Table S1. Animals and testing sessions in post-training, related to Results and STAR Methods. Number: the number of testing sessions under a behavioral condition. Blank: no experiments conducted under this condition.

All testing sessions were conducted after the animals reached the criterion performance under the standard Demo condition in training. For the 6 recorded rats, the tetrode implantation surgery was performed after training. About 2 weeks after the surgery, the rats were re-trained (2 - 3 sessions per rat) under Demo back to the criterion performance without neural recording before testing sessions with recording began. For the rats with infusion, the infusion surgery was performed after training (if animals were tested under behavioral conditions other than the Demo condition, they were re-trained back to the criterion performance before the infusion surgery) and further testing sessions under Demo began 2 weeks after the infusion surgery.

Animal ID	**Neural recording**				**No neural recording**					**NMDA infusion**	**Vehicle infusion**
	Demo	**Object**	**Empty**	**Blocked view**	**No lick**	**Mixed bedding**	**Blocked view**	**Object**	**Empty**	**Demo**	**Demo**
Rat1	6		2								
Rat2	3		2								
Rat3	3			2							
Rat4	5	2	2				2				
Rat5	2	4	3	2			2				
Rat6		5	5								
Fblue					3	3	3	3			7
Ggreen					3	3	3	3			7
Hgreen					3	3		3			
Iblue									3	6	
Igreen					3	3	3	3			
Jgreen					3	3		3			7
Kblue									3		7
Lblue											7
Lgreen									3	6	
Mblue										7	
Nblue										7	
Ngreen										6	

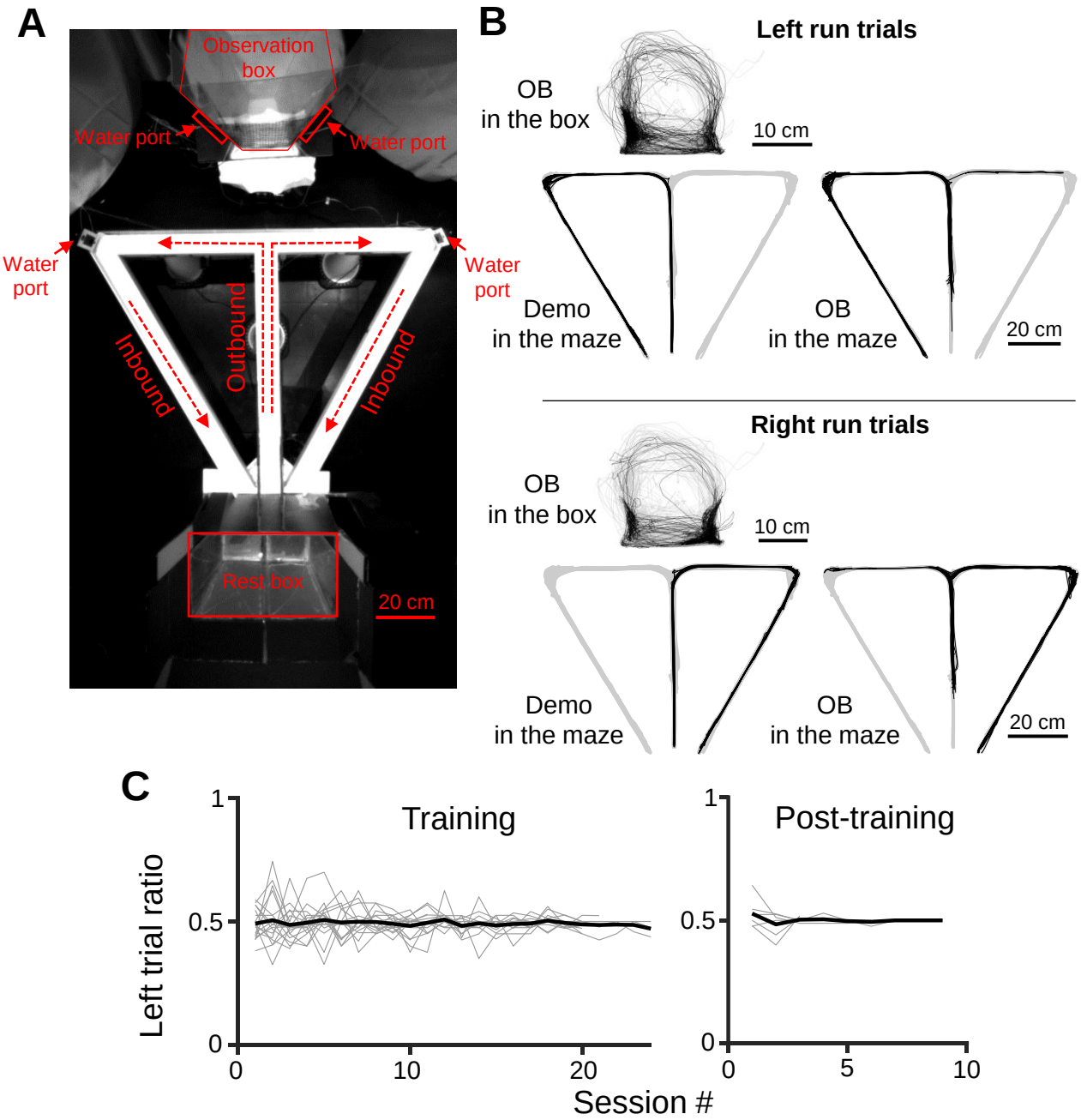

Figure S1. Behavior of OB and Demo in the observational spatial working memory task, related to Figures 1 & 2.

(**A**) Top-down view of the apparatus.

(**B**) Head movement trajectories (black traces) of an OB and its Demo in an example post-training session, plotted for left (*N* = 22 trials) and right (*N* = 22) trials separately. Positions in the box and maze are plotted in different scales for clarity. Gray traces: trajectories of all trials in the session. Note that the OB's trajectories in the box were biased toward the Demo's choices of side in the maze and that the OB's trajectories in the maze were similar to the Demo's.

