

Background

- The pre-frontal cortex (PFC) is associated with higher cognitive functions such as decision-making and working memory
- The PFC is vital to cognition because it can bridge sensation and action-related signals via persistently elevated neural activity, which is prominent in the dorsolateral regions of PFC (dlPFC)
- How sensory, memory, and motor information are distributed across the various subregions of dlPFC is unclear.

Hypothesis

- Sensory, memory, and action-related signals are spatially segregated in dlPFC, or alternatively, these three types of signals are commingled.

Approach

- Analyze neurophysiological data from the dlPFC of a primate performing a memory task
- Data has been collected from 11 subregions of dlPFC using high-density intracranial electrodes, with recordings from 200-700 neurons in each site.

Glossary:

Receptive Field (RF) - region in visual space where a given neuron responds maximally to stimulus

Non-receptive Field (NRF) - in this experiment, the non-receptive field is the opposite region in space from the receptive field

A Topographic Map of Sensory, Motor, and Memory Neurons in the Dorsolateral Prefrontal Cortex

Procedure

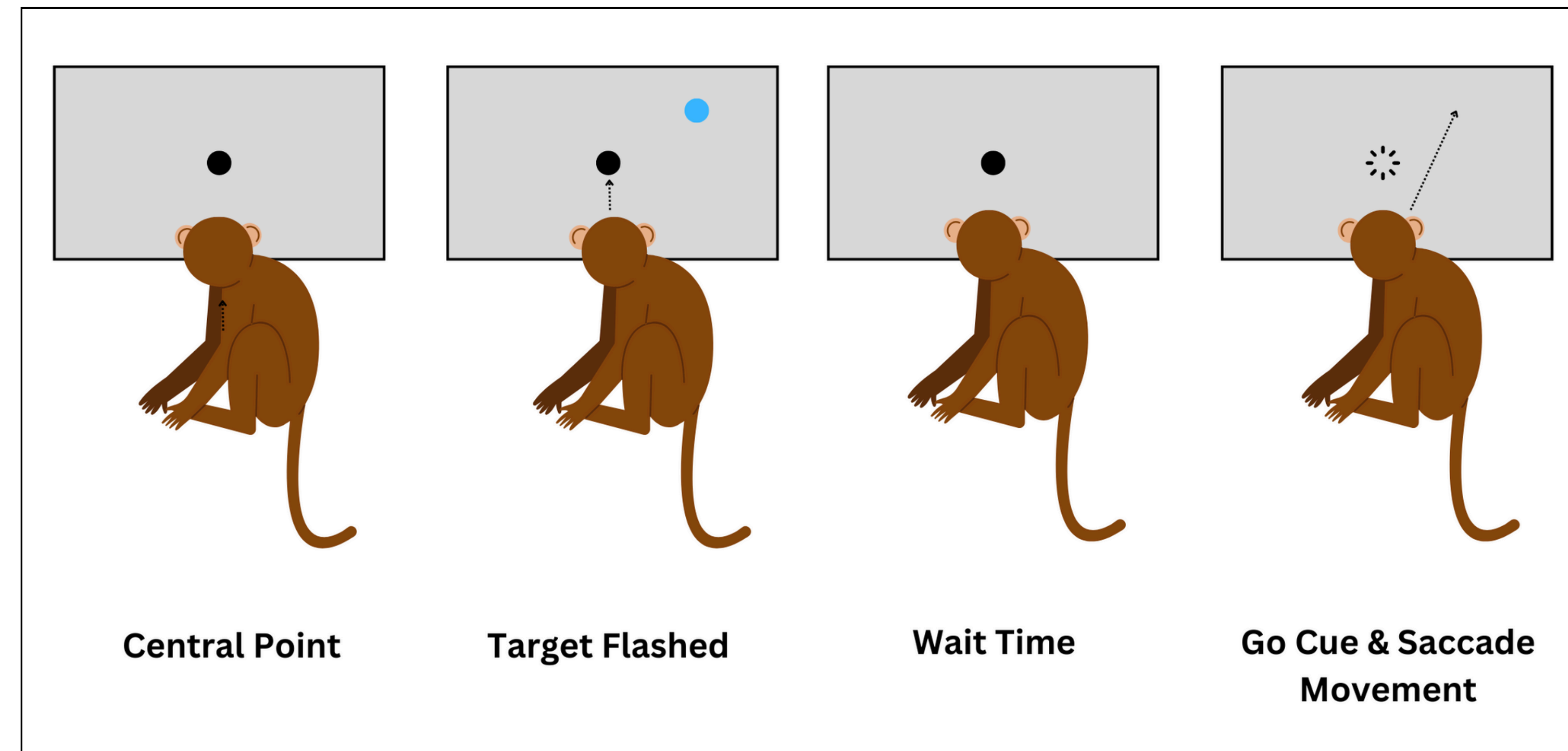


Figure 1.1: The Behavioral Task: The animal first focuses on a central point shown on a monitor. In the periphery of the screen, a target is flashed briefly. The location of the target flash changes from trial to trial. The animal must remember the location while waiting for a cue that takes about a second to appear. When a cue is given, the animal makes an eye movement to the remembered location of the target's flash.

