**Supplementary File 1A**

|  |  |  |
| --- | --- | --- |
| **Cell type** | **Response type** | **%** |
| **Robot cell** |
|  | Excitation | 45 (18) |
|  | Inhibition | 2 (0.8) |
| **Pellet cell** |
|  | Excitation | 31 (12.4) |
|  | Inhibition | 6 (2.4) |
| **Robot+Pellet** |  |
| Excitation + Excitation | 17 (6.8) |
|  | Inhibition + Inhibition | 2 (0.8) |
|  | Inhibition + Excitation | 6 (2.4) |
| **Non-responsive** |
|  |  | 141 (56.4) |
| **Total**  | 250 (100) |
|  |  |  |  |
| Same responses between the pre-robot and robot sessions | 7.6 |
| Different responses between the pre-robot and robot sessions | 36 |
| Non-responsive during the pre-robot and robot sessions | 56.4 |
| Total  | 100 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Properties** |  | **Pre-robot** | **Robot** | **Post-robot** |
|  Average firing rate (Hz)   | Nest | 0.38 (0.17, 0.88) | 0.55 (0.30, 1.03) | 0.51 (0.28, 1.01)  |
| Proximal | 0.46 (0.21, 0.70) | 0.51 (0.33, 1.14) | 0.39 (0.30, 1.14) |
| Distal | 0.39 (0.17, 0.67) | 0.52 (0.29, 0.89) | 0.57 (0.34, 0.94)  |
| Field size (cm2)    | Nest | 381.48 ± 14.32  | 468.59 ± 11.28 | 375.28 ± 13.28  |
| Proximal | 505.73 ± 39.60 \* | 454.15 ± 30.45 | 417.15 ± 27.97  |
| Distal | 508.50 ± 23.36 \*\*\* | 537.86 ± 22.33 \*\*\* | 499.73 ± 21.98 \*\*\* |
|  Peak rate (Hz)   | Nest | 4.62 (2.35, 8.65) | 5.75 (2.99, 10.12) | 5.82 (2.60, 11.72)  |
| Proximal | 5.43 (3.24, 13.25) | 5.09 (3.06, 10.68) | 5.89 (3.66, 12.45) |
| Distal | 5.31 (2.73, 10.07) | 5.27 (3.12, 11.21) | 7.19 (3.69, 12.74)  |
|  Spatial info (bits/s)   | Nest | 10.18 (5.61, 21.63) | 7.67 (4.66, 11.72) | 10.32 (4.72, 20.53)  |
| Proximal | 5.94 (3.58, 9.86) \*\* | 5.70 (2.91, 10.32) | 4.78 (2.75, 13.56) \* |
| Distal | 3.91 (2.21, 7.75) \*\*\* | 3.84 (2.63, 7.41) \*\*\* | 4.07 (1.92, 7.90) \*\*\* |
|  Running speed (cm/s)   | Nest | 13.31 (12.72, 14.54) | 18.13 (16.61, 19.96) | 11.49 (10.30, 12.49)  |
| Proximal | 13.66 (13.10, 14.40) | 16.52 (14.85, 18.13) \*\* | 11.26 (10.05, 12.27)  |
| Distal | 14.28 (13.12, 15.02) \* # | 18.42 (16.61, 19.48) # | 11.59 (10.78, 12.49)  |

**Supplementary File 1B**

**Supplementary File 1C**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Properties** |  | **Pre-stimulation** | **Stimulation** | **Post-stimulation** |
|  Average firing rate (Hz)   | Nest | 0.76 (0.39, 1.41) | 0.42 (0.23, 0.89) | 0.40 (0.13, 0.78) |
| Proximal | 0.59 (0.27, 1.36) | 0.43 (0.22, 0.72) | 0.26 (0.17, 0.94) |
| Distal | 0.58 (0.31, 1.01) | 0.52 (0.33, 1.13) | 0.34 (0.17, 0.78) |
| Field size (cm2)    | Nest | 486 (378, 594) | 540 (423, 657) | 405 (288, 567) |
| Proximal | 450 (261, 567) | 477 (333, 567) | 396 (315, 522) |
| Distal | 567 (445.5, 688.5) \*\* # | 603 (477, 688.5) # | 540 (382.5, 679.5) \*\*\* # |