(**C**) The choices of Demos did not show bias toward the left or right side of the maze either during training (*N* = 18 rats) or during post-training after the surgery in the recorded animals (*N* = 6). Gray lines: ratio of left choices over all trials for individual Demos. Black lines: average over all Demos.

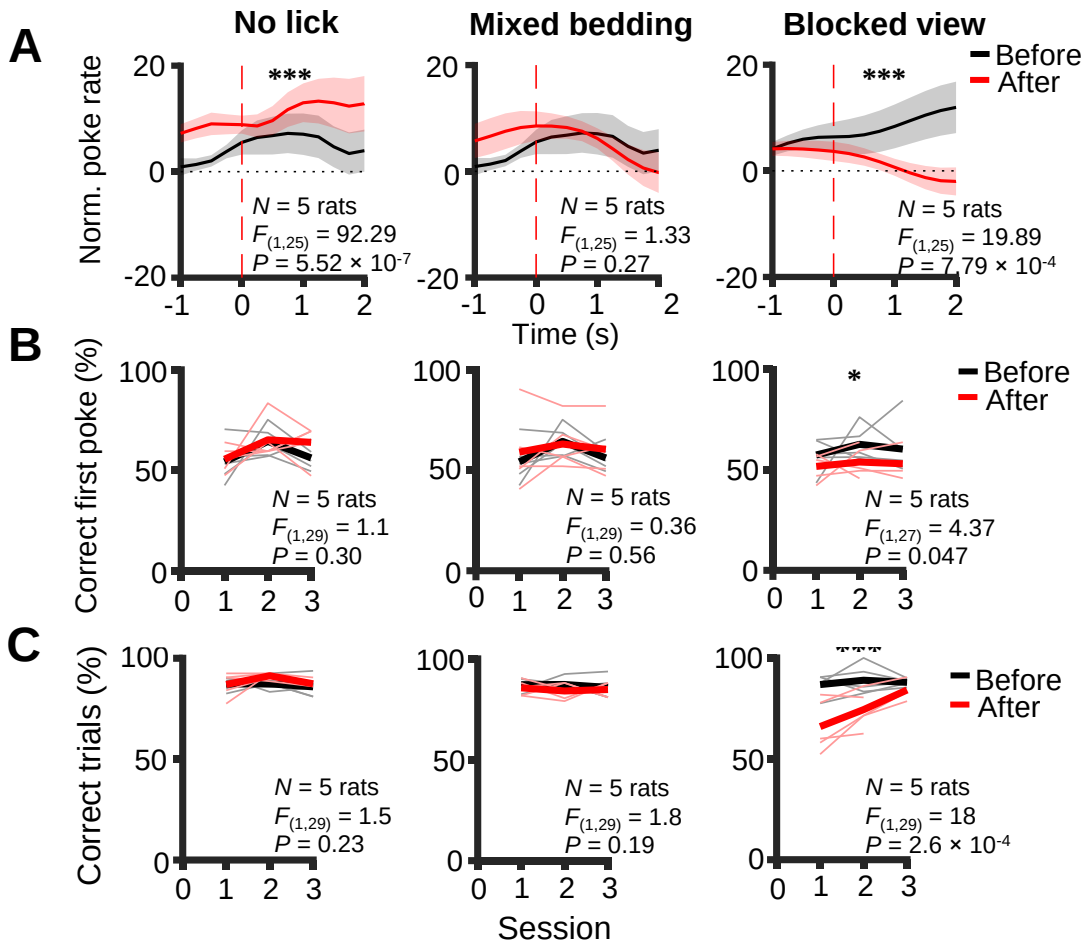

Figure S2. Observer rats' performances in the observation box and in the maze under additional behavioral manipulations, related to Figure 3.

(**A**) Average (mean ± SEM) poke performance curves in the observation box. Black: the last 3 sessions during training under the standard Demo condition before the behavioral manipulations (Before). Red: the first 3 testing sessions under various behavioral manipulations (After), as specified below. *N*: number of sessions. *F, P*: *Two-way ANOVA* test F-value and significance p-value comparing Before and After in each panel.

- **No lick**: Demo made choices normally, but no water was delivered. Thus, the Demo's licking sound was absent.
- **Mixed bedding**: Demo made choices normally, but the central and the horizontal arms were covered with the Demo's home cage bedding, which was scrambled in every trial. Thus, the odor cue was masked and could not be used by the OB to make choices.
- **Blocked view**: Front side of the observation box was covered with a piece of black cloth.

(**B**) Same as (**A**), but for the percentage of correct first pokes in the box.

(**C**) Same as (**A**), but for the OBs' performance in the T-maze, measured by the percentage of correct trials.

Note that the OBs' performance in either the box or in the maze was largely unchanged under No lick or Mixed bedding (there was a significant change in the poke performance curve under No lick, but the values remained positive; the percentage of correct first pokes or percentage of correct trials did not change). Under Blocked view, the OBs' performance in the box and in the maze was significantly reduced, but performance in the maze was still above chance (50%) level, especially in later sessions.

