# The Spatial Resolution of Artificial Touch Via Intracortical Microstimulation and its Neural Determinants

**N. D. Shelchkova[1], C. M. Greenspon[2], T. G. Hobbs[3], C. Verbaarschot[3], E. I. Berger-Wolfe[4], J. E. Downey[2], R. A. Gaunt[3,5,6,7], S. J. Bensmaia[1,2,8*]**

*[1]Committee on Computational Neuroscience, University of Chicago, Chicago, IL; [2]Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL; [3]Rehab Neural Engineering Labs, University of Pittsburgh, Pittsburgh, PA; [4]Middlebury College, Middlebury, VT; [5]Department of Physical Medicine and Rehabilitation, University of Pittsburgh, Pittsburgh, PA; [6]Department of Bioengineering, University of Pittsburgh, Pittsburgh, PA; [7]Department of Biomedical Engineering, Carnegie Mellon University, Pittsburgh, PA; [8]Neuroscience Institute, University of Chicago, Chicago, IL.*

*P.O. Box 60637, Chicago, USA. E-mail: sliman@uchicago.edu

*Introduction:* When we interact with objects, tactile signals from the hand convey information about the objects and our interactions with them. A basic feature of these interactions – the location of object contact on the hand – is typically only available via the sense of touch because vision of the contact points is occluded. Even when visual feedback is available, it is a poor substitute for the exquisite resolution of the tactile system. Signaling contact location via bionic hands leverages the apparent labelled line coding of location in somatosensory cortex (S1). Delivering current through an electrode in S1 evokes a touch percept that is experienced at a specific location – the electrodes projected field (PF) – and is hypothesized to be determined by the electrode's location on the somatosensory homunculus. Force sensors on the bionic hand can then drive stimulation through electrodes in S1 that evoke sensations on the corresponding location on the phantom or deafferented hand, thereby intuitively conveying information about contact location. The objectives of the present study were to quantitatively characterize the stability of PFs over time and the degree to which PFs tile the hand. In two participants with tetraplegia and residual sensation in their hands, we also assessed the degree to which the PF of an electrode coincided with its receptive field (RF), defined as the patch of skin that activates neurons around the electrode tip.

*Materials, Methods, and Results:* Over the span of years, participants reported where on the hand they experienced a touch percept when stimulation was delivered through each of 64 electrodes in S1. We also measure the receptive fields (RFs) for the neurons recorded on each electrode by assessing the areas of skin where mechanical stimulation evoked spiking activity. We found that PFs were distributed across the hand and followed the expected somatotopic organization, with some local deviations from this pattern. PFs tended to remain on the same finger pad over the testing period but their area and center of mass varied across testing sessions (on average 3 mm). The PF of an electrode tended to be smaller than but largely subsumed by its RF, consistent with the labelled line hypothesis.

*Discussion and Significance:* While PFs are stable over time, they vary over a range (0 - 12mm), which will ultimately set a limit on the spatial resolution of artificial touch. The PF of an electrode is largely determined by its RF, consistent with the labelled line hypothesis of touch localization, wherein the spatial pattern of activation on the homunculus – whether by touch or by electrical stimulation – determines the location of the evoked touch sensation.

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