Characterizing the population receptive fields of the hand dorsum and palm

Presented During: Poster Session
Tuesday, June 11, 2019: 12:45 PM - 02:45 PM

Submission No:

T816

Submission Type:

Abstract Submission

Authors:

Raffaele Tucciarelli[1], Elisa Infanti[2], Luigi Tamè[1], Matthew Longo[1]

Institutions:

[1]Birkbeck University of London, Department of Psychological Sciences, UK, [2]University College London, Experimental Psychology, UK

Introduction:

In an fMRI study, we explored the population receptive field (pRF; Dumoulin & Wandell, 2008) properties of the voxels in the dorsum and palm area of the primary somatosensory region (area 3b). Behavioural studies adopting tactile discrimination tasks suggested that these two skin surfaces are represented differently, with the dorsum representation being more distorted than the palm representation (Longo & Haggard, 2011). Longo and Haggard (2011) explained these results by suggesting that the receptive fields of the dorsum surface are more elongated along the proximodistal hand axis than the ones of the palm – the pixel model. The authors based this idea mostly on animal studies (e.g. Alloway et al, 1989; Brooks et al, 1961; Brown et al, 1975). However, it is not clear if this is also the case for humans as, to the best of our knowledge, no study so far has investigated the pixel hypothesis systematically.

Methods:

The same participant was tested in two fMRI experiments (12 runs for experiment 1; 6 runs for experiment 2). In separate runs, the experimenter manually stimulated either the participant's dorsum or palm with an object (a circle covering 4 grid cells when centred at one intersection in experiment 1, a square covering one cell in experiment 2). A 4x4 grid (7 cm per side) was drawn on the participant's palm and dorsum (Figure 1). In experiment 1, the intersections of the grid lines were numbered from 1 to 25, whereas in experiment 2 each cell of the grid was numbered from 1 to 16. An acoustic cue instructed the experimenter on which skin region to stimulate and for how long. In experiment 1, we employed a random sequence in which each grid intersection was stimulated once per run interleaved with 7 randomly presented null trials. Each trial was 4 seconds and included the delivery of the touch on the instructed location plus small rotatory movements in anti-clockwise and clockwise directions. In experiment 2, we used an ordered sequence from 1 to 16 and back which was repeated 4 times in each run (2 null trials were presented every 4 trials). A tactile stimulation lasted for 2 seconds and consisted of 4 tactile events (~ 2Hz) in which the object gently touched the target skin location. We estimated the

shape of the pRFs in anatomically and functionally predefined regions of interests (see Figure 2A). To fit the data, we used an oriented elliptical Gaussian with four parameters: the stimulated skin location (x and y); the long and short axes of the ellipse (σ1 and σ2), and the orientation (ϑ). We defined the anisotropy as the absolute value of the logarithm of the ratio between the horizontal and vertical axis. Orientations were transformed such that ellipses with the long axis running along the proximodistal orientation had an angle of 90 degrees.

