Supplemental Information

Preconfigured, skewed distribution of firing rates in the hippocampus and entorhinal cortex

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Figure S1, related to Figure 1

Brain state-dependent changes of firing rates

(A) Firing rates of hippocampal and EC principal cells and putative interneurons during maze exploration (RUN), REM sleep, immobility (IMM) and slow wave sleep (SWS). Median, lower and upper quartiles are shown. Brackets indicate significant differences ($P < 0.05$, Kruskal-Wallis ANOVA, followed by Tukey's honestly significant difference test).

(B) Firing rate changes of individual neurons across different brain states (mean ± S.E.M). Firing rate ratio of each neuron was calculated as the difference between firing rates of two brain states divided by the sum. Note unique constellations of rate shifts in principal cells and interneurons across states. Directions of firing rate changes in upstream principal neurons (e.g., EC2 and EC3) do not predict rate changes in their downstream targets (CA1, CA3 and DG). Note that the brain state-dependent firing rate changes of principal cells and interneurons within the same layer were mostly uncorrelated.

(C and D) Firing rate distribution of principal cells (C) and interneurons (D). Dots, data; Lines, lognormal fit. Note similar brain state-dependent changes of rate distributions in the various hippocampal regions and EC layers. CA1 data is the same as in Figure 1B.

Figure S2, related to Figure 2

Spike bursts of principal cells in different brain states

(A) Burst event rate and burst index in different hippocampal regions and EC layers. Median, lower and upper quartiles are shown. Brackets indicate significant differences ($P < 0.05$, Kruskal-Wallis ANOVA, followed by Tukey's honestly significant difference test).

(B) Burst index as a function of log firing rate in different states for principal cells in hippocampal regions and EC layers.

(C) Correlation coefficients (R) between log rate and burst index. Only significant correlations ($P < 0.05$) are shown.

Figure S3, related to Figure 3

Distribution of firing rates in place cells

Distribution of peak firing rates and mean within-field firing rates of CA1 and CA3 pyramidal cells on the square maze. Each row represents the different place field criteria. The histograms of the bottom row are the same as Figure 3.

Figure S4, related to Figure 4

Firing rates are correlated with place cell features

Relationship between log firing rate during RUN and number of place fields (A), place field size (B) and phase precession slope (C) for CA1 and CA3 pyramidal cells. (A) and (B), data from the open field, (C) data from the linear track (Mizuseki et al., 2009).

Figure S5, related to Figure 5

Distribution of ripple-related firing patterns

(A-*C*) Top, example of wide-band signals, ripple-band filtered (140-230 Hz) signals and spiking activity of a CA1 principal neuron. Ripple epochs are shadowed. Middle and bottom, distribution of CA1 pyramidal neurons and interneurons during SWS and IMM.

(A) Proportion of spikes of CA1 pyramidal cells and interneurons emitted during ripple relative to all spikes during SWS and IMM.

(B) Proportion of ripples in which the neuron fired at least one spike.

(C) Mean number of spikes per ripple event.

Figure S6, related to Figure 6

Firing rates of the same principal neurons in two different mazes are correlated

(A-C) Example of CA3 pyramidal neurons simultaneously recorded during both linear and square maze sessions on the same day.

(A) Comparison of firing rates in linear maze (250 cm long) and square maze (120 x 120 cm). Firing rates are significantly correlated at both linear (left) and log (right) scales.

(B) Comparison of firing rates during ambulation in the opposite directions on the linear maze. In (A) and (B), each dot represents a single CA3 pyramidal neuron recorded from single linear and square maze session.

(C) Firing rate map of CA3 pyramidal cells shown in (A) and (B). Color code, firing rate of the neuron.

