Projects *(for some of these we have previous student project files that you can use and propose to extend*).

1. **Simulate the effects of drugs that affect inhibition in the hippocampus** Simulating effects of different levels of inhibition on memory in the hippocampus - e.g. to model effects of drugs such as anti-anxiety and sleep medications (benzodiazepenes which affect GABA-A receptors), or drugs that affect neuromodulation, such as dopamine, on episodic memory.
2. **Simulate how pattern separation in the hippocampus affects memory as a function of overlap in stored memories.** The hippocampus’s specialty in pattern completion/separation helps it overcome catastrophic interference. Subprojects: i) Explore the consequences of varying the overlap in input patterns to be stored and the impact of pattern separation. ii) Often people categorize episodic events in one way or another, for example when observing a white tiger drinking water, a person might encode all aspects of that memory while also saying “that’s a feline”. Add an additional output layer that classifies the input pattern as part of one category or another (e.g., feline vs canine) and explore the consequences on memory for individual items. Prior go code available.
3. **Simulate Synesthesia.** Synesthesia occurs when the experience of one sense (e.g. the color green) involuntarily triggers another sensory experience (e.g. taste). This is thought to occur through either top-down feedback from multimodal integration areas or from cross activation of sensory areas (Grossenbacher & Lovelace, 2001; van Leeuwen et al., *J. Neuroscience,* 2011). Show how both mechanisms can result in synesthesia and whether they make different predictions, using a Stroop task in which the model either has to name the actual color of a stimulus or the color-associated with the synesthetic representation (Dixon, Smilek & Merikle 2004) .
4. **Feedback and Feedforward Projections between V1 and IT cortex**. The object recognition model we considered in class considered only bidirectional connections between each level of the hierarchy and the one above/below it, while the anatomy suggests that there are also projections from lower levels that project to higher levels (ie direct projections from V1 and V4/IT and back). Add these connections with different types of topographies and explore their influence on the model’s object recognition.
5. **Explore different learning rules**. The self-organized and error-driven learning rules you have been using rely on the XCAL learning rule. You could alter this to test other forms of learning rules or the impact of other assumptions (e.g. weight symmetry) while simulating any of the projects that you have completed in the class, by modifying the associated Go code in ~/go/src/github.com/ emer/leabra/leabra/learn.go and/or the DWt function in ~/go/src/github.com/ emer/leabra/leabra/prjn.go .
6. **Test whether a balance between excitation and inhibition affects information coding in a network performing perceptual discrimination.**Perceptual discrimination can be explored by varying the overlap between different input patterns and asking a network to perform pattern separation. For a given layer size and proportion overlap, how many patterns can a network discriminate, and how does excitation-inhibitory balance (e.g., varying amount of feedforward feedback inhibition) affect this ability?
7. **Build a new Go (or Python) version of one of the basal ganglia models** described [here](http://ski.clps.brown.edu/BG_Projects/Emergent_7.0+/), which were implemented in older versions of emergent. These models are more realistic versions of the BG network you explored in chapter 7, and allow you to explore the impact of dopamine manipulations on learning and decision making, and of BG network dynamics on oscillations that emerge to characterize tremor in Parkinson’s disease due to negative feedback loops between the subthalamic nucleus and globus pallidus. This project is advanced.
8. **Explore the Opponent Actor Learning (OpAL\*) model of the basal ganglia** can adapt to varying reward contingencies and is more effective at doing so than standard computer science models of reinforcement learning (see paper [here](https://elifesciences.org/articles/85107), Python code available here <https://github.com/amjaskir/opal-star> – this is a more abstract model of the BG not in a neural network, so no Go code needed). There are several other manipulations one can do to test the efficiency of this model in new situations, and we are happy to suggest some if you choose this option.
9. **Simulate the effects of sleep on episodic memory consolidation**. REM sleep is important in memory consolidation, a process during which memory is actually improved. One theory of how this occurs is though oscillations of inhibition that have the effect of strengthening weak memories (Norman, Newman & Perotte, *Neural Networks*, 2005). A more recent Go implementation shows how the hippocampus can spontaneously reactive memories during sleep to consolidate them in the cortex and reduce interference in memory (Singh et al 2022, *PNAS,* [*here*](https://www.pnas.org/doi/10.1073/pnas.2123432119)). You can access the Go code associated with this paper and explore the impact of oscillations during sleep on memory. This project is complex but you would have code to work from and manipulate parameters.
10. **Amnesia and stroke**. Damage to the hippocampus and the medial temporal lobe from stroke can cause both anterograde amnesia (the loss of the ability to form new memories) and retrograde amnesia (the loss of previous memories). Simulate stroke damage to hippocampus and dissociate the effects of the two forms of amnesia.
11. **Simulate epilepsy (seizures) related to dysregulated inhibition** and attempt to remediate this by other compensatory treatments (e.g. brain stimulation, neuromodulation).
12. **Alter the input patterns in the object recognition model to ask questions related to visual illusions (e.g. object closure) or to simulate processing of other types of inputs (e.g. faces).**
13. **Simulate schizophrenia in a PFC-BG network** by changing dopamine levels and relate their effects to abnormal gating of working memory.
14. **Test whether a vision model of object recognition can recognize textures rather than object identities** (code to build off available)**.**
15. **Build a model that can regulate its learning rate as a function of its own uncertainty about the task contingencies** (for an example of this in the basal ganglia, see Franklin & Frank 2015, *eLife*, but one can attempt this in a more generic cortical network).
16. **Simulate higher order sequential dependencies or learning of context sensitive and/or context-free grammars in a PFC-BG working memory model; compare to SRN or LSTM (advanced).**
17. **Explore and extend one of the language chapter models** (e.g. of dyslexia)**.**
18. **Compare activation-based accounts of working memory to those suggesting memory is encoded “silently” in a neural network (e.g. Stokes et al., 2013, *Neuron*; Rose et al., 2016, *Science*).**
19. **Simulate the effects of hallucinogenic drugs in network attractor dynamics.** Drugs (e.g. LSD) may cause neurons to oscillate more asynchronously among possible attractor steady states (e.g. visual perspectives in the Necker cube). Prior Go code available.
20. **Simulate the impact of altered inhibition due to drugs or changes in top-down attention in the simple spatial attention model using the Posner task**
21. **Build or extend a model of online motor control in a virtual environment (Krishn has code to build off!)**