ward (2007) have since introduced a reaction-time task to authenticate vision-touch synaesthesia. The participant's task was to report the location of touch administered to his or her own body while observing touch administered to another person. The location of touch administered to the participant's body was either congruent or incongruent with the location of viewed touch. This task was difficult for the individuals with vision-touch synaesthesia because of the requirement to distinguish actual physical touch from synaesthetic tactile sensation. Individuals with vision-touch synaesthesia were faster to report the location of physical touch when it was congruent (as compared to incongruent) with the location of viewed touch. Control participants without vision-touch synaesthesia did not demonstrate this effect. Moreover, individuals with vision-touch synaesthesia were prone to errors in the incongruent condition; for example, they reported touch at two locations – the location of physical touch and the location of viewed touch. Control