Figure S1

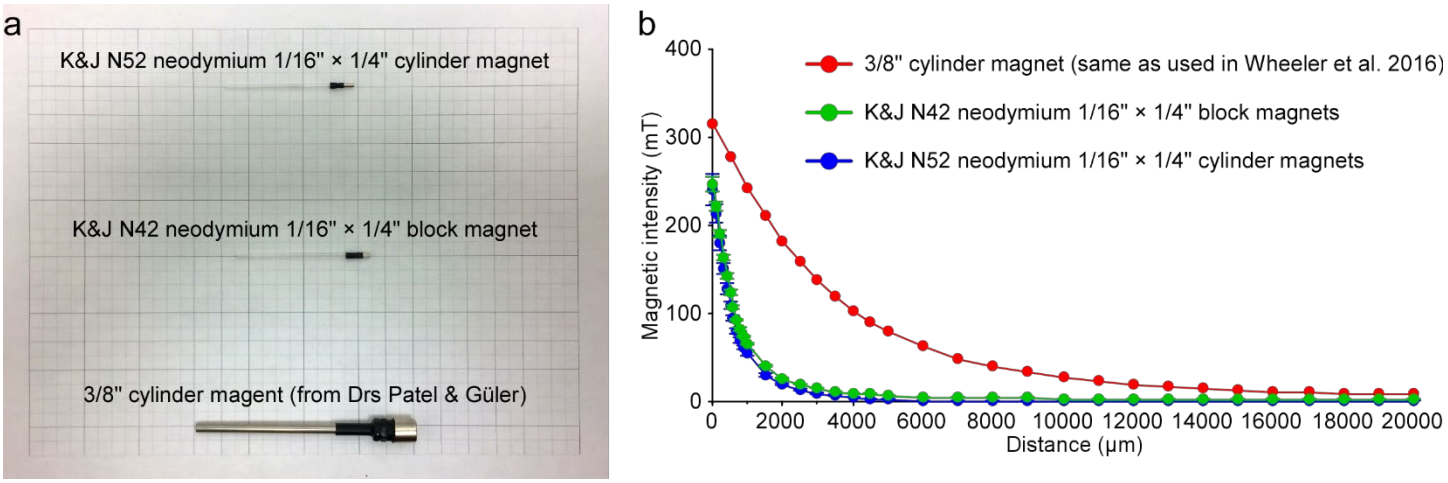

Figure S1. Properties of magnets used in experiments.

(**a**) Image shows the two frequently used magnets attached to a 2 mm diameter borosilicate glass or a 4 mm diameter stainless steel rod.

(**b**) Plots of the magnetic intensity against the distance of N42 neodymium 1/16" × 1/4" block magnets (K&J Magentics, Inc.; *n*=4) and a 3/8" cylinder magnet (the same as used in the previous report[1]; *n*=1).