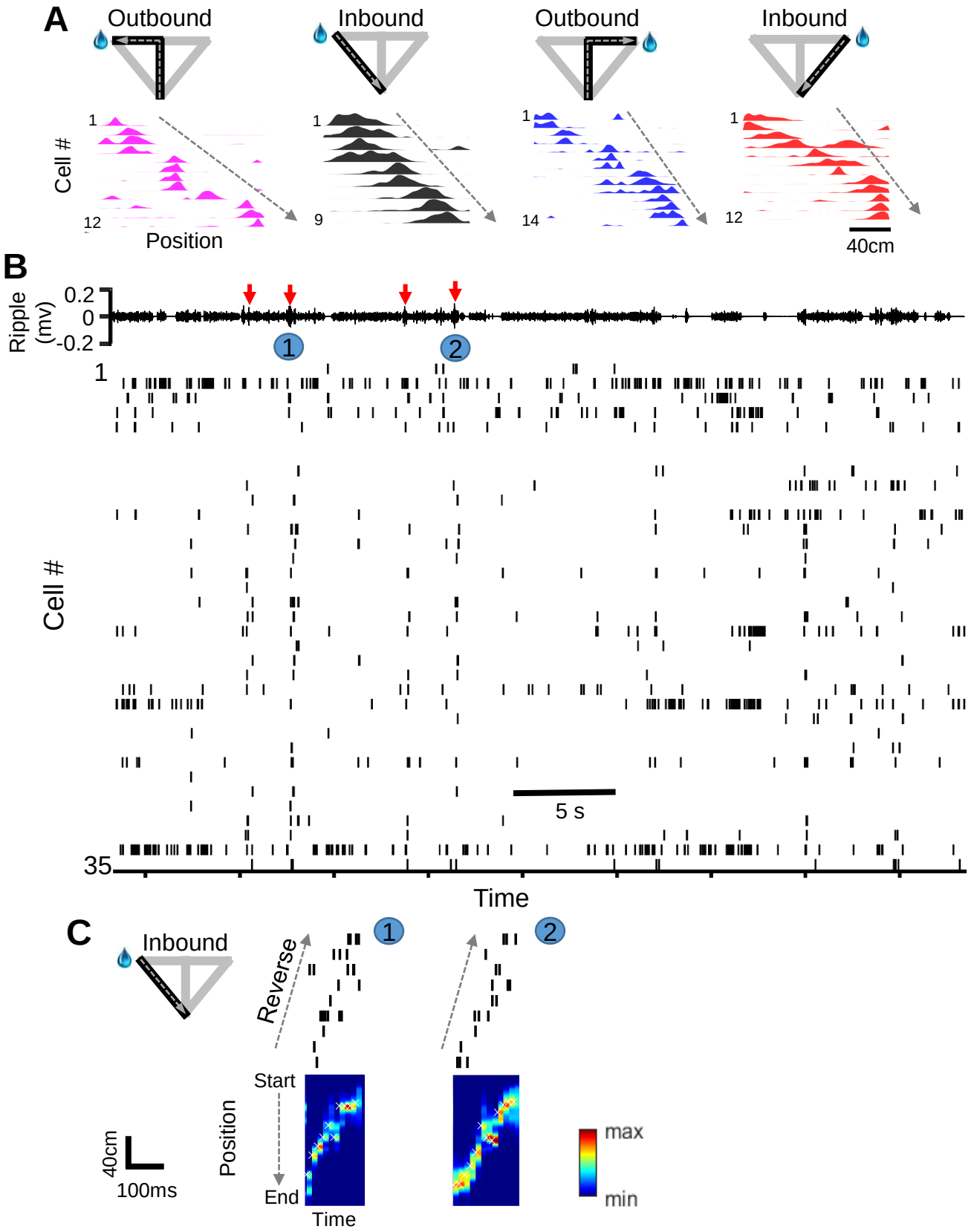

Figure S3. More examples of remote awake replay during water consumption in the observation box, related to Figure 4. Under the Demo condition - Rat1**.** The plots are arranged similarly to Figure 4.

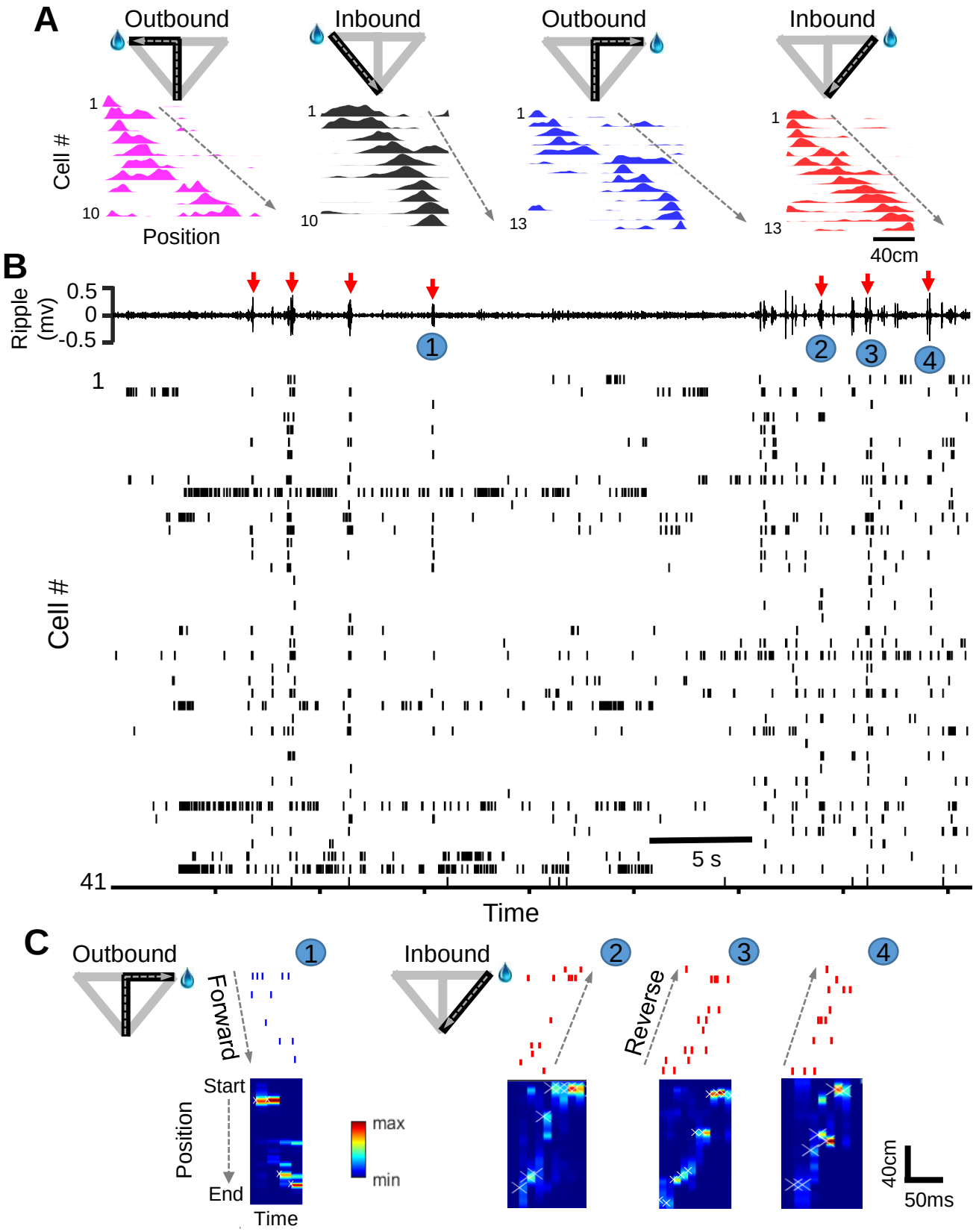

Figure S4. More examples of remote awake replay during water consumption in the observation box, related to Figure 4. Under the Demo condition – Rat4**.** The plots are arranged similarly to Figure 4.

