Associative Memory-I: Storing Patterns

Learning and recalling memories are important to animals' survival.

Navigational memory is important for locating food. Odor memory is important for determining if food is safe to eat.
Some types of memories can be broken up into their constituent elements.

A basic element of learning is pattern storage and retrieval. Patterns can consist of sensory, motor, or both elements.
Storing Patterns Associatively

Memories can be stored associatively by linking the components together.

Associative patterns link elements together. When parts of the pattern are presented, they recruit the other parts, recalling the whole.
Association with Neurons

Populations of neurons can represent the elements in a pattern.

Populations of neurons represent elements.

Patterns can be stored by synapses in two ways:
- change in input synaptic strengths
- change in recurrent synaptic strengths
Missing elements of a pattern can be recruited by the active elements.

**Strengthened recurrent synapses can recruit missing elements of a pattern, recalling the original.**

**Associative memory is useful for recalling memories similar to the current situation.**

---

### Neurons Associate

![Image](image_url)

Place cells respond the same in a maze when all identifying elements are present (full cue) as when most of them are removed (partial cue) [Nakazawa et al, 2002].

**After learning to navigate a maze with four identifying elements, mice perform as well when three elements are removed.**

This can be interpreted as the network performing associative recall.
Abstract Association: The Hopfield Network

The (eight-neuron) Hopfield network is characterized by all-to-all recurrent connectivity and employs a hebbian learning rule to store (eight-bit) binary patterns.

The Hopfield network stores patterns by strengthening recurrent synapses among neurons that are in a pattern together.

The Hopfield Network-II
Strengthened synapses make some network states more stable than others.

The network approaches these stable attractor states.

Neurons Associate with Recurrent Connections

Place cells respond less with a partial cue compared to the full cue [Nakazawa et al, 2002].

Genetically eliminating learning at recurrent CA3 synapses (by eliminating NMDARs) damages place cell activity. After learning to navigate a maze with four identifying elements, mutant mice perform poorly when three elements are removed.
A More Biological Model-I

Our network is characterized by spiking neurons that make random local recurrent connections to each other that employs STDP to store binary patterns.

Like the Hopfield network, our network stores patterns by strengthening recurrent synapses among coactive neurons.

A More Biological Model-II

Before STDP

After STDP

Rate(Hz)
After STDP stores a pattern, potentiated neurons recall the whole pattern when half of the neurons in the pattern are activated.

The network recalls a pattern when a subset of its neurons are activated.