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Research Report

# Visually induced feelings of touch

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ABSTRACT

Recent studies have reported that vision can enhance tactile perception, even in patients with somatosensory deficits. However, it is unclear in these previous studies whether visual input truly enhances detection of tactile stimuli or induces a higher propensity for reporting touch by changing response criteria. In this study, we demonstrate in neurologically normal subjects that in addition to small increases in tactile sensitivity when a non-informative, suprathreshold visual stimulus is presented, there are highly consistent changes in response criteria for reporting touch with vision, even when no tactile stimulus is delivered. These results suggest that some of the previously reported enhancements of touch from vision may rather be a consequence of strategic sensory encoding processes that rely upon the typical correlations between multisensory events.



## 1. Introduction

All of our incoming sensations help to build our perception of the world. However, vision appears to be our most important and relied on sensory modality, typically dominating or altering our other senses. For example, several studies have demonstrated that other senses adapt to a distorted visual image (Harris, 1963; Sekiyama et al., 2000; Stratton, 1897). These studies show that the proprioceptive system adapts to the visual environment, especially when vision and proprioception provide conflicting sensory information. When visual and tactile processing provide conflicting information, the visual system not only dominates but can also alter touch perception (Pavani et al., 2000; Rock and Victor, 1964, 1965; Ro et al., 2004). For example, using a mirror to induce a conflict between vision and touch, Ro et al. (2004) enhanced tactile perception for several minutes and established that this visual enhancement of touch induced by the conflict occurs in the posterior parietal cortex.

Other research has also shown that vision can augment tactile perception, even in cases without any influences from proprioceptive orienting (Kennett et al., 2001; Taylor-Clarke et al., 2002; Tipper et al., 1998, 2001). In one study, for example, Tipper et al. (1998) used a video camera to display a participant's hand on a monitor placed directly in front of the subject and demonstrated that tactile perception was facilitated (i.e., response times were faster) with vision of the hand, independent of proprioception of the head. In a follow-up study, vision influenced tactile detection at body sites that could not be directly viewed by the participants, such as the face or the back of the neck (Tipper et al., 2001). The effect of non-informative vision on tactile spatial resolution has also been investigated (Kennett et al., 2001). Participants were significantly better at a two-point discrimination task when their arm was visible, compared to when the arm was not visible or when viewing a neutral object. Tactile perception was further increased with magnification of the participant's arm. Using event-related potentials (ERPs), Taylor-Clarke et al. (2002) suggested that vision of a to-be-touched body part might modulate tactile processing in the somatosensory cortex via back projections from multimodal posterior parietal areas.

Based on the multisensory facilitation depicted in the previous experiments, some patient studies have investigated

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whether vision can systematically enhance touch perception. In one study, Halligan et al. (1996) reported a right hemisphere stroke patient who detected all contralesional tactile stimuli when he viewed his left hand being touched, but felt nothing when he could not see the touch. When the patient could not see his hands, however, he could still reliably transfer information from his impaired hand (which he did not know was being touched) to his normal hand. Importantly, in relation to the current study, when the patient watched a previously taped video of his hand being touched, he also reported feeling touches even when no tactile stimuli were delivered. Halligan et al. (1996) suggested that correlated visual information decreased the patient's threshold for touch sensations, but it remains unclear why the patient made false reports of touch under some conditions.

Rorden et al. (1999) investigated another patient whose tactile detection of a tap was also improved by the sight of a non-informative flash of light on a rubber hand placed in the same orientation directly above the patient's own concealed hand. When a salient, but non-predictive light, was attached to the rubber hand, the patient's touch perception was enhanced compared to when the light was in the same location but on the hand of an experimenter who was sitting across from the patient. On light-only trials, when the visual but not the tactile stimulus was presented to the patient, his false alarm rates were very low and did not differ between the rubber hand and experimenter hand conditions. Rorden et al. (1999) concluded that the presence of the light on the rubber hand dramatically increased tactile sensitivity because the patient viewed the rubber hand as being his own but did not feel that way towards the experimenter's hand.

Based on the two previously described patient studies, it is unclear whether visual input consistently enhances tactile perception or changes response biases. Since we have lifelong experiences of visual input correlated with touch, perhaps response biases operate to induce feelings of touch even when no tactile stimulus is present, such as when seeing an insect induces a sensation of something crawling on one's skin. Therefore, we tested whether a non-informative[1] simultaneous visual stimulus can increase threshold-level tactile perception in neurologically normal subjects, with or without associated changes in response biases. We hypothesized that a response bias would raise both the reported detection of touch when a simultaneous but non-predictive flash of light is presented with the tactile stimulus and would also increase errors in reporting touch when a light is presented alone. Using analyses based on Signal Detection Theory (Macmillan and Creelman, 1991), we examined whether the presence of a visual stimulus enhances detection and/or changes response criteria.

## 2. Results

Five experiments determined that non-informative visual information not only modulated near-threshold touch perception but consistently induced shifts in biases for reporting touch with vision. In each experiment, tactile stimulation was delivered to subjects' hands through ring electrodes attached to their middle fingers. A small red LED was also taped to the ring electrodes and was illuminated for 5 ms when serving as the visual stimulus (Fig. 1).

### 2.1. *Experiment 1 results*

Experiment 1 used a non-informative light simultaneously paired with a near-threshold tactile stimulus in the critical condition to determine whether it would influence touch detection and response biases. The experiment had four conditions that were presented equally often and in a randomized order throughout the experiment: (1) Light trials; (2) Touch trials; (3) Both light and touch trials; and (4) Catch trials on which no sensory stimulation was delivered to the subject. The subjects' task was to state whether they saw a light, felt a touch, perceived both, or detected nothing. Responses were considered correct if the participants accurately reported all stimuli administered on a particular trial or reported 'none' on the Catch trials. Trials on which subjects were given a Catch trial and responded "touch" or were given a Light trial and responded "both" were considered false alarms.

**Fig. 1 – The apparatus and stimuli used in Experiments 1, 2, and 3 are shown. Experiment 4 had a second set of ring electrodes and another LED attached to a participant's left index finger, while Experiment 5 had the ring electrodes and LED attached to the participant's right middle finger.**

[1] We use the term non-informative to refer to the fact that the presentation of the light did not signal whether a touch would be given. However, when a light was presented on a trial, it was temporally informative so that participants knew that if a corresponding tactile stimulus was also presented, it occurred simultaneously with the visual stimulus. This temporal information was not available when the touch was presented alone. Note, however, that we did give consistent temporal information on every trial by always providing a warning tone 500 ms before the stimuli were delivered during the experiments. Thus, the additional temporal information supplied when vision was provided with touch was likely to be minimal.