Supplemental figures

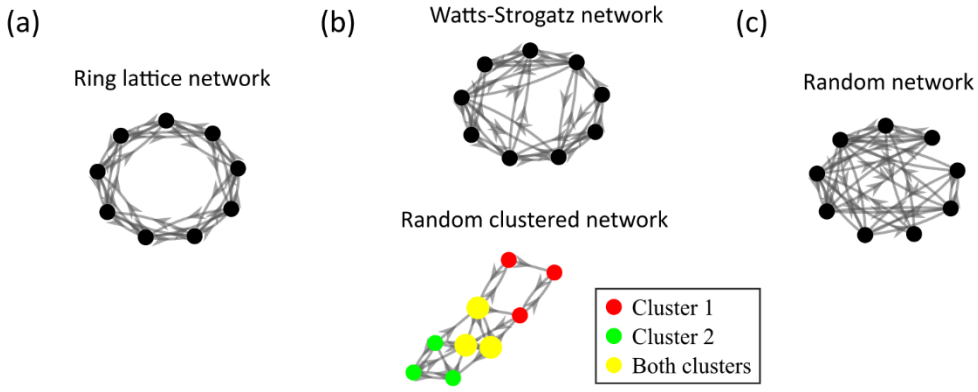

Figure 1—figure supplement 1: Comparison of the randomly clustered network and the canonical Watts-Strogatz small-world network
(a) A small ring-lattice network. **(b)** Example small-world networks. Top, a Watts-Strogatz network with re-wiring parameter $\beta = 0.2$. Bottom, a randomly clustered network with two clusters and a cluster participation of 1.25. **(c)** Example randomly connected network.

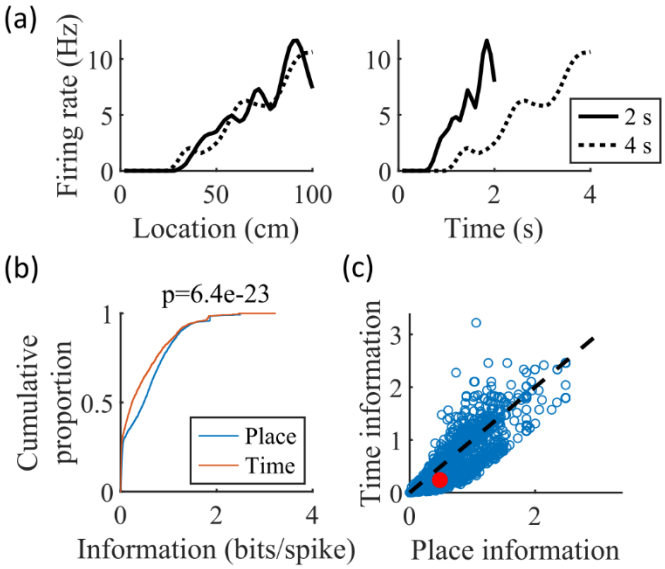

Figure 3—figure supplement 1: The simulated cells have greater place information than time information.
(a) Place fields (left) and time fields (right) for an example cell calculated from simulated trajectories that took 2 seconds (solid line) or 4 seconds (dotted line) to traverse the track. **(b)** CDFs of the information content of the place fields ("Place") and time fields ("Time") of all cells. The spatial information is significantly greater than the temporal information (KS-test, p=6.4e-23). **(c)** Scatter plot of the data in (b), with the median values marked in red.

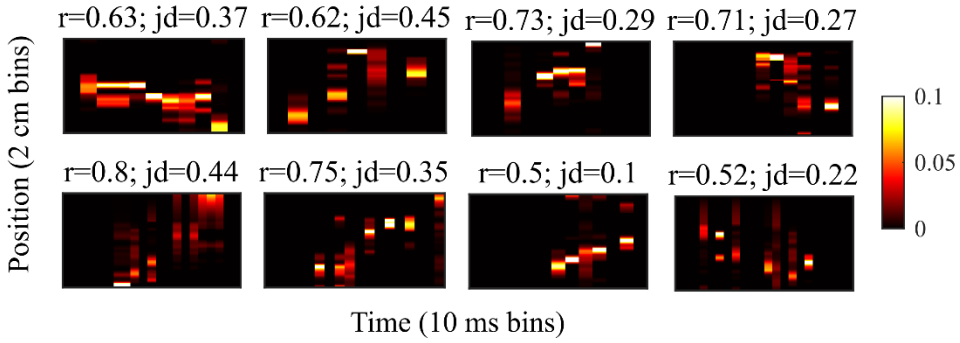

Figure 4—figure supplement 1: Example preplay events from the Shin et al., 2019 data

Example preplay events. Same as Figure 2f but for events from the hipopcampal data from Shin et al., 2019. The height of each plot spans the length of the trajectory used for decoding, divided into 2 cm spatial bins. The width of each plot spans the duration of the detected event, divided into 10 ms time bins. Probability is show in color.

