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External location of touch is constructed post-hoc based on limb choice

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Abstract When humans indicate on which hand a tactile stimulus occurred, they often err when their hands are crossed. This finding seemingly supports the view that the automatically determined touch location in external space affects limb assignment: the crossed right hand is localized in left space, and this conflict presumably provokes hand assignment errors. Here, participants judged on which hand the first of two stimuli, presented during a bimanual movement, had occurred, and then indicated its external location by a reach-to-point movement. When participants incorrectly chose the hand stimulated second, they pointed to where that hand had been at the correct, first time point, though no stimulus had occurred at that location. This behavior suggests that stimulus localization depended on hand assignment, not vice versa. It is, thus, incompatible with the notion of automatic computation of external stimulus location upon occurrence. Instead, humans construct external touch location post-hoc and on demand.

Introduction

Spatial perception and actions rely on multiple spatial codes, often associated with different reference frames. For instance, the accuracy of pointing or reaching with an arm or finger to a visual target depends not only on the position of target relative to gaze (***Fiehler et al., 2011***; ***Thompson et al., 2014***), but also on salient world-centered landmarks (***Schütz et al., 2013***). Similarly, judgment of visual location during whole-body movement is influenced by a target's position relative to gaze, as well as by the location of the target relative to the body (***Tramper and Medendorp, 2015***).

In touch, too, space is coded in several reference frames. Touch activates specialized sensory receptors embedded in the skin, and the arrangement of the peripheral sensors is reflected in the homuncular organization of primary somatosensory cortex (***Penfield and Boldrey, 1937***; ***Roux et al., 2018***), referred to as a skin-based or somatotopic layout. However, because our body can take various postures, the stimulus location in space – often referred to as its external location – must be derived by combining skin location and body posture, a process termed tactile remapping (***Heed et al., 2015a***). Indeed, there is evidence that external tactile locations can be coded in a gaze-centered reference frame (***Harrar and Harris, 2010***; ***Mueller and Fiehler, 2014a***; ***Mueller and Fiehler, 2014b***), but also relative to anchors such as the head, torso, and hand (***Alsmith et al., 2017***; ***Heed et al., 2016***).

It is less clear, however, according to which principles these different spatial codes are employed. Both bottom-up features such as the availability of sensory information (***Bernier and Grafton, 2010***) and the spatial reliability of a sensory channel (***Ernst and Banks, 2002***; ***van Beers et al., 2002***), as well as top-down information such as task-constraints (***Badde et al., 2016***; ***Schubert et al., 2017***), action context (***Mueller and Fiehler, 2014b***), and cognitive load (***Badde et al., 2014***) can affect the relative contributions of different reference frames, presumably in a weighted manner

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