|  Peak rate (Hz)   | Nest | 6.03 (3.28, 11.37) | 4.94 (2.57, 9.56) | 4.39 (1.51, 7.31) |
| Proximal | 4.51 (1.71, 8.37) | 3.39 (2.19, 6.11) | 3.45 (1.53, 9.42) |
| Distal | 7.37 (3.55, 13.13) | 4.33 (2.54, 9.62) | 4.19 (2.03, 9.46) |
|  Spatial info (bits/s)   | Nest | 6.78 (4.00, 11.40) | 5.30 (3.45, 7.98) | 7.10 (4.25, 11.07) |
| Proximal | 7.12 (3.71, 14.74) | 5.71 (3.96, 10.22) | 6.87 (5.33, 12.99) |
| Distal | 2.62 (1.40, 5.16) \*\*\* ### | 4.77 (3.38, 6.90) | 4.01 (2.18, 7.74) \*\*\* ## |
|  Running speed (cm/s)   | Nest | 14.55 (12.66, 16.91) | 16.70 (12.83, 20.86) | 13.47 (11.04, 15.78) |
| Proximal | 15.86 (13.54, 17.95) | 17.06 (12.86, 22.53) | 13.47 (11.85, 15.78) |
| Distal | 15.41 (12.66, 16.26) | 17.06 (12.83, 21.82) | 13.47 (10.67, 16.61) |

**Supplementary File 1D**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Properties** |  | **Pre-stimulation** | **Stimulation** | **Post-stimulation** |
|  Average firing rate (Hz)   | Nest | 0.55 (0.27, 0.97) | 0.62 (0.43, 1.55) | 0.70 (0.35, 1.17) |
| Proximal | 0.54 (0.26, 0.82) | 0.62 (0.50, 0.79) | 0.70 (0.52, 0.96) |
| Distal | 0.46 (0.34, 0.83) | 0.59 (0.30, 1.01) | 0.75 (0.35, 1.07) |
| Field size (cm2)    | Nest | 342 (175, 504) | 400.5 (256.5, 571.5) | 423 (270, 603) |
| Proximal | 252 (189, 463) | 445.5 (272.25, 564.75) | 247.5 (229.5, 321.75) |
| Distal | 486 (400.5, 711) \* | 594 (400.5, 675)  | 558 (346.5, 720) # |
|  Peak rate (Hz)   | Nest | 4.03 (1.53, 6.41) | 7.26 (3.96, 9.50) | 7.40 (3.96, 9.50) |
| Proximal | 3.60 (2.59, 6.28) | 5.09 (2.41, 5.93) | 3.28 (2.28, 4.32) |
| Distal | 4.94 (3.47, 8.02) \*\*\* # | 5.06 (3.44, 9.00)  | 4.95 (3.31, 11.42) # |
|  Spatial info (bits/s)   | Nest | 11.93 (5.64, 21.33) | 6.21 (3.34, 12.68) | 6.56 (3.37, 15.44) |
| Proximal | 17.39 (4.98, 23.18) | 12.02 (6.28, 19.04) | 23.96 (14.50, 35.41) |
| Distal | 2.83 (1.53, 5.96) | 3.19 (2.11, 6.37) | 3.84 (1.65, 8.15) |
|  Running speed (cm/s)   | Nest | 15.17 (14.02, 16.03) | 13.51 (13.14, 13.79) | 11.63 (11.40, 11.83) |
| Proximal | 15.72 (15.30, 15.80) | 13.79 (13.63, 13.96) | 11.83 (11.72, 12.22) |
| Distal | 14.61 (13.47, 15.72) | 13.73 (13.51, 13.79) | 11.83 (11.63, 12.73) |

**Supplementary File 1E**

|  |  |  |  |
| --- | --- | --- | --- |
| **Experiment descriptions** | **Figure No.** | **Dorsal hippocampus****(dHPC)** | **Basal amygdala****(BA)** |
| **Coordinates (from bregma)** | **Procedure** | **Coordinates****(from bregma)** | **Procedure** |
| Simultaneous recording from the dHPC and BA | Figure 1-2 | AP: -4.0 mm ML: 2.0 mm DV: -1.5 mm (from dura) | Tetrodes implant | AP: -2.8 mm ML: 5.0 mm DV: -6.5 mm (from dura) | Tetrodes implant |
| Optrode recording from the BA | Figure 3 *A-E* |  |  | AP: -2.8 mm, ML: 5.0 mm (virus) -5.2 mm (optrode)DV: -8.8 mm (virus)-5.5 mm (optrode from dura) | Virus injection, optrode implant |