Figure S7, related to Figure 7

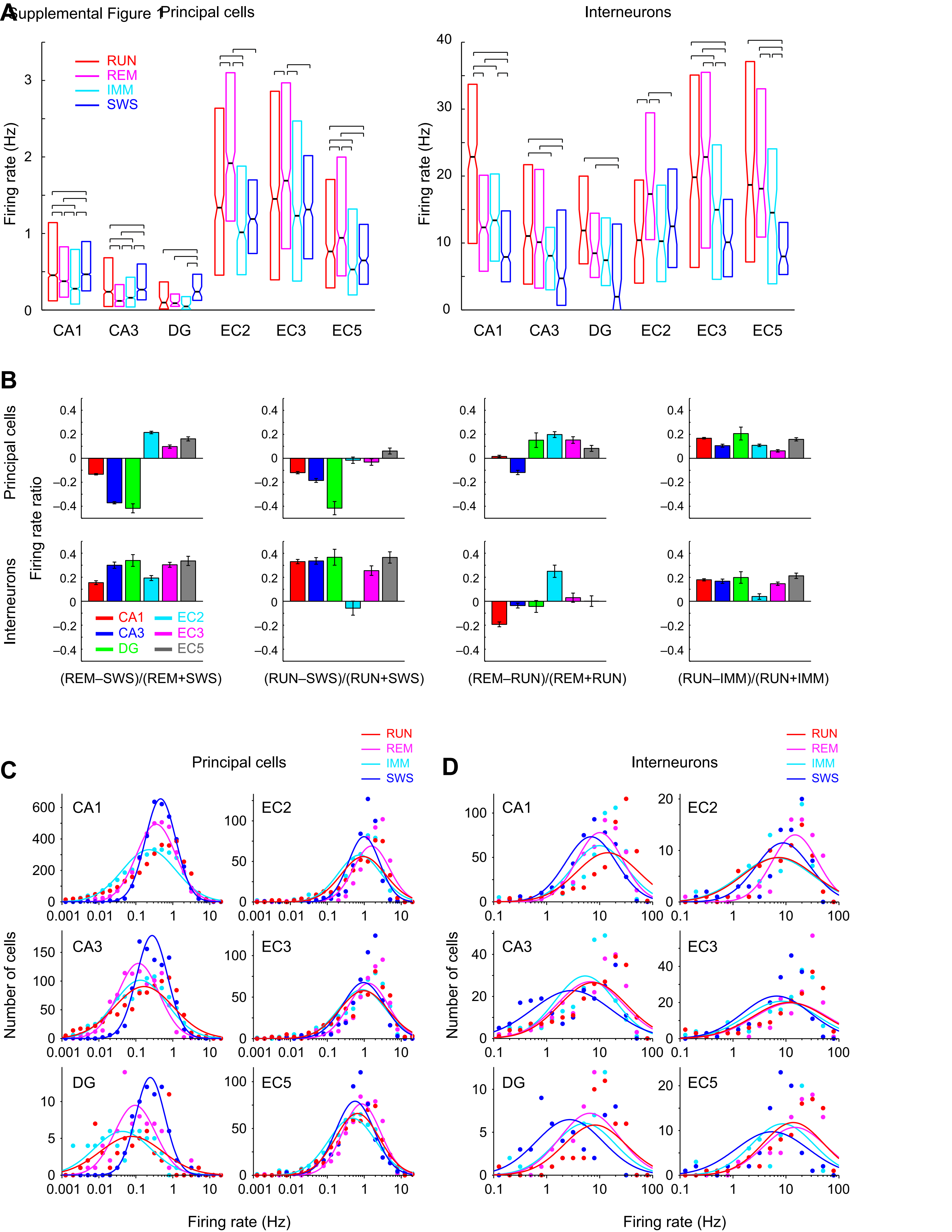
Probability of spike transmission from principal neurons to interneurons

(A) Spike transmission probability distributions in different brain states in different brain regions. Neuron pairs from all EC layers were combined. CA1 data is the same as Figure 7B.

