STDP enhances phase-coding in recurrent network

Hippocampal formation: Trisynaptic circuit through dentate gyrus, CA3, and CA1 originates and terminates in entorhinal cortex (insert, rat brain). p-p–point-to-point; f–fanning; S–subiculum; PAS/PRS–pre/parasubiculum [Lisman99, Moser06]

Hippocampal neurons have precise spike timing (~10ms).
How they overcome heterogeneity is unclear.
Hypothesis: Plasticity enhances phase-coding.
Phase and rate coding

CA1 hippocampal cells’ rate (middle) and timing (bottom) codes [O’Keefe’03]

Heterogeneity reduces timing precision

Phase encodes input strength (top) only when excitability doesn’t vary (bottom).
STDP enhances phase-coding

STDP potentiates synapses from excitable to lethargic neurons, advancing their firing.

STDP compensates for variable excitability
STDP (5sec) improves timing precision (SD) from 8.9ms to 4.0ms.

STDP compensates for noisy inputs too

STDP (5sec) improves timing precision (SD) from 16.7ms to 10.5ms.
Synapse count versus temporal order

Early neurons make more synapses (green); late ones receive more synapses (purple).

Next Lecture: Feedforward synapses

STDP strengthens/weakens synapses driving late/early-spiking cells [Laurent07]