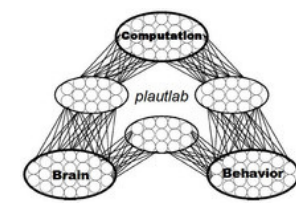




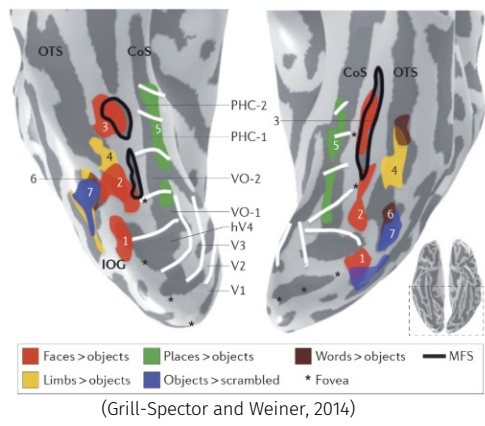
A connectivity-constrained computational model of the topography of human ventral temporal cortex



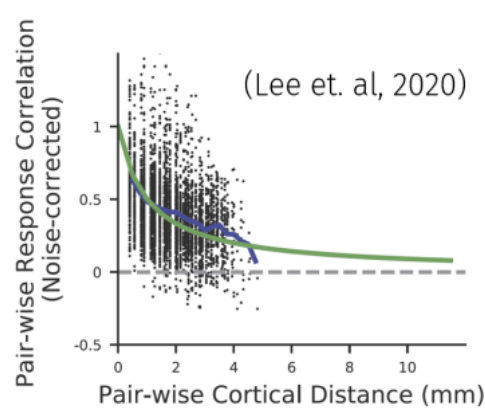
Nicholas M. Blauch^{1,2}, Marlene Behrmann^{2,3}, David C. Plaut^{2,3}

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*correspondence: blauch@cmu.edu

Domain-level and generic organization in high-level visual cortex



Posterior-to-anterior stream of selective areas for a given domain (e.g. faces), arranged consistently across domains



Neuron response correlation decays smoothly with distance

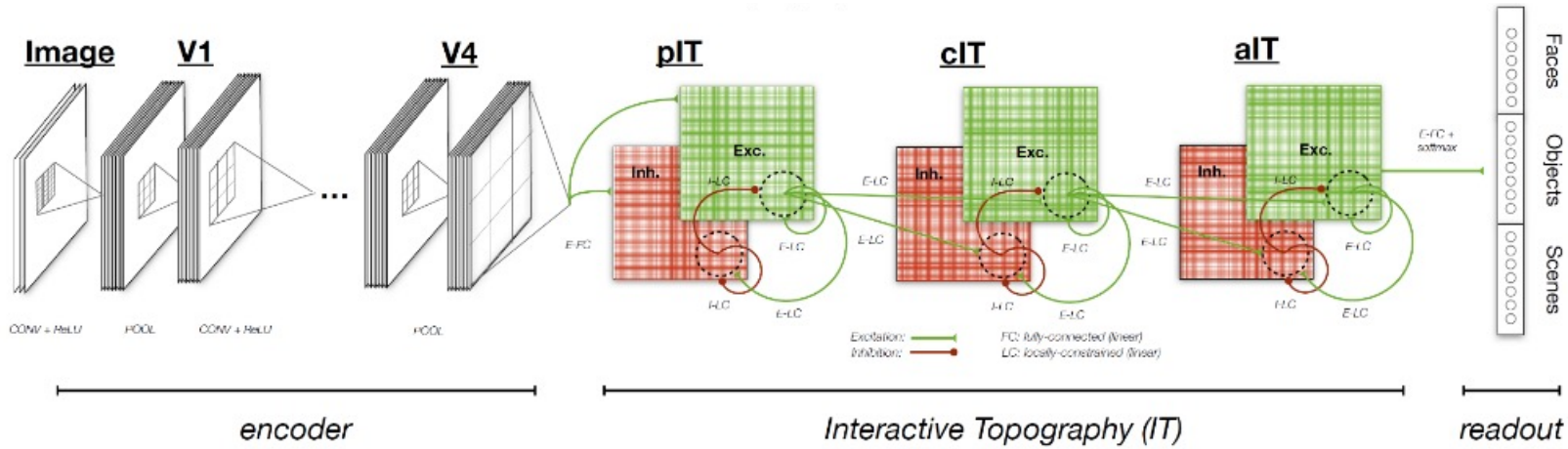
What factors might underly the organization of VTC?