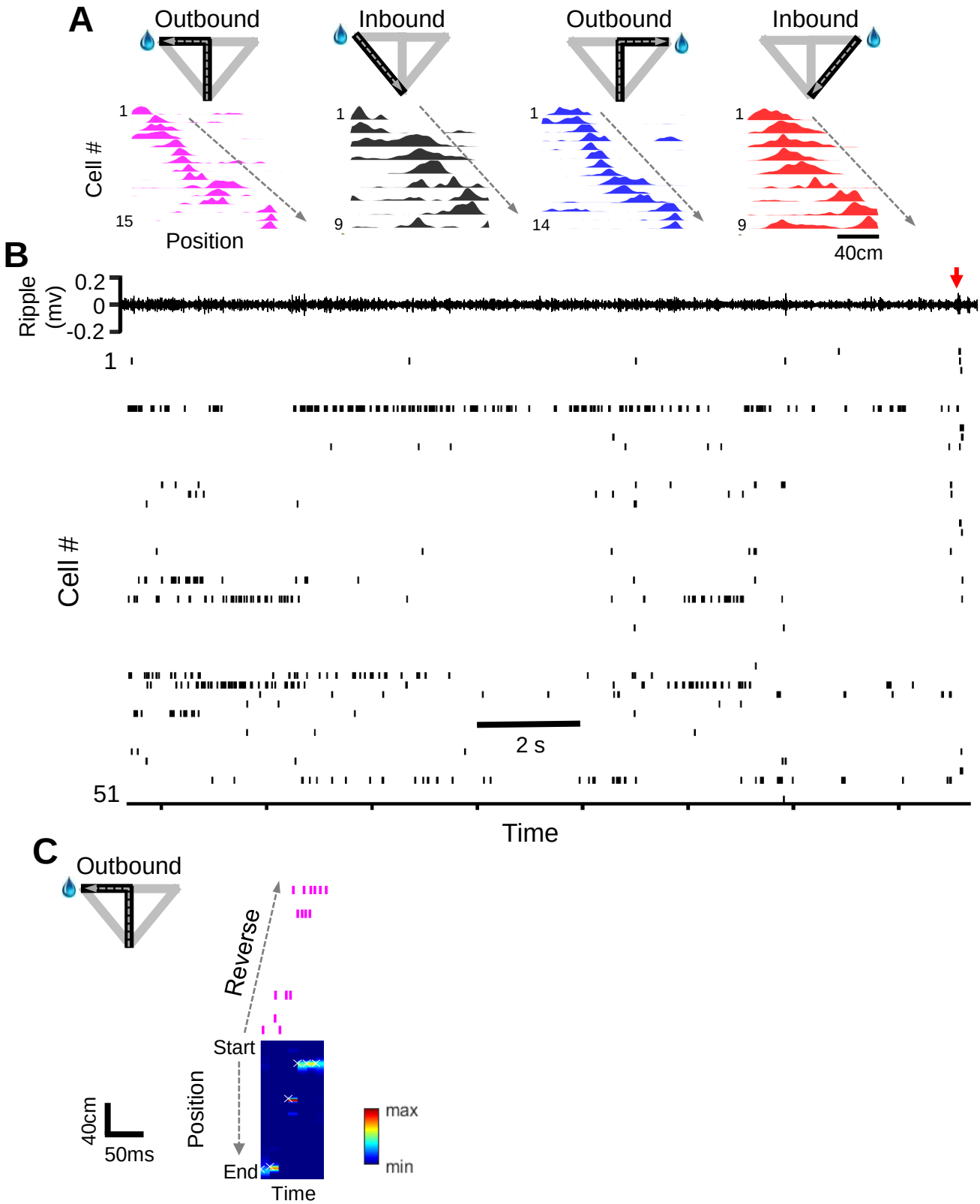

Figure S5. More examples of remote awake replay during water consumption in the observation box, related to Figure 4. Under the Object condition - Rat6. The plots are arranged similarly to Figure 4.

