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Supplemental Information

Hippocampal SWR Activity Predicts Correct Decisions during the Initial Learning of an Alternation Task

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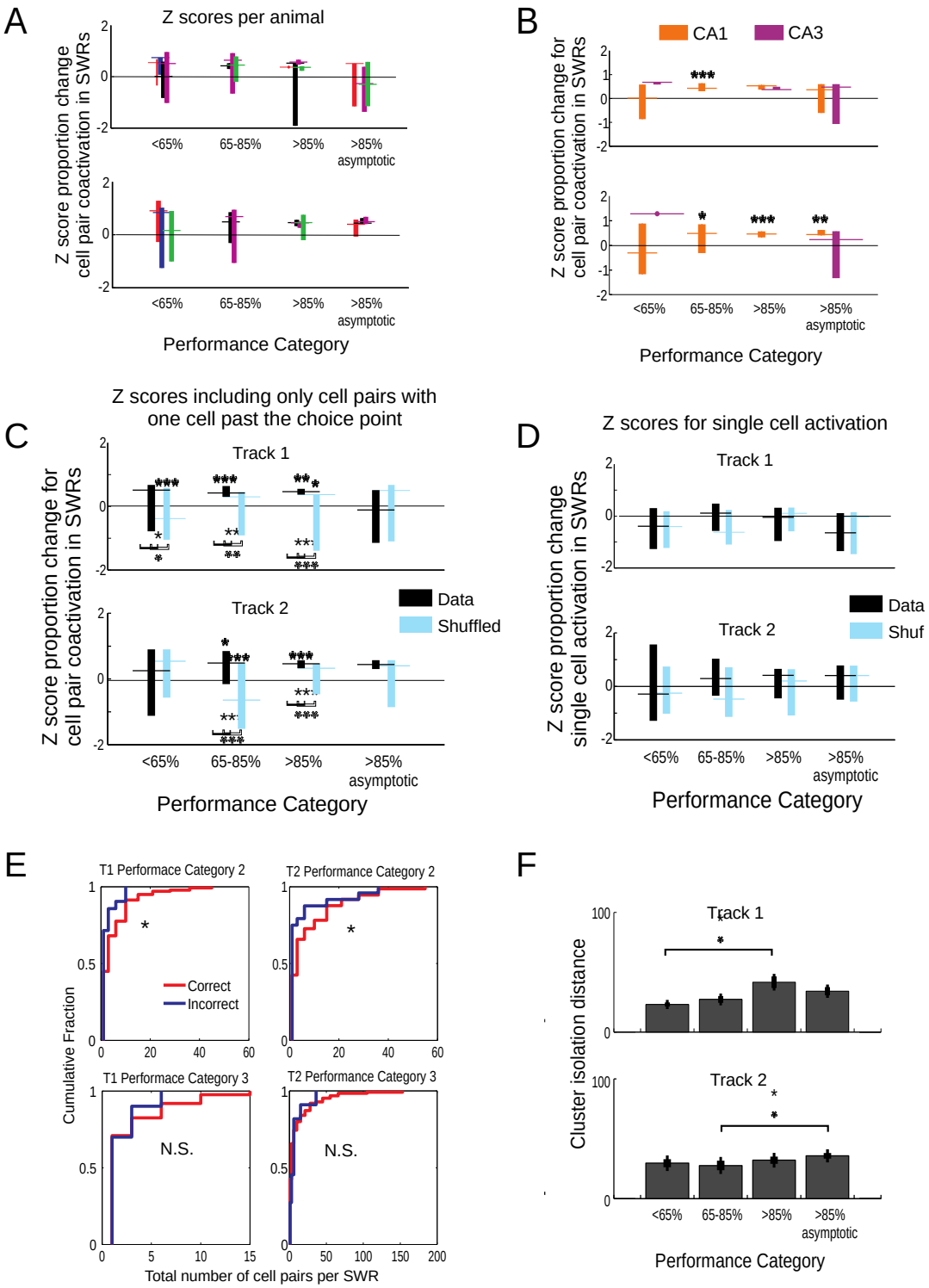

Figure S1. Comparison of activity preceding correct and incorrect trials. Related to Figures 2 and 5. A. Per animal Z score for the difference in proportion of SWRs in which each cell pair was active preceding correct and incorrect trials across performance categories. Performance categories are as follows: 1 – the first session in which the animal performed at

