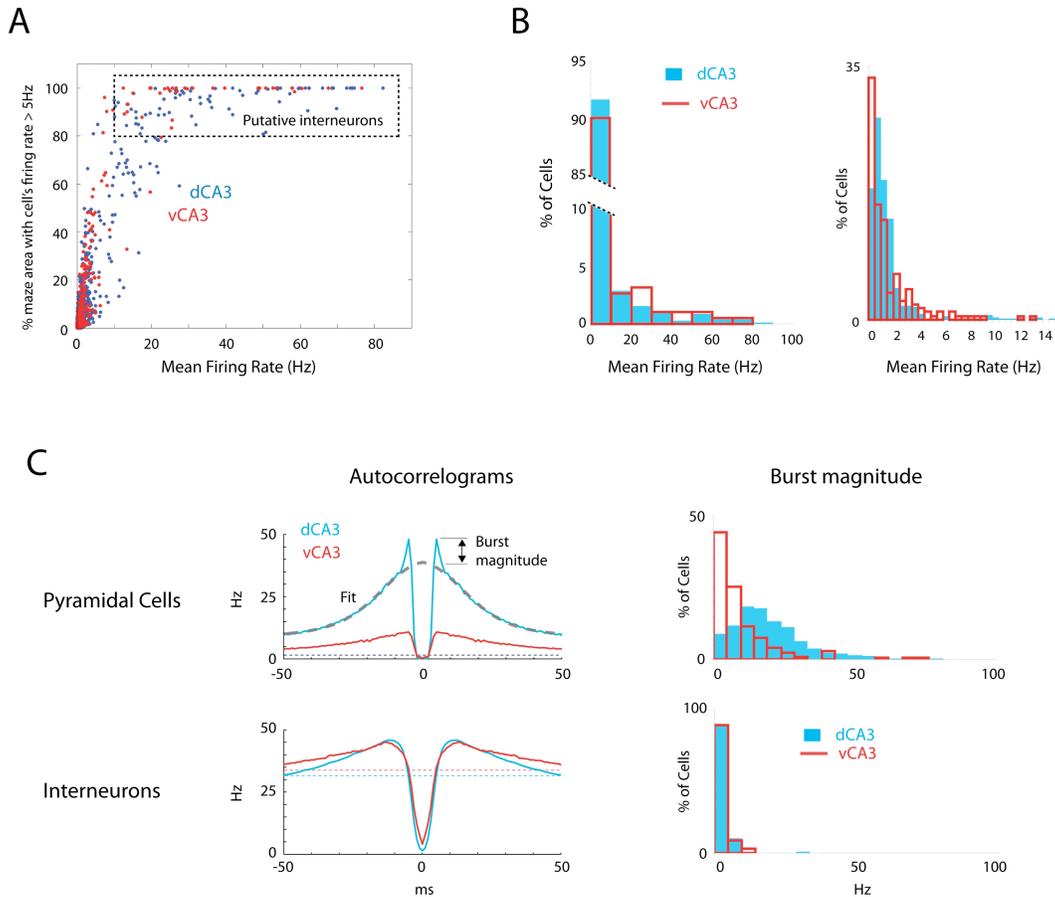
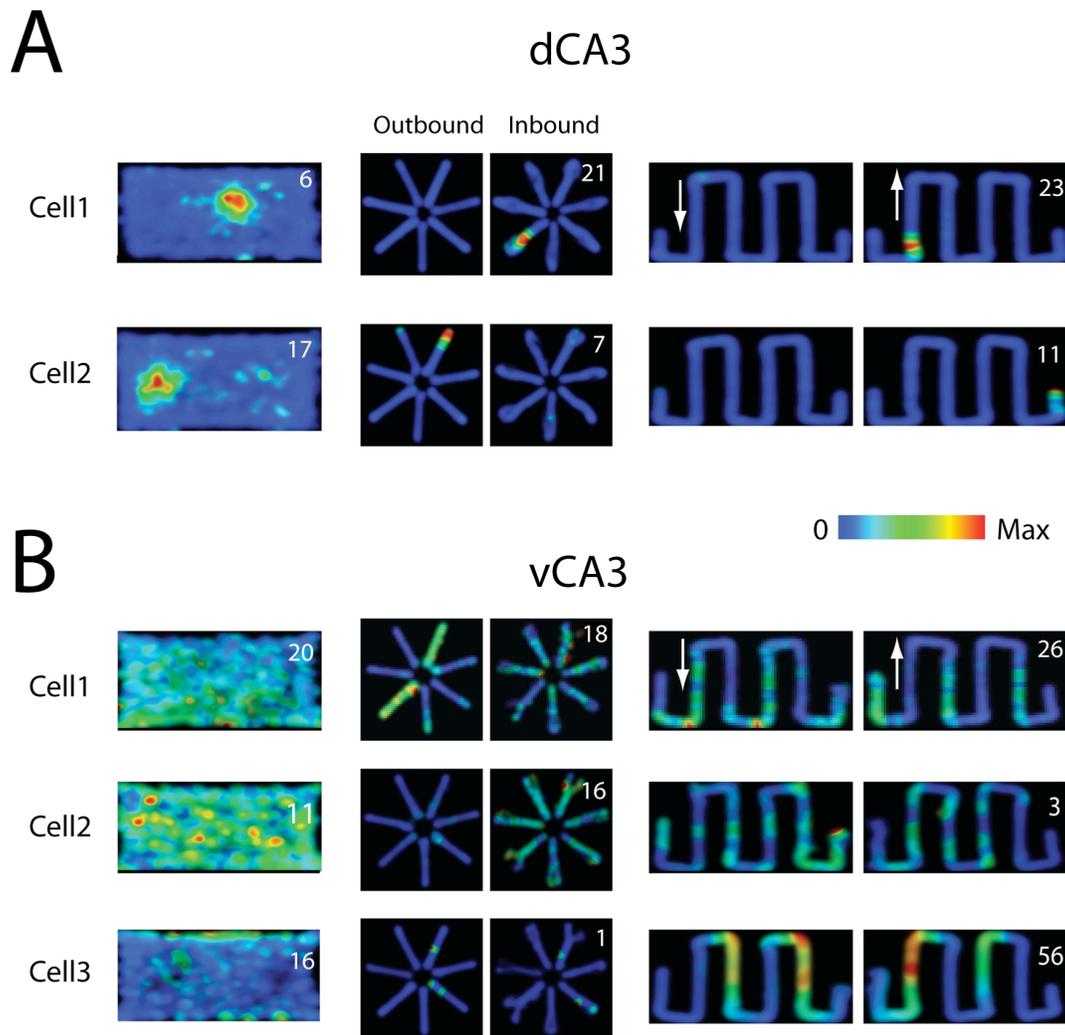


