

Figure S1: Details of Calcium Imaging (Related to Figure 1)

- A) Histological confirmation of recording location, showing the presence of GCaMP6f primarily localized to dorsal CA1. Note the intact cell layer below where superficial cortex was removed to enable insertion of the GRIN lens. Blue = DAPI, Green = GCaMP6f
- B) Example imaging window. Light areas indicate regions of background fluorescence. Dark lines indicate blood vessels. Scale bar = 100 µm.
- C) Maximum projection of imaging window for mouse in b with all neuron ROIs overlaid in red. Scale bar = 100 µm.

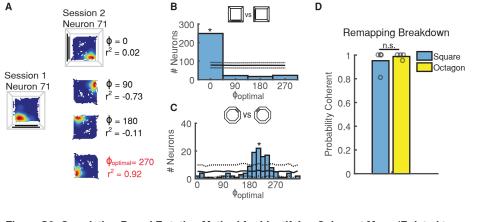
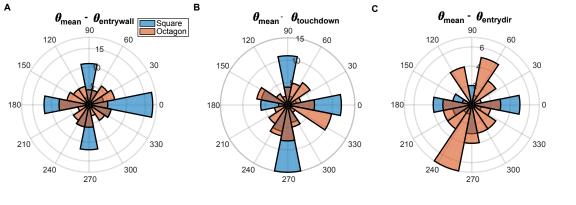


Figure S2: Correlation Based Rotation Method for Identifying Coherent Maps (Related to Figure 2)

- A) Methodology for identifying the angle of rotation of a neuron's spatial firing between sessions. The correlation between calcium event maps for session A and session B was calculated after rotating the mouse's trajectory in session B by the angle ϕ in 90 degree increments in the square and 15 degree increments in the octagon. ϕ_{optimal} was defined as the rotation that maximizes the correlation between calcium event maps. This method is less sensitive than the center-out method (Figure 2B, Methods) because the minimum angle change it can resolve is equal to the increments of ϕ noted above (90 degrees in the square and 15 degrees in the octagon). However, it does not require making any arbitrary assumptions required to identify place fields.
- B) $\phi_{optimal}$ distribution between two sessions recorded the same day in the square arena. Clustering of $\phi_{optimal}$ values at 0 degrees indicates coherent mapping between sessions. Black solid line = shuffled distribution mean, black dashed line = 95% CI of shuffled distribution. *p = 0, χ^2 = 8.4e4, df = 3.
- C) $\phi_{optimal}$ distribution between two sessions recorded the same day in the octagon arena. Clustering of $\phi_{optimal}$ values at ~210 degrees indicates coherent mapping between sessions. Same conventions as B. *p = 0, χ^2 = 6.1e4, df = 23.
- D) Probability of session-pairs utilizing a coherent map in each arena. Open circles indicate proportions for each mouse. p = 0.46, Wilcoxon rank-sum test.



A) Circular histogram of mean place field rotation (θ_{mean}) between sessions minus the angle difference between the mouse's entry walls ($\theta_{entrywall}$). If mice utilized the wall over which they entered the arena to anchor their place field maps between sessions, then the distribution should cluster around 0. Since values do not preferentially cluster at 0 over other orientations, we conclude that mice do not utilize the wall over which they entered the arena to orient their place field maps between sessions. p = 0.12 (square), p = 0.25 (octagon) shuffle-test.

Figure S3: The Direction of Mouse Entry to the Arena Does Not Predict Coherent Place Field Rotations (Related to Figure 3)

B) Mouse orientation upon touching the arena floor does not dictate coherent place field rotations. Same as A, but for mouse orientation when his paws first touch the floor ($\theta_{louchdown}$), p = 0.06 (square), p = 0.31(octagon) shuffle-test.

C) Mouse orientation while crossing over the entry wall does not dictate coherent place field rotations. Same as A, but for mouse orientation (nose direction) upon first crossing into the arena while being carried ($\theta_{entrydir}$). p = 0.57 (square), p = 0.15 (octagon) shuffle-test.