Figure created by O. Odebo in Canva

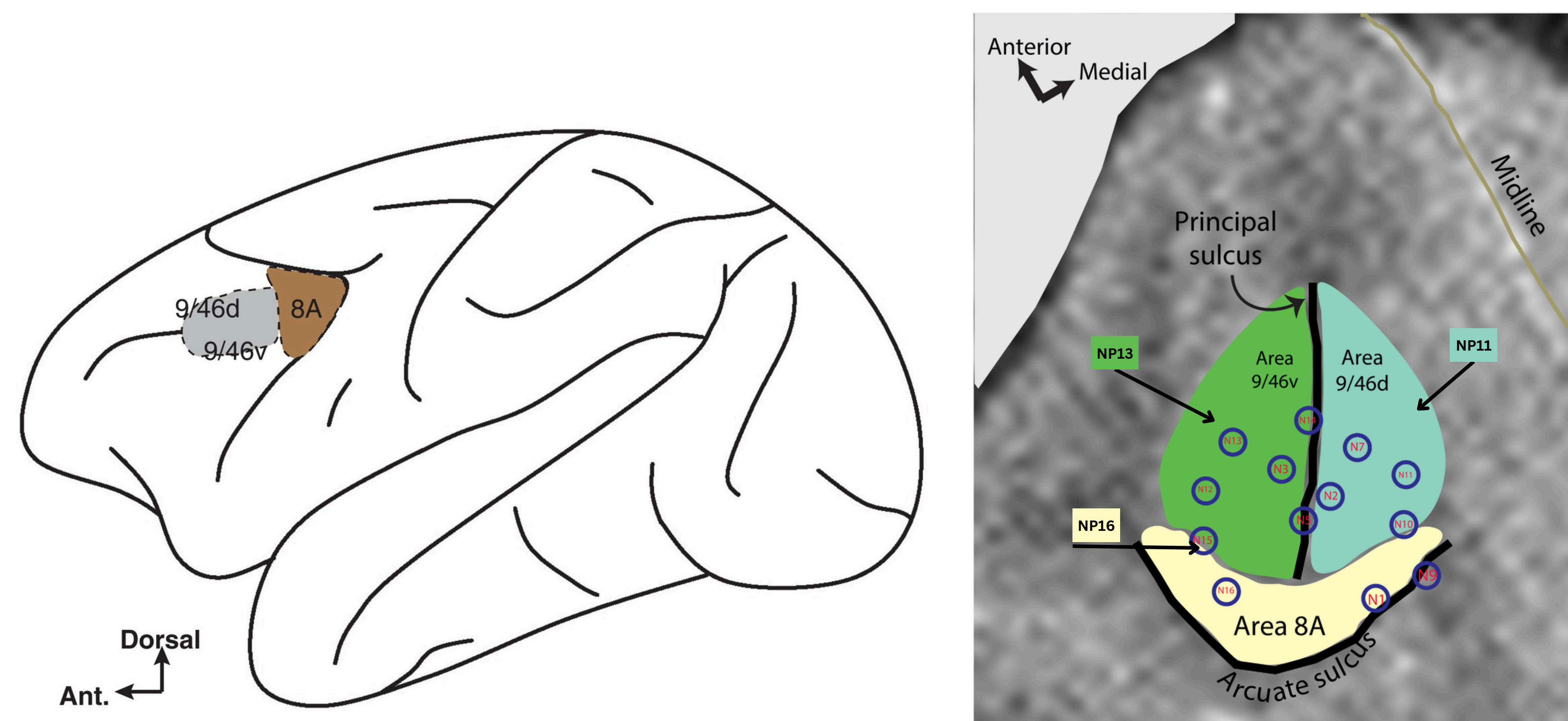


Figure 1.2-3: Anatomy of dlPFC. Left figure shows the location of dlPFC in a monkey brain, highlighting the three subregions. Right figure shows an MRI image of the region superimposed with the locations of the 13 recording sites.