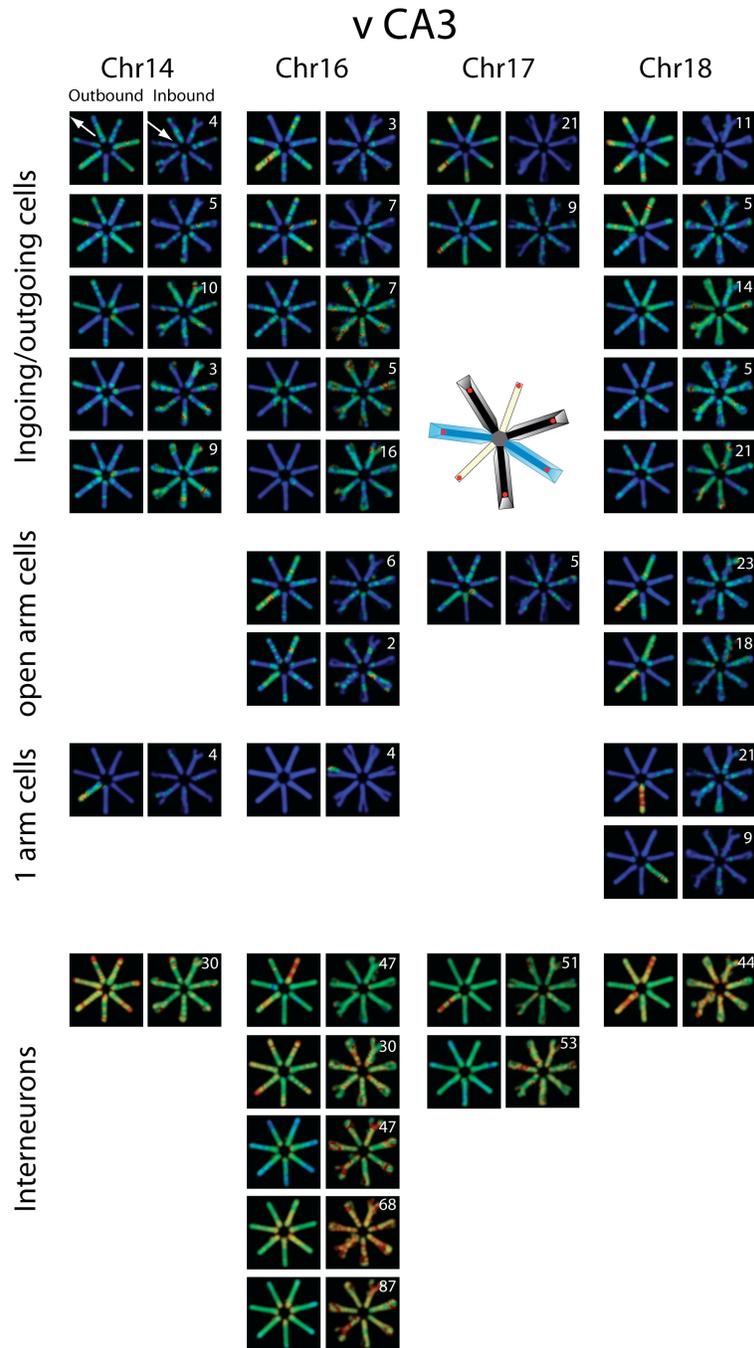
Supplementary Fig. 1. Examples of neuron firing patterns and clusters in vCA3. (A) Firing fields of two example pyramidal cells on the radial maze and corresponding filtered (800 Hz-5 kHz) waveforms for each tetrode wire (B). (C) Clusters of spikes of the two neurons. (D) Autocorrelograms of the two neurons and their cross-correlogram (white). Note refractory periods in the autocorrelograms and absence of refractoriness in the cross-correlogram. The features indicate that the green and blue spikes are generated by two neurons (Harris et al. 2000). E to H, identical arrangement as in A-D for another tetrode recording for a pyramidal cell (blue) and a fast firing interneuron (purple). I-L, identical arrangement as in A-D, for two pyramidal cells and a putative interneuron (purple). Note short latency sharp peak at 2 msec prior to the reference interneuron spike in the cross-correlogram (arrow), indicating that the red pyramidal cell monosynaptically discharges the interneuron (Csicsvari et al. 1998). The monosynaptic drive may explain the enhanced firing of the interneuron on the open arms, similar to the arm-selective firing of the red pyramidal cell (Marshall et al. 2002; Maurer et al. 2006).