less than 65% correct, 2 – the first session between 65 and 85 percent correct, 3— the first session greater than 85 percent correct, and 4 – the first of subsequent sessions greater than 85 percent correct. Bars indicate upper and lower quartiles, horizontal line shows median for T1, top, and T2, bottom. For the per-animal plots bars and medians are shown only if there were at least 5 cell pairs included. The colors per animal are the same used in Figure 1b,c. **B.** Z scores for the difference in proportion of SWRs in which each cell pair was active preceding correct and incorrect trials across performance categories for cells in CA3 (purple T1: 3, 0, 7, 17 cells, T2: 1, 0, 0, 15 cells for performance categories 1-4, respectively in 3 animals) or CA1 (orange T1: 155, 217, 64, 20 cells, T2: 23, 154, 314, 63 cells for performance categories 1-4, respectively in 5 animals)**. C.** SWR coactivation probability of cell pairs with place fields past the CP is enhanced preceding correct trials during task acquisition. The plot shows Z scores for the difference in proportion of SWRs in which each cell pair was active preceding correct and incorrect trials across performance categories, only including cell pairs with at least one cell with a place field peak past the CP. The same trends are seen as when all cell pairs are included, although with this more limited dataset, the difference there is also a significant effect for T1, performance category 1. As this was not present for T2, performance category 1, we did not consider this to be a reliable effect across datasets. **D.** Z score for the difference in proportion of SWRs in which each single cell was active preceding correct and incorrect trials across performance categories for T1, top, and T2, bottom. There were no significant differences for individual track / performance category combinations (p's > 0.02 which is not significant when taking into account multiple comparisons, T1: 43, 45, 48, 61 cells, T2: 24, 28, 39, 67 cells for performance categories 1-4, respectively). Thus, differences in single cell activation probabilities cannot account for the pairwise results. This analysis included all cells with place fields on the track, but the results were statistically indistinguishable when we included only those cells that were included in at least one pair for the pairwise analysis. **E.** Number of cell pairs activated in SWRs preceding correct (red) and incorrect (blue) trials in T1 performance category 2 (top left), T2 performance category 2 (top right), T1 performance category 3 (bottom left), and T2 performance category 3 (bottom right). We first noted that were no consistent differences in the number of single cells active per SWR before correct and incorrect trials (Komolgorov-Smirnov tests, p's > 0.2 for T1 performance category 2 & 3 and T2 performance category 3; $p = 0.0265$, T2 performance category 2). At the same time, because the number of coactive pairs increases in a combinatorial fashion with the number of active cells, we also examined the number of cell pairs activated per SWR. This analysis examines the total number of pairs, but does not examine the number of times a specific pair was active. We found that there were marginally significantly more cell pairs activated during SWRs for data from T1 and T2, performance category 2 (p's < 0.02), but no significant differences for T1 and T2, performance category 3 (p's > 0.4). Thus, overall differences in the number of cell pairs activated during SWRs could contribute to the differences in z-scores for performance category 2 and the trial-by-trial predictions of correct choices, but cannot account for the differences in z-scores from performance category 3. As a reminder, the z-score analyses examine differences in coactivation for specific pairs, and the lack of significance for the total number of cell pairs activated suggests that the z-score results are driven by particular pairs that were coactivated strongly during SWRs preceding correct trials. This finding is consistent with the data plotted in Fig. 1H, which shows strong coordinated activity preceding correct, but not incorrect, trials. **F.** Isolation distance for all cells included in the analysis across performance categories. While isolation distance differed between some Track / performance category pairs, these differences could not explain our observations of greater coactivation probability specifically for 65-85% and >85% correct performance categories. * $p < 0.015$, ** $p < 0.001$, *** $p < 0.0001$. Stars above a bar indicate comparison to zero, stars between bars indicate comparison between real and shuffled data.

