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Independent Small Group Discussion Write-up

1. **What was the motivation for this study? (e.g. big picture questions motivating experiments, prior work motivating experiments, etc**

ON and OFF inputs have consistent mapping from orientation and spacial to the columnar map (absolute space). Visual cortex circuits use ON and OFF pathways for columnar representations of stimulus orientation - topographic constraints are not obvious for these accounts. ON–OFF convergence is shown within the receptive fields (layer 2/3 neurons). Two-photon imaging of GCaMP6 calcium signals allow them to discern ON and OFF fields in simple cells- showing very different mappings to spatial and orientation preference. OFF centers are found only in a certain part of visual space and have a smooth visuotopic progression. However ON centers cover more of visual space and are orientation-specific- which is consistent with orientation preference map structure. As a result, cortical columns have aggregate receptive field structure. OFF subfields are delimited through ON subfields. List the key methodological details (species, preparation, recording/anatomical techniques, data analysis methods)

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A tree shrew was used to provide an accurate model for what a human hyper column might be like. The tree shrew was chosen since the ON and OFF inputs from the lateral geniculate nucleus separate populations and layer 2/3 bring about the convergence of ON and OFF. The f GCaMP6 calcium signals were measuredly observing epi-fluorescence and through two-photon imaging. The precision of visuotopic mapping was measured- receptive fields of the neurons in a 1-mm2 field of view always exhibited clear progressions in both azimuth and elevation.

3. For each figure, describe the important points including how the authors interpret the findings and what the findings may actually show.

Figure 1)

Simple cell ON and OFF subfields are shown in visual space.

a) Spatiotemporal receptive fields and ON or OFF subfields of cortical neurons (shown with the help of calcium imaging and reverse correlation). A sparse noise stimulus was used to stimulate these cells. Small circles show the center of the ON and OFF subfields.

b) Two-photon field and receptive fields for layer 2/3 neural population.

c) Receptive fields distributions of OFF and ON subfields centers are shown for visual space. These have a clustered distribution pattern relative to random shuffles.

d) The pairwise distance between center of mass for is shown for RF, OFF, ON cells , and for shuffled data is shown in the white bars. RF, OFF subfields, and subfields sharing the same signs are more clustered. Real and shuffled data in the bottom figure, positive values mean it's scattered and negative values show there is a pattern relative to random shuffles.

Figure 2)

Visuotopic measurement is different for simple cell ON and OFF subfields.. a) Location for simple cells at different cortical depths superimposes orientation mappings.

b) ON and OFF subfields for neurons in Figure A are color coded using angle and elevation values for their center of mass.

c) Visual field locations from neurons in Figure A are shown with different elevations and azimuth.

d) Cortical distance and elevation axis for the RF and ON and OFF subfields with covariance shown in the second figure.

e) Summary of the deviations of the experimental data from smooth visuotopy and the other chart shows the smooth visuotopy explained variance

Figure 3)

Orientation columns have invariant aggregate receptive fields

a) Displacement of ON and OFF subfields in visual space, like in other mammals, predicts the preferred orientation in individual cells.

b) RFs in simple cells in a single orientation column. Lines connect the ON subfield (red) and the OFF subfield (blue) centres of individual simple cell receptive fields. The ON centres form two clusters that define the aggregate ON-dipole of the column.

c) The aggregate ON-dipoles from all the simple cells within individual orientation columns predict the orientation.

d) The normalized simple cell receptive fields from a single column in b were averaged for the aggregate receptive field then fit with a Gabor function.

e) Cortical columns have invariant ARF structure and OFF simple cell receptive field are shown in the charts relating it to the specific relative phase, number of half-cycles, and aspect ratio.

f) ARF Gabor fit involves orientation, visual position, and spatial relate then to frequency column's preferred orientation and visuotopic location.

Figure 4)

Smooth progression over absolute spatial phase for different orientations

a) Eight static grating stimuli produce a tuning curve with Gaussian fit

b) Phase preference for vertical and horizontal grating stimuli (using two-photon imaging) are displayed wit depth contours. Preferences are different based on the orientation.

c) Imaging creates a phase map with vertical grating, orientation and azimuth. The smooth progression of preferred phase is on visuotopic axis- showing thus the stimulus orientation. The first figure shows a linear fit of the phase signal for the vertical orientation domains to make a phase preference map.

d) The two-photon and epi-fluorescence has smooth phase progression that's linearly fitted. Smooth progression had more variance in the experimental data than in the shuffled data.

4. What is your assessment of the overall findings? Did the experimental data support the authors' interpretation? Why or why not?

Off- center cells are way more clustered than on-center cells. Topologies of ON and OFF inputs to layer 2/3 simple cells is reminiscent of the structural and functional differences that have been described for ON- and OFF retinal ganglion cells. Retinal asymmetries in the ON and OFF pathways are also directly mapped to cortical structure they represent. Convergence of ON and OFF makes orientation-selective simple cells, and cortical organization that is common to a broad range of species with well-developed columnar architecture. Orientation preference and receptive field structure in mouse visual cortex, adjacent neurons exhibit specificity in the overlap of their ON and/or OFF subfields that is predictive of connectivity. ON and OFF inputs directly map to cortex regardless of if there are cortical columns.

5. Describe new insights that you gained from the small group discussion of this paper.

I learned about why the the maps were related to cortical columns. Also we discussed the color mapping and concluded that in figure 1, OFF center cells showed less spread than ON center cells and figured out some asymmetries in the data.

6. List all of your questions and/or points in the paper that you did not understand.

I'm not sure what the orientation map in figure 1A shows the orientation selectivities at roughly the same size. Also I don't understand the explained variance chart in figure 2e.