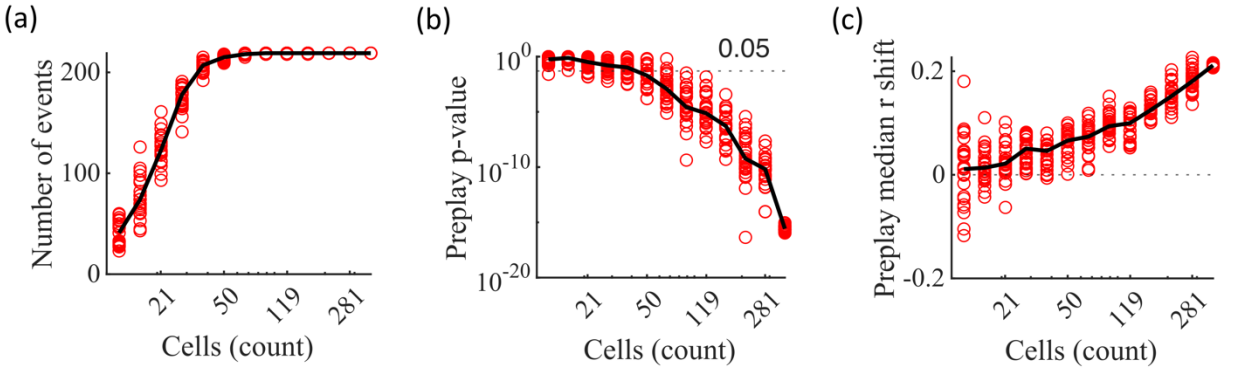

Figure 4—figure supplement 2: Significant preplay can typically be identified with as few as 50 cells

(a-c) Results from performing the same Bayesian decoding on the same simulated population burst events (PBEs) in Figure 4c but using only random subsets of the excitatory cells for performing the decoding analysis. Each circle is the result of an analysis performed on one random subset of the cells. 25 random subsets were analyzed for each analyzed cell count. The subset sizes are logarithmically spaced. Black lines show the median value. The variability at N=375 is due to the variation in the randomness of the time-bin shuffles**. (a)** Number of events meeting the inclusion criterion for decoding analysis. **b)** P-value of the KS-test comparing actual vs shuffled event absolute weighted correlations. A majority of the random subsets of 50 cells (17 out of 25) produce preplay p-values below 0.05. **(c)** Shift in the median absolute weighted correlation of actual events relative to shuffled events.