Supplementary Fig. 2. Physiological features of dCA3 and vCA3 neurons. A. Unit classification criteria of putative pyramidal cells and interneurons. The two parameters that allowed best separation between the two putative anatomical groups in the ventral CA3 region were firing rate and behavior-related firing pattern. The percentage of the maze area in which the neuron's firing rate > 5 Hz is plotted against the neuron's mean firing rate for all dCA3 (blue dots) and vCA3 (red dots) neurons. The neurons within the dotted line are classified as putative interneurons. Note effective bimodal separation of vCA3 neurons (with the exception of 5 units). Exclusion of these 5 cells from the data analysis does not affect our conclusions described in the manuscript. B. Firing rate distributions of dCA3 and vCA3 neurons, shown separately at two timescales and bin sizes. Note lack of bimodal distribution of rate of either group into putative pyramidal cells and interneurons. C. Average autocorrelograms of pyramidal cells and interneurons. Each neuron's autocorrelogram was implemented with a time bin of 1 ms. To quantify 'complex spike bursting' (Ranck, 1973), the autocorrelogram of each neuron was fit with a Gaussian function between the interval of -50 to -10 ms (black dashed line). The burst magnitude was defined as the peak of the autocorrelogram between -10 and 0 ms minus the high of the Gaussian curve at the same time. This method quantifies 'excess' bursts beyond those expected by the theta phase-locked increased firing rate. Right, distribution of excess bursts. Note that vCA3 pyramidal cells burst significantly less than their dCA3 peers ($P < 0.01$; unpaired t-test). Interneurons in both regions lack true bursts. Horizontal lines indicate mean firing rates of the respective populations (dCA3 pyramidal cells: 1.3 Hz; vCA3 pyramidal cells: 1.5 Hz; $P = 0.11$; dCA3 interneurons: 32 Hz; vCA3 interneurons: 34 Hz; $P = 0.66$; unpaired t-test).



