Orientation-selective random(n)ess in mouse V1

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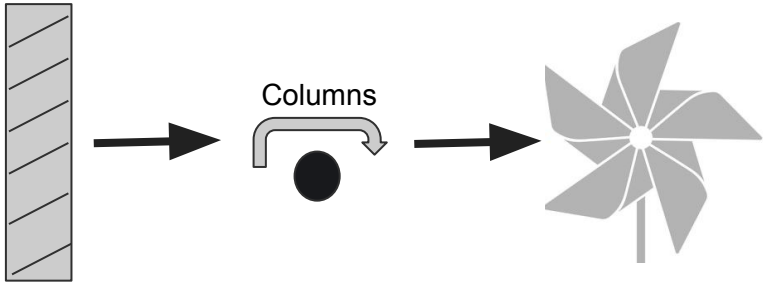
Believe us: pin there, done that.

Background

V1 map:
Coding of stimulus features, e.g. ***orientation of edges***, motion direction, spatial frequency, eye of origin

Organization of orientation selective cells:
structured vs. random



Mouse: cells are intermingled both horizontally across the V1 map and vertically through the cortical layers

→ Is this "random" though?

→ What if the functional organization changes through layers?

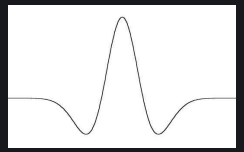
→ Is it possible to define the population-based functional features by only one type of distribution?

Hypotheses

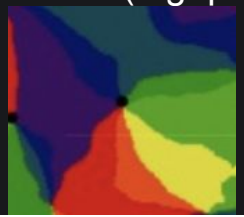
3 Shades of Clustering:

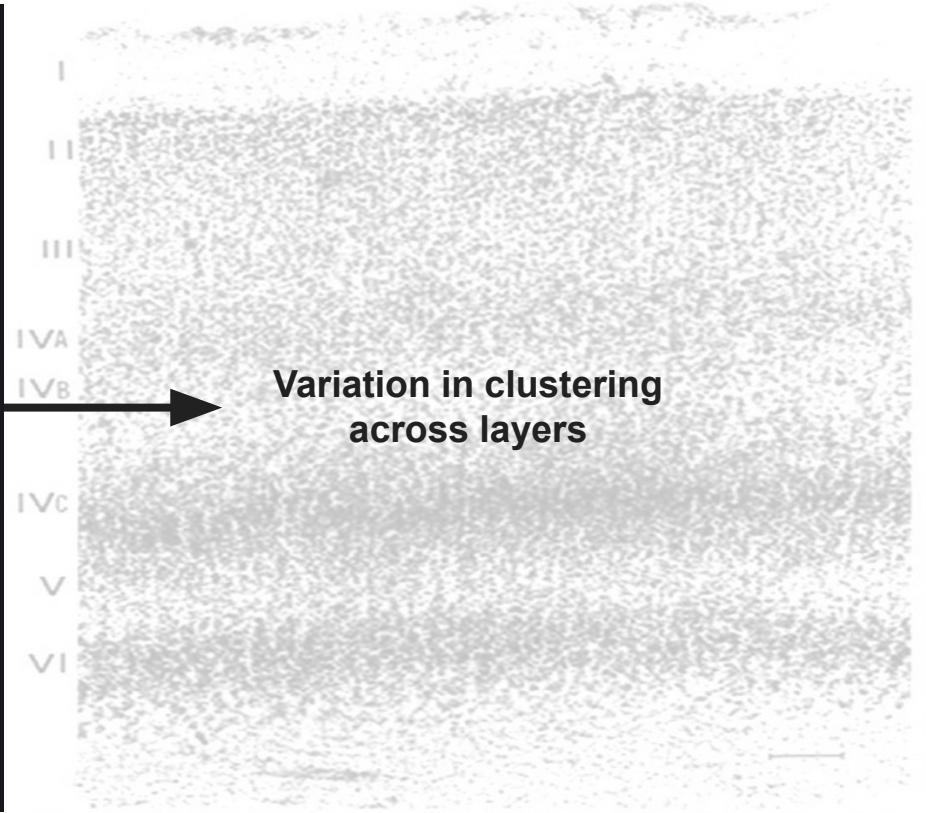
1) No clustering

2) Local clustering (e.g. Mexican-hat patterns) but global disorder



3) Global organisation (e.g. pinwheels)