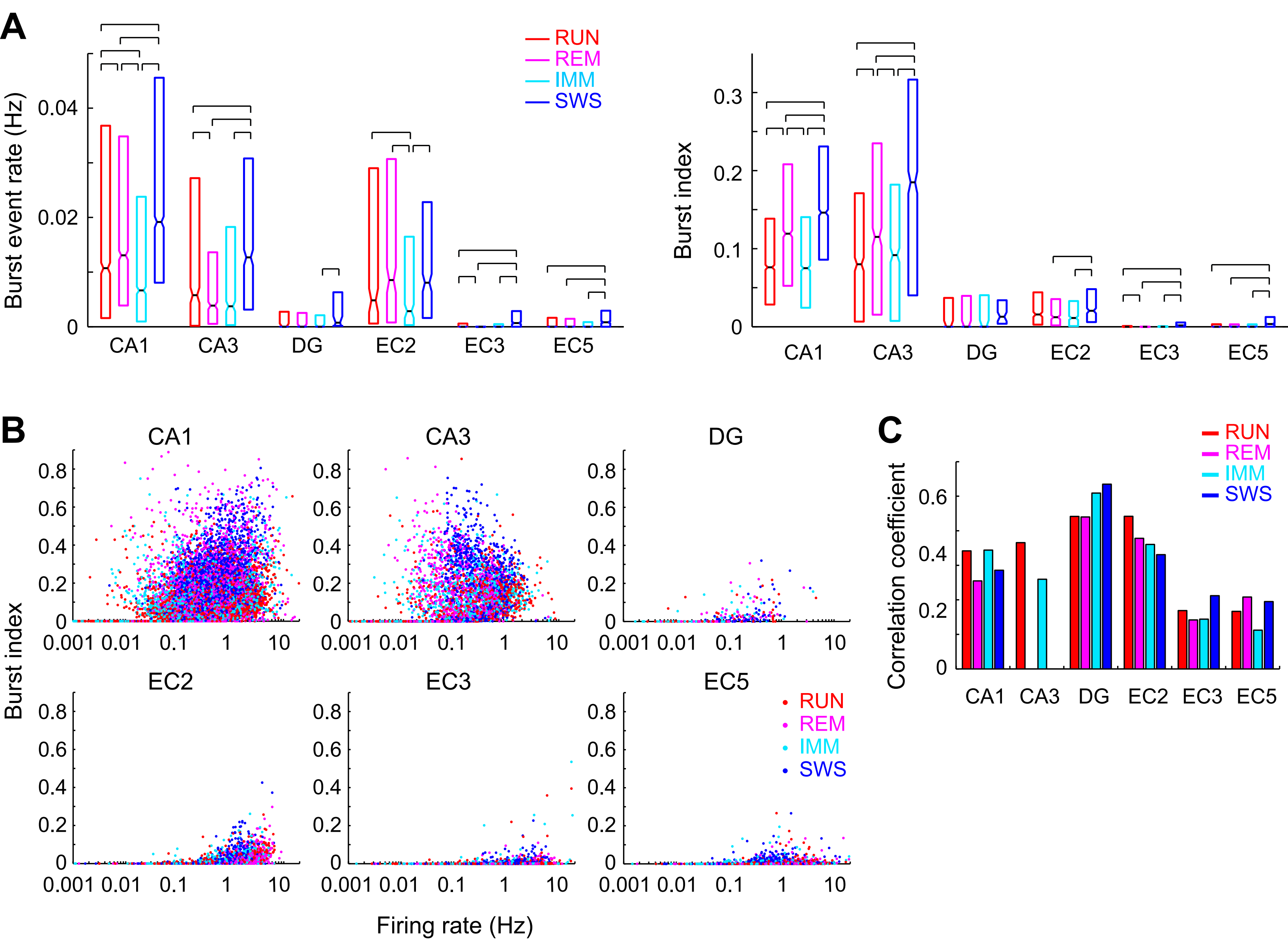
(B) Spike transmission probability of individual cell pairs varies across states in a region-specific manner. Probability changes of spike transmission between principal cells and interneurons across different brain states. Probability ratio of each cell pair was calculated as the difference between spike transmission probabilities of two brain states divided by the sum. Mean and SEM for CA1, CA3 and EC regions are shown separately. Significance is based on t-test.