Figure S2

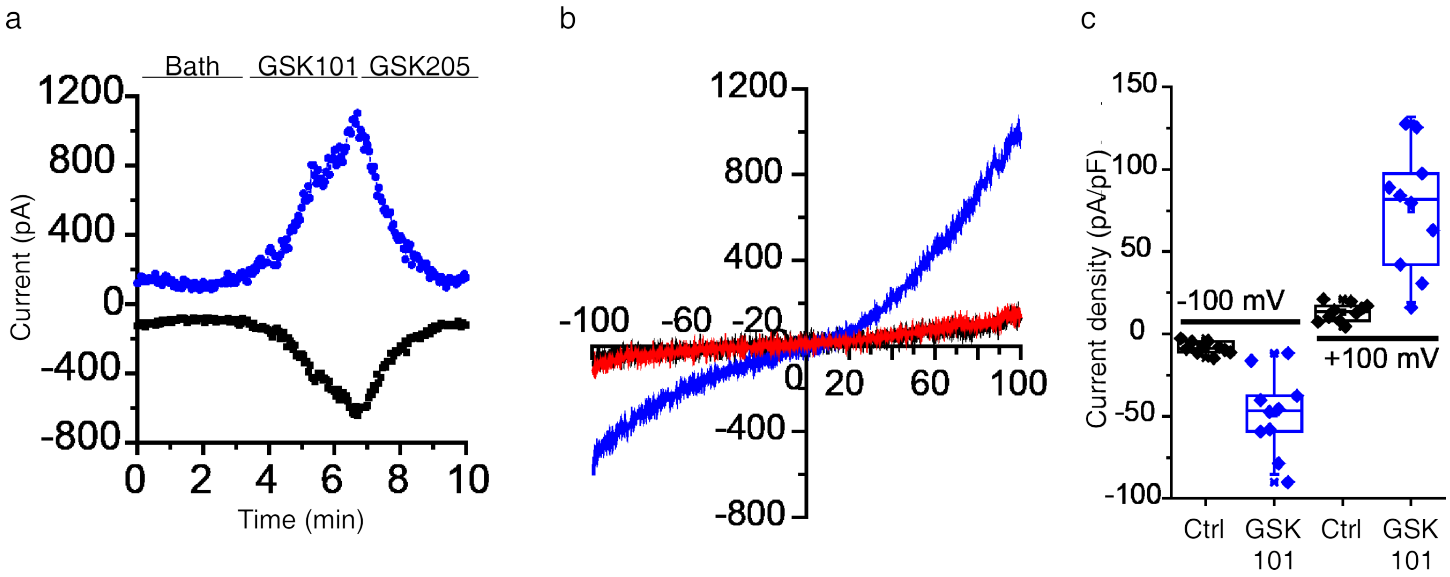

Figure S2. TRPV4-specific currents in TRPV4-P2A-ferritin-P2A-mCherry expressing 293T cells.

(**a**) Whole-cell patch-clamp recordings of outward (at 100 mV, blue trace) and inward (at -100mV, black trace) currents in 293T cells expressing control TRPV4-P2A-ferritin-P2A-mCherry in response to TRPV4 agonist GSK101 (10 nM) and antagonist GSK205 (10 μM).

(**b**) Current-voltage relationships of control (black trace), the GSK101- (blue trace) and GSK205- (red trace) evoked responses in 293T cells expressing TRPV4-P2A-ferritin-P2A-mCherry.

(**c**) Box charts showing quantification of the peak currents in 293T cells expressing TRPV4-P2A-ferritin-P2A-mCherry (Ctrl: -8.3±1.2 pA; GSK101: -48.5±7.8 pA; n=10, Z=-2.803, p<0.01, for inward currents at -100 mV; Ctrl: 13.1±1.7 pA; GSK101: 75.5±11.9 pA; n=10, Z=2.803, p<0.01, for outward currents at 100 mV).

