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Last but not least

Active and passive movements give rise to different judgments of coldness

Abstract. When the right index fingertip of twelve subjects was moved across a cold (15 °C) tile by a machine (passive-guided condition), the subjects rated the temperature of the tile as being colder than when they moved the finger across the stimulus themselves (active condition). Results confirmed that active movements were associated with an attenuation of 'coldness'. When these findings are considered alongside those of earlier experiments (see VanDoorn et al, 2005 *Perception* **34** 231 – 236), it may be concluded that intentionality of movement plays some role in this attenuation.

Gibson's (1962) early research into the distinction between touching and being touched provided a foundation for psychobiological theory in which perceptual awareness may be modulated by cues from active movement (see Blakemore et al 1998). Bolanowski et al's (2004) contention was that active exploration generates an awareness of the object that is touched. In contrast, being passively guided over an object evokes a "distinctly different subjective percept, that of an internal sensation confined not to the environment but to oneself" (Bolanowski et al 2004, page 41). We investigated the effects of active versus passive movements on the interpretation of 'cold' stimuli.

Twelve students (eight female, mean age 20.17 years) volunteered for the experiment. All were recruited from Monash University's Gippsland Campus.

A Peltier tile was attached to an aluminum cantilever. The piece of aluminum was secured to a second piece and served as a swinging arm (see figure 1). The swinging arm array was connected to the tactile display system (TDS). This arrangement ensured a constant pressure on the upturned fingertip.

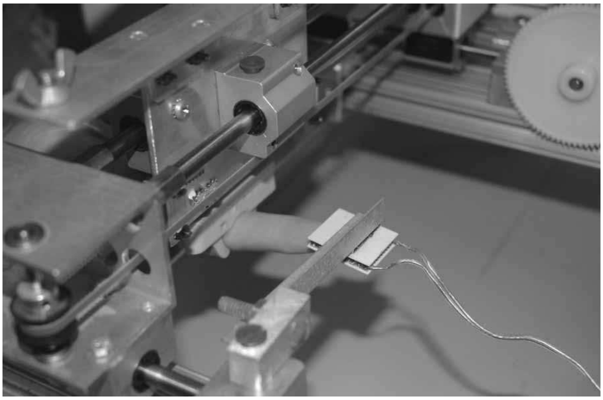

Figure 1. View of the swinging arm array and finger holder.

The TDS includes a plastic cradle in which the sides of the participant's index finger are lightly gripped, leaving the finger-pad free. The experimenter pre-recorded a left-to-right exploration pattern which provided the time and movement constraints of each 'passive' trial. These movements were replayed to guide the participant's index finger across the tile.

After receiving an explanation of the procedure, the participant placed the index finger of the right hand, pad up, into the TDS's finger holder. The finger holder allows active and passive movements along the x-axis. In condition 1 (active movement), this arrangement allowed regular, self-generated movements across the stationary Peltier tile.

A practice session was given before the experimental session, without cold, to familiarise subjects with the type of movement they would be required to make.

In condition 2 (passive movement), participants did not actively move but were guided across the Peltier tile by the TDS. The finger was moved across the stationary Peltier tile at an average rate of 2.5 cm (from left-edge to right-edge) every 2 s. Thus, the rate and extent of the active and pre-recorded lateral movements were consistent.

To ensure that subjects' experiences were matched, thermal stimuli lasted 10 s. Once 10 s had elapsed, the experimenter removed the tile from the participant's finger. At this point, an estimation of the degree of coldness was recorded. Participants made a mark on a solid black line (10 cm in length) to represent the perceived coldness. In all trials, participants were free to put a mark at any point along the scale. If no 'coldness' was perceived on a given trial, the participant was instructed to mark 'zero' (ie the leftmost position on the line). Inclusion of this response option was necessary to ensure that coldness was actually detected. The rightmost position of the line was to represent a 'very cold' temperature.

The interstimulus-onset interval (ISI) was 90 s. This phase allowed the Peltier tile to return to its pre-trial state. The temperature (15 °C) was the same across all trials.

The experiment consisted of two trials, one in the active and one in the passive condition. The order of movement types (active vs passive) was counterbalanced between participants. The results were analysed with a paired-samples *t*-test. The dependent variable was the estimation of 'coldness', operationally defined as the distance between the left end of the line and the mark made by the participant.

Figure 2 presents descriptive data (means and standard errors) for the 'coldness' judgments.

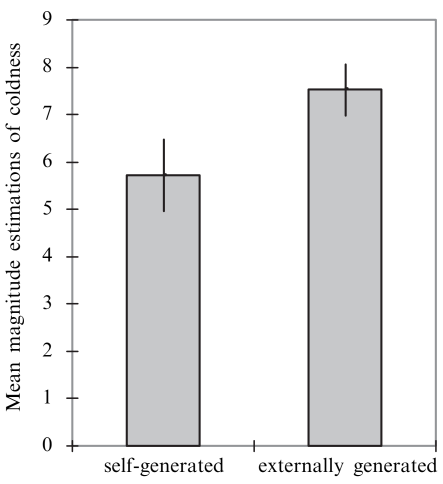

Figure 2. Perceived temperature as a function of active and passive movement types. Means and standard errors.

Estimated coldness associated with active movement was significantly less than that of the passive condition.

In an earlier experiment, the left hand had been used to move the Peltier tile across the stationary index fingertip of the right hand (VanDoorn et al 2005). In the current experiment, the right hand was still used to detect temperature but was also employed to generate movement. Although similar findings were present in the original experiment, the discussion had made mention of a possible corollary discharge mechanism. This explanation seems unlikely when considering that attenuation occurs whether or not the motor signals were distal (original experiment) or proximal (current experiment) to the stimulated skin. Consequently, it appears that intentionality of movement plays some role.

Chapman et al (1966) found that active movement lowers the firing rate of tactile inputs into the cortex. In their research, this movement-related gating was absent during passive conditions. It may be that passive perception is sometimes more informative than active simply because the former condition yields a less-filtered experience, and a less-governed or attenuated response, than the latter.

In summary, this experiment demonstrates a perceived attenuation in subjective coldness judgments during active movements. Although these findings are consistent with corollary discharge theory, there is uncertainty in the origins of the attenuation which may be attributed to expectancy, attentional factors, or suppressed afferents.

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