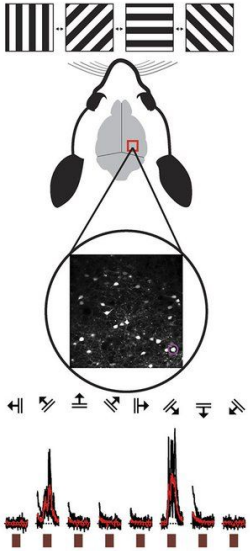




Data and Methods

Stringer Dataset:

- Calcium imaging
- Presentation of visual stimuli (gratings)
- Neural response data and xyz-positions of 23589 mouse V1 neurons



Analyses:

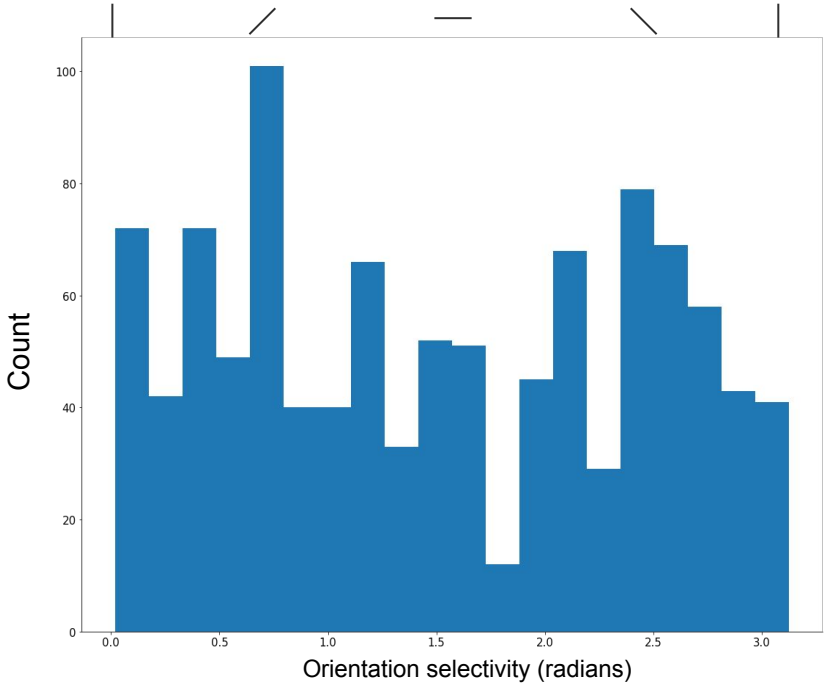
- Calculate orientation selectivity (OS) for all selective neurons
- Comparison distributions and functional organisation of OS
- Quantify how OS changes as a function of position in each layer

Stringer, C., Michaelos, M., Tsyboulski, D., Lindo, S. E., & Pachitariu, M. (2021). High-precision coding in visual cortex. *Cell*. https://doi.org/10.1016/j.cell.2021.03.042

