*Supplementary Material*

# Conditional knockout of Cav2.1 disrupts the accuracy of spatial recognition of CA1 place cells and spatial/contextual recognition behavior.

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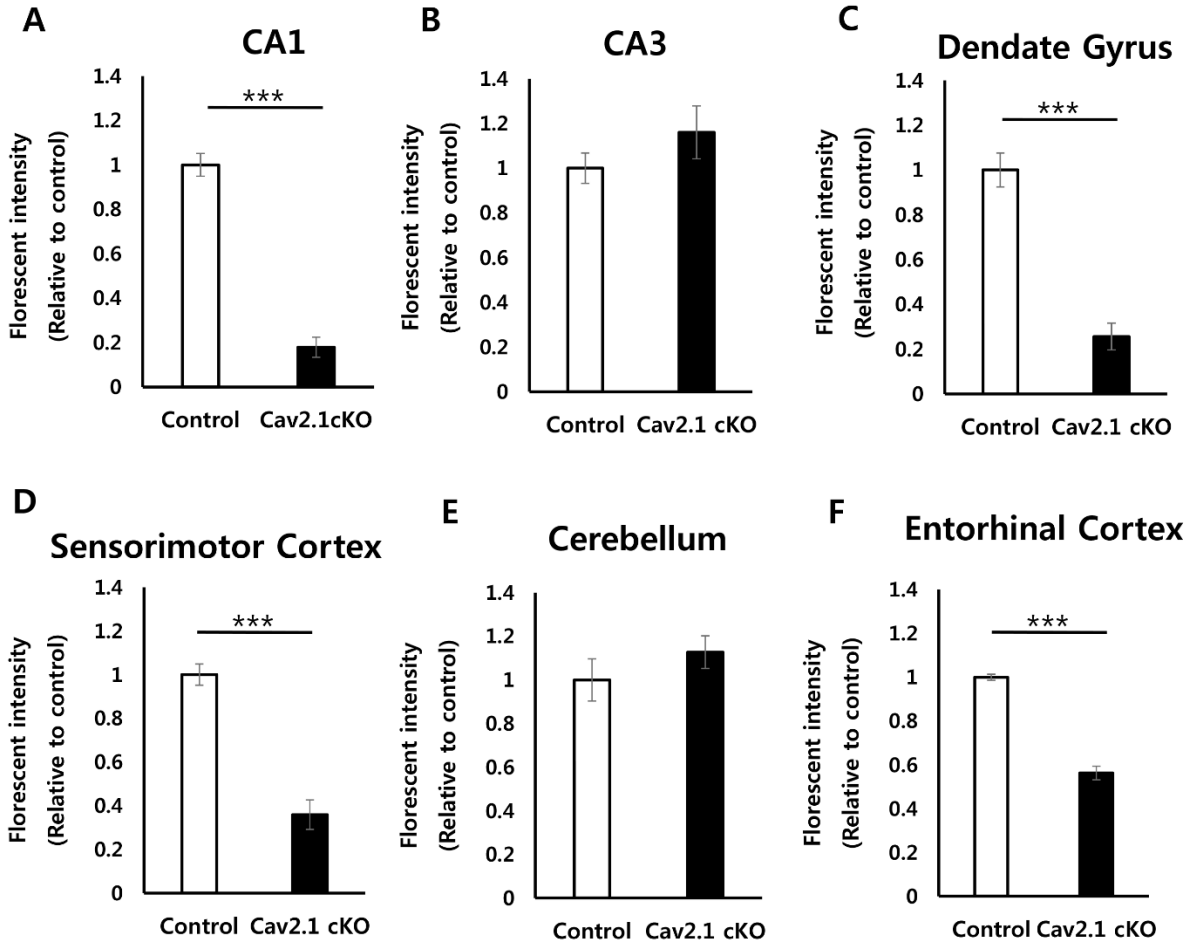
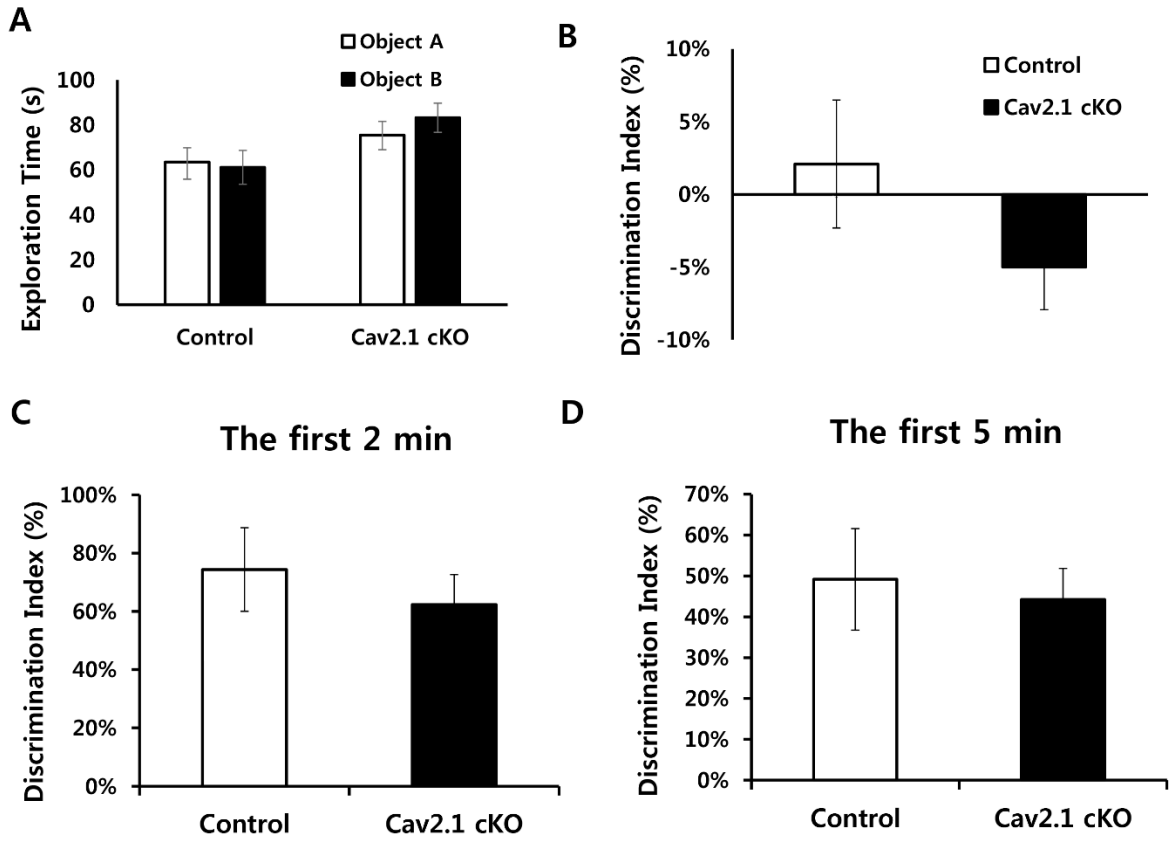
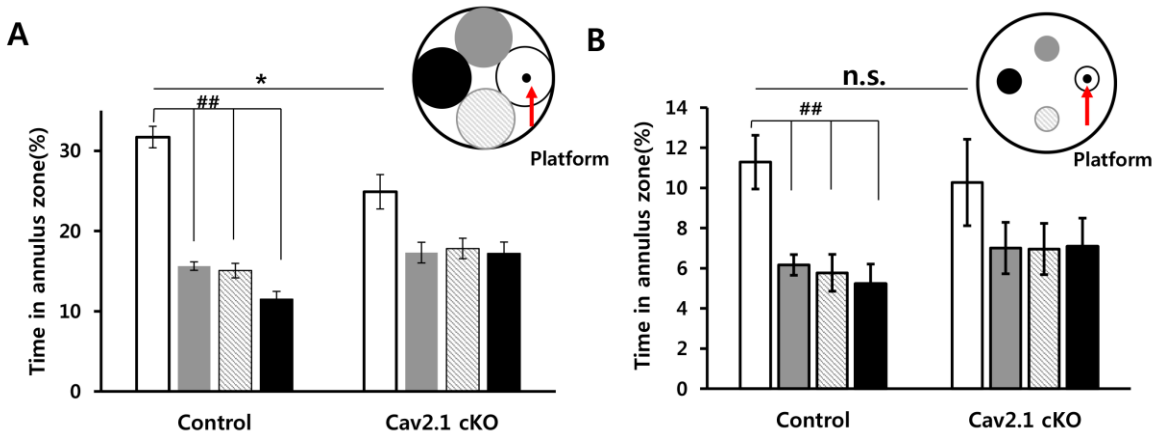