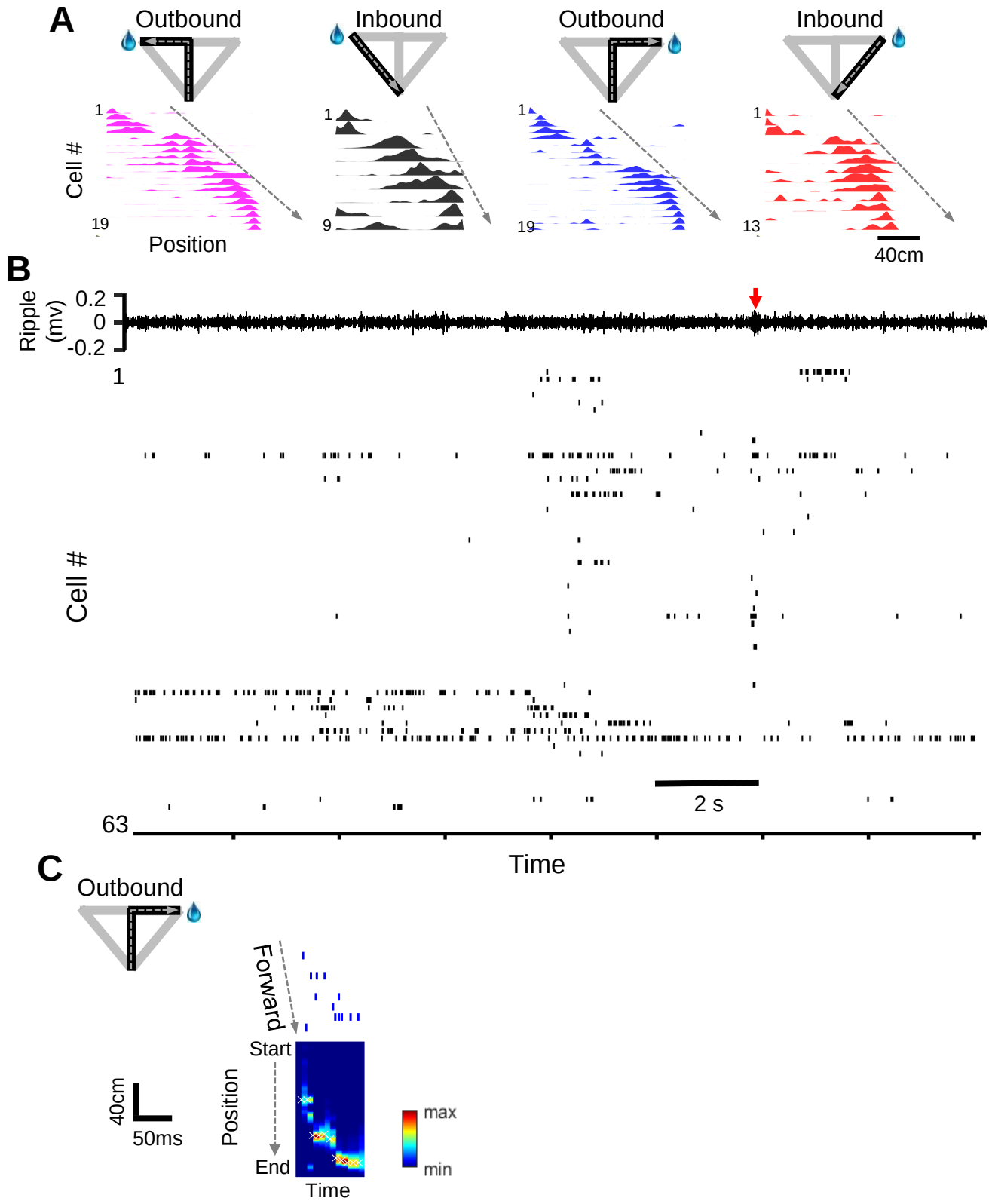

Figure S6. More examples of remote awake replay during water consumption in the observation box, related to Figure 4. Under the Empty condition - Rat5. The plots are arranged similarly to Figure 4.

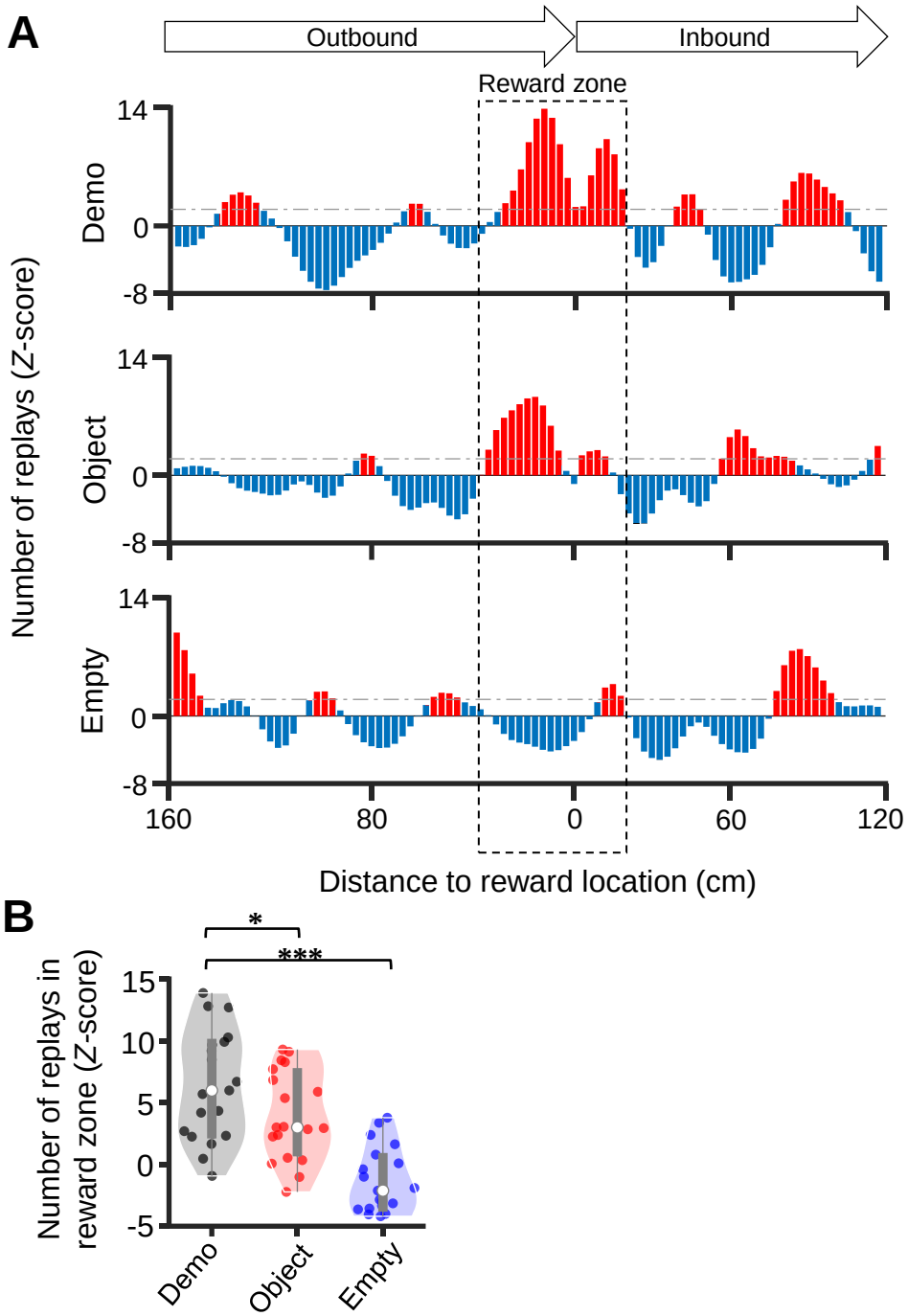

Figure S7. Termination bias of decoded replay trajectories, related to Figure 6.