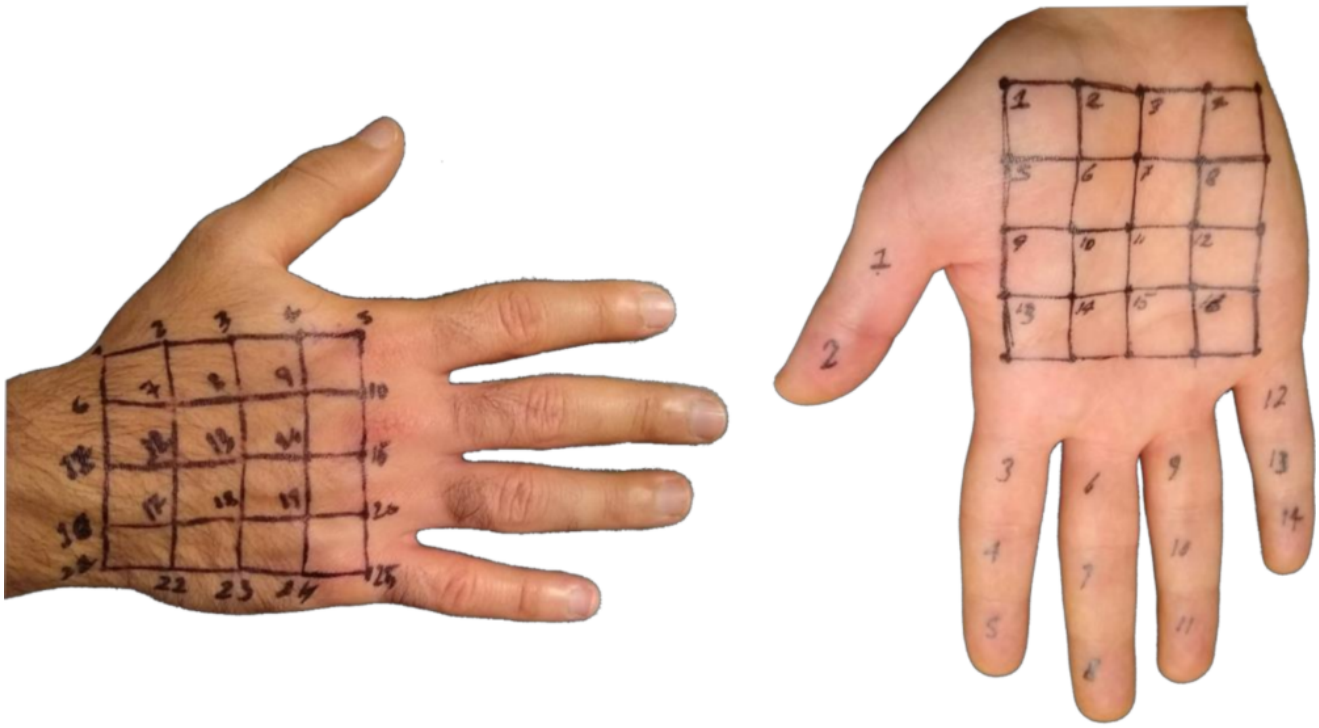

Figure 1. A) Participant's hand dorsum with the grid used in Experiment 1; **B)** Participant's hand palm with the grid used in Experiment 2;

Results:

Figure 2B shows the results for the voxel with the highest goodness of fit for each of the skin surfaces stimulated in experiment 2. The green dot indicates the centre of the elliptical shape. The estimated pRF on the dorsum has a higher anisotropy than the one on the palm. Figure 2C shows the locations of all the estimated pRFs. In Figure 2D, we plotted each semi-major axis angle as an oriented line with the length proportional to the level of anisotropy. Ellipses oriented along the proximodistal axis of the hand appear vertical in the plot. The thick line indicates the resultant vector which gives an indication of the general orientation and anisotropy within the area. In both experiments, the dorsum showed higher anisotropy and both skin surfaces showed a slight deviation from the vertical orientation.