(A) and (B), Neuron pairs from all EC layers were combined.

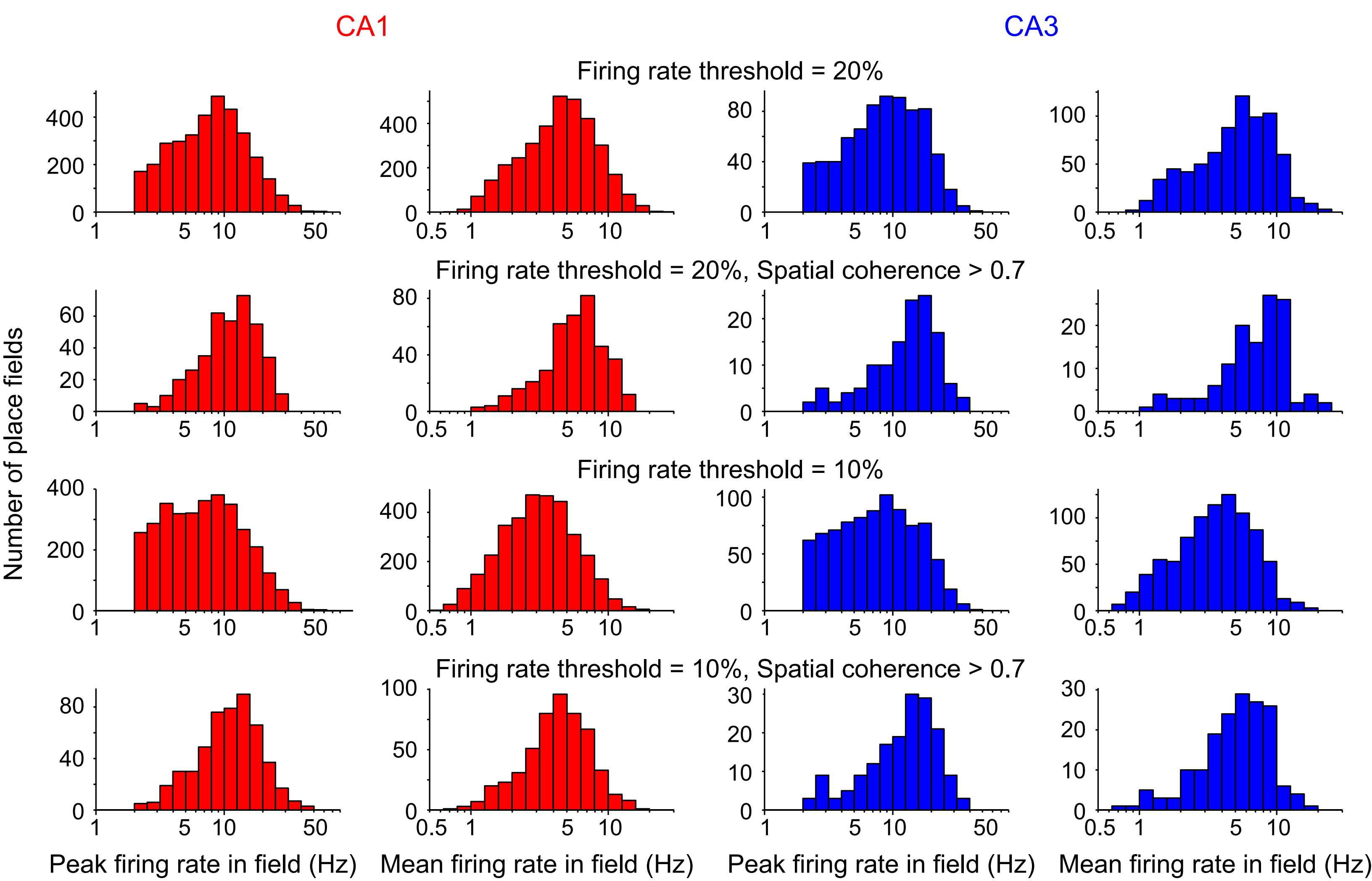
