Abstract: The ability to represent time is an essential component of cognition but its neural basis is unknown. Although extensively studied both behaviorally and electrophysiologically, a general theoretical framework describing the elementary neural mechanisms used by the brain to learn temporal representations is lacking. It is commonly believed that the underlying cellular mechanisms reside in high order cortical regions but recent studies show sustained neural activity in primary sensory cortices that can represent the timing of expected reward. Here, we show that local cortical networks can learn temporal representations through a simple framework predicated on reward dependent expression of synaptic plasticity. We assert that temporal representations are stored in the lateral synaptic connections between neurons and demonstrate that reward-modulated plasticity is sufficient to learn these representations. We implement our model numerically to explain reward-time learning in the primary visual cortex (V1), demonstrate experimental support, and suggest additional experimentally verifiable predictions.

Journal: Proceedings of the National Academy of Sciences of the United States of America

Volume: 106

Pagination: 6826-6831

Date Published: 04/2009

Notes: {PMID:} 19346478

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