Comparing curvature and pixel models of shape selectivity across the macaque ventral visual pathway

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Introduction

V4, a visual area important for object recognition, is selective for boundary curvature and orientation (Roitman et al. 2012; Pasupathy & Connor 1999). Previous work has shown that the curvature and orientation tuning of V4 neurons can be captured using a model consisting of a product of two Gaussians (curvature model), when using a diverse stimuli set (Pasupathy & Connor 2001). We examine an alternative model (pixel model) that is able to capture the tuning of curvature and orientation within V4 populations with a limited stimuli set (Eshkol-Amichai et al. 2016). We explore the models’ ability to capture shape selectivity across the ventral visual pathway and propose a new model for V4 receptive fields.

Methods

Neurophysiology

- Two 96 channel Utah Arrays in 4 macaques
- Fixation task with shapes presented 100 ms on 100 ms off
- Shapes at either 4 orientations or 3 positions or 8 orientations/1 position

Curvature calculation

- Convex: 0.96, 0.98, 0.64, 0.48, 0.28, 0.14, -0.34, -0.40, -0.69, -0.96, -0.99
- Concave: 0.99, 0.95, 0.84, 0.56, 0.38, 0.20

Logistic Squashing Function

- Nonlinear transformation of turning angle into curvature between -1 and 1

Model performance

- Models generalize to unseen data similarly in V4
  - Models perform best in V4
  - Pixel model achieves higher average variance explained (VE) across visual areas

Conclusions

- Pixel model explains more variance on average than the curvature model
- Models predict other positions well when assuming object-centered stimulus code
- V4 receptive fields may produce shape selectivity with image computable pixel model suamnt (right)
- Future analysis will aim to determine the differences in the models

References

References to be added

Acknowledgements

Funding to be added

Figure captions

- Single unit responses to shape and orientation (Oleskiw et al. 2014)
- Different methods yield similar results in capturing shape selectivity in V4
- Models capture object-centered shape selectivity
- Shuffled data displays no correlation across position
- Models achieve similar performance across majority of sites

Data shows position invariance for shape selectivity

- Shape selective sites are highly correlated for stimuli presented at different spatial positions. This is consistent with known V4 position invariance (Pasupathy & Connor 1999)

Models capture object-centered shape selectivity

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