Lab of Natural and Designed Intelligence

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"A neural circuit model of the striatum resolves the conflict between context and dominance apparent in the prefrontal cortex."

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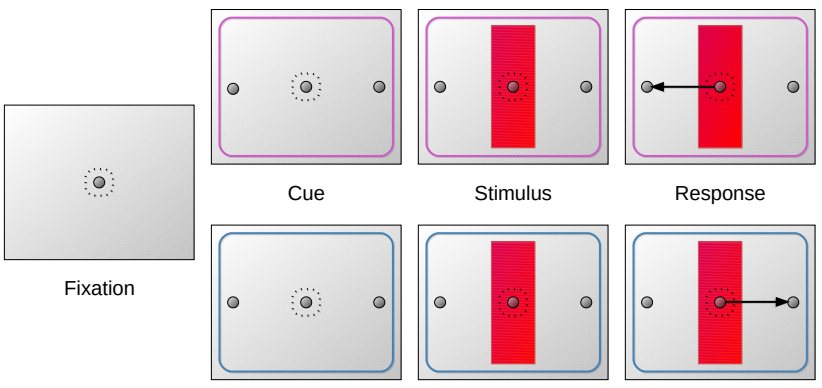
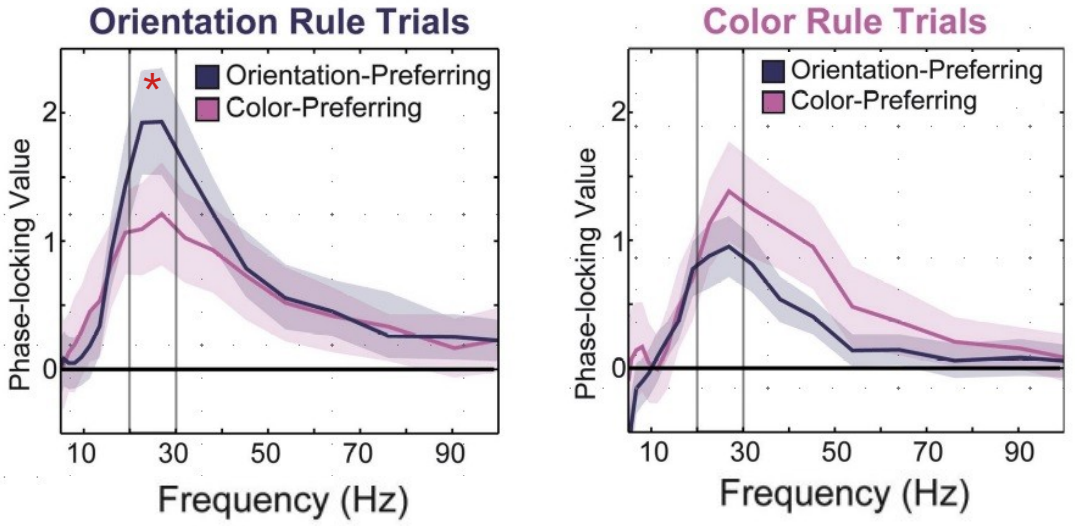
Rule-based decisions of non-dominant features are not resolved in the prefrontal cortex (PFC)

Task



Observations

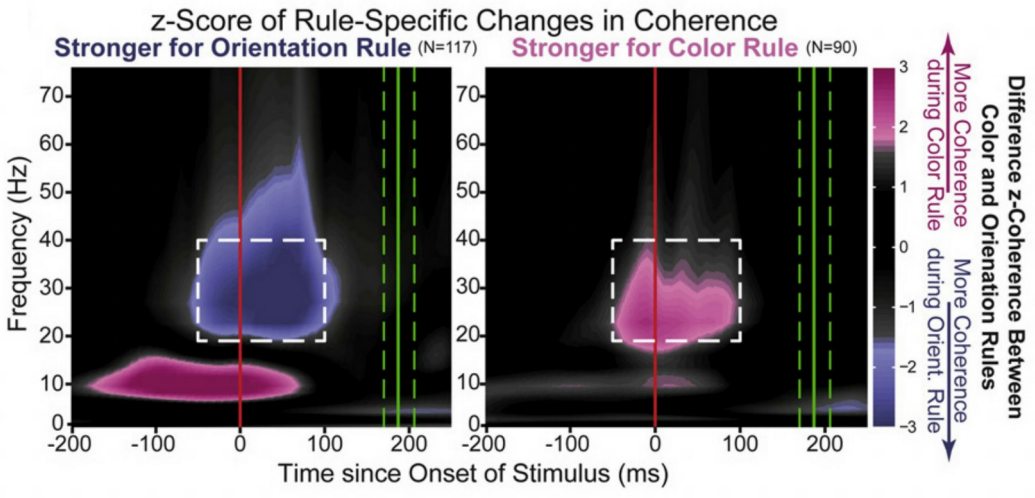


* Significant differences

Buschman et al., Neuron (2012)