Figure S3

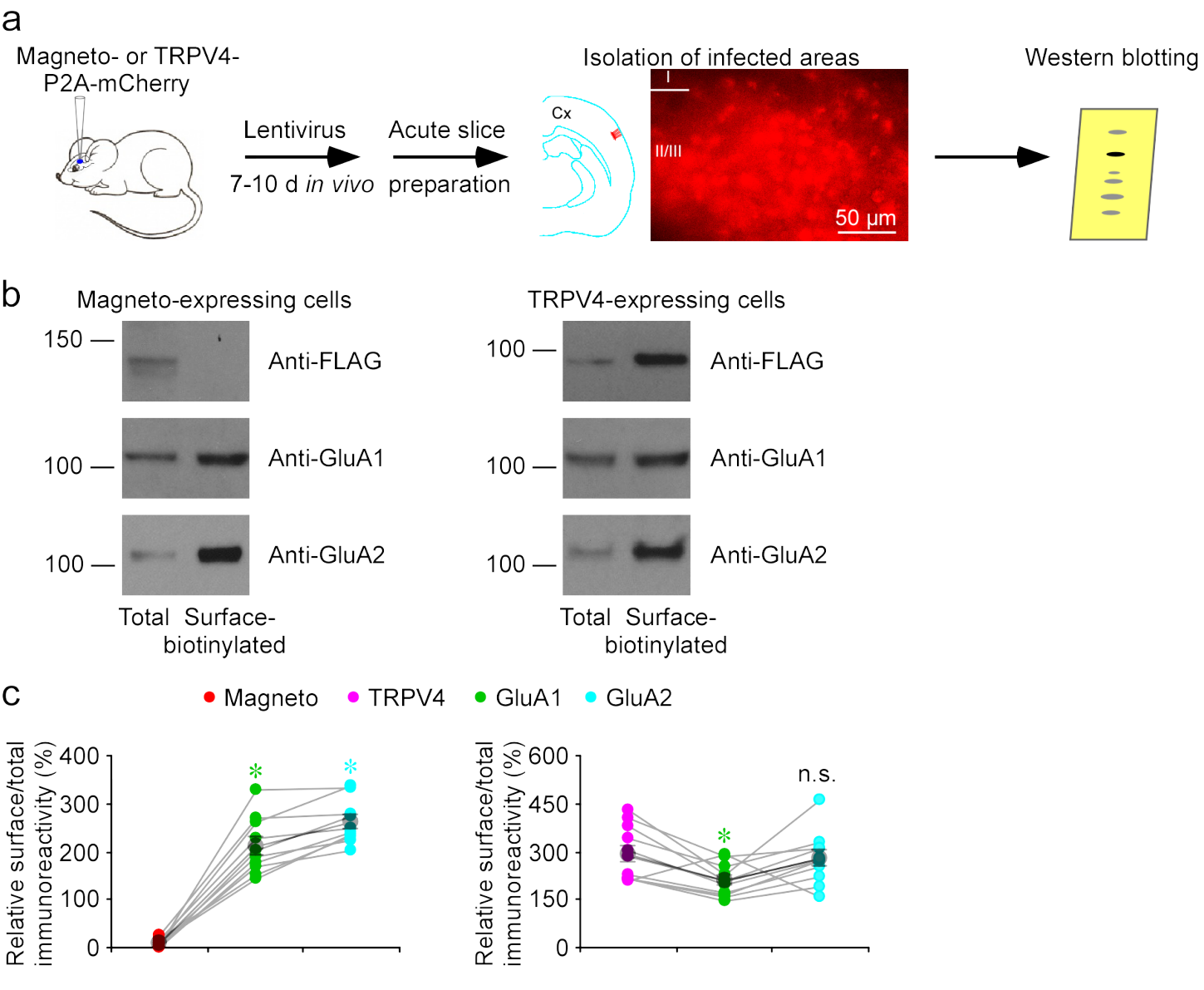

Figure S3. Membrane surface trafficking of Magneto2.0 is impaired in barrel cortical cells *in vivo*.

(**a**) Schematic drawing outlines the design of biochemistry analysis of Magneto2.0 and TRPV4 (both of which are FLAG tagged) expressed in the intact mouse barrel cortex with lentivirus. The inset image shows the expressing barrel cortical area identifiable by mCherry fluorescence. Note the majority of barrel cortical neurons nearby the viral injected site expressing mCherry.

(**b**) Western blots of total and membrane surface-biotinylated recombinant Magneto2.0 and TRPV4, and endogenous GluA1 and GluA2 in barrel cortical neurons after 7-10 days of expression. Each lane loaded with 40 μg proteins.

(**c**) Relative levels of membrane surface-biotinylated vs. total Magneto2.0 (Magneto2.0: 9.9±2.5%; GluA1: 212.2±18.7%, n=10, Z=2.803, p<0.01; GluA2: 260.3±14.2%; n=12, Z=2. 803, p<0.01) and TRPV4 (TRPV4: 293.2±25.4%; GluA1: 209.9±14.6%, n=11, Z=-2.401, p<0.05; GluA2: 276.2±24.3%, n=11, Z=-1.607, p=0.29) compared to GluA1 and GluA2. Asterisks indicate p<0.05 (Wilcoxon tests).