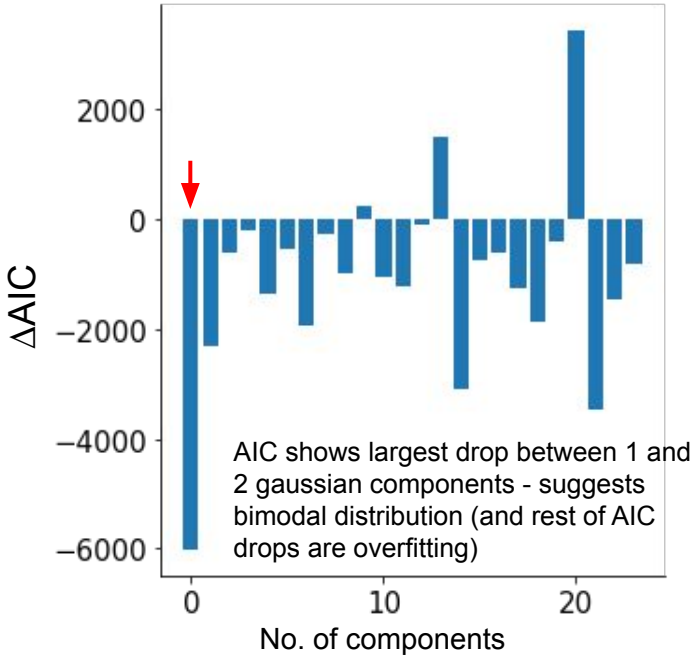
Results

~50% of neurons show orientation selectivity

Distribution of preferred orientation for layer at depth 450um in V1

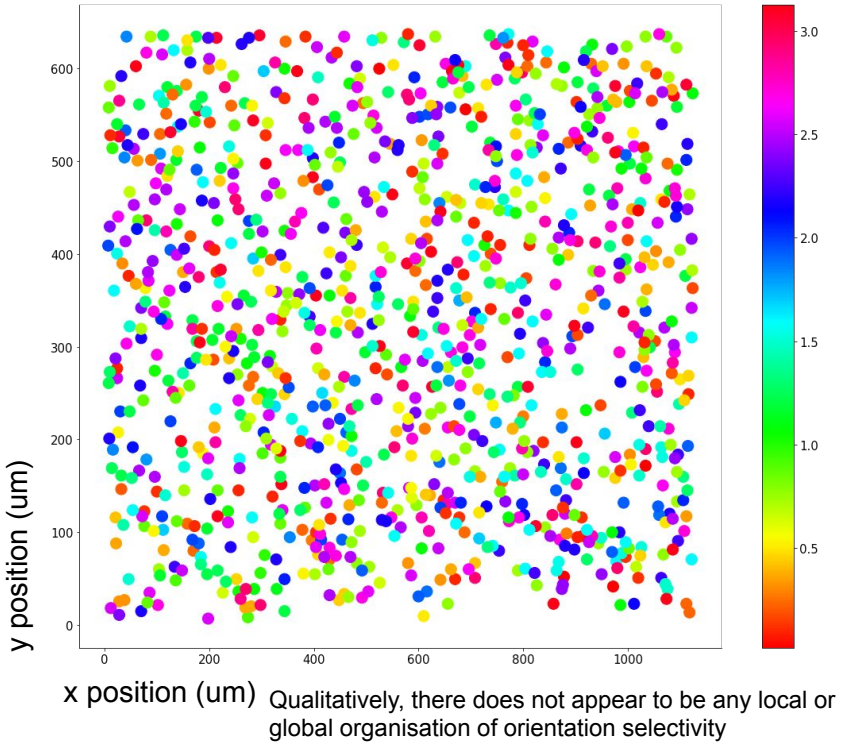


Change in AIC for Gaussian mixture modelling with an increasing number of components.