| Optogenetic stimulation of the BA | Figure 3 *F-K* |  |  | AP: -2.8 mm ML: ±5.0 mm DV: -8.8 mm (virus) 8.4 mm (optic fiber) | Virus injection, optic fiber implant |
| Optogenetic stimulation of the BA and place cell recording from the dHPC | Figure 4 | AP: -4.0 mm ML: 2.0 mm DV: -1.5 mm (from dura) | Tetrodes implant | AP: -2.8 mm, ML: 5.0 mm (unilateral) ±5.0 mm (bilateral)DV: -8.8 mm (virus) 8.4 mm (optic fiber) | Virus injection, optic fiber implant |

**Supplementary File 1F**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Figure** | **Test** | **N** | **Statistics** | **P** | **Posttest** | **p (post)** |
| **Main figure statistics** |
| 1 | Bleft | One-way repeated-measures ANOVA | 32 recording days from 4 rats | *F2, 62* = 4089 | p<0.0001 | Bonferroni *post hoc* analysis | \*\*\*\*p<0.0001 |
| Bright | One-way repeated-measures ANOVA | 32 recording days from 4 rats | *F2, 62* = 27.21 | p<0.0001 | Bonferroni *post hoc* analysis | \*\*\*\*p<0.0001 |
| 2 | Dmiddle | Kruskal-Wallis test | Nest=213 cellsProximal=25 cellsDistal=81 cells | *H* = 17.96 | p<0.0001 | Dunn’s multiple comparisons test | \*\*p=0.0062\*\*\*p=0.0003 |
| Dright | Kruskal-Wallis test | Nest=213 cellsProximal=25 cellsDistal=81 cells | *H* = 23.54 | p<0.0001 | Dunn’s multiple comparisons test | \*\*p=0.0047\*\*\*\*p<0.0001 |
| Gnest+proximal | Two-tailed unpaired *t*-test | nonRobot cell-paired nest+proximal=29 cellsRobot cell paired nest+proximal=17 cells | *t*(44)= 0.2600 | p=0.7961 |  |  |
| Gdistal | Two-tailed unpaired *t*-test | nonRobot cell-paired distal=15 cellsRobot cell paired distal=6 cells | *t*(19)= 2.797 | p=0.0119 |  |  |
| Hnest+proximal | Mann-Whitney test | nonRobot cell-paired nest+proximal=36 cellsRobot cell paired nest+proximal=17 cells | *U* = 624.5 | p=0.5939 |  |  |
| Hdistal | Two-tailed unpaired *t*-test | nonRobot cell-paired distal=19 cellsRobot cell paired distal=15 cells | *t*(32)= 2.113 | p=0.0430 |  |  |
| Ifirst | Mann-Whitney test | Robot cell paired nest+proximal=19 cellsRobot cell paired distal=6 cells | *U* = 33.50 | p=0.1420 |  |  |
| Isecond | Mann-Whitney test | nonRobot cell paired nest+proximal=30 cellsnonRobot cell paired distal=13 cells | *U* = 155 | p=0.2972 |  |  |
| Ithird | Mann-Whitney test | Robot cell paired nest+proximal=23 cellsRobot cell paired distal=14 cells | *U* = 142.5 | p=0.5723 |  |  |
| Ifourth | Mann-Whitney test | Robot cell paired nest+proximal=51 cellsRobot cell paired distal=18 cells | *U* = 317 | p=0.2242 |  |  |
| Jleft | Mann-Whitney test | Nest+proximal-paired Robot cells=13 cellsDistal-paired Robot cells=5 cells | *U* = 31.50 | p=0.9444 |  |  |
