Project 17: The role of sleep in learning

1) Crick & Mitchison (1983) suggested that dream sleep might result in unlearning of associations. Ackley, Hinton & Sejnowski (1985) developed the Boltzmann machine model that uses a learning rule consisting of "wake" (learning) and "sleep" (unlearning) phases. Show how this model could be used to formalize the Crick & Mitchison hypothesis.

2) Simulate a memory task in which a Boltzmann machine (without hidden units) is exposed to a set of patterns, each corresponding to an item on a list to be memorized. After training, query each item by presenting a partial pattern and measuring how well the rest of the pattern is reactivated. The patterns should be generated from a distribution such that items share representational structure. For example, you can sample each unit from a Bernoulli distribution with a mean that is fixed across patterns. This will allow you to designate some patterns as high probability or low probability under the generating distribution. Exclude the highest and lowest probability patterns from the training set, but include them in the memory test. These are "lures" analogous to those used in the study of semantic memory intrusions. Compare your simulations to experimental data reported by Mak et al. (2023).

2) Unfortunately for the Crick and Mitchison hypothesis, there is virtually no evidence for anti-Hebbian learning during sleep. However, there is evidence for synaptic downscaling (e.g., De Vivo et al., 2017), where strong synapses get weakened during sleep. Speculate about how this might fit into the computational picture.

References:

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Mak, M. H., O'Hagan, A., Horner, A. J., & Gaskell, M. G. (2023). A registered report testing the effect of sleep on Deese-Roediger-McDermott false memory: greater lure and veridical recall but fewer intrusions after sleep. *Royal Society Open Science, 10*, 220595.