Representations of population activity during sensorimotor transformation for visually-guided eye movements

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① Introduction

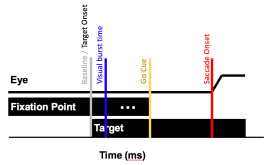
The superior colliculus (SC) is a hub for sensorimotor integration. To better characterize different representations of population activity during this process of converting visual stimulus information into a motor command, we analyzed neural activity patterns across two conditions: the delayed saccade task and gap task. In this project, we focus on **the similarities and differences between visual and saccadic bursts under the two conditions in a low-dimensional state space,** with the goal of determining whether there is a different pattern of population activity relayed to downstream areas.

Experimental Methods

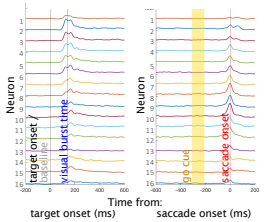
- 16-channel linear microelectrode array (AlphaOmega Inc.) inserted orthogonal to SC surface of a Rhesus monkey
- Delayed saccade and gap task to distinguish population activity patterns at key time points in a trial
- One target in preferred direction (determined by microstimulation)

② Task Design

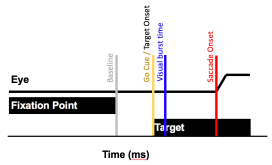
Delayed Saccade Task



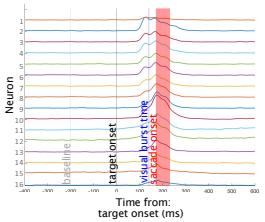
- baseline / target onset
- estimated visual burst time
- go cue / end of delay
- saccade onset



Gap Task

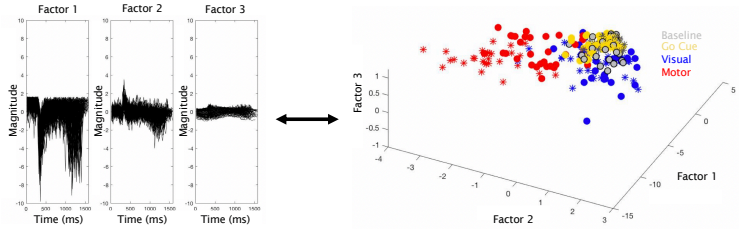


- baseline (beginning of gap)
- go cue / target onset
- estimated visual burst time
- saccade onset



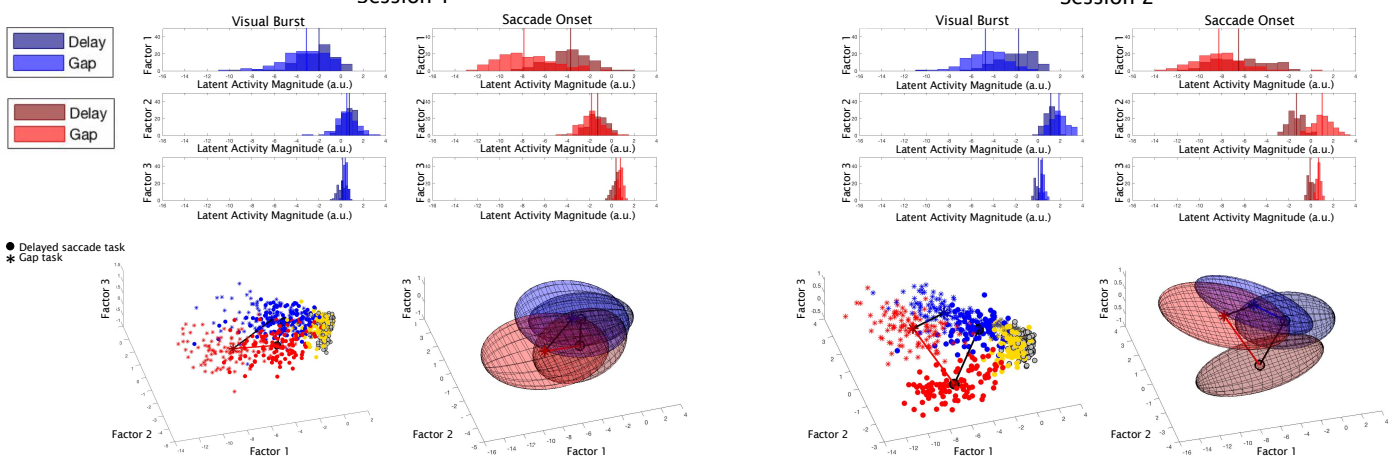
③ Dimensionality Reduction

- Used Gaussian-process factor analysis (GPFA) model on 16-channel spike trains aligned to target onset (20 ms smoothing factor) for delayed saccade task data[1,2]
- Retained the first 3 latent dimensions
- Projected smooth gap task data into the same, previously fit low-dimensional space as the delayed saccade task[1]



ABOVE: Schematic of top 3 latent dimensions (left) found via GPFA[1] and a state space representation (right) of both tasks in the same low-D space.

④ Subspaces Occupied at Key Time Points



TOP PANEL: Spread of latent activity magnitudes in each dimension for delayed saccade (muted) and gap task (brightly-colored) trials; two example sessions (left and right, respectively).

BOTTOM PANEL: 95% confidence ellipsoids (left) and the mean across trials for each condition and visual/motor time points (right)

- Visual subspaces have greater overlap across tasks than motor

⑤ Conclusions

- Sensorimotor transformation is fundamentally similar across both tasks
  - visual and motor activity are separable
- Distributions of population activity differ depending on task conditions
  - visual activity largely overlaps while motor does not
- These differences in neural signals across tasks may be relevant to how downstream structures process visual and motor information

References

1. Yu, B., Cunningham, J., Santhanam, G., Ryu, S., Shenoy, K. and Sahani, M. (2009). Gaussian-Process Factor Analysis for Low-Dimensional Single-Trial Analysis of Neural Population Activity. J Neurophysiol, 102(1), 614-635.

2. Cowley, B., Kaufman, M., Butler, Z., Churchland, M., Ryu, S., Shenoy, K., and Yu, B. (2013). DataHigh: graphical user interface for visualizing and interacting with high-dimensional neural activity. J Neural Eng, 10(6).

Acknowledgements

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