Supplemental Figure 1



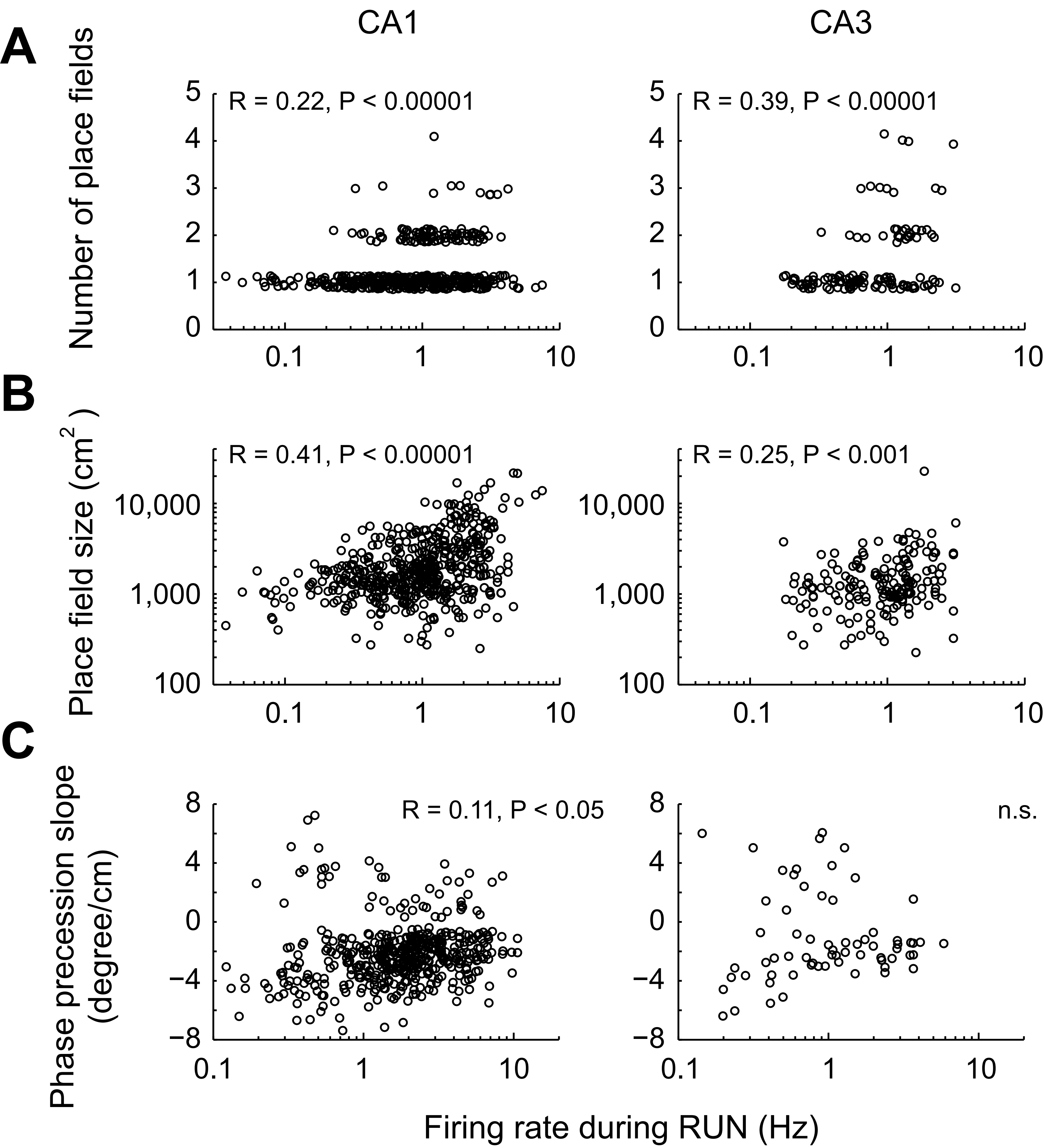
Supplemental Figure 2



