

Negative BOLD in Somatosensory Cortex during Simple Finger Tapping

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TARGET AUDIENCE: Neuroscientists, MR scientists, Psychologists.

PURPOSE: The sensorimotor system has been intensively studied in human brain, using fMRI over the last decades. One interesting focus of research is the role of the somatosensory cortex during self-generated touch, leading to the surprisingly simple question of why it is impossible to tickle oneself^{1,2}. Previous studies found a decreased BOLD signal in somatosensory cortex during self-generated tactile stimuli, compared with externally produced stimuli¹. It has also been shown that the anticipation of tactile stimuli, obviously greater during self-generated touch, leads to deactivation of certain areas within the somatosensory cortex². We used 7T fMRI, with sub-millimeter resolution and a simple finger tapping paradigm, to locate these areas precisely.

METHODS: All experiments were performed on a 7 T whole-body MR scanner using a 24-channel phased array head coil. The study was carried out with ethical approval from the local university, and informed consent was obtained from the 10 subjects. To identify the central sulcus, a whole-brain T_1 -weighted data set was acquired prior to the functional experiment (see Fig. 1). For fMRI, zoomed EPI slices were positioned axially at the “hand knob”. The sequence parameters were: TR = 3.3 s; TE = 25 ms; FA = 80°, voxel size (0.75 mm)³. The stimulus paradigm consisted of 2 simple conditions: “classical” finger tapping (“tapping”), and movement of the fingers without touching the finger tips (“moving”). The activation maps were corrected for multiple comparisons, with $p < 0.05$ (FDR). No spatial smoothing was applied. The activation maps were overlaid on the mean EPI image.

RESULTS: Deactivation maps of 4 representative subjects acquired during “tapping” are shown in Fig. 2. These show axial views of the hand knob area, indicated by the red square in Fig. 1. A specific area within the somatosensory cortex is consistently deactivated (red circles). While the extent of the deactivated area varies, its position is strikingly similar across subjects. In Fig. 3, activation and deactivation maps acquired during “tapping” and “moving” in a fifth subject are shown. It can be seen that “tapping” and “moving” produces similar activation in the primary motor cortex (anterior bank of the central sulcus) whereas, as expected, “tapping” causes more activation in the somatosensory cortex (posterior bank of the central sulcus) compared with “moving”. However, the location and extent of the deactivated area introduced in Fig. 2 is very similar for both conditions (red circles). To facilitate distinction between primary motor and somatosensory cortex, the central sulcus is indicated by a blue line in Fig. 3.



Fig. 1. T_1 -weighted image.

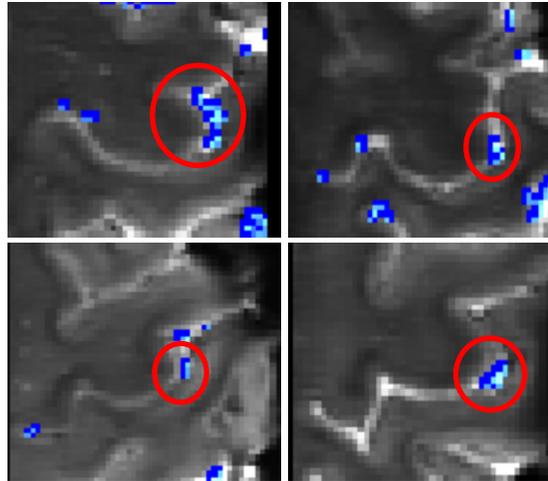


Fig. 2. Deactivation maps (“tapping”) of 4 subjects.

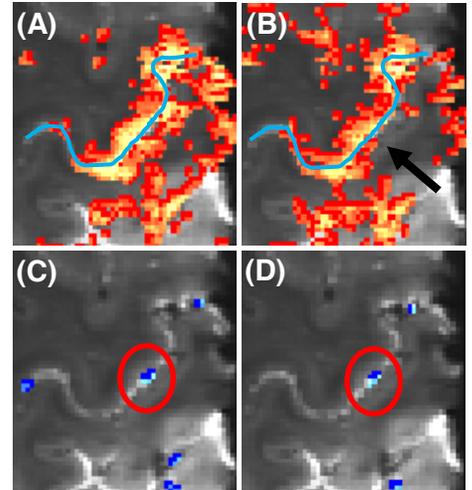


Fig. 3. Activation maps: (A) “Tapping”, (B) “Moving”; and deactivation maps: (C) “Tapping”, (D) “Moving”.

DISCUSSION: Sub-millimeter fMRI during simple finger movements robustly shows an area of deactivation within Brodmann area 3b. This may arise from an attenuation of incoming signal from self-generated movements². In line with other studies, the deactivation occurs even if the actual touch is only anticipated², as with the “moving” task. Somatotopic maps suggest that the deactivated area lies at the medial border of the digit representations³, consistent with a PET study showing decreased blood flow in areas surrounding the locus of awaited stimuli⁴. Comparing Fig. 3A with 3B and 3C further supports this notion, as the deactivated area coincides with a border (indicated by the black arrow) dividing the somatosensory cortex into a medial part activated by both “tapping” and “moving” and a lateral part activated only by “tapping” and therefore likely comprising the somatotopic digit representations.

CONCLUSION: Deactivation during finger tapping and finger movement was observed in a localized area within Brodmann area 3b, consistent with neural inhibition of this region in anticipated and actual self-touch. Unsmoothed high resolution 7T fMRI crucially allows such observations, which may provide novel insights into somatosensory neural function.

REFERENCES: [1] Blakemore et al. *Nat Neurosci* 1998;1:635-40. [2] Carlsson et al. *J Cogn Neurosci* 2000;12:691-703. [3] Sanchez-Panchuelo et al. *J Neurophysiol* 2010;103:2544-56. [4] Drevets et al. *Nature* 1995;373:249-52.