- Visual recognition requires a hierarchy of representations
- Visual tasks may cluster representationally and have different input and output demands
- Connectivity in the brain is constrained
 - myelinated axons take space
 - excitation and inhibition are mediated by separate neurons
 - between-area connections are mediated primarily by excitatory neurons

Can **learning to perform tasks** under **biological connectivity constraints** account for the development of within- and between-area topographic organization?

Emergent visual cortical organization in Interactive Topographic Networks (ITNs)

Blauch, Behrmann, Plaut (2022). *Proceedings of the National Academy of Sciences*



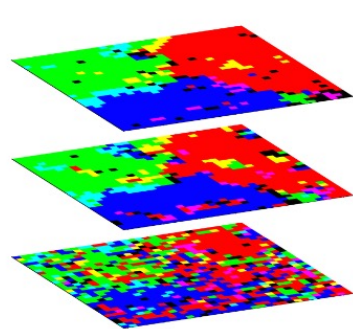
$$\mathcal{L}_w^{(a,b)} = \sum_{i,j} \frac{(\mathcal{D}_{ij}^{(a,b)})^2 (W_{ij}^{(a,b)})^2}{1 + (W_{ij}^{(a,b)})^2} \quad \mathcal{L}_w = \sum_{a,b} \mathcal{L}_w^{(a,b)}$$

$$\mathcal{L} = \mathcal{L}_t + \lambda_w \mathcal{L}_w$$

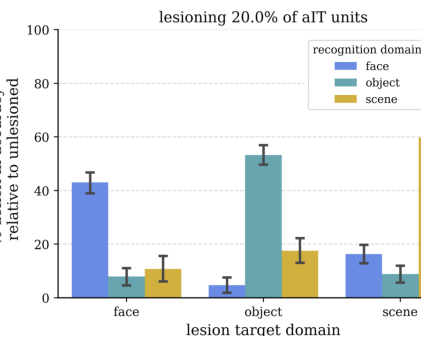
Sign-based constraints

- Parallel sheets of excitatory and inhibitory units
- Excitatory units send feedforward connections

