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Regenerating space

Various studies have shown that some hippocampal pyramidal neurons, termed place cells, fire only when an animal enters a given area of an environment — their place field. However, the cellular and network mechanisms underlying these firing patterns remain unclear. A new study shows that regenerative dendritic events in place cells can predict certain properties of place fields, suggesting that such events have a role in the representation of space in the hippocampus.

Regenerative dendritic events include spikes of activity that are generated within the dendrite itself or triggered by back-propagating action potentials. Previous studies have suggested that these events have a role in determining place field firing, but the supporting evidence has been indirect.

Sheffield and Dombeck examined whether regenerative dendritic events occur in behaving animals by conducting two-photon microscopy on CA1 pyramidal cells through an imaging window in head-restrained mice while these animals navigated a virtual track. By sparsely labelling the cells with a genetically encoded calcium indicator and using an electric lens that switched rapidly between two focal planes, the authors were able to acquire movies of calcium transients in the somal and dendritic compartments of active CA1 place cells.

The authors identified place cells by the recurrence of somatic calcium transients (a surrogate marker of action potential firing) when an animal entered specific track positions. Strikingly, somatic place field firing was often accompanied by calcium transients in dendritic branches, arising partly from regenerative dendritic events (referred to by the authors as 'branch spikes').

Among place cells, somatic place field firing was accompanied frequently by branch spikes in one or more dendrites. Moreover, the number of branches that showed spiking in individual place cells varied from one place field traversal to the next. Given this heterogeneity, the authors calculated the average fraction of dendrites exhibiting branch spikes for a given place field, which they termed the average branch spiking prevalence (BSP), and they identified place fields associated with low, medium and high average BSP.

The authors examined the relationship between branch spiking and place field precision, which relates to the consistency at which a place cell fires over many entries into a given place field. Interestingly, average BSP for a place field correlated with place field precision. The authors also examined the relationship between BSP and place field stability, which refers to the persistence of place fields over days. They found that stable fields (assessed over a 2-day period) had a higher average BSP and that this measure was a more accurate indicator of place field persistence than somatic firing intensity.

Together, these data show that regenerative dendritic events occur in place cells as an animal navigates an environment, and that such events can predict some of the properties of place fields. These findings therefore suggest that such events may have a role in hippocampal spatial representation.

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ORIGINAL RESEARCH PAPER Sheffield, M. E. J. & Dombeck, D. A. Calcium transient prevalence across the dendritic arbour predicts place field properties. *Nature* http://dx.doi.org/10.1038/nature13871 (2014)

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