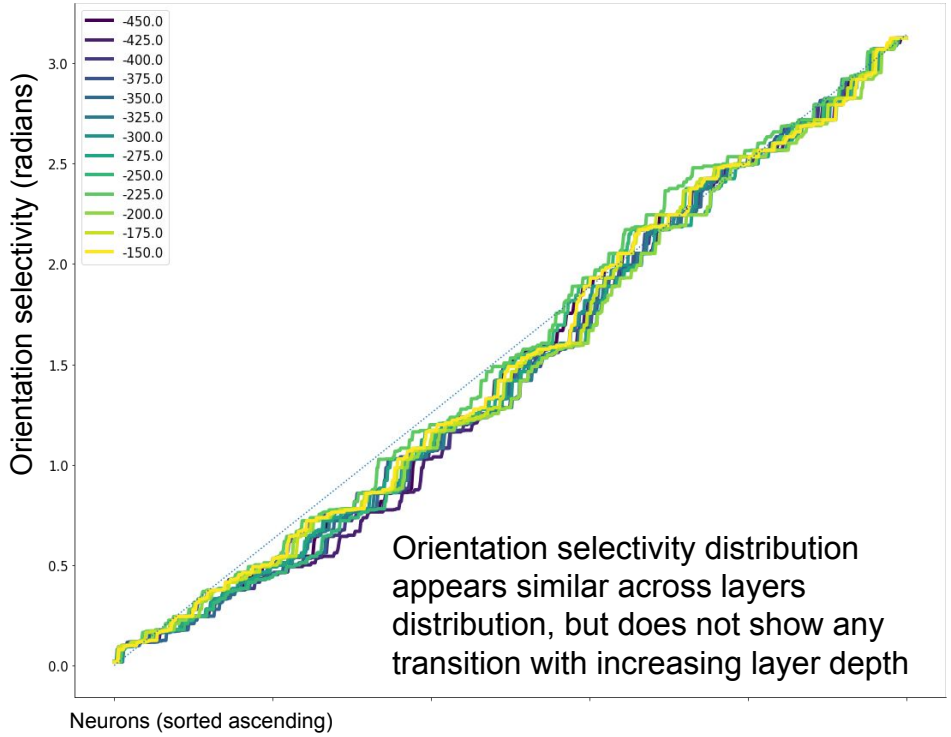
Results

Orientation selectivity maps for layer at depth 450 um in V1



Qualitatively, there does not appear to be any local or global organisation of orientation selectivity

Cumulative distribution of orientation selectivity across layers in V1



Conclusion

- We find evidence for orientation selectivity in ~50% of V1 neurons
- This orientation selectivity follows a bimodal distribution that is consistent across all layers, with a preference for vertical orientations
- We find no evidence for the functional organisation of orientation selectivity in any particular layer - although this needs to be confirmed quantitatively.
- Likewise, while orientation selectivity distributions are similar across layers, there is no clear structure with respect to layer separation.

Single neuron tuning

Within layer organisation

Across layer organisation

Thank you for your attention!

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Special thanks…
… to our mentor Julien Grimaud
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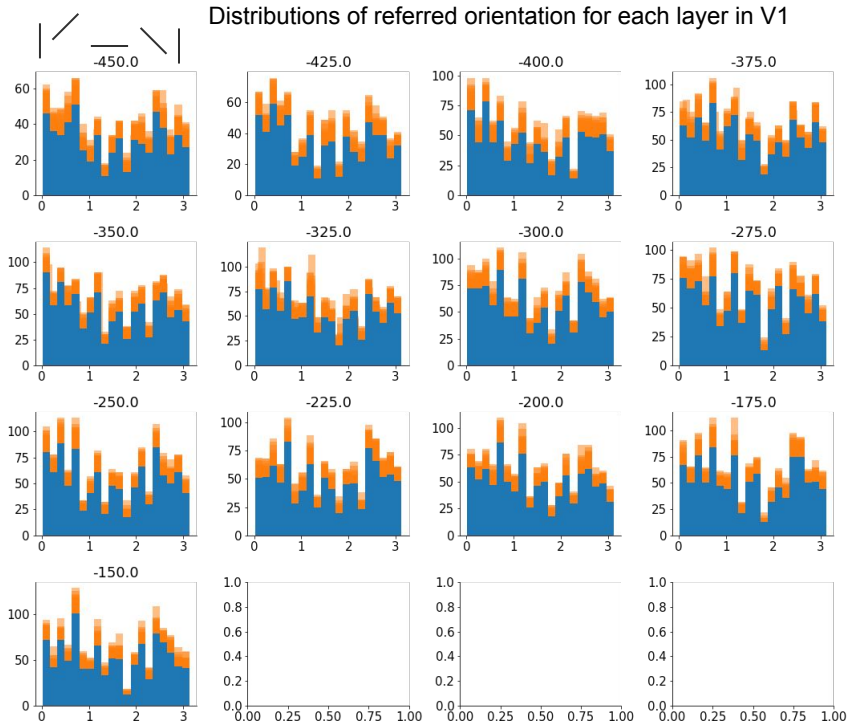
… to our TA Zahra Azizi
… and to the neuromatch organisers!

Supplemental



Bootstrapping (100x) shows reasonably certain distribution with dips around the centre. Possible bias in orientation selectivity?

Supplemental