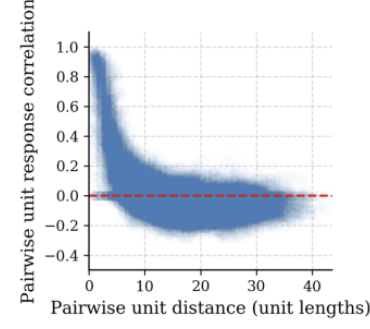
Hierarchical domain-level topography



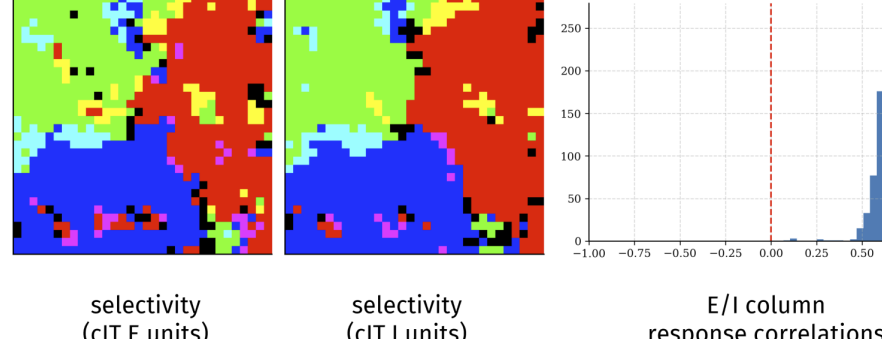
Selective lesion deficits



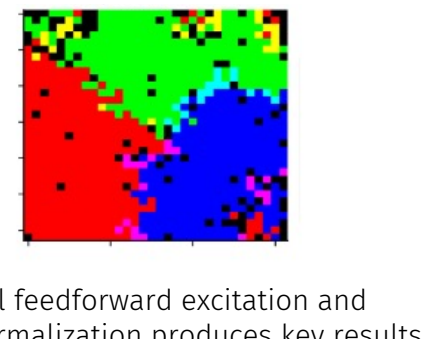
Generic organization



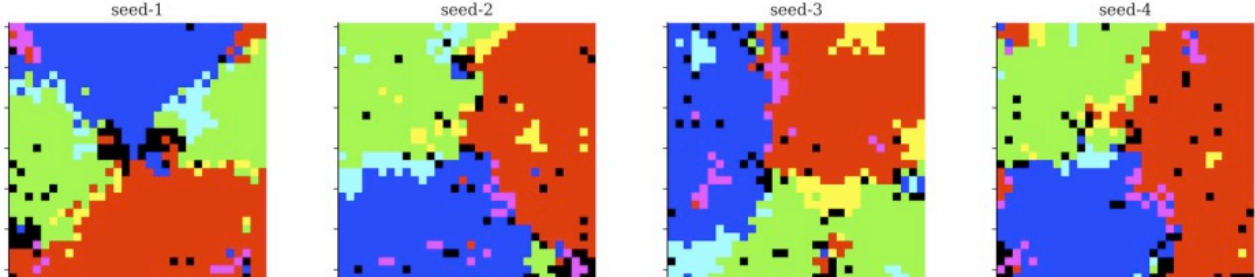
Cortical columns



A simplified model



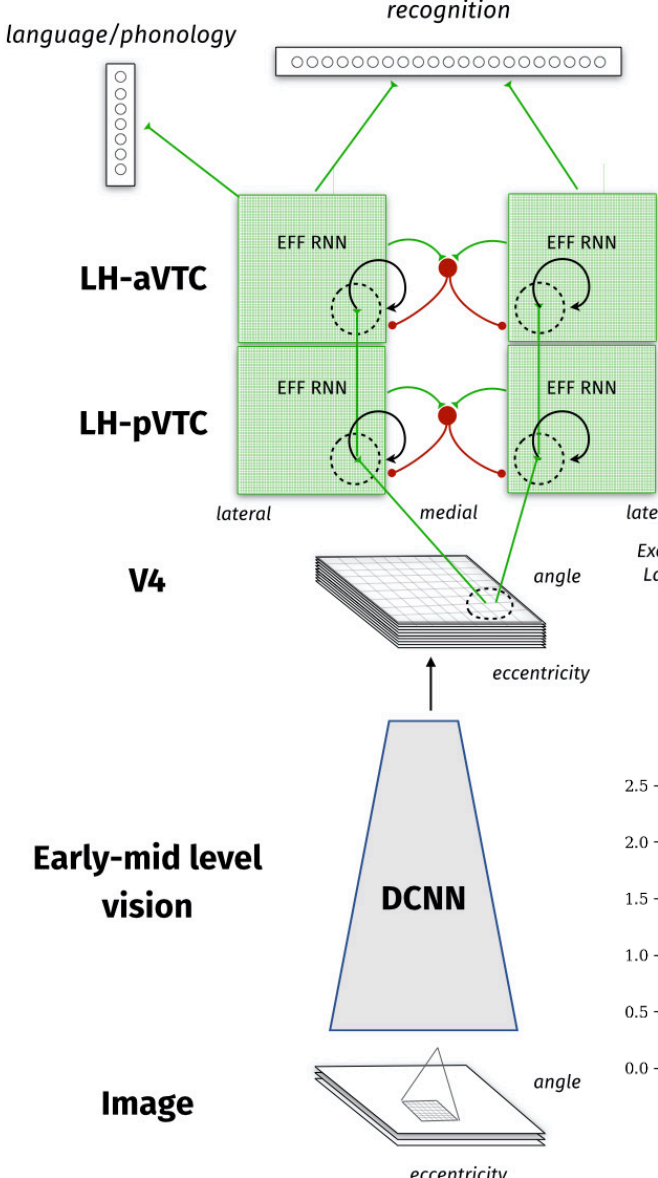
But no consistent global layout...