| Jright | Mann-Whitney test | Nest+proximal-paired Robot cells=17 cellsDistal-paired Robot cells=9 cells | *U* =68 | p=0.6723 |  |  |
| 3 | JOFF | Two-tailed unpaired *t* test | EYFP=4ChR2=5 | *t*(7) = 0.2845 | p=0.7843 |  |  |
| JON\_75cm | Mann-Whitney test | EYFP=4ChR2=5 | *U* =6 | p=0.0159  |  |  |
| JON\_25cm | Mann-Whitney test | EYFP=4ChR2=4 | *U* =0 | p=0.0286  |  |  |
| K | Two-way RM ANOVA | EYFP=4ChR2=5 | Interaction effect *F72, 1908* =0.02540;Trial effect *F1.829, 12.80* =10.36;Group effect *F1,7* = 0.025;Subject effect *F7,21* = 5.497 | Interaction p=0.9944;Trial p=0.0025;Group p<8788;Subject effect p=0.0011 |  |  |
| 4 | A | Friedman test | n=17 recording days | *χ²* = 32.72 | p<0.0001 | Dunn’s multiple comparisons test | Pre-stim vs. Stim: \*\*\*\*p<0.0001; Stim vs. Post-stim:\*\*\*\*p<0.0001 |
| Cleft | One-way ANOVA | Nest=107 cellsProximal=21 cellsDistal=125 cells | *F2, 250* = 3.559 | p=0.031 | Bonferroni *post hoc* analysis | Nest vs. distal: \*p=0.039 |
| Cright | Kruskal-Wallis | Nest=107 cellsProximal=21 cellsDistal=125 cells | *H* = 8.019 | p=0.018 | Dunn’s multiple comparisons test | Nest vs. distal: \*p=0.019 |
| Enest | Friedman test | Nest=107 cells | *χ²* = 20.81 | p*<*0.001 | Dunn’s multiple comparisons test | Pre-stim vs. post-stim: \*\*\*\*p<0.0001;Stim vs. post-stim: p=0.0028 |
| Eproximal | Friedman test | Proximal=21 cells | *χ²* = 1.300 | p=0.5220 |  |  |
| Edistal | Friedman test | Distal=125 cells | *χ²* = 10.70 | p=0.0048 | Dunn’s multiple comparisons test | Pre-stim vs. stim: \*\*p=0.0063Stim vs. post-stim: \*p=0.0416 |
| F | Friedman test | n=6 recording days |  *χ²* = 1.000 | p*>*0.999 |  |  |
| Hleft | One-way ANOVA | Nest=30 cellsProximal=8 cellsDistal=26 cells | *F2, 68*= 0.8399 | p=0.4362 |  |  |
| Hright | One-way ANOVA | Nest=30 cellsProximal=8 cellsDistal=26 cells | *F2, 68*= 0.0512  | p=0.950 |  |  |
| Jnest | Friedman test | Nest=30 cells | *χ²* = 3.350 | p=0.1873 |  |  |
| Jproximal | Friedman test | Proximal=8 cells | *χ²* = 0.5806  | p=0.7642 |  |  |
| Jdistal | Friedman test | Distal=26 cells | *χ²* = 1.806  | p=0.4054 |  |  |
| **Supplemental figure statistics** |
| S1 | DdHPC→BA | One-way repeated-measures ANOVA | N=40 | *F2, 39* = 28.86 | p<0.0001 | Bonferroni *post hoc* analysis | Pre-surge vs. post-surge: \*\*\*\*p<0.0001;Pre-surge vs. pre-pellet: \*\*\*\* p<0.0001 |
| DBA→dHPC | One-way repeated-measures ANOVA | N=40 | *F2, 39* = 17.09 | p<0.0001 | Bonferroni *post hoc* analysis | Post-surge vs. pre-surge: \*\*\*p=0.0004;Post-surge vs. post-pellet: \*\*\* p=0.0001 |
| EdHPC→BA | One-way repeated-measures ANOVA | N=59 | *F2, 58* = 37.08 | p<0.0001 | Bonferroni *post hoc* analysis | Pre-surge vs. post-surge: \*\*\*\*p<0.0001;Pre-surge vs. pre-pellet: \*\*\*\* p<0.0001 |