Figures created by S. Shushruth

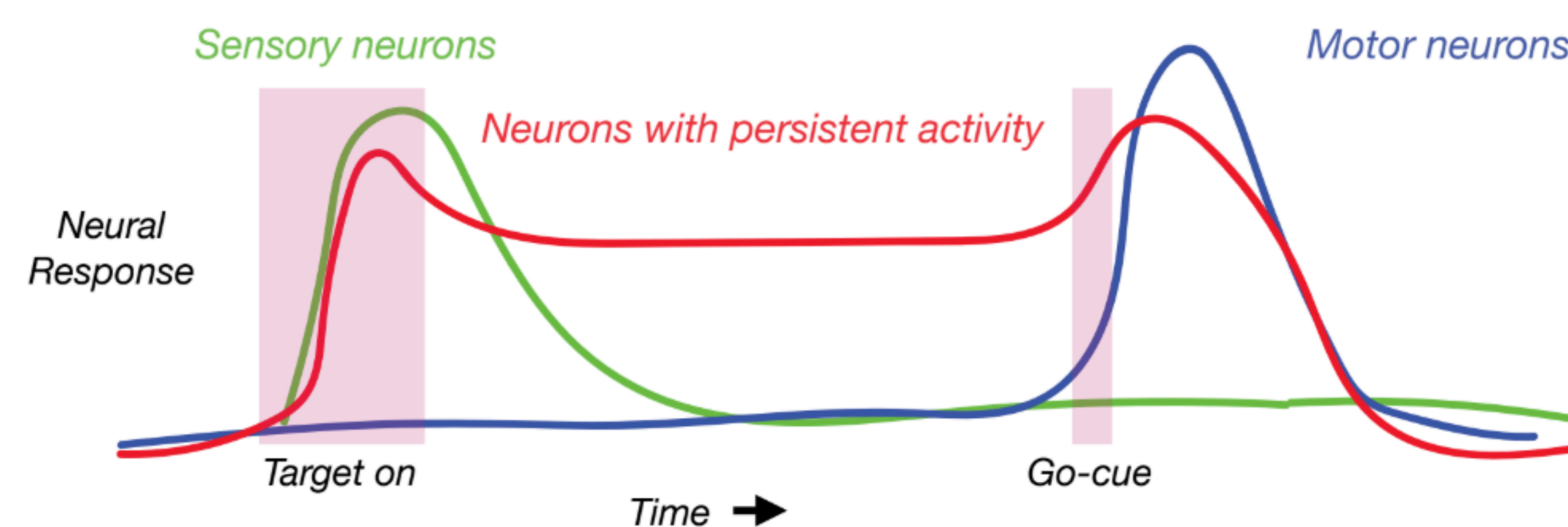


Figure 1.4: Persistent Activity Paradigm: Purely sensory neurons will respond maximally in the time surrounding target onset. Motor neurons respond maximally in the time before action propagation. Neurons that encode memory information; however, demonstrate persistent elevated neural activity in the dorsolateral regions of the PFC (dlPFC). This suggests that the prefrontal neurons correlated to mnemonic events.