Summary of prior results:

- Connectivity constraints within high-level vision
- Optimization for task performance and minimal wiring cost
- Domain-level selectivity with functional significance
- Generic organization
- Simple cortical columns of E/I units with similar selectivity
- Sufficiently simplified model variants: separation of E/I can be removed for simplicity or to reduce computational demands
- Problem: Inconsistent global layout of domain selectivity

Modeling the global layout of human VTC through input and output constraints

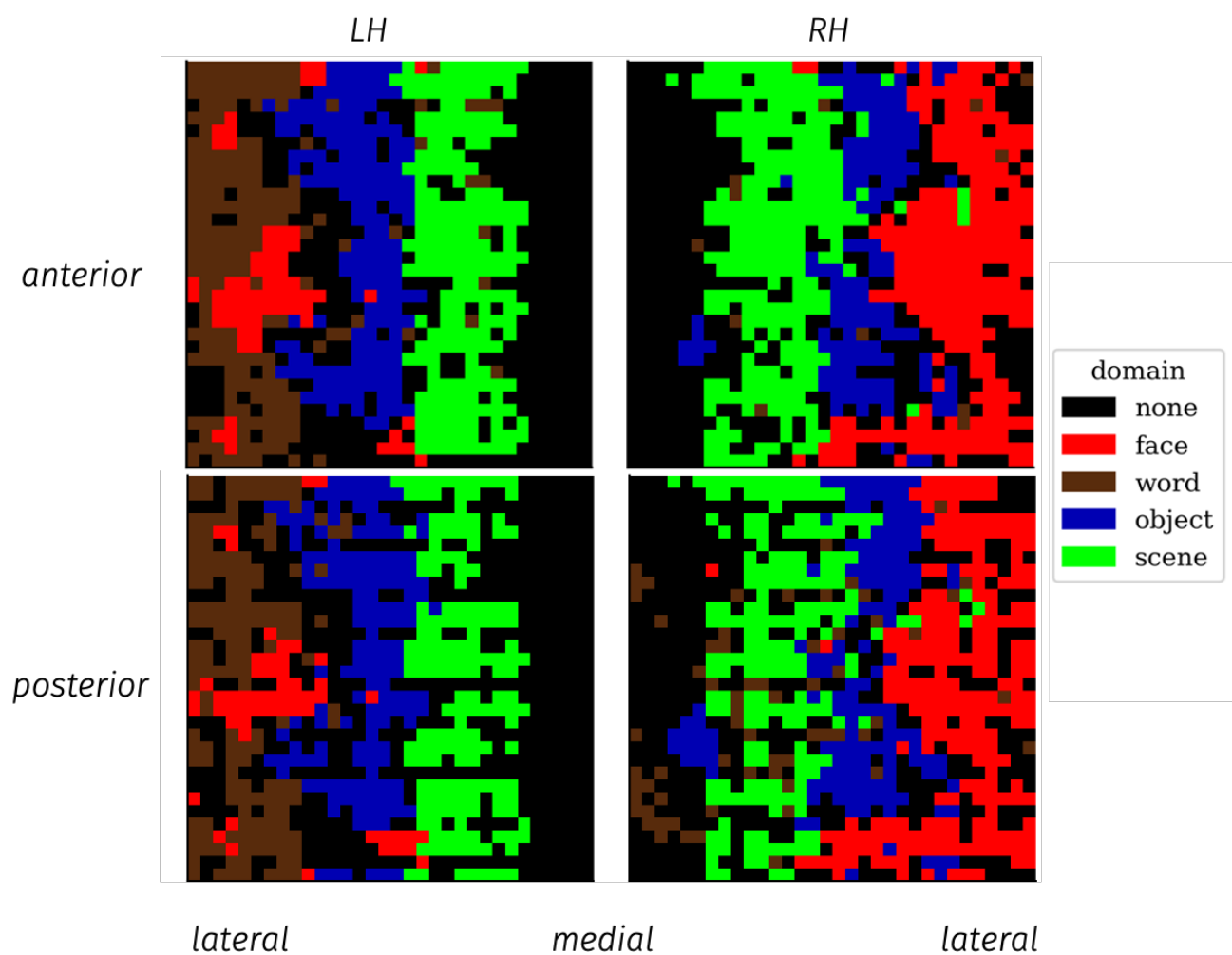


Input constraints:

- Scenes viewed at larger sizes than objects, faces, words
- Early visual cortex is organized in polar retinotopic coordinates

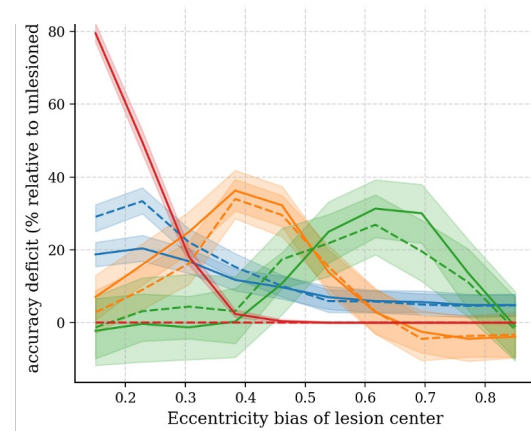
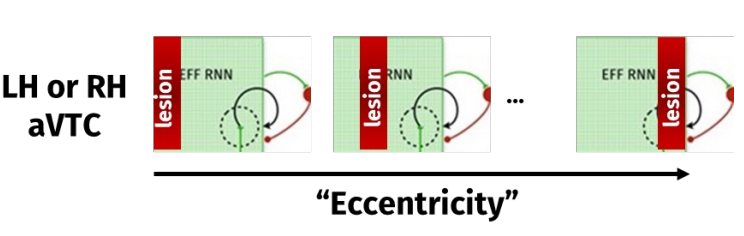
Output constraints:

- All categories interact with bilateral semantic representations
- Visual word representations need to interact with left-hemisphere dominant "phonological" representations

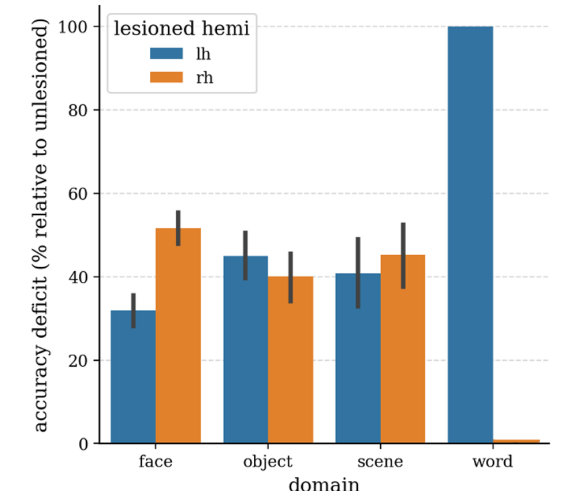
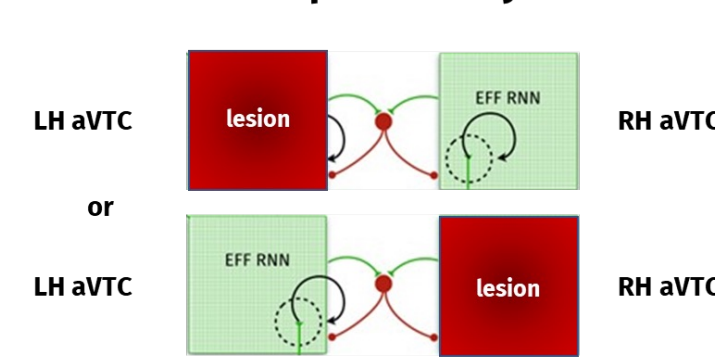


Is the layout significant?