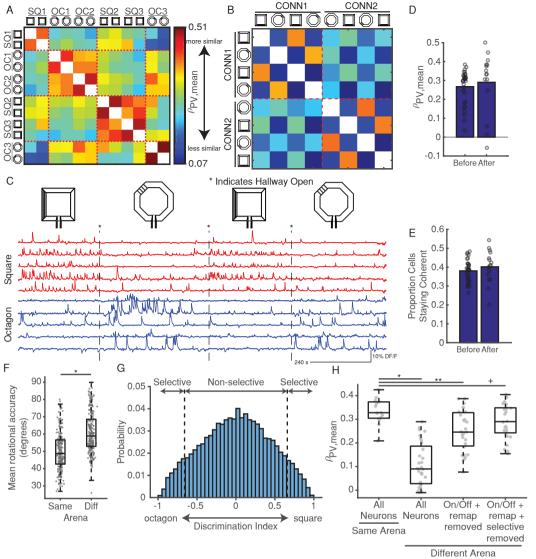


Figure S4: Neuronal Population Segregation (Related to Figure 4 and Figure 5)

- A) Mean PV similarity between all non-connected sessions in each arena, sorted chronologically. Same color scheme as Figure S4B (and 4D).
- B) Mean PV similarity between all sessions in each arena on connected days, sorted chronologically. Same color scheme as Figure S4A (and 5A).
- C) Neurons modulate calcium event rate between arenas. Example neuron traces during arena connection (CONN1). Arena occupied by the mouse indicated at top. Traces are color coded as follows: red = highly selective for square, blue = highly selective for octagon. Vertical dashed lines denote time points when the mouse crossed between arenas via the hallway.
- D) Mean PV similarity between arenas does not change from before to after arena connection. Open circles = mean PV for all mice/session-pairs exactly one day apart. p = 0.23, Wilcoxon rank-sum test.
- E) Proportion of cells staying coherent between sessions from before to after arena connection. Open circles = proportion all mice/session-pairs exactly one day apart. p = 0.22, Wilcoxon rank-sum test.
- F) Place fields rotate less accurately between different arenas than in the same arena. Close circles = mean rotational accuracy of all place fields between sessions <= 6 days apart. *p = 8.7e-21, Wilcoxon rank-sum test.
- G) Neurons active in both arenas modulate calcium event rates in both directions between different arenas, as indicated by the spread of Discrimination Index values from -1 (active only in the octagon) to 1 (active only in the square). All mice/session-pairs (On/Off cells excluded for clarity, see Figure 5F). Dashed lines denote extent of neurons that are active in each arena but "selective" for one arena versus the other (i.e. those neurons that produce at least 66% more calcium events in one arena than the other).
- H) On/Off neurons, random remapping neurons, and "selective" neurons (see S4G) all contribute to PV discrimination between arenas during connection, since the neuronal population fails to distinguish between arenas only when all three subpopulations are removed from the PV. *p = 6.2e-8, **p = 0.0016, *p = 0.072 (n.s.) Wilcoxon rank-sum test.

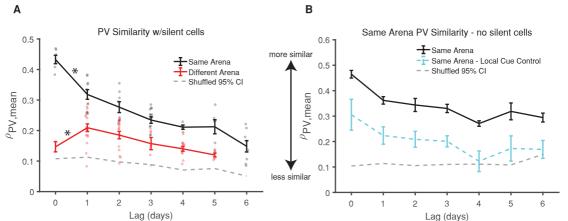


Figure S5: Population Similarity Versus Time (Related to Figure 6)

A) PV correlations at $\phi_{optimal,p}$ vs. time between sessions including silent cells. The distribution of PV correlations remains above chance at each time point, indicating the population remains coherent at short and long time lags even with neurons becoming silent/active between sessions. Black = same arena, red = different arena, gray dashed = upper 95% CI from shuffled distribution. Colored dots indicate mean PV correlation of each session-pair across all mice. Error bars indicate s.e.m. *p < 0.001, Student's t-test of mean PV vs. chance at all time lags.

B) Assuming mice use local clues exclusively for orientation produces low PV correlations. Black = same arena PV correlations at $\phi_{\text{optimal,p}}$. Blue dashed = same arena PV correlations with place fields calculated after rotating mouse trajectories such that arena cues are aligned between sessions (assumes mice utilize local cues for place field alignment), gray dashed = upper 95% CI from shuffled distribution. Error bars indicate s.e.m.