Figure created by S. Shushruth

Results

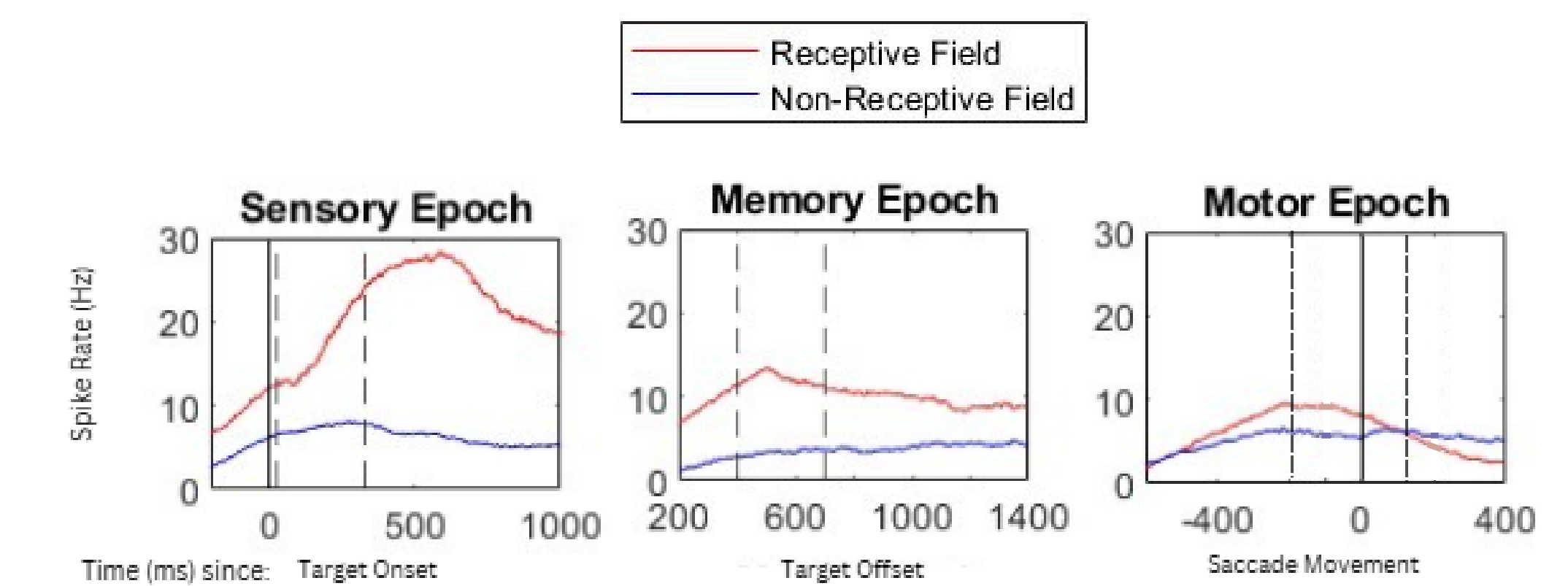


Figure 2.1: NP16 Cluster 142 Peri-Stimulus Time Histogram: An example of a tri-responsive neuron ($p < 0.05$), demonstrating temporal commingling. The sensory epoch is defined by its relation to the time of target onset; memory to target offset; and motor to the time of the saccade movement.

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Cluster 142 Receptive Field Heat Maps

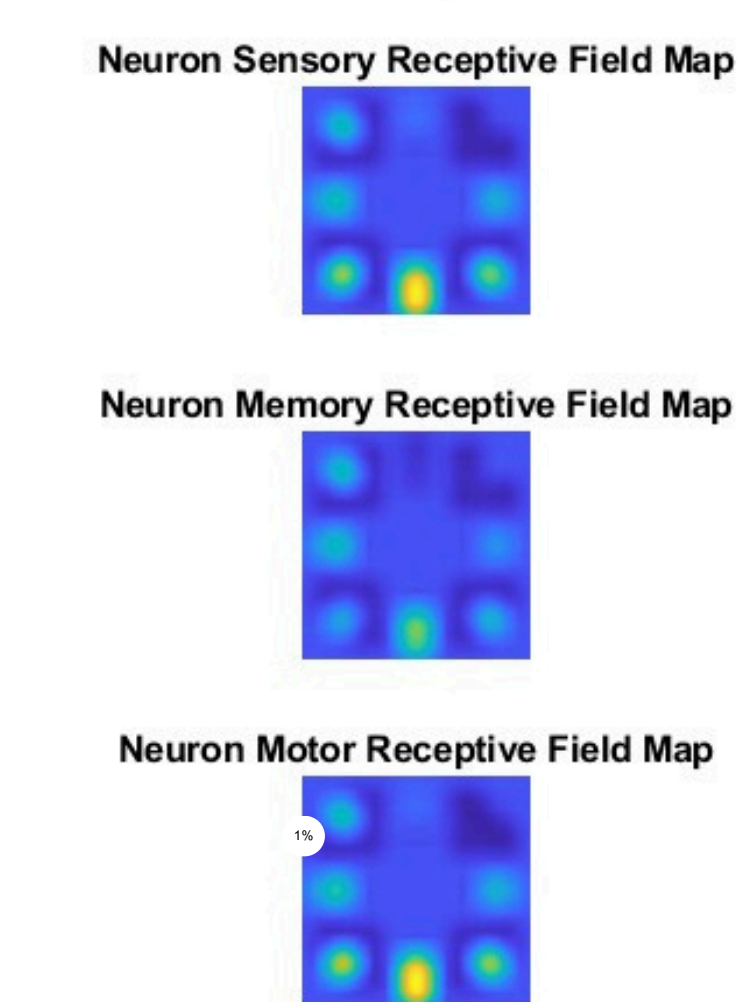
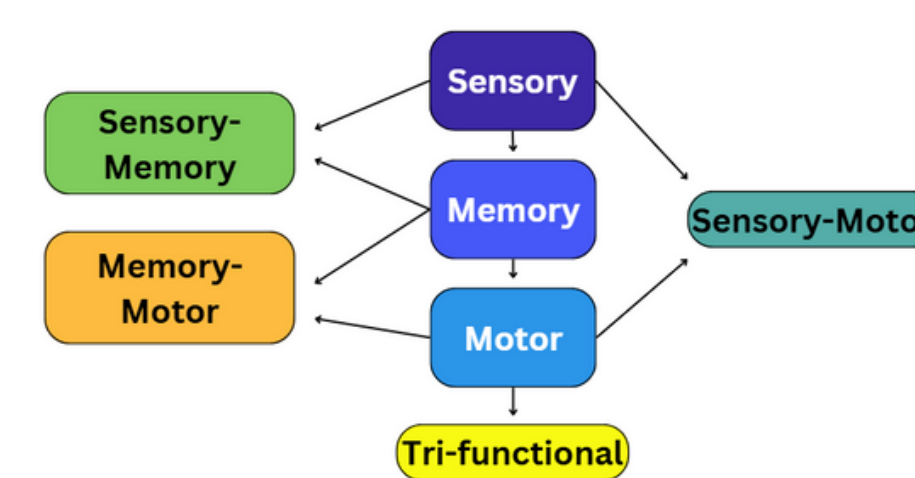


