Modeling Population Receptive Fields of the Fingertips in Human Primary Somatosensory Cortex

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Abstract

Although between-fingertip maps have been extensively studied in human primary somatosensory cortex (S1), surprisingly little is known about their fine-grained architecture. To address this issue, we set out to estimate 2D population receptive fields (pRFs) of the tip of the index finger in human S1. Using 7T-fMRI at submillimeter resolution and prospective motion correction, we recorded S1 responses whilst participants sensed a row of vibrotactile pins moving along cardinal axes over a portion of the fingertip. To estimate pRF position and size, we fit a 2D Gaussian pRF model to the data (as is common in vision science). Our results show that the recorded S1 responses do not contain enough information to obtain plausible pRF estimates without further modeling constraints. Simulation analyses suggest this is likely because the size of pRFs in S1 surpasses the area on the fingertip that was stimulated, resulting in an incomplete mapping of pRFs. When constraining the fitting procedure and the 2D Gaussian pRF model (by keeping pRF size constant), our results for pRF position suggest that the ulnar-to-radial axis spanning the fingertip might be represented along a superior-to-inferior axis in S1. Although this representation is largely replicable, cross-validation and simulation analyses indicate that our constrained 2D Gaussian pRF model performs only slightly better than a pRF model without any spatial tuning, which might be yet another consequence of partial pRF mapping. Both the putatively "large" pRF size and the pRF position gradient we uncover here appear compatible with receptive field properties in monkeys.

Keywords: population receptive field modeling, fingertip, primary somatosensory cortex, 7T, fMRI, human, simulations

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