The bias might be mediated by short-term synaptic depression acting within the striatum

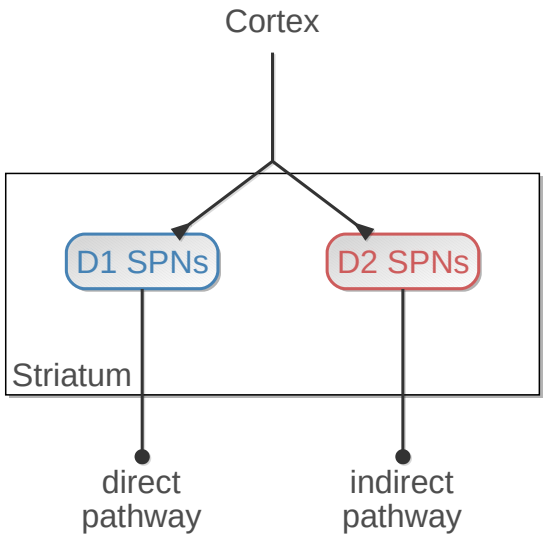
- Trigger: Emerging alpha activity in the PFC after the cue onset in the population encoding the dominant feature (Buschman et al., Neuron 2012)

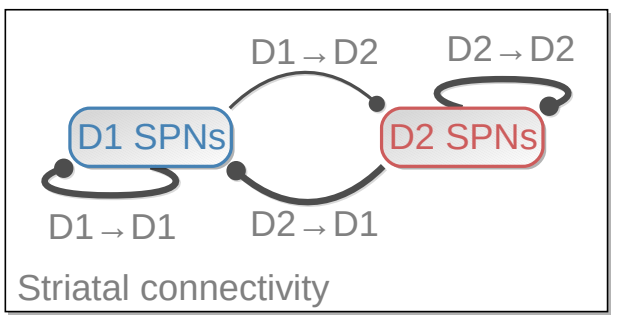


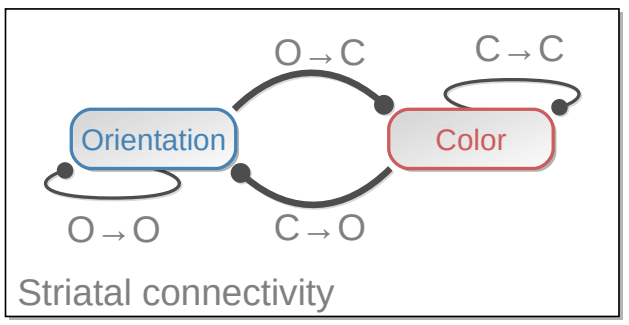
- Cortical inputs target the principal neurons of the striatum, both of the direct (D1 SPNs) and the indirect (D2 SPNs) pathway
- Short-term synaptic depression acts on D1 and D2 SPNs

Testing the hypothesis in a computational model

Neural circuit model derived from Ardid et al., PNAS (2019):

