Behavioral tools for studying object vision in the Northern Tree Shrew

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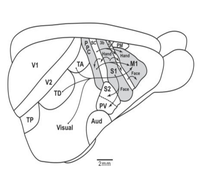
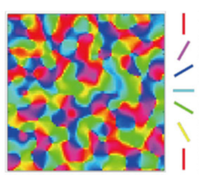
Introduction

- The macaque monkey has classically provided a key model for visual processing, due to its amenability to psychophysical tasks and well-delineated visual hierarchy.
- More recently, the rodent has emerged as a new model for visual processing, due to the availability of molecular and genetic tools.
- An ideal model system would satisfy both needs: amenability to complex psychophysical tasks and tractability for molecularly-based recording and perturbation techniques.
- Towards this goal, we have embarked on an effort to establish the northern tree shrew as a model organism for study of high-level object vision.

The tree shrew

A diurnal animal, the tree shrew has high visual acuity (>10x that of rodents), a cone dominant retina, and a columnarly-organized visual cortex. Moreover, tree shrew cortex is lissencephalic, enabling increased optical access for imaging neural circuit dynamics compared to the macaque. Due to its small size (~150-200 grams) and relatively short reproductive and developmental cycles (6 weeks gestation, 4-6 months from birth to adulthood, 1-6 offspring per litter), the tree shrew offers experimental and genetic accessibility similar to rodents.

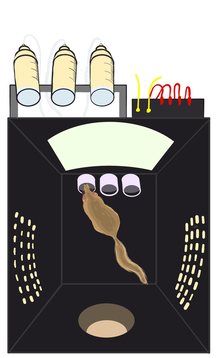




1. Remple MS, Reed JL, Stepniewska I, Lyon DC, Kaas JH. 2007
2. Kaschube M, Schnabel M, Löwel S, Coppola DM, White LE, Wolf F. 2010

Behavior system

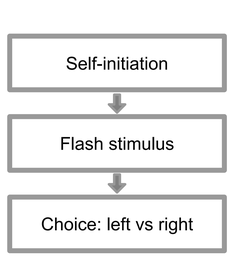
We built on top of the design and the architecture of Bpod[3] and pyBpod[4] a high-throughput, low-cost, automated behavioral apparatus allowing visual behaviors in the tree shrew to be rapidly assayed.

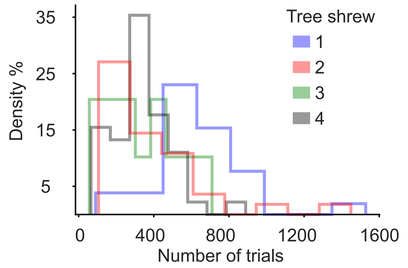


3. Sanworks LLC. www.sanworks.io
4. Scientific Software Platform (Champalimaud Foundation)

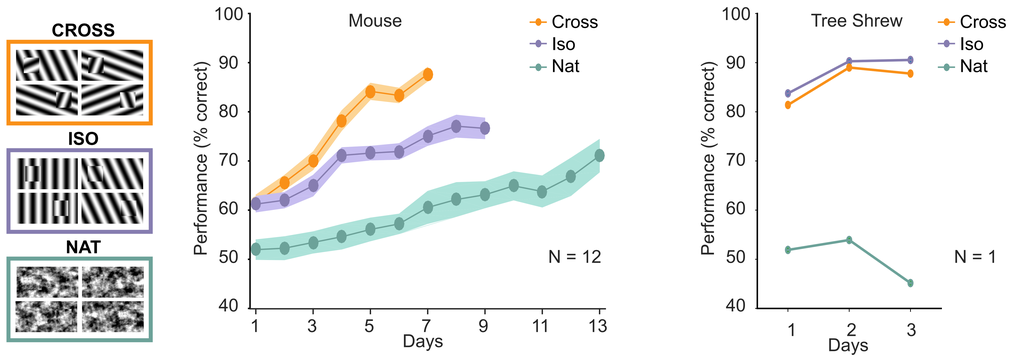
Behavior summary statistics

- 5 sessions per week.
- 1.5 hour ± 10 minutes session length.
- ~ 400 trials ± 100 trials each session.
- Water regulated, juice reward.
- Two alternative forced choice (2AFC).