(**A**) Distribution of the number of replay vectors that terminated at different locations along the T-maze under different conditions. The numbers are Z-scored relative to those at all locations. Dotted line: *Z*-scores at 95% confidence level. Red bars: locations with actual *Z*-score exceeding the 95% confidence level.

(**B**) *Z*-scored number of replay vectors terminated at locations within the reward zone across the 3 conditions. Each dot is a spatial bin. Demo: 5.98 [2.41 9.85], N = 19; Object: 2.99 [0.96 7.48], N = 19; Empty: -2.12 [-3.51 0.61], N = 19. *Kruskal-Wallis* test: $\chi^2_{(df = 2)}$ = 26, P = 2.3 x 10^{-6}; *Wilcoxon signed-rank* test: Z = 2.1, P = 0.019 between Demo and Object, Z = 3.7, P = 9.87 × 10^{-5} between Demo and Empty.

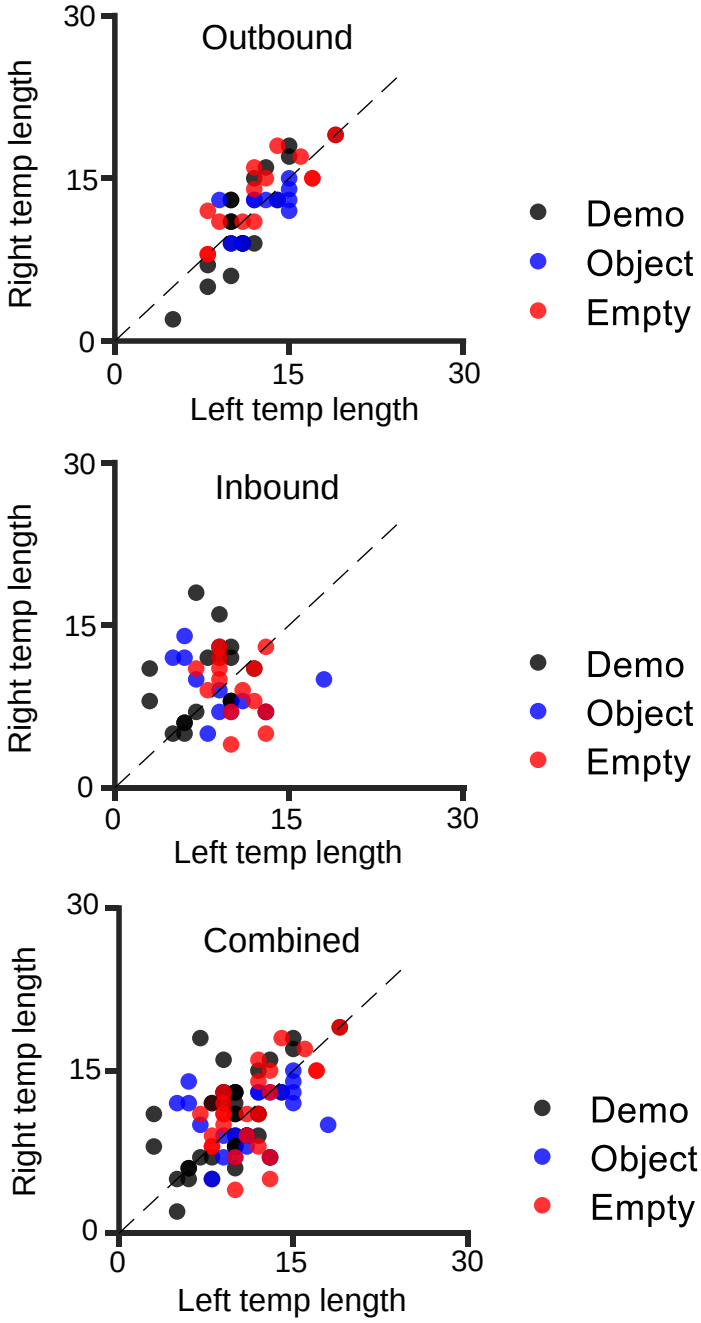

Figure S8. Template lengths were similar between left and right outbound/inbound trajectories, related to Figure 7.

Template length was the number of active place cells on a trajectory. Each dot is a session. Sessions under the Demo, Object and Empty conditions are color-coded.

There was no significant difference in template length between left and right templates for outbound trajectories (*t*-test, $t(43) = -0.47$, $N = 44$, $P = 0.64$), inbound trajectories ($t(43) = -0.57$, $N = 44$, $P = 0.57$), or outbound and inbound trajectories combined ($t(87) = -0.73$, $N = 88$, $P = 0.47$).