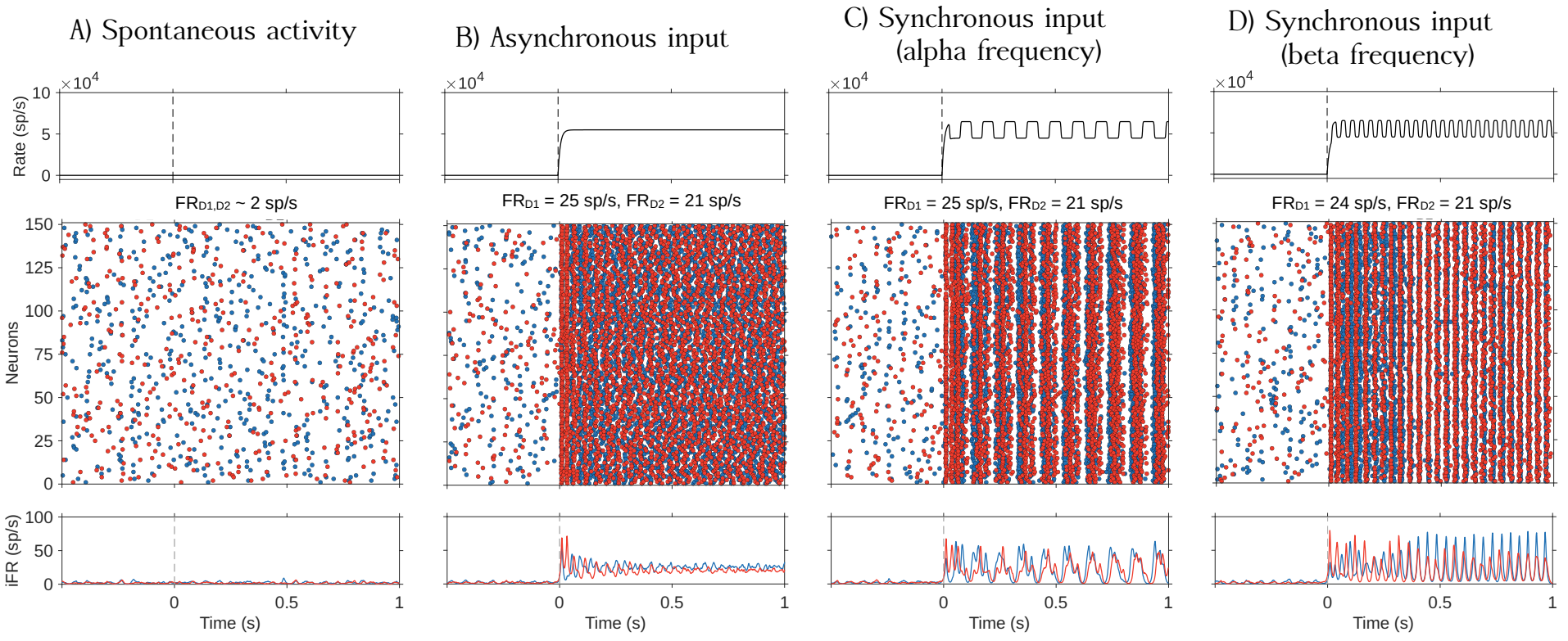




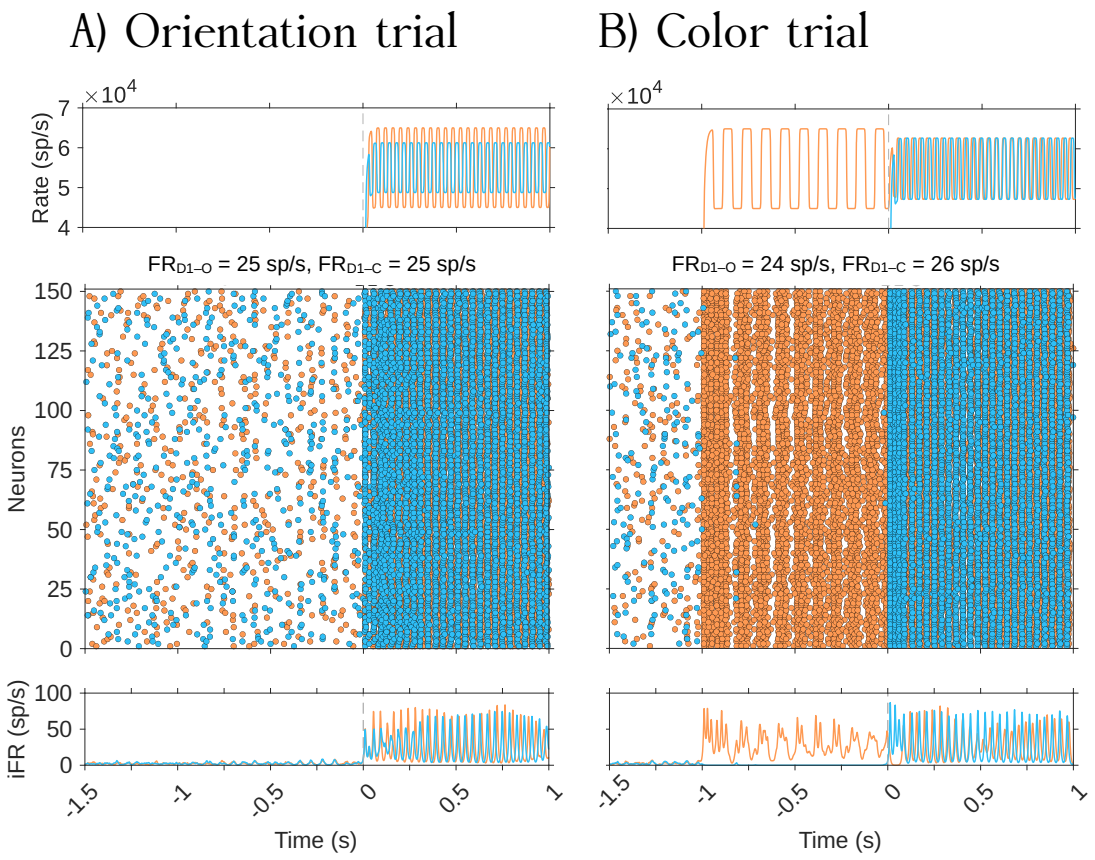


- Two modules according to feature selectivity: Orientation (dominant) and Color (non-dominant)
- Stronger inhibition between than within feature-selective populations