| EBA→dHPC | One-way repeated-measures ANOVA | N=71 | *F2, 70* = 37.88 | p<0.0001 | Bonferroni *post hoc* analysis | Post-surge vs. pre-surge: \*\*\*\*p<0.0001;Post-surge vs. post-pellet: \*\*\*\*p<0.0001 |
| F | Chi-squre | Pre-surge: dHPCleading=40, BAleading=40;Post-surge: dHPCleading=59, BAleading=71 | *χ²* = 0.4234 | p=0.5153 |  |  |
| S2 | C | Two-way RM ANOVA | N=45 | Interaction effect: *F18, 1320* = 13.99Session effect: *F2, 1320*=417.3Time effect: *F9, 1320*= 21.94 | Interaction p*<*0.0001;Time p*<*0.0001;Group p*<*0.0001 | Bonferroni *post hoc* analysis | Pre-robot vs. robot: \*\*\*\*p<0.0001 for 0-6 s; \*\*\*p=0.0006 for 7 s; \*\*p=0.0021 for 8 s; Robot vs. post-robot:\*\*\*\*p<0.0001 for 0-6 s; \*\*p=0.0062 for 7 s; \*\*p=0.0031 for 8 s; \*p=0.0127 for 0 s |
| S3 | Bleft | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 5.010 | p=0.007 | Bonferroni *post hoc* analysis | Nest vs. distal: \*p=0.028;Proximal vs. distal: \*p=0.022 |
| Bright | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 1.749 | p=0.176 |  |  |
| Cleft | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 3.269 | p=0.039 | Bonferroni *post hoc* analysis | Nest vs. proximal: \*p=0.036 |
| Cright | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 7.383 | p=0.0007 | Bonferroni *post hoc* analysis | Nest vs. distal: \*\*p=0.0011;Proximal vs. distal: \*p=0.0201 |
| D | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 3.714 | p=0.0254 | Bonferroni *post hoc* analysis | Nest vs. distal: \*p=0.0103; |
| E | Two-way ANOVA | Nest=32 cellsProximal=11 cellsDistal=16 cells |  | Interaction effect *F4, 168*= 0.7340;Session effect *F2, 168*= 0.7782;Group effect *F2, 168*= 12.05 | Interaction p*=*0.57;Session p*=*0.4609;Group p*<*0.0001 | 2. Nest vs. distal: \*\*\*p=0.0009;3. Nest vs. distal: \*\*p=0.0039 |
| Hleft | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 7.477 | p=0.0007 | Bonferroni *post hoc* analysis | Nest vs. distal: \*\*p=0.0017;Proximal vs. distal: \*\*p=0.0097 |
| Hmiddle | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 4.453 | p=0.0124 | Bonferroni *post hoc* analysis | Nest vs. distal: \*p=0.0472;Proximal vs. distal: \*p=0.0304 |
| Hright | One-way ANOVA | Nest=213 cellsProximal=25 cellsDistal=81 cells | *F2, 316*= 2.676 | p=0.070 |  |  |
| I | One-way repeated-measures ANOVA | N=32 | Treatment effect *F3, 93*= 5.660;Individual effect *F31, 93*= 12.96 | Treatment effect p=0.0013; Individual effect p<0.0001 | Bonferroni *post hoc* analysis | 2 vs. 5: \*p=0.0193;2 vs. 10: \*\*p=0.0012 |
| S4 | Cnest+proximal:pre-surge | Two-tailed unpaired *t*-test | nonRobot cell-paired nest+proximal=29 cellsRobot cell paired nest+proximal=17 cells | *t*(44)= 1.315 | p=0.1952 |  |  |