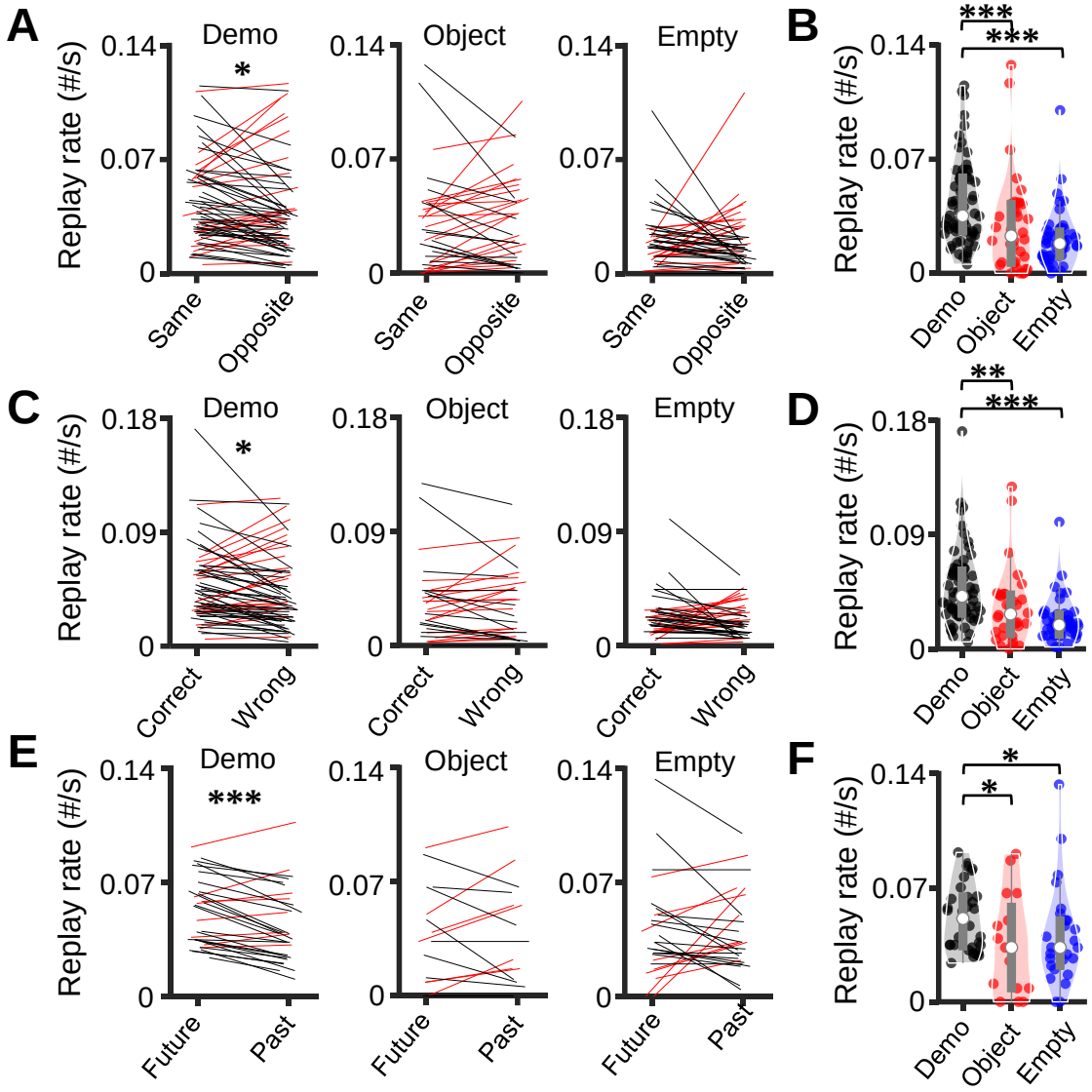

Figure S9. Remote replay rate was biased toward future correct choices in the maze, related to Figure 7.

(**A**) Replay rate for the templates representing the same vs. that for the opposite templates under the Demo, Object and Empty conditions. There was a significant difference under Demo (same: 0.035 [0.026 0.058], opposite: 0.032 [0.019 0.050]; *Wilcoxon signed-rank* test: Z = 2.3, P = 0.011, N = 66 templates), but not under Object (same: 0.023 [0.0064 0.043], opposite: 0.023 [0.0064 0.046]; Z = -0.75, P = 0.77, N = 36) or Empty (same: 0.018 [0.011 0.026], opposite: 0.015 [0.0082 0.025]; Z = 1.0, P = 0.15, N = 48).

(**B**) Directly comparing replay rate for the same templates under Demo, Object and Empty. *Kruskal-Wallis* test: $\chi^2_{(df = 2)}$ = 29, P = 4.8 x 10^{-7}; Post-hoc *Dunn's* test: P = 8.9 x 10^{-4} between Demo and Object, P = 2.0 x 10^{-7} between Demo and Empty.

(**C, D**) Same as (**A**, **B**), but for the correct vs. wrong templates. There was a significant difference under Demo (correct: 0.042 [0.028 0.062], wrong: 0.033 [0.020 0.058]; Z = 2.3, P = 0.012, N = 64 templates), but not under Object (correct: 0.028 [0.012 0.043], wrong: 0.030 [0.0087 0.048]; Z = -0.043, P = 0.52, N = 32) or Empty (correct: 0.019 [0.011 0.027], wrong: 0.017 [0.0099 0.027]; Z = 0.89, P = 1.7 x 10^{-4}, N = 45). Directly comparing the 3 conditions for the same templates: $\chi^2_{(df = 2)}$ = 32, P = 1.1 x 10^{-7}; Post-hoc: P = 0.0022 between Demo and Object, P = 2.6 x 10^{-8} between Demo and Empty.

(**E, F**) Same as (**A**, **B**), but for the future vs. past templates. There was a significant difference under Demo (future: 0.051 [0.034 0.064], wrong: 0.038 [0.025 0.058]; Z = 3.6, P = 1.7 x 10^{-4}, N = 32 boundtypes), but not under Object (future: 0.033 [0.0083 0.058], wrong: 0.028 [0.0092 0.059]; Z = -0.31, P = 0.62, N = 16) or Empty (future: 0.033 [0.022 0.050], wrong: 0.033 [0.022 0.050]; Z = 0.30, P = 0.38, N = 26). Directly comparing the 3 conditions for the future templates: $\chi^2_{(df = 2)}$ = 6.5, P = 0.039; Post-hoc: P = 0.035 between Demo and Object, P = 0.033 between Demo and Empty.