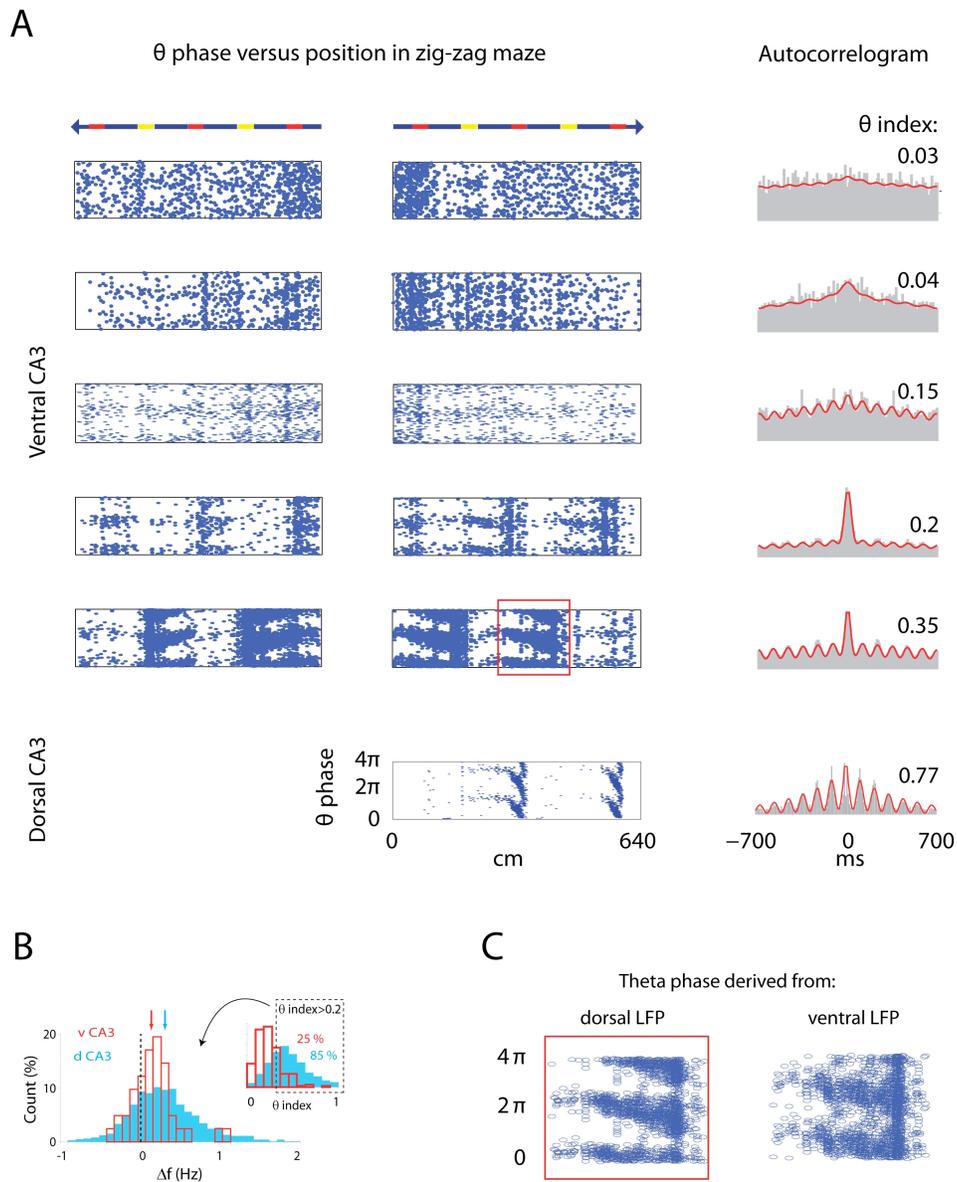
Supplementary Fig. 3. Firing pattern of pyramidal cells across mazes. Example of two dCA3 (A) and three vCA3 (B) stable pyramidal cells that could be recorded in the 3 different mazes. Note different firing fields in the different mazes, indicating ‘remapping’ of activity.