Medio-lateral lesion

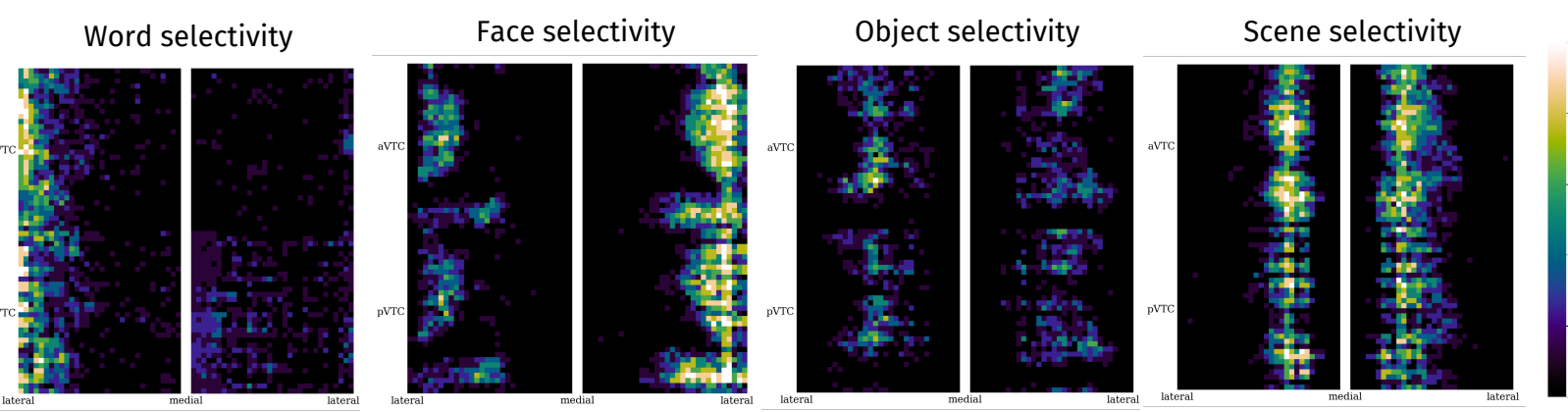


Hemispherectomy

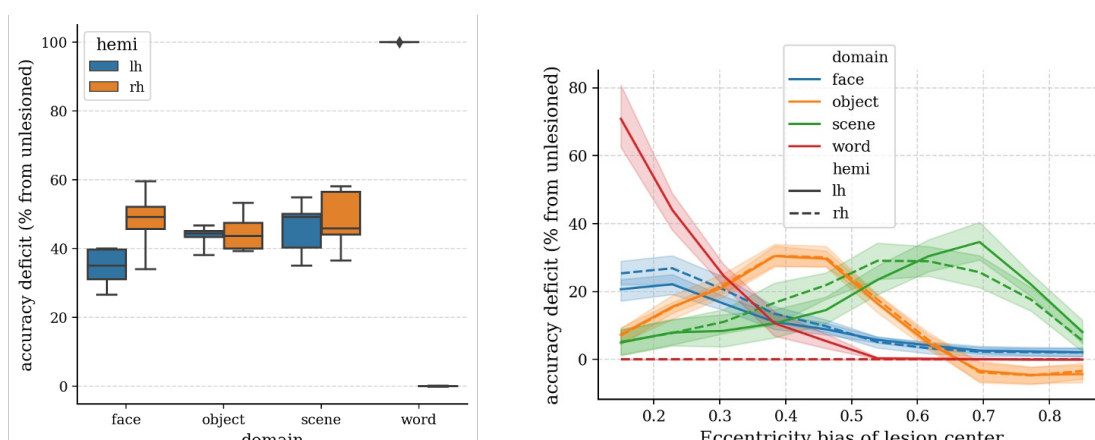


Is the layout consistent?

Group probability maps (n=8)



Group lesion results



Discussion

Summary of results:

- Medial-to-lateral layout corresponding to peripheral-foveal biases (independent of testing size)
- Left lateralization of words, relative right lateralization of faces due to competition
- Consistent layout

Future work:

- More realistic downstream task demands (e.g. sentence reading, action) and connectivity (e.g. interhemispheric connectivity, white matter fiber bundles)
- Modeling interindividual variability

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