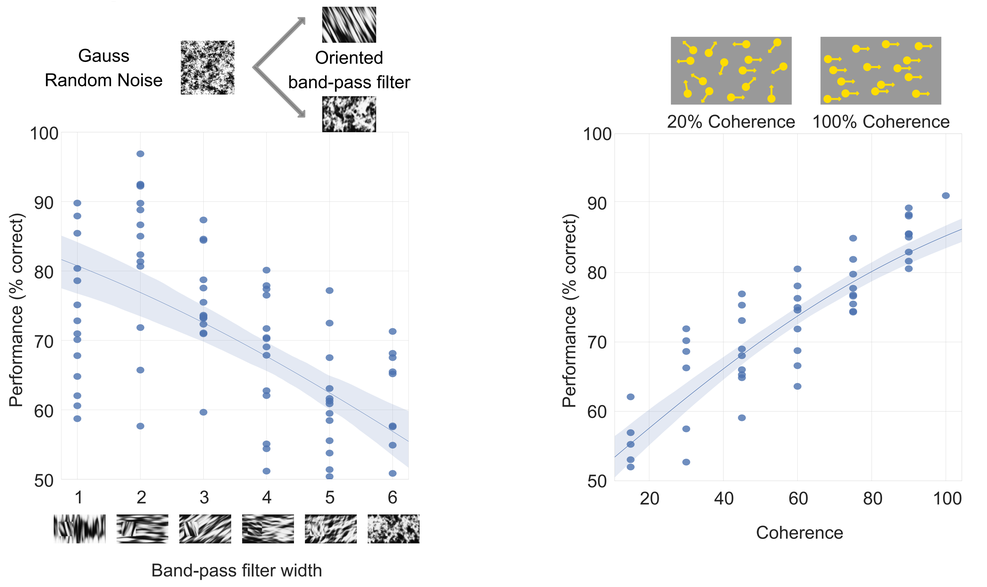




Fast behavior learning rates of tree shrews

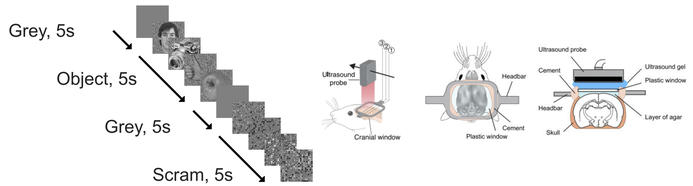


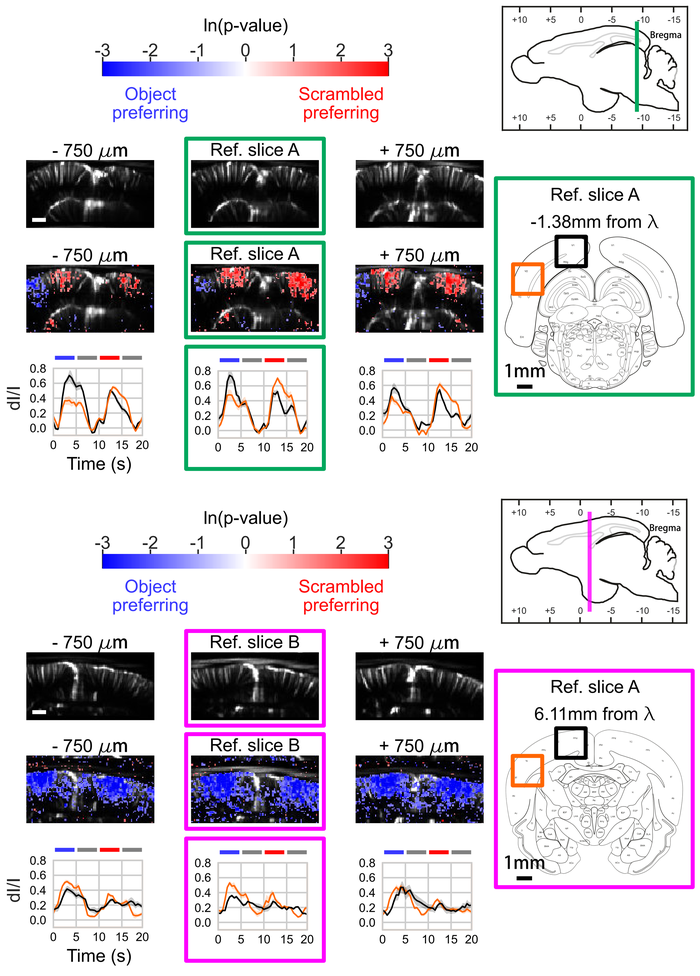
Performance depends on image spatial statistics



Performance for coherence dots stimulus

Functional ultrasound imaging





5. Zhou JN, Ni RJ. 2016
6. Mace´ E, Montaldo G, Trenholm S, Cowan C, Brignall A, Urban A, Roska B. 2018

Conclusions

- We developed a scalable, high-throughput behavior system.
- We successfully trained tree shrews to perform 2AFC tasks with different types of visual stimuli in a high-throughput, freely moving paradigm.
- Behavior comparable to mice with much faster learning rates.
- FUS is a promising technique for assaying cortical functional organization.