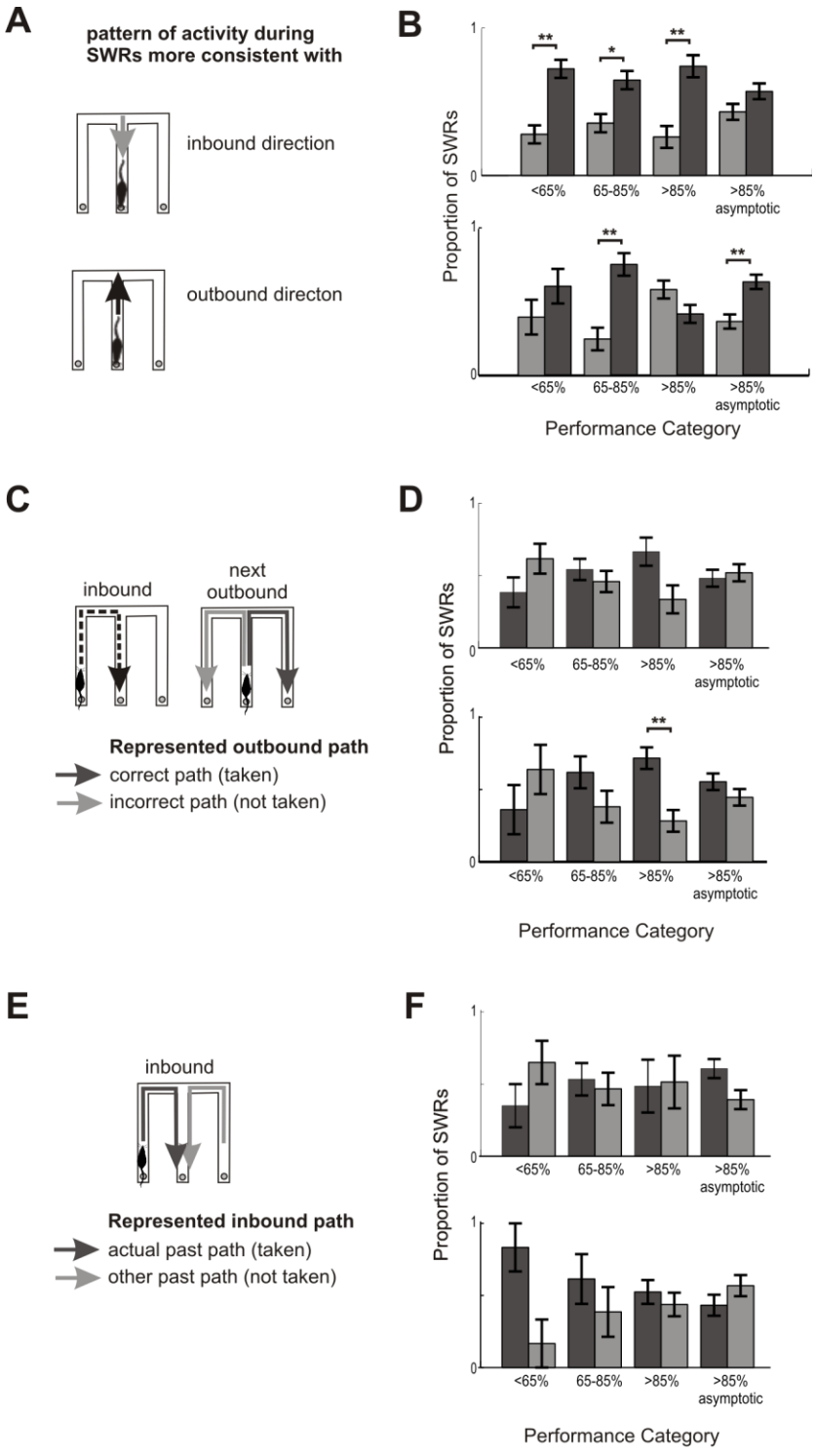

Figure S2. Related to Figure 6. SWR reactivation contains information about possible trajectories. A. Diagram of inbound (grey arrow) and outbound (black arrow) trajectory directions. **B.** Proportion of SWRs per trial in which the order of cells active during the SWR was more consistent with outbound (dark grey) or inbound (light grey) directions in T1, top, and T2, bottom. **C.** Diagram of an example inbound trial and the subsequent correct future trajectory (dark grey arrow) and incorrect future trajectory that was not taken (light grey arrow). **D.** Proportion of SWRs per trial in which cells active during SWRs have more place field activity on the future correct (dark grey) or future incorrect (light grey) trajectory in T1, top, and T2, bottom. **E.** Diagram of a most recent past trajectory (dark grey arrow) and the other possible past trajectory (not taken; light grey arrow). **F.** Proportion of SWRs per trial in which cells active during SWRs have more place field activity on the most recent past (dark grey) or other (light grey) trajectory in T1, top, and T2, bottom. * $p < 0.05$, ** $p < 0.005$, *** $p < 0.0005$. Only trials in which at least 1 SWR met criteria for analysis were included. Past comparison: p's > 0.015 which is not significant when taking into account multiple comparisons; T1: 10, 15, 7, 48 SWRs, T2: 6, 7, 26, 42 SWRs for <65%, 65%-85%, >85%, and >85% asymptotic, respectively.

Table S1. Number of trials per animal per performance category. Related to Figures 2 and 3.

Animal	Track	<65% Inc.	<65% Corr.	65-85% Inc.	65-85% Corr.	> 85% Inc.	> 85% Corr.	85% asymp. Inc.	85% asymp. Corr.
1	1	2	4	0	4	2	11	10	45
1	2	4	4	0	0	0	0	10	70
2	1	2	3	2	4	4	15	15	39
2	2	8	3	6	8	6	15	0	0
3	1	1	1	0	5	4	17	3	20
3	2	0	0	2	11	2	14	5	14
4	1	3	4	3	4	1	3	5	33
4	2	0	0	2	3	1	7	4	16
5	1	0	1	1	3	2	10	6	33
5	2	2	2	0	0	1	6	1	10
Totals	1	8	13	6	20	13	56	39	170
Totals	2	14	9	10	22	10	42	20	110

Trials were only included in the analyses if there was at least one coactive cell pair that where both cells fired during an SWR. Incorrect: Inc., Correct: Corr., asymptotic: asymp.