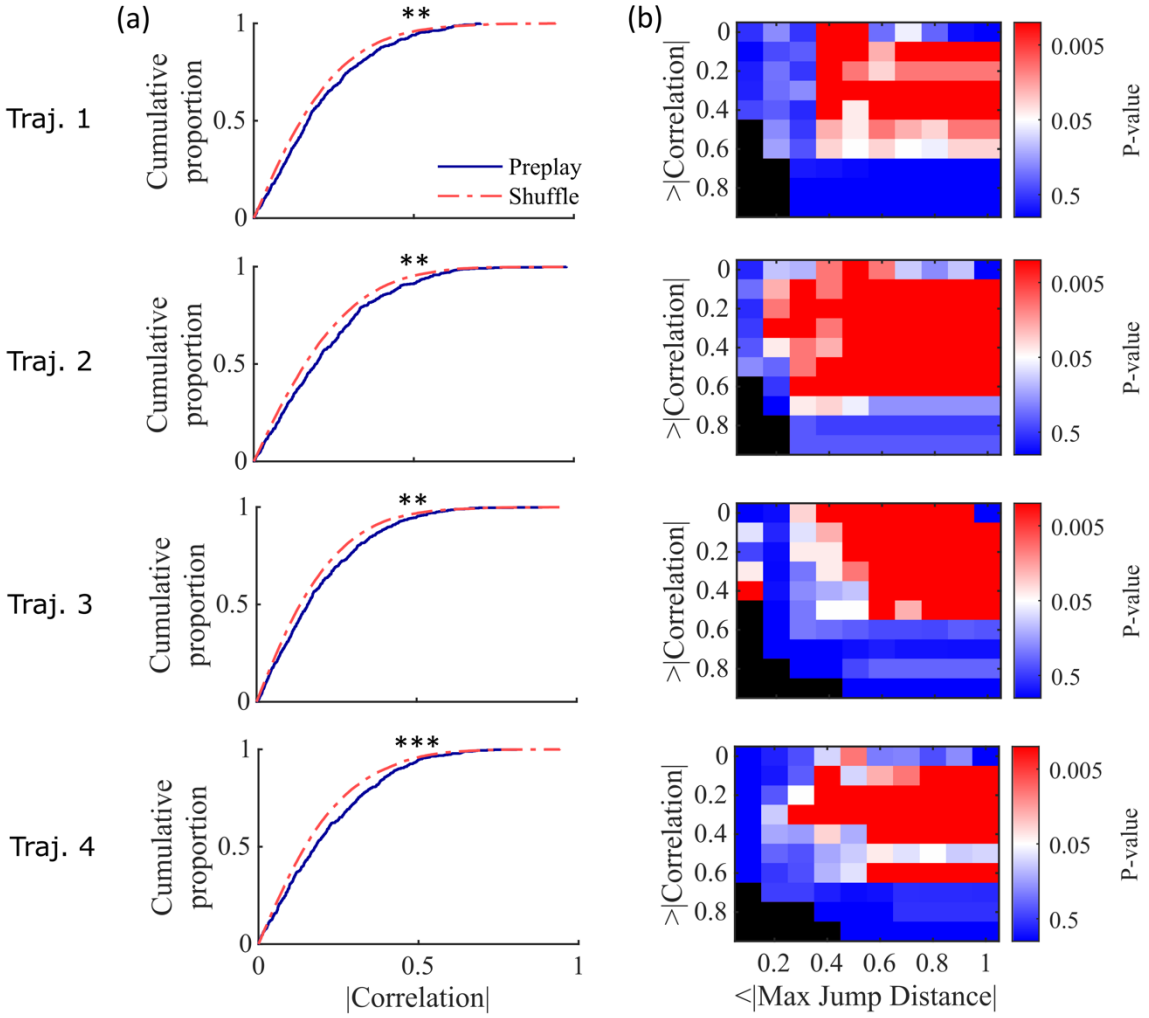

Figure 4—figure supplement 3: Preplay statistics by trajectory for Shin et al., 2019 data.

(a) Same as Figure 4a but separated by results from decoding by each of the 4 trajectories of the W-track individually (trajectory 1, center arm to right arm; trajectory 2, right arm to center arm; trajectory 3, center arm to left arm; trajectory 4, left arm to center arm). KS-test for each trajectory: trajectory 1, p=0.0030; trajectory 2, p=0.0028; trajectory 3, p=0.0027; trajectory 4, $p=5.461\times10^{-5}$. ** p<0.01, *** p<0.001. **b)** Same as Figure 4b but separated by results from decoding by each of the 4 trajectories individually.