| Cdistal:pre-surge | Two-tailed unpaired *t*-test | nonRobot cell-paired distal=15 cellsRobot cell paired distal=6 cells | *t*(19)= 0.9140 | p=0.3722 |  |  |
| Cnest+proximal:post-surge | Two-tailed unpaired *t*-test | nonRobot cell-paired nest+proximal=36 cellsRobot cell paired nest+proximal=17 cells | *t*(51)= 0.4426 | p=0.6599 |  |  |
| Cdistal:post-surge | Two-tailed unpaired *t*-test | nonRobot cell-paired distal=19 cellsRobot cell paired distal=15 cells | *t*(32)= 2.825 | \*\*p=0.0081 |  |  |
| Dleft | Two-tailed unpaired t-test | Distal-nonRobot=16Distal-Robot=12 | *t*(26) = 2.692 | p=0.0123 |  |  |
| Dright | Two-tailed unpaired t-test | nonRobot-distal=18Robot-distal=9 | *t*(25) = 2.269 | p=0.0321 |  |  |
| S5 | C | Mann-Whitney test | Robot cells =25nonRobot cells=44 | *U*=191.5 | p<0.0001 |  |  |
| D | Two-tailed unpaired t-test | Robot cell-paired nest+proximal cells =37Robot cell-paired distal cells =17 | *t*(52) = 2.585 | p= 0.0126 |  |  |
| Eleft | Paired t-test | N=8 | *t*(7) = 0.7607 | p= 0.4717 |  |  |
| Eright | Paired t-test | N=9 | *t*(8) = 0.6660 | p= 0.5241 |  |  |
| F | Paired t-test | N=9 | *t*(8) = 3.926 | p= 0.0044 |  |  |
| Gleft | Paired t-test | N=7 | *t*(6) = 0.8892 | p= 0.4081 |  |  |
| Gright | Paired t-test | N=17 | *t*(16) = 1.356 | p= 0.1941 |  |  |
| H | Paired t-test | N=13 | *t*(12) = 4.593 | p= 0.0006 |  |  |
| S7 | Dleft | One-way ANOVA | Nest=107 cellsProximal=21 cellsDistal=125 cells | *F2, 250*= 3.517 | p=0.0312 | Bonferroni *post hoc* analysis | Nest vs. distal: \*\*p=0.0350 |
| Dright | Kruskal-Wallis | Nest=107 cellsProximal=21 cellsDistal=125 cells | *H* = 4.832 | p=0.089 |  |  |
| Eleft | Kruskal-Wallis | Nest=107 cellsProximal=21 cellsDistal=125 cells | *H* = 7.646 | p=0.022 | Dunn’s multiple comparisons test | Nest vs. proximal: \*p=0.021Proximal vs. distal: \*p=0.026 |
| Eright | Kruskal-Wallis | Nest=107 cellsProximal=21 cellsDistal=125 cells | *H* = 10.64 | p=0.0049 | Dunn’s multiple comparisons test | Proximal vs. distal: \*p=0.0110 |
| G | Kruskal-Wallis | Nest=107 cellsProximal=21 cellsDistal=125 cells | *H* = 1.829 | p=0.4007 |  |  |
| H | One-way ANOVA | Nestneutral=114 Nestexcited=7Nestinhibited=4 | *F2, 122*= 0.398 | p=0.6725 |  |  |
| One-way ANOVA | Distalneutral=93 Distalexcited=10Distalinhibited=4 | *F2, 104*= 0.712 | p=0.4930 |  |  |
| Kleft | One-way ANOVA | Nest=30 cellsProximal=8 cellsDistal=26 cells | *F2, 61*= 0.5627 | p=0.5726 |  |  |
| Kright | Kruskal-Wallis | Nest=30 cellsProximal=8 cellsDistal=26 cells | *H* = 0.9559 | p=0.620 |  |  |
| Lleft | One-way ANOVA | Nest=30 cellsProximal=8 cellsDistal=26 cells | *F2, 61*= 1.752 | p=0.182 |  |  |
| Lright | Kruskal-Wallis | Nest=30 cellsProximal=8 cellsDistal=26 cells | *H* = 6.288 | p=0.0431 | Dunn’s multiple comparisons test | Proximal vs. distal: \*p=0.0469 |