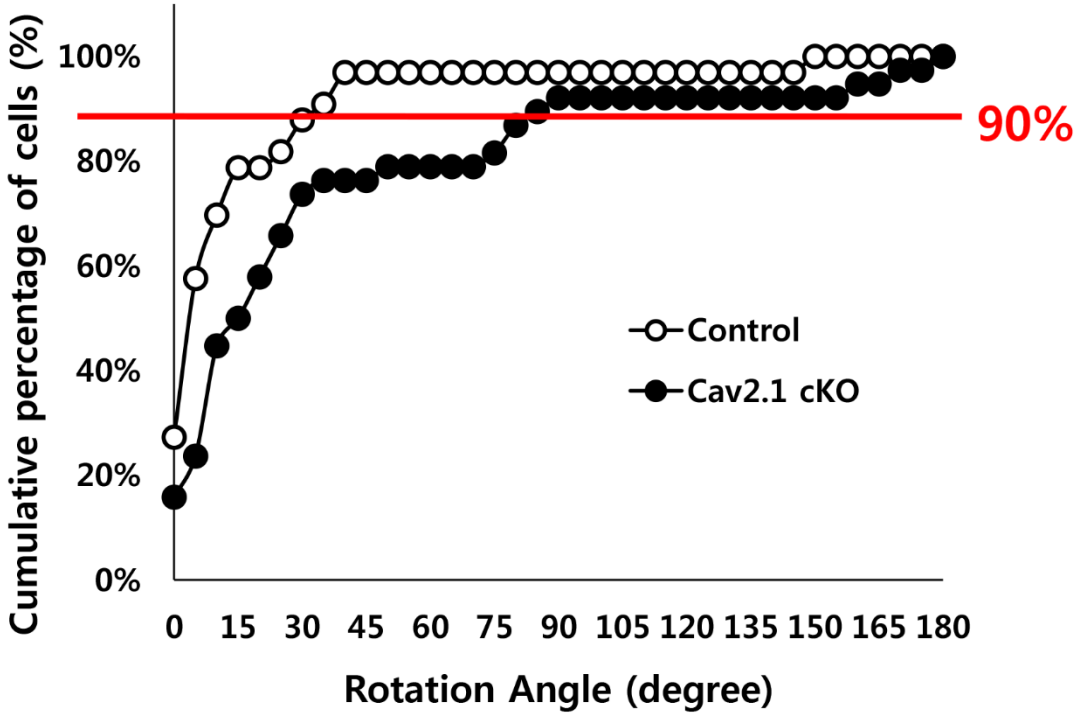

**Supplementary Figure S1.** Quantification of Cav2.1 expression by comparing the mean fluorescent intensity. (A) CA1 (Control=1±0.051; cKO=0.17+0.045; P<0.001) (B) CA3 (Control=1±0.067; cKO=1.15+0.118; P=0.25) (C) Dendate gyrus (Control=1±0.076; cKO=0.25+0.059; P<0.001) (D) Sensorimotor cortex (Control=1±0.048; cKO=0.36+0.067; P<0.001) (E) Cerebellum (Control=1±0.096; cKO=1.12+0.074; P=0.29) (F) Entorhinal cortex (Control=1±0.013; cKO=0.56±0.31; P<0.001) ***P<0.001



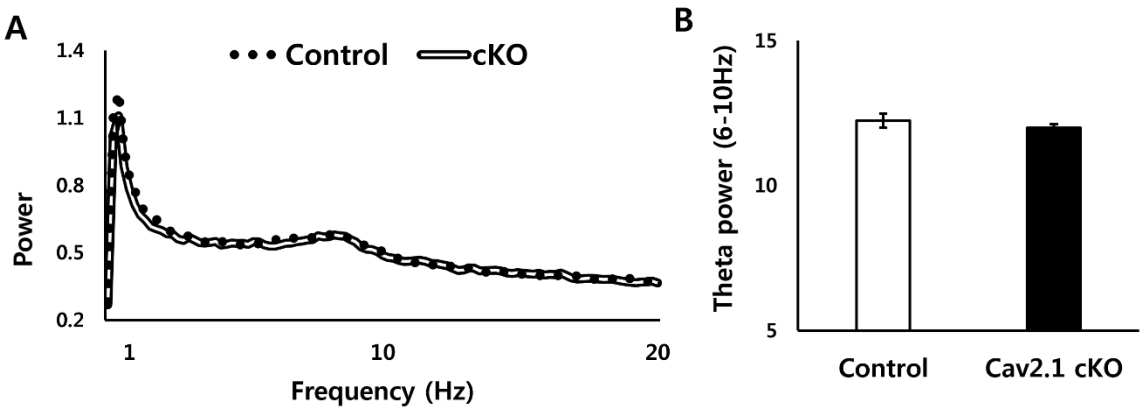

**Supplementary Figure S2.** Novel object recognition task. (A,B) During training phase. (A) Both groups did not show any preference over the two objects (Control P=0.83; cKO P=0.39). (B) Discrimination indices were similar in both groups (Control 0.02±0.044 ; cKO -0.05±0.030; P=0.21). (C,D) During task phase. (C) Discrimination index during the first 2 min (Control 0.74±0.143 ; cKO 0.62±0.102; P=0.51). (D) Discrimination index during the first 5 min (Control 0.49±0.124 ; cKO 0.44±0.076; P=0.74).




