Questions to guide your reading – Week 4

Paper 1. Lappalainen et al., “Connectome-constrained deep mechanistic networks predict neural responses across the fly visual system at single-neuron resolution.” *Nature*. 2024

Q1: Which fundamental question(s) about neural connectivity and function did the authors seek to answer in this study?

Q2: What is the “Universal function approximation theorem” and what does it say about the types of network connectivity that can perform a given computational task? What are the implications for using neural connectivity to study neural circuit function?

Q3: What is task-optimization and which task did the authors optimize their DMN for? Why did they select this task? What is this task missing that a real nervous system may have evolved to do? How does this study represent an advance over previous task-optimization modeling studies?

Q4: Why did the authors train an ensemble of 50 networks rather than just 1? After training, how did the authors seek to test/validate their resulting network model(s)?

Q5: What kinds of networks did the authors use as ‘control’ comparisons to their trained networks? Why did they use these ‘controls’?

Q6: Which known properties of which fly visual neuron cell classes did they test for in their trained network models? Which new predictions were made that have yet to be tested in real flies?

Q7: Which biological neural network properties are still missing from such connectome-constrained models?

Paper 2. Cowley et al. “Mapping model units to visual neurons reveals population code for social behaviour.” *Nature.* 2024

Q1: What was the overall goal of the paper as it relates to the term “1-to-1 network”?

Q2: What is the architecture of the 1-to-1 network and how does its components relate to real fly neuron types / brain regions?

Q3: Describe how their “knockout training” works and why it is more promising than previous approaches that have used DNNs to understand the roles of neurons in sensorimotor processing?

Q4: What is one way in which the authors validate their trained one-to-one networks?

Q5: In the best performing network, what was the conclusion drawn about LC unit encoding of visual stimuli and what alternative model was refuted?

Q6: How do the authors identify which LC units are most important for a behavior and what did they discover with respect to the number of LC units contributing to each behavior?

Q7: What do the authors find in the real fly brain connectome that further supports their model of LC-based visual processing?