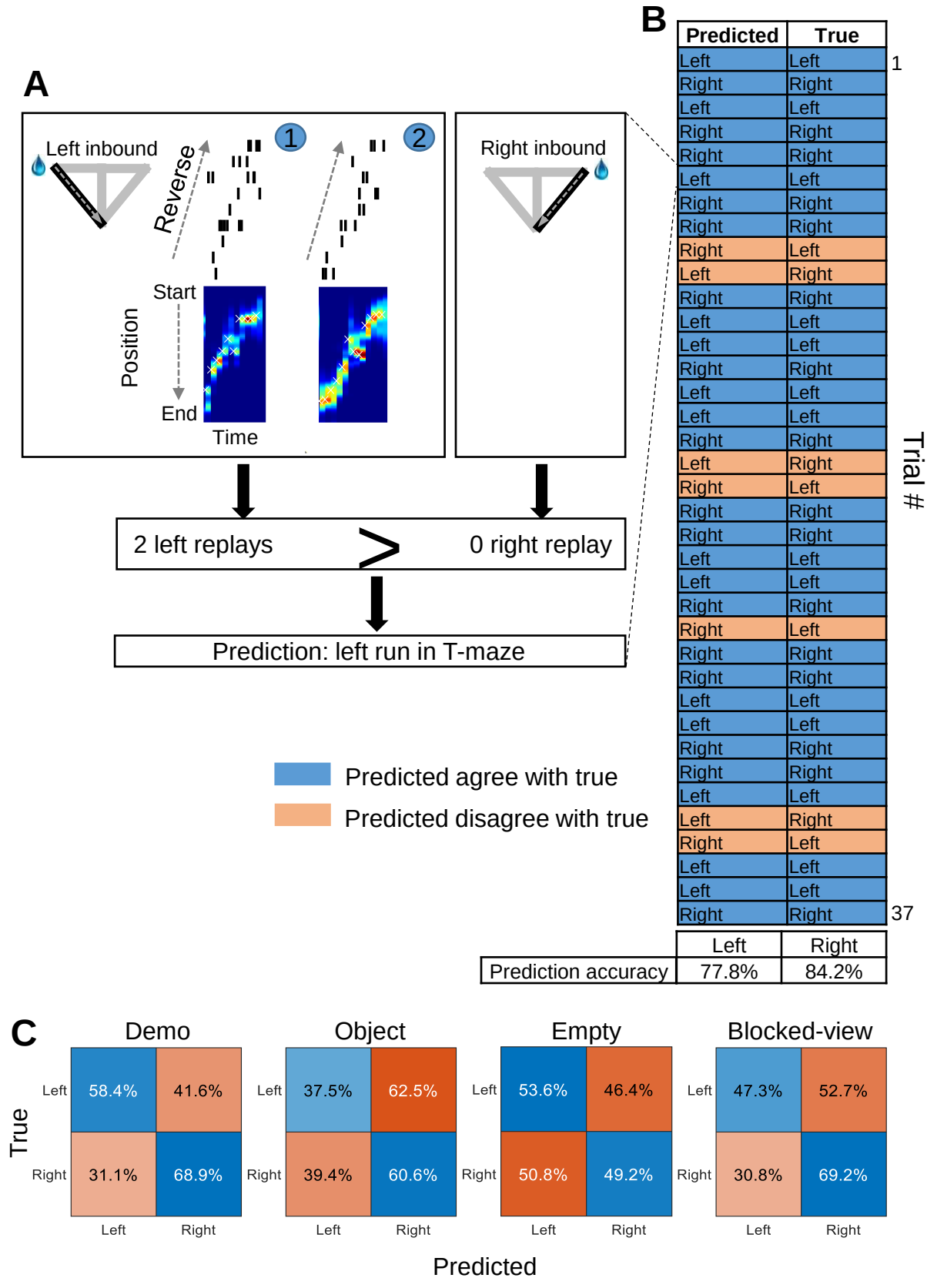
A
Left inbound
Reverse
1
2
Start
Position
End
Time
Right inbound
2 left replays
>
0 right replay
Prediction: left run in T-maze
Predicted agree with true
Predicted disagree with true
B
Predicted
True
Trial #
1
37
Left
Right
Prediction accuracy
77.8%
84.2%
C
Demo
Object
Empty
Blocked-view
True
Predicted
Left
Right
58.4%
41.6%
31.1%
68.9%
37.5%
62.5%
39.4%
60.6%
53.6%
46.4%
50.8%
49.2%
47.3%
52.7%
30.8%
69.2%

Figure S10. Remote replay predicted trial-by-trial choices of OBs in the maze, related to Figure 7.

(**A**) Remote replay on inbound trajectories (same as Figure S3C - Rat1) were used to predict the OB's trajectory in the maze in an example trial (see also Methods).

(**B**) The predicted and the true choices of the OB for all trials in a session under the Demo condition. The prediction accuracy was the percentage of true choices (left or right) that were correctly predicted.

(**C**) Contingency tables of OBs' predicted and true left/right choices in the maze. Each value is the percentage of trials where the predicted left or right choice agreed with the true left or right choice under different conditions (all trials under a condition combined). Overall prediction accuracy (left and right trials combined) was highly significant (against a null hypothesis that the predicted and true left/right choices were independent) under Demo (*Fisher's* exact test, $P = 1.7 \times 10^{-12}$, N = 650 trials in 19 sessions, overall accuracy = 63.7%), moderately significant under Blocked-view (P = 0.046, N = 126 trials in 4 sessions, overall accuracy = 56.4%), but not significant under Object (P = 0.67, N = 315 trials in 11 sessions, overall accuracy = 44.8%) or Empty (P = 0.33, N = 423 trials in 14 sessions, overall accuracy = 52.3%).

Direct comparison among conditions shows that the prediction in the Demo condition was significantly better than in the Object and Empty conditions but not than in the Blocked-view condition (*Fisher's* exact test, $P = 1.95 \times 10^{-8}$ between Demo and Object, $P = 1.27 \times 10^{-4}$ between Demo and Empty, P = 0.073 between Demo and Blocked-view). The prediction in the Blocked-view condition was better than the Object but not the Empty condition (P = 0.018 between Blocked-view and Object, P = 0.24 between Blocked-view and Empty).

The result indicts that remote replay content in the box under the Demo condition predicted OBs' choices in the maze on a trial-by-trial basis, but not under the control (Object, Empty) conditions. Under the Blocked-view condition, when social information was partially available, the prediction was reduced, suggesting that social information in the observation box might be needed for the prediction accuracy of remote awake replay.