Supplementary Fig. 4. Firing patterns of vCA3 neurons in the radial maze. Representative pyramidal cells (above) and interneurons (bottom) from the vCA3 pyramidal layer in different rats (Chr 16-19). First group, differential firing between reward-bound (outgoing) and center-bound (ingoing) travels. Note that these neurons typically fire on multiple arms. Second group, differential firing on open versus walled arms. Third group, a small fraction of vCA3 pyramidal cells were active only on a single arm (see also Fig. 3 and Supplementary Fig. 1). vCA3 interneurons also had multiple firing fields and they strongly differentiated between ingoing and outgoing travels and arm types, similar to vCA3 pyramidal neurons. Two vCA3 interneurons fired differentially in the open and closed arms (with peak firing rates 47 Hz top and 44 Hz right; another is shown in Fig. 3).



Supplementary Fig. 5. Firing patterns of vCA3 neurons in the zigzag maze. Representative vCA3 pyramidal cells and interneurons in different rats (Chr 16-19). Neurons with symmetric firing fields (top group). Note the tendency of this ‘symmetric’ neurons to fire at different locations but at approximately same distance from the goal (water reward) or from start. vCA3 interneurons also show symmetric firing patterns, largely reflecting vCA3 pyramidal cells.



Supplementary Fig. 6. Phase precession of spikes in vCA3 neurons. (A) Examples of theta phase of spike as a function of position in the linearized zig-zag maze for 5 vCA3 neurons and 1 dCA3 neuron. Leftward and rightward directions of travel are shown. LFP from the dorsal hippocampus was used to determine the theta phase of spiking. Right, spike autocorrelograms and theta modulation indices. (B) Distribution of the difference between neuronal and simultaneously recorded LFP theta oscillation frequency. Only neurons with theta indices >0.2 are included (inset). Arrows: population means. (C) Zoomed display for a selected maze segment (red box), with theta phase derived from either dorsal CA1 (left) or local (right) hippocampal LFP.

Supplementary References:

Csicsvari J, Hirase H, Czurko A, Buzsáki G (1998). Reliability and state dependence of pyramidal cell-interneuron synapses in the hippocampus: an ensemble approach in the behaving rat. *Neuron*,21(1):179-89.

Harris, KD., Henze DA, Csicsvari J, Hirase H, and Buzsáki G (2000). Accuracy of Tetrode Spike Separation as Determined by Simultaneous Intracellular and Extracellular Measurements. *J. Neurophysiol*,84: 401-414

Marshall L, Henze DA, Hirase H, Leinekugel X, Dragoi G, Buzsáki G (2002). Hippocampal pyramidal cell-interneuron spike transmission is frequency dependent and responsible for place modulation of interneuron discharge. *J Neurosci*. Jan 15;22(2):RC197.

Maurer AP, Cowen SL, Burke SN, Barnes CA, McNaughton BL (2006). Phase precession in hippocampal interneurons showing strong functional coupling to individual pyramidal cells. *J Neurosci*. Dec 27;26(52):13485-92.

Ranck,J.B., Jr. (1973). Studies on single neurons in dorsal hippocampal formation and septum in unrestrained rats. I. Behavioral correlates and firing repertoires. *Exp. Neurol*. 41, 461-531.