Poster 291.06

Stimuli for Fast Mapping of Feature Tuning in Mouse Visual Cortex

D. YATSENKO[1,2], P. G. FAHEY[1,2], E. FROUDARAKIS[1,2], J. REIMER[1,2], E. Y. WALKER[1,2], F.H. SINZ[1,2], E. COBOS[1,2], A. S. TOLIAS[1,2]

[1] *Department of Neuroscience, Baylor College of Medicine, Houston, TX, USA*

[2] *Center for Neuroscience and Artificial Intelligence, Baylor College of Medicine, Houston, TX, USA*

Baylor College of Medicine

INTRODUCTION

Parametric stimuli quickly characterize the basic visual response properties of sensory neurons. An effective stimulus evokes strong, reliable responses and thoroughly samples a rich parametric space.

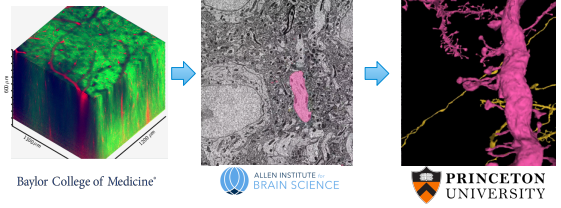
We present two new parametric visual stimuli, ***Monet*** and ***Trippy***, designed to simultaneously and rapidly characterize linear receptive fields, motion tuning, and, for Trippy, the spatial and temporal frequency tunings. These stimuli are used in the MICrONS project for high-throughput functional circuit description.

MICrONS Study

Functional Description of All Neurons in 1 mm^3
- 2-photon Ca^{2+} Imaging
- 3-photon Ca^{2+} Imaging
- Visual Stimulation: natural and synthetic

Electron Microscopy

Structure and Connectivity



Visual Stimuli

"Monet"

Smoothened Gaussian noise with with coherent orientation motion of varying directions.

"Trippy"

Irregular and fluid ripples wriggling randomly across the visual field — synthesized as the cosine of a smooth Gaussian noise movie.

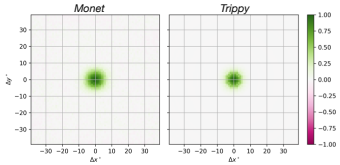
"Natural"

movies of natural scenes synthetic movies of simulated scenes

Linear Receptive Fields
Direction of Motion Tuning
Frequency tuning: spatial + temporal
Localization of directional response

Modeling
Validation
Ethological relevance

Spatial Autocorrelation (at any location)



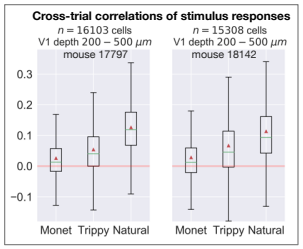
Despite the prominent global visual features present at any moment, the spatial and temporal autocorrelations of both Monet and Trippy are, by design, similar and are space-invariant, circularly symmetric (in visuotopic space), unbiased, and compact.

These properties enable computation of linear receptive fields by simple **spike-triggered averaging**.

RESULTS

Stimulus Drive

Visual stimuli with similar contrast and energy may vary greatly in their ability to elicit strong reliable responses from neurons. We measure the *stimulus drive* as the correlations between the responses to two presentations of identical 15-s movie snippets shuffled across the experiment session.

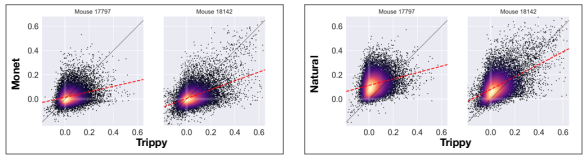


Natural movies produced strongest drive with mean cross-trial response correlations of 0.11 — 0.13 in L2–4 of V1 when computed at 4 Hz.

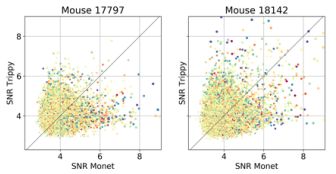
Trippy with mean cross-correlations 0.05 — 0.07 significantly outperformed Monet (~0.03). p=0 in paired tests.

The increase from Monet to Trippy is mostly due to increased responses.

The increase from Trippy to Natural is mostly due to increased breadth of activation.

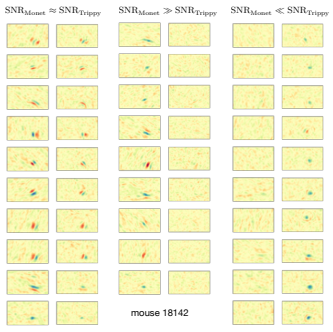


Linear receptive fields



Trippy and Monet have similar autocorrelation functions; therefore, an ideal linear system would produce similar spike-triggered average receptive fields.

However, Trippy and Monet elicited responses from distinct subpopulations of cells that differed in their functional properties.



Cells responsive to both types of stimuli produce similar receptive fields from both stimuli.

Cells responsive to Monet but not to Trippy tend to be oriented and have multiple subfields.

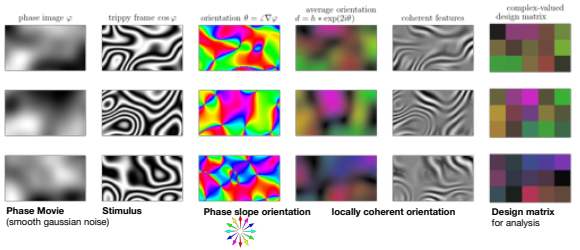
Cells selective to Trippy but not to Monet predominantly comprise a single negative punctate subfield (circular with a weak annular or crescent surround) .

Directional Tuning

The Monet stimulus comprises periods of coherent motion and orientation. Its analysis is not much different from that of conventional drifting grating stimuli.

The Trippy stimulus is derived from an underlying phase movie, which provides a direct representation of local direction of motion and orientation, spatial and temporal frequency. This representation allows direct model fitting to these properties with locality information.

Steps of Analysis of Trippy Stimulus for orientation tuning

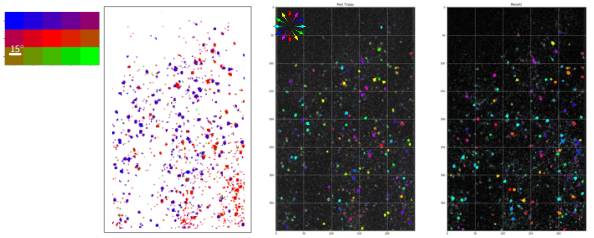


Pixelwise Orientation Map

Visuotopic location of max orientation response

Orientation tuning (Trippy)

Orientation tuning (Monet)



Monet and Trippy elicit responses from an overlapping population of cells. When cells respond to both, they indicate the same orientation preference.

CONCLUSIONS AND FUTURE WORK

Two synthetic stimuli with similar spectral properties but different global structures revealed the robustness of orientation tuning and linear receptive fields of subgroups of cortical neurons. But the comparison also differentiated subpopulations of cells with distinct functional properties in a consistent pattern. In ongoing work, we will relate structural and connectivity information reconstructed from electron microscopy to elucidate the anatomical regularities underlying these functional distinctions.

ACKNOWLEDGMENTS

Supported by the Intelligence Advanced Research Projects Activity (IARPA) via Department of Interior/Interior Business Center (DOI/IBC) contract number D16PC00003. The U.S. Government is authorized to reproduce and distribute reprints for governmental purposes notwithstanding any copyright annotation thereon. Disclaimer: The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of IARPA, DoI/IBC, or the U.S. Government.