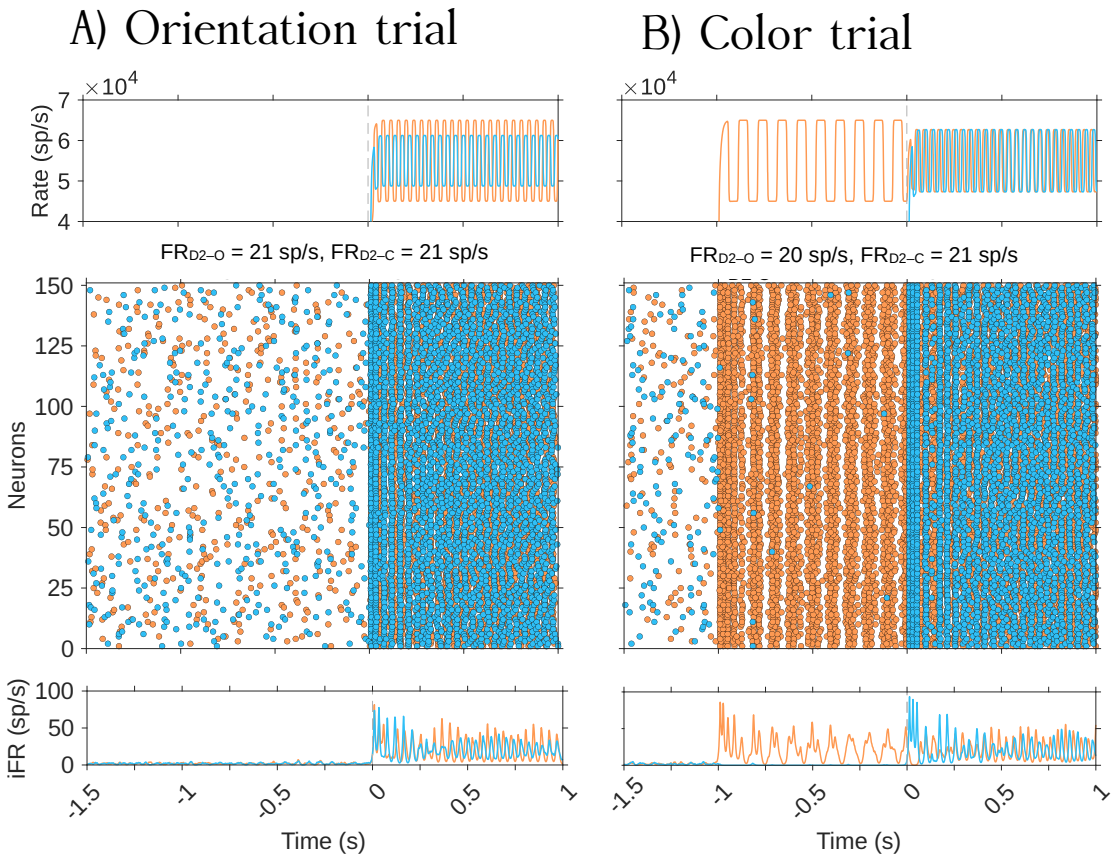
Spontaneous activity and response to cortical inputs



Trials resolution: indirect pathway (D1 SPNs)



Trials resolution: indirect pathway (D2 SPNs)



Conclusions

- PFC drives the bias for the dominant feature when it is relevant (orientation trial)
- However, PFC activity does not resolve acting upon the non-dominant feature (color trial)
- Hypothesis: a bias could be present in the striatum mediated by short-term synaptic depression
- Trigger: alpha activity appears in the dominant PFC population (orientation) previous to the stimulus presence
- Assumption: long-range inhibition between populations is stronger than short-range inhibition within populations
- The model shows a bias in the direct pathway following the context: higher instantaneous firing rate amplitude in the orientation trial and higher average firing rate in the color trial
- Next steps:
  - Currently analyzing the properties of a single read-out for the two types of biases
  - In a follow-up study, we are testing the hypothesis that the pattern of long- vs. short-range inhibition is shaped during feature-selectivity learning