Figure 2.2: NP16 Cluster 142 Heatmaps Visualizing the average response in Hz at each target location, diversity and overlap in its RF provides insight into the visual commingling of the dlPFC.

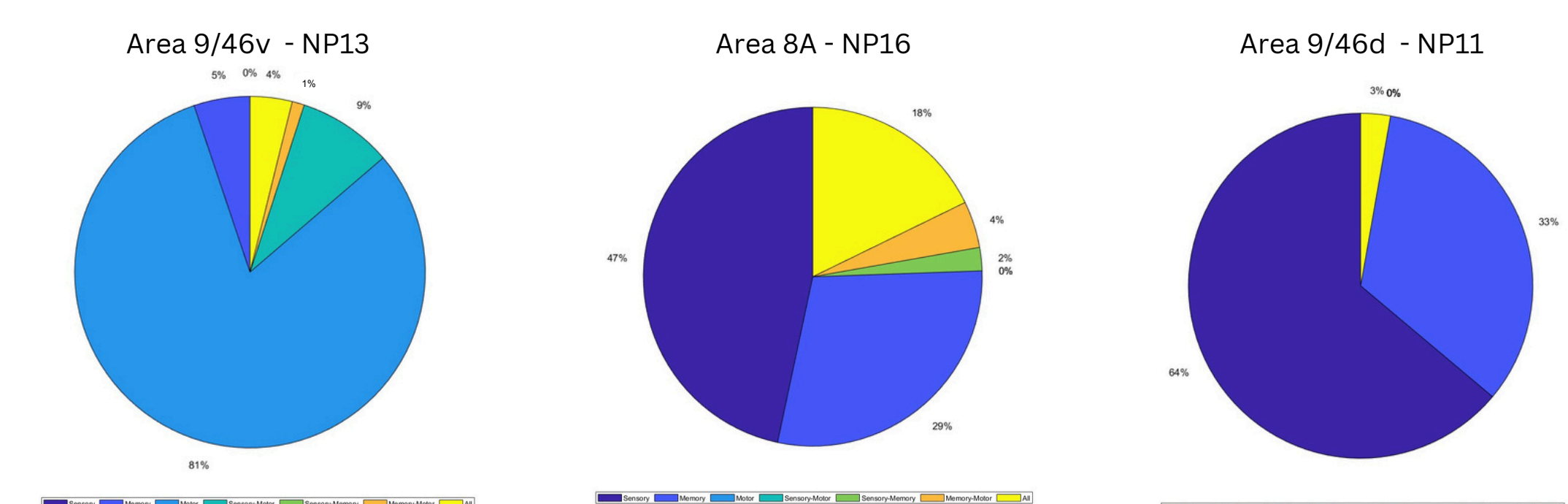
Figures created by O. Odebo in MATLAB

Figure 3.1-4: Significant Response Pie Charts

Figure 3.1 represents the seven neuron classifications. Figures 3.2-3.4 are pie charts representing the distribution of neuron function in NP13, NP16, and NP11. These figures demonstrate the functional and spatial commingling of dlPFC.



Figures created by O. Odebo in MATLAB



Conclusions

- Individual dlPFC neurons demonstrate a wide variety of mixture of sensory, memory and motor signals.
- Subregions of dlPFC contain varying proportions of different types of neurons.
- These results may one day guide future targeted treatments for pathologies of cognition.