

Hippocampal replay in a large environment spans multiple ripples

Thomas J. Davidson, Fabian Kloosterman, and Matthew A. Wilson

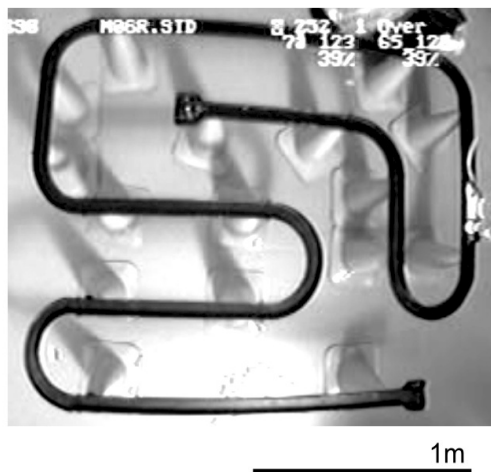
Picower Institute for Learning and Memory, Massachusetts Institute of Technology, Cambridge, MA.

Firing of hippocampal place cells may subserve spatial learning. Ensemble recordings in rats have shown that these cells re-express behavioral firing sequences (termed 'replay') during slow-wave sleep and during wakefulness. These phenomena are hypothesized to play a role in memory consolidation.

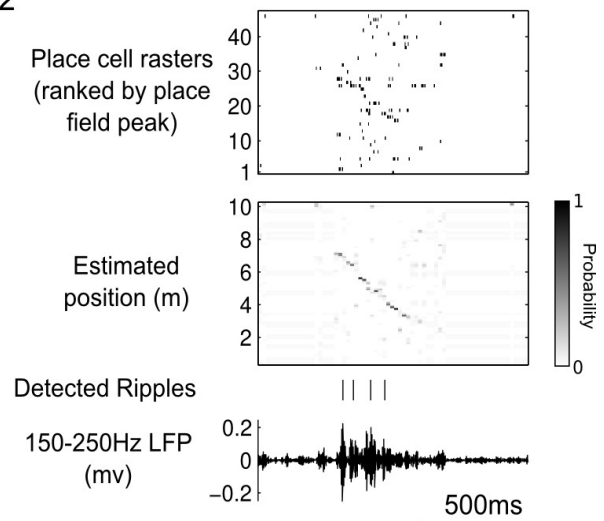
We have made ensemble recordings of place cells in area CA1 on day 2 or 3 of exposure to a 10m linear track (Fig. 1; rat visible at right). Many place cells exhibit multiple peaks on this track, making replay detection by cell firing order difficult. We therefore employ a simple probabilistic decoding algorithm to serially estimate position from short windows of the spiking record (Fig. 2). Replay is then defined as 'virtual trajectories' in this reconstructed signal. During periods of immobility, both forward and reverse replay are prevalent, with significant replay episodes occurring at a rate of ~ 2.5 /minute. Replayed trajectories last up to 700ms and span up to 8m of the track, and occur at a 'virtual' velocity of ~ 10 m/s. Replay is correlated with increased power in the ripple-band (150-250Hz) in the local field potential, with previously unreported bursts of sharp-wave/ripple (SWR) complexes frequently co-occurring with replay (Fig. 2).

This prolonged replay is not predicted by existing models¹⁻³ which explain replay as an 'unmasking' of progressively weaker, local place-related inputs. We propose instead a model in which short hippocampally-generated sequences (paired with SWRs) are chained together via the entorhinal-hippocampal loop, allowing for the expression of arbitrarily long hippocampal sequences.

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References:

1. Reverse replay of behavioural sequences in hippocampal place cells during the awake state. Foster, D. J. & Wilson, M. A. *Nature* 440(7084):680-683, Mar 2006.
2. Forward and reverse hippocampal place-cell sequences during ripples. Diba, K. & Buzsaki, G. *Nat. Neurosci.*, Sep 2007.
3. Place-selective firing contributes to the reverse-order reactivation of CA1 pyramidal cells during sharp waves in open-field exploration. Csicsvari, J. *et al. Eur. J. Neurosci.* 26(3):704-716, Aug 2007.