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Research report

Watching what's coming near increases tactile sensitivity: An experimental investigation

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HIGHLIGHTS

- Results of somatosensory examinations could be affected by approaching the patient.
- Seeing someone approaching your body with a device increases tactile sensitivity.
- Visuo-tactile interactions are especially apparent close to the body.

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ABSTRACT

During medical examinations, doctors regularly investigate a patient's somatosensory system by approaching the patient with a medical device (e.g. Von Frey hairs, algometer) or with their hands. It is assumed that the obtained results reflect the true capacities of the somatosensory system. However, evidence from crossmodal spatial research suggests that sensory experiences in one modality (e.g. touch) can be influenced by concurrent information from other modalities (e.g. vision), especially near the body (i.e. in peripersonal space). Hence, we hypothesized that seeing someone approaching your body could alter tactile sensitivity in that body-part. In the In Vivo Approaching Object (IVAO) paradigm, participants detected and localized threshold-level vibrotactile stimuli administered on the left of right hand (=tactile targets). In Experiment 1, this was always preceded by the experimenter approaching the same (congruent trials) or the other (incongruent trials) hand with a pen (=visual cue). In Experiment 2, a condition was added in which a point further away from the hands (also left vs. right) was approached. Response Accuracy was calculated for congruent and incongruent trials (Experiment 1 & 2) and compared between the close and far condition (Experiment 2). As expected, Response Accuracy was higher in congruent trials compared to incongruent trials, but only near the body. As a result, evidence was found for a crossmodal interaction effect between visual and tactile information in peripersonal space. These results suggest that somatosensory evaluations—both medical or research-based—may be biased by viewing an object approaching the body.

1. Introduction

Imagine undergoing a medical examination, such as pressure algometry. Would your response be affected by seeing the doctor approaching you with the algometer? Health care providers often approach and touch the patient with testing devices such as von Frey hairs, algometers, or with their hands. These tests are often part of daily clinical practice but may also be part of specialized sensory evaluation such as the Quantitative Sensory Testing (QST) in patients with neuropathic pain. When these patients are approached and tested, they usually report upon the experience elicited by reporting the presence of the sensation, or rating the sensation (e.g. pain on a visual analogue scale). The assumption is that these reports reflect the capacity of the somatosensory system. However, such examinations do not consist only of somatosensory input. While approaching the body, also visual and possibly auditory information is present. It may well be that the integration of information from several perceptual modalities contributes to the experience of the patient.

This idea of crossmodal interactions has been the subject of extensive research in humans and animals [1–3]. In a typical study of Spence et al. [2], participants were faster and more accurate in

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making speeded discriminations of tactile targets on the hand when a visual stimulus was presented on the same hand, as opposed to the other hand. Electrophysiological and neuroimaging studies have also confirmed crossmodal links in spatial attention [4–7]. For example, Sambo and Forster [8] recorded somatosensory evoked potentials of increased magnitude when the tactile stimuli applied to one hand were presented concomitantly with a visual cue near that hand. Multisensory interactions have also been proposed for pain, which would facilitate the localization of painful stimuli in close proximity to the body [9,10]. De Paepe et al. [11] have shown that judgment about the detection of nociceptive stimuli is facilitated by visual stimuli delivered close to the body part on which is applied the nociceptive stimuli.

It seems reasonable to hypothesize that the visual information resulting from an object approaching a body part in close proximity will facilitate the somatosensory processing of that body part. There is some evidence in support of this idea [12], but no study has investigated visuo-tactile interactions in situations resembling clinical and/or QST practices. Therefore, we developed the "In Vivo Approaching Object paradigm", which mimics clinical examinations but also allows for experimental control over stimulus delivery. During each trial, a pen was directed by the experimenter towards a hand of the participant. Once in close proximity to the hand, a vibrotactile stimulus (at sub- or supra-threshold) was delivered to either the approached hand (congruent trials) or the other hand (incongruent trials). The participants' ability to accurately detect and locate the vibrotactile stimulus was measured. In Experiment 1, the pen was directed towards the proximal space of one of the hands. Experiment 2 extended Experiment 1 by also including a condition in which the object was directed towards a location at a further distance from the hands. It was expected that detection accuracy would be higher for congruent than incongruent trials, especially when the pen approached the proximal space of the hand, as opposed to a location at a further distance from it.

