STDP enhances phase-coding in a 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 (~10 ms). 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 corrupts phase-coding

Phase encodes input strength (top) only when excitability doesn’t vary (bottom).
STDP combats heterogeneity

STDP potentiates synapses from excitable to lethargic neurons, advancing their firing.
Spike rasters and histograms

STDP improves timing precision (SD) from 4.1ms to 1.8ms.
Synapse count versus temporal order

Early neurons make more synapses (green); late ones receive more synapses (purple) [Arthur06].
Next Lecture: Limits of STDP

STDP fails to improve phase-coding when input is too noisy (50Hz).