

Neural covariability under the attentional modulation

Background: Each individual neuron in brain networks fires irregularly for most of the time. However, people do observe a certain amount of covariability in various of cortical area under different cognitive states. Evidences have been reported that different cognitive functions might participate in changing the neural covariability, such as attention and arousal. In this project, we mainly focus on attentions. One of the conventional postulation of attentional mechanism is a selective top-down signal modulating the gain of neurons in primary sensory cortex. To test the hypothesis, we ask the question that whether different attentional-modulated subtypes can emerge from the circuitry interactions plus top-down regulating inputs? If not, what new hypothesis and mechanism might be the candidate for attentional modulations.

Project setups: We provide the experimental measures of neural covariability under different task states. Also we provide the Wilson-Cowan model that can primarily explain the results as a first step towards modeling. [Jupyter Notebook demo]

Project map: The project core is covered by Q1-4 ; subsequent questions can be taken in any order.

Q1. Model the experimental setups using Wilson-Cowan model. What is the key parameter in the model that effects the neuronal covariability?



Q2. Turn the model to fit the neural covariability measurements in experiments. Is your solution unique?



Q2. Play with your model. How does neural covariability changes when the attentional condition changes? What is your model predictions about the neural covariability under the conditions that haven't recorded by experiments.



Q5. Verify your predictions obtained in the WC model.



Q4. Switch to more biologically detailed model, spiking neuronal networks (SNNs). Build a homogeneous SNN, containing both E/I neurons, and try recreating the modeling results obtained in WC model.



Q6. Add spatial-dependent connectivity structures. Does it helps the modeling?



Q7. Neural covariability are believed to promote the information processing in brain. Can you design some tests based on your model to give some arguments about this postulate? (You may compute the mutual information between the input and output of the network.)