2. Experiment 1

2.1. Method

2.1.1. Participants

Thirty undergraduate students took part for course credits (age: $M = 21.00$; $SD = 5.59$; range = 17–43 years; 3 men; 5 left handed). Exclusion criteria were insufficiently corrected visual impairments, the self-report of current medical/psychiatric conditions, or current medication intake affecting somatosensory sensitivity. None of the participants had to be excluded. The study was approved by the Ethics Committee of Ghent University. All participants gave their written informed consent.

2.1.2. Stimuli and apparatus

During the In Vivo Approaching Object (IVAO) task, participants were seated with their hands, palms down, resting on a table (see Fig. 1). Two square metal plates ($\pm 4\,cm^2$) were used as electrical contacts. They were attached to the table, 50 cm apart from each other and positioned between the thumb and index finger of each hand. The distance between the edge of the table—near the participant's trunk—and the plates was 30 cm. At a distance of 55 cm in front of the edge of the table and ~35 cm apart from each metal plate, a black fixation cross was presented on the table to prevent participants from shifting their gaze during the task. The participant's head was fixed using a chin wrest. Headphones with continuous white noise (46 dB) were used to mask auditory stimuli from the immediate environment. The experimenter was sitting on the other side of the table, at a distance of approximately 1 meter, facing the participant.

2.1.2.1. Visual stimuli. A black pen was held by the experimenter and served as a visual stimulus. The experimenter (LV) held the pen in her left or right hand, and smoothly moved her arm towards one of the two metal plates near the participant's hands, and finally tapped the metal plate. She then moved back to the starting position of the movement. Depending on the plate that had to be approached (left or right), the arm closest to that side was used to perform the movement. Tapping the plate triggered the delivery of a tactile stimulus after a time interval of ~2 ms.

2.1.2.2. Vibrotactile stimuli. Two magnet linear actuators (C-2 TACTOR, Engineering Acoustics Inc., Casselberry, Florida) were attached to the sensory territory of the superficial radial nerve of each hand and released vibrotactile stimuli (50 ms duration; 50 Hz). The actuators were driven by a self-developed controlling device and software. The intensities of the vibrotactile stimuli were near the perceptual threshold, which was individually determined using an adaptive procedure. The procedure has been used in previous studies [13,14]. The procedure consisted of four independent yet randomly intermixed staircases of 20 trials (two series for each hand) randomly administered (80 trials in total). Each series had a starting value of 0.068 Watt (W) for the first stimulus. The intensity decreased each time the participants reported feeling the stimulus, and increased when no sensation was reported. The perceptual threshold was determined for each hand, based upon the mean intensity of the last stimulus of each of the two series of that particular hand. Sub-threshold and supra-threshold values were calculated for each hand by respectively subtracting one eighth from the perceptual threshold value, or adding one eighth to it (see [15]).

2.1.3. Self-report measures

Participants completed a socio-demographic questionnaire also consisting of the pain grading scale [16], allowing the classification of participants as a function of experienced painand disability during the last 6 months. Also, current treatment for medical or psychiatric conditions, medication intake and perceived health quality were assessed. Participants also completed the Dutch versions of the Pain Catastrophizing Scale (PCS; [17]) and of the Trait scale of the State-Trait Anxiety Inventory (STAI; [18]). The PCS and the STAI were included for a meta-analytic investigation on the role of individual differences in studies on this topic. Individual studies often lack the statistical power to reveal precise estimations of such effects, and hence these data will not further be discussed, but can be requested by addressing the authors.

After each block, a series of self-report items assessed to what extent participants made an effort to fulfill the task; were concentrated on the task; felt tense/fearful during the task; directed their attention towards the pen and the tactile stimuli; experienced the pen as threatening; and used the pen to predict the location of the tactile targets. Each item was rated using a 11-point graphic rating scale (0 = "not at all"; 10 = "very much").

2.1.4. Procedure

Participants started with filling out the socio-demographic questionnaire, the PCS and the STAI, after which the staircase procedure followed. Participants were instructed to lay their arms on the table and to find a comfortable position by having the chin wrest and their chair adjusted. A computer screen was placed in front of the participant and instructions about the staircase procedure were given. Following this, the headphones were turned on and the staircase procedure started. First, a visual stimulus (a letter X, 1000 ms duration) appeared in the middle of a computer screen, accompanied by a vibrotactile stimulus either on the left or right hand (position unknown to the participant). Participants verbally reported whether they had felt a vibrotactile stimulus ("yes"