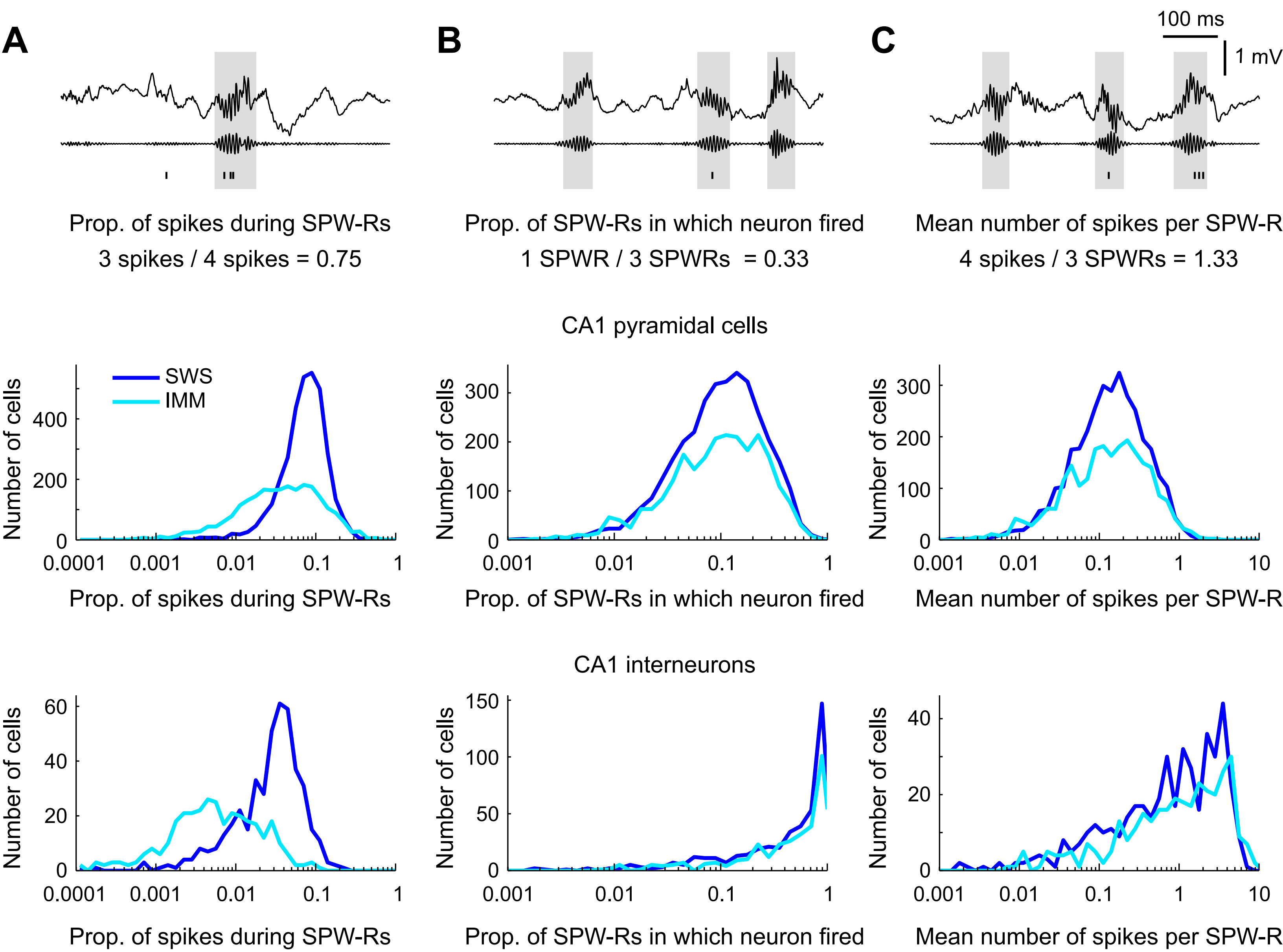
Supplemental Figure 3



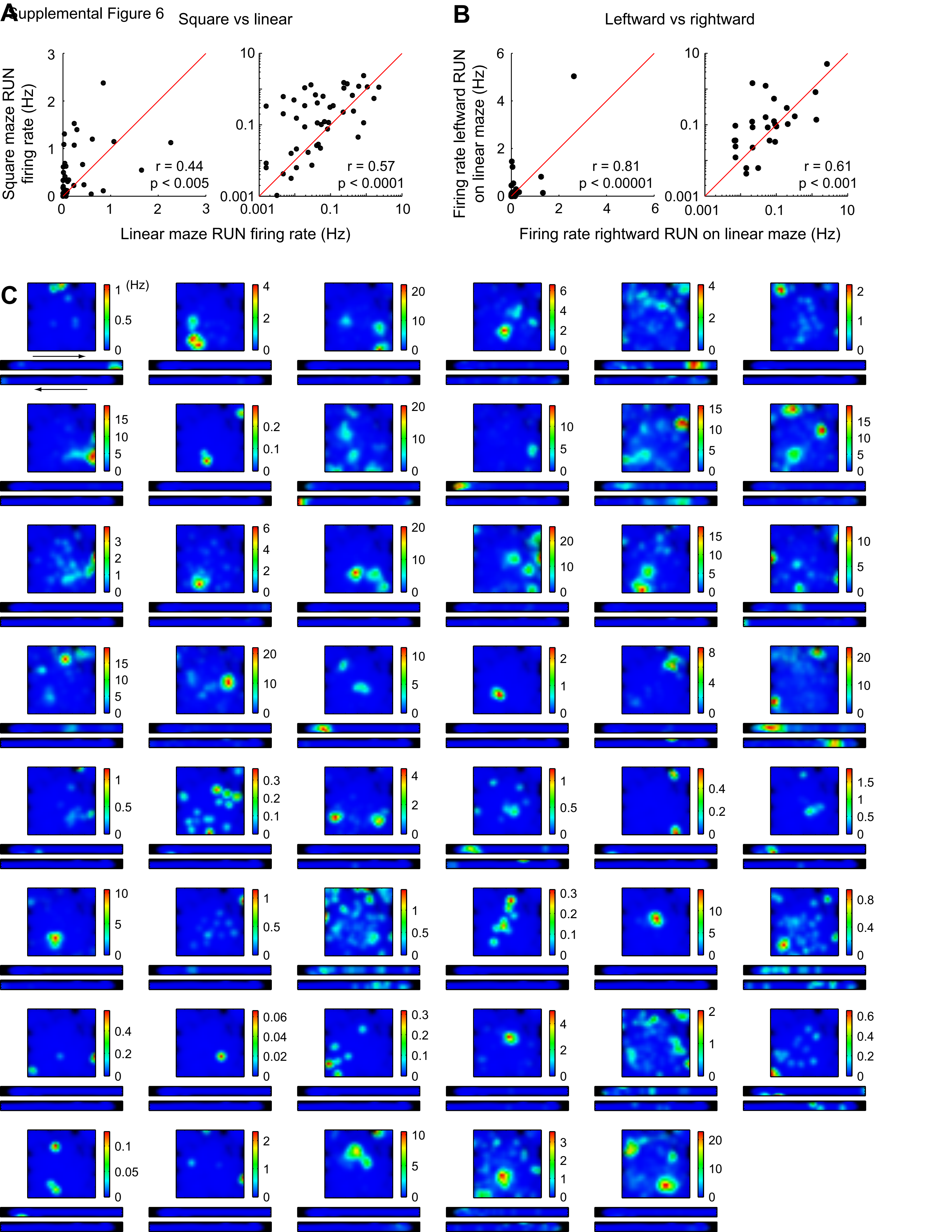
Supplemental Figure 4



Supplemental Figure 5



Supplemental Figure 6



Supplemental Figure 7