**Supplementary Figure S3.** Swimming time (%) in annulus zone during the probe test of a water maze task. (A)Time spent in annulus zone (quadrant size) during probe test. In control group, time in target annulus was significantly different from others ($F_{(3)}$=8.15 P<0.001; ANOVA with LSD post hoc analysis), while cKO group show similar extent of spending time in all zone ($F_{(3)}$=1.07 P=0.085; ANOVA with LST post hoc analysis). (B)Time spent in annulus zone (3x platform size) during probe test. In control group, time in target annulus was significantly different from others ($F_{(3)}$=8.15 P<0.001; ANOVA with LSD post hoc analysis, while cKO group show similar extent of spending time in all zone($F_{(3)}$=1.07 P=0.37; ANOVA with LST post hoc analysis) *P<0.05 indicates comparision between control and cKO groups, ## P<0.001 indicates target annulus zones vs other annuluses within each group.




**Supplementary Figure S4.** Cumulative distribution of rotation angle. Cumulative percentage of place cells at each rotation angle, where each cell has the highest similarity (Max SIM). 90% of place cells in control group have rotation angles within 35 degree. In contrast, 90% in cKO have rotation angles within 90 degree, showing more deviated distribution of angle.




**Supplementary Figure S5.** Power spectra density of CA1 place cell was analyzed on neuronal spike trains using NeuroExplorer (Nex Technologies). (A) Spectrum of 0-50Hz was obtained and normalized to present power(%) in frequency(Hz) ranging from 0 to 20 Hz. (B) Theta power was calculated within the theta frequency (6-10Hz).

| | Control | | Cav2.1 cKO | |
|---|---|---|---|---|
| | Session1 | Session2 | Session1 | Session2 |
| **Firing rate (Hz)** | 1.70±0.267 | 1.92±0.277 | 1.77±0.231 | 1.71±0.203 |
| **Mean ISI (ms)** | 1.13±0.154 | 1.13±0.234 | 1.10±0.167 | 1.22±0.280 |
| **Field size (cm2)** | 162.1±7.31 | 153.8±6.92 | 163.3±4.24 | 162.7±4.33 |
| **In field firing rate (Hz)** | 3.09±0.477 | 3.32±0.449 | 3.17±0.38 | 2.95±0.313 |
| **Selectivity** | 1.1±0.04 | 1.0±0.04 | 1.0±0.03 | 1.0±0.04 |
| **Coherence** | 0.970±0.0021 | 0.970±0.0023 | 0.971±0.0025 | 0.972±0.0019 |
| **Spatial info, bits per s** | 3.10±0.203 | 3.20±0.211 | 3.09±0.200 | 2.90±0.185 |

**Supplementary Table S1.** Place cell properties between groups during session 1 and 2. All scores were not significantly different between group (two tailed t-test).

| | Control | Cav2.1 cKO |
|---|---|---|
| **Signed firing rate (Hz)** | -0.052±0.0327 | 0.001±0.0447 |
| **Signed mean ISI (ms)** | 0.052±0.0326 | -0.0003±0.0444 |
| **Signed field size (cm2)** | 0.025±0.0240 | 0.002±0.0139 |
| **Signed in field firing rate (Hz)** | -0.039±0.0321 | 0.011±0.0443 |
| **Signed selectivity** | 0.024±0.0129 | 0.020±0.0134 |
| **Signed coherence** | -0.00014±0.000973 | -0.00062±0.001304 |
| **Signed spatial info, bits per s** | -0.021±0.0251 | 0.034±0.0244 |
| **Unsigned firing rate (Hz)** | 0.15±0.022 | 0.21±0.029 |
| **Unsigned mean ISI (ms)** | 0.145±0.220 | 0.206±0.0286 |
| **Unsigned field size (cm2)** | 0.098±0.0172 | 0.069±0.0080 |
| **Unsigned in field firing rate (Hz)** | 0.143±0.0209 | 0.212±0.0273 |
| **Unsigned selectivity** | 0.062±0.0079 | 0.067±0.0081 |
| **Unsigned coherence** | 0.0044±0.00058 | 0.0056±0.00092 |
| **Unsigned spatial info, bits per s** | 0.121±0.0135 | 0.123±0.0147 |

**Supplementary Table S2.** Changes between sessions on individual cell basis. Session1(R1) and session 2(R2) were normalized to observe changes on a cellular basis. Signed value was defined as (R1-R2)/(R1+R2). Unsinged value was the absolute value of the sign. All scores were not significantly different between group (two tailed t-test).