Interaction between Synaptic Plasticity and Network Dynamics

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Synaptic plasticity is believed to serves as a cellular substrate of learning and memory. However, it is unclear how specific forms of synaptic plasticity shape different aspects of network dynamics, and conversely, how network dynamics influence synaptic plasticity. Using cultured networks of hippocampal neurons as a model system, we found that repeated stimulation of single neurons could drive the emergence of quasi-rhythmic bursting activity in the network with conserved spatiotemporal patterns. The emergence of reverberation required functional NMDA receptors and was accompanied by increases in reverberation duration and overall synaptic strength, indicating a positive feedback loop between synaptic potentiation and network reverberation as proposed by Hebb. Intriguingly, both increases quickly stopped soon after the reverberation emerged, suggesting a negative feedback mechanism. However, in networks that had experienced chronic inactivation, this negative feedback was ineffective. These results begin to reveal the multifaceted interaction between synaptic plasticity and network dynamics that may underlie the self-organization of functional neural circuits.