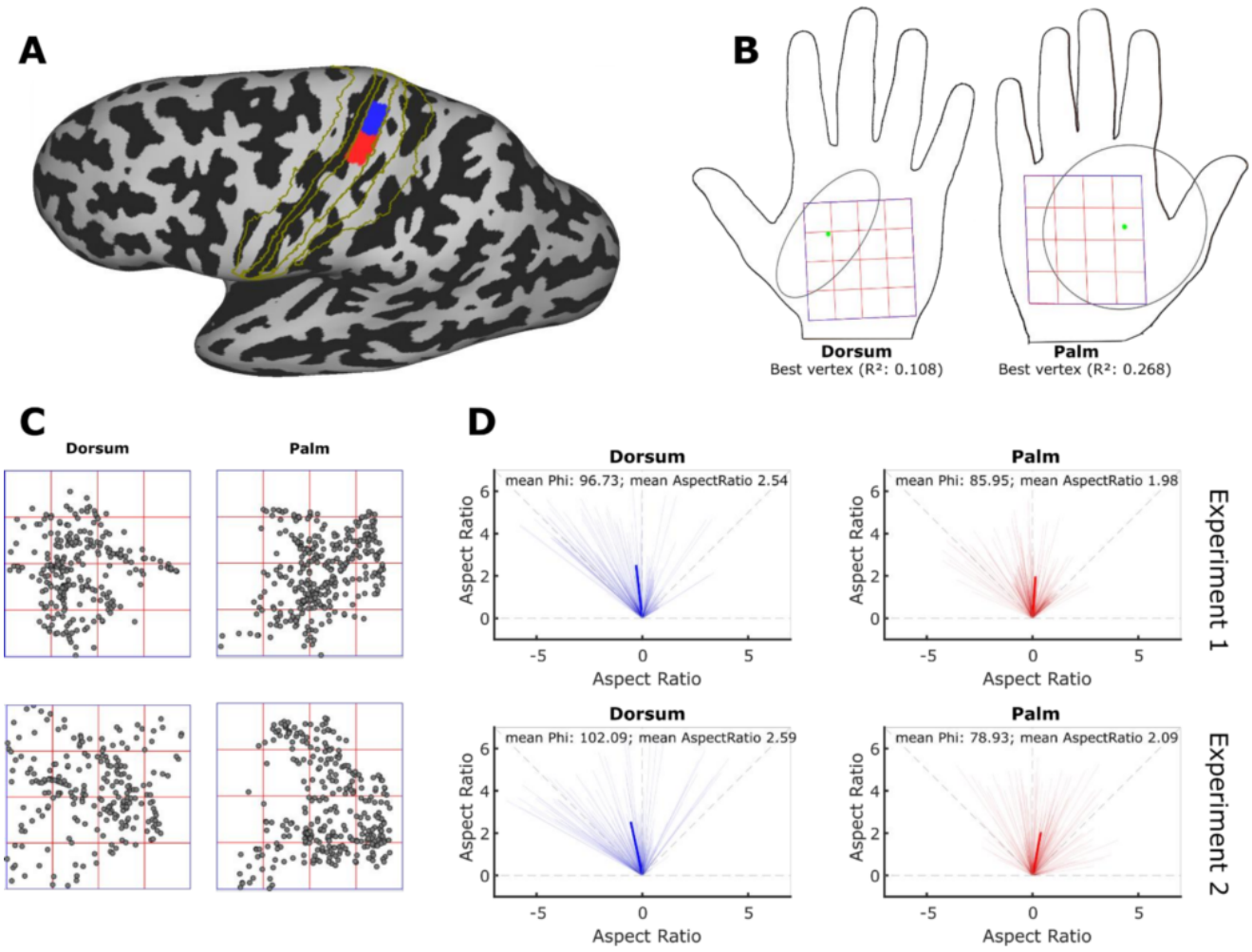

Figure 2. A) Selected ROIs for the dorsum (red) and palm (blue). Green lines indicate the borders of (from left to right) area 4, 3a, 3b, 1, 2 as defined in the Glasser's atlas (Glasser et al., 2016). **B)** The pRF with the best GoF for the two skin surfaces; **C)** Estimated pRF locations; **D)** Orientations of the long pRF axis. The length of each line indicates the anisotropy level. The thick line is the resultant vector.

Conclusions:

In this study, we were able to estimate the pRF locations and shapes of the hand dorsum and palm. Our results suggest that many pRFs of the dorsum are oval-shaped and oriented along the proximodistal axis of the hand; the pRFs on the palm also show a similar characteristic, but less than dorsum. This provides some support for the pixel model (Longo & Haggard, 2011).

Imaging Methods:

BOLD fMRI [2]

Modeling and Analysis Methods:

Univariate Modeling

Perception and Attention:

Perception: Tactile/Somatosensory [1]

Keywords:

FUNCTIONAL MRI
Touch

[1|2]Indicates the priority used for review

My abstract is being submitted as a Software Demonstration.

No

Please indicate below if your study was a "resting state" or "task-activation" study.

Task-activation

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Healthy subjects

Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Yes

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

Not applicable

Please indicate which methods were used in your research:

Functional MRI

For human MRI, what field strength scanner do you use?

1.5T

Which processing packages did you use for your study?

SPM
Free Surfer

Provide references using author date format

Alloway, K. D. (1989). 'Quantitative measurements of receptive field changes during antagonism of GABAergic transmission in primary somatosensory cortex of cats', Experimental Brain Research, 78(3), 514–32.
Brooks, V. B. (1961). 'Peripheral receptive fields of neurons in the cat's cerebral cortex'. Journal of Neurophysiology, 24(3), 302–325.
Brown, P. B. (1975). 'Parametric studies of dorsal horn neurons responding to tactile stimulation'. Journal of Neurophysiology, 38(1), 19–25.
Dumoulin, S. O. (2008). 'Population receptive field estimates in human visual cortex', NeuroImage, 39(2), 647–660.
Glasser, M. F. (2016). 'A multi-modal parcellation of human cerebral cortex'. Nature, 536(7615), 171–178.
Longo, M. R. (2011). 'Weber's illusion and body shape: anisotropy of tactile size perception on the hand'. Journal of Experimental Psychology. Human Perception and Performance, 37(3), 720–726.