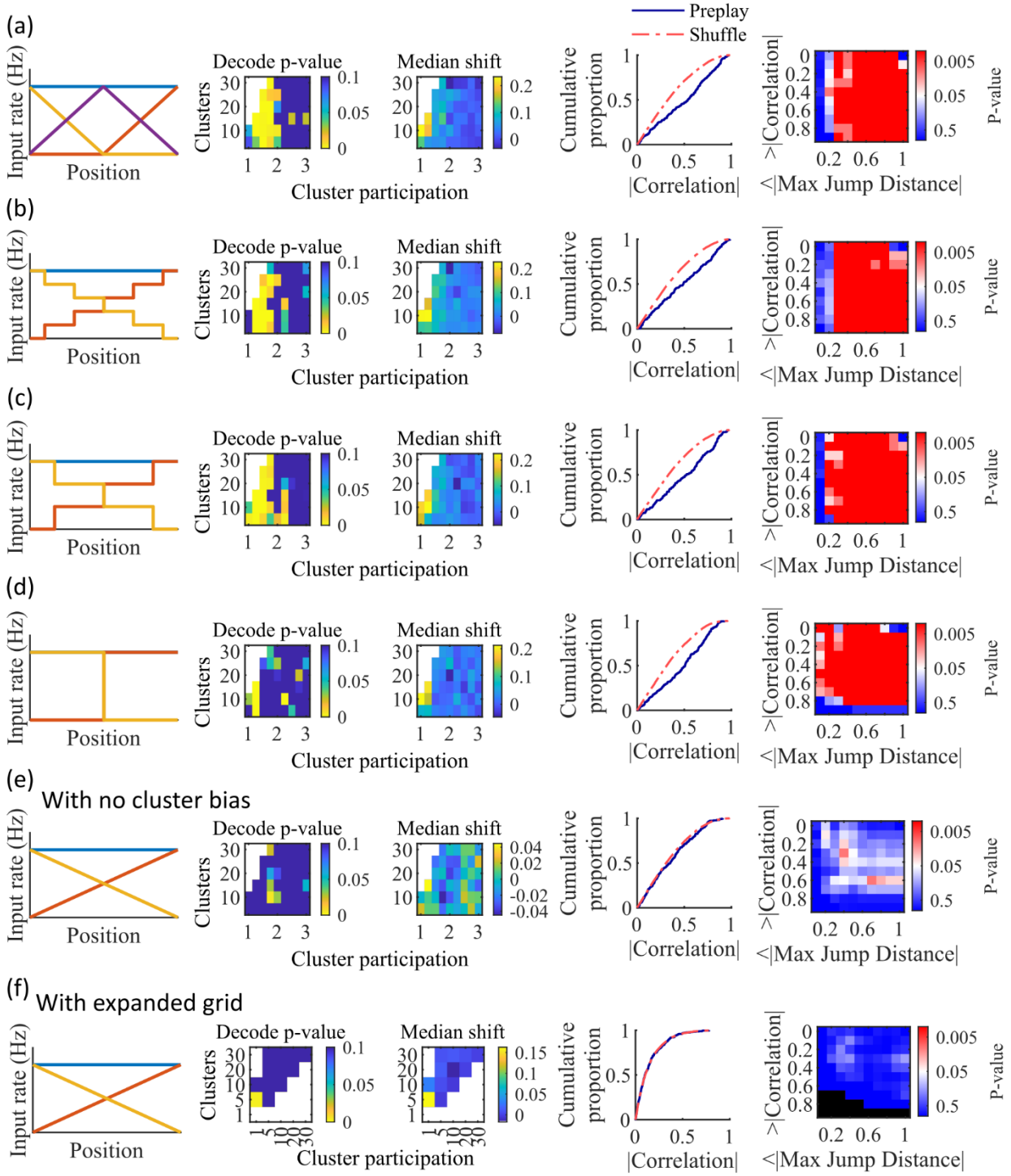

Figure 4—figure supplement 4: Additional simulations support the consistency and robustness of the model to variations in spatial input forms.
Each row corresponds to a different parameter grid simulation, with statistics calculated as in the corresponding panel from Figure 4. **(a)** Preplay statistics are similar to the main

simulation results when a third linearly varying spatial cue is included in the inputs to the network (CDF KS-test, p=3.9e-13, KS-statistic=0.26). **(b)** Preplay statistics are similar to the main simulation results when a stepped input is used (CDF KS-test, p=2.5e-08, KS-statistic=0.20). The stepped input is less spatially informative since stretches of adjacent locations on the track have identical spatial input. **(c)** Same as (b), but with three step increments (CDF KS-test, p=6.2e-13, KS-statistic=0.26). **(d)** Same as (c), but with a single step increment (CDF KS-test, p=4.9e-13, KS-statistic=0.26). With this input the fiducial parameter set still shows significant preplay (right two columns), but most of the parameter grid loses significant preplay. **(e)** When the bias in cluster spatial input location is removed preplay is no longer significant (CDF KS-test, p=0.34, KS-statistic=0.063). **(f)** A parameter grid that shows greater values of cluster participation do not have significant preplay. Values along the diagonal where clusters equals cluster participation are equivalent to a random cluster-less network. Example parameter point is at clusters=5 and cluster participation=5 (CDF KS-test, p=0.99, KS-statistic=0.02).

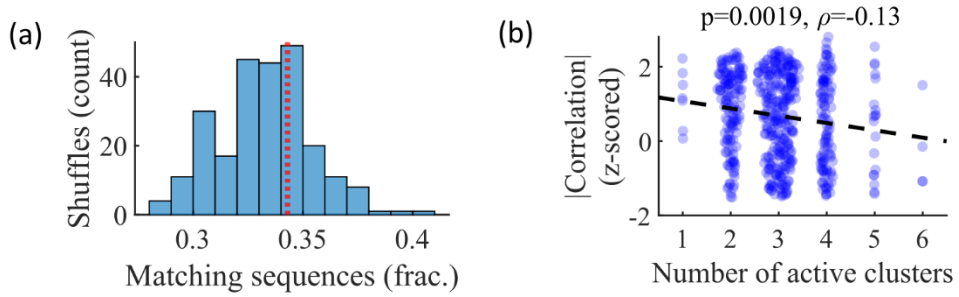

Figure 5—figure supplement 1: Relationship between cluster activation and preplay. **(a)** Out of all events from the fiducial parameter set simulations where 3 unique clusters were active, the fraction of those events with sequences that match the order of cluster biases on the track (red line) is consistent with the values expected by randomly sampling clusters (blue). **(b)** Z-scored absolute weighted preplay correlation is negatively correlated with the number of active clusters (Spearman's rank correlation).