Figure S4

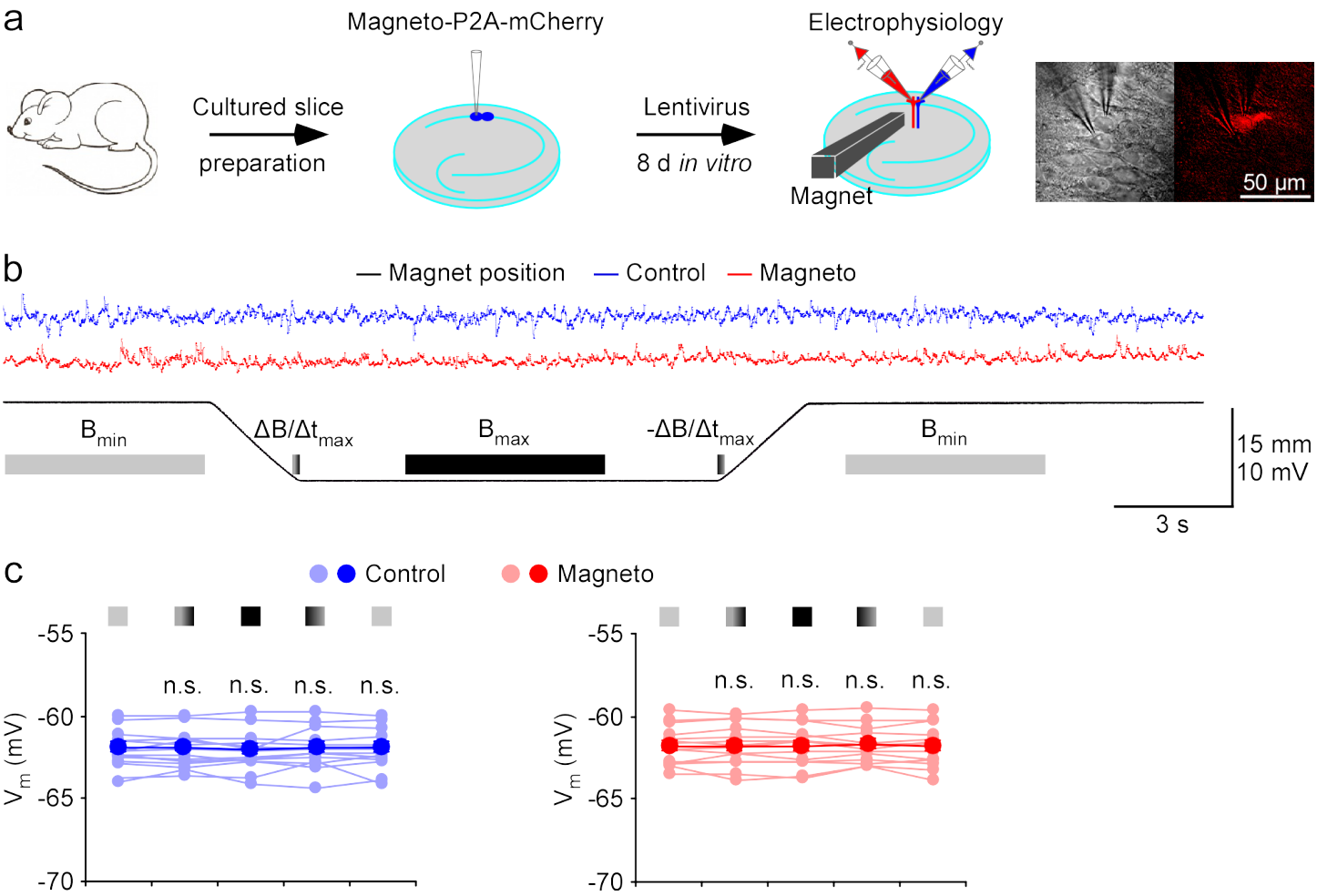

Figure S4. No magnetic effect in rat CA1 neurons expressing lentivirus-delivered Magneto2.0.

(**a**) Schematic drawing outlines the design of *in vitro* lentiviral expression, magnetic stimulation and electrophysiological recordings in cultured rat hippocampal slices. The right images show simultaneous whole-cell recordings from a pair of control non-expressing and Magneto-P2A-mCherry expressing CA1 pyramidal neurons under transmitted light (left) and fluorescence microscopy with RFP filter (right).

(**b**) Recordings of membrane potentials of the pair of control non-expressing and Magneto-P2A-mCherry expressing CA1 pyramidal neurons before, during and after magnetic stimuli delivered with a K&J N42 1/16" permanent block magnet mounted on a micromanipulator.

(**c**) Values of membrane potentials of control non-expressing (Initial B_{min}: -62.0±0.3 mV; $\Delta B/\Delta t_{max}$: -61.9±0.3 mV, Z=-0.220, p=0.83; B_{max}: -62.0±0.3 mV, Z=-0.471, p=0.64; $-\Delta B/\Delta t_{max}$: -61.9±0.3 mV, Z=0.282, p=0.78; Ending B_{min}: -61.9±0.3 mV, Z=1.287, p=0.20; Wilcoxon tests) and Magneto-P2A-mCherry (Initial B_{min}: -61.8±0.3 mV; $\Delta B/\Delta t_{max}$:

-61.8±0.3 mV, Z=0.282, p=0.78; B_{max}: -61.8±0.3 mV, Z=0.659, p=0.51; $-\Delta B/\Delta t_{max}$: -61.7±0.3 mV, Z=-0.220, p=0.83; Ending B_{min}: -61.8±0.3 mV, Z=0.345, p=0.73; Wilcoxon tests) expressing CA1 pyramidal neurons when the permanent magnet was away from (light), approaching to (light-dark transient color), close to (dark), retracting from (dark-light transient color), and away from (light) recorded neurons (n=14 from 6 animals). Note no difference in membrane potential in control non-expressing and Magneto-P2A-mCherry expressing CA1 pyramidal neurons in all the experimental stages (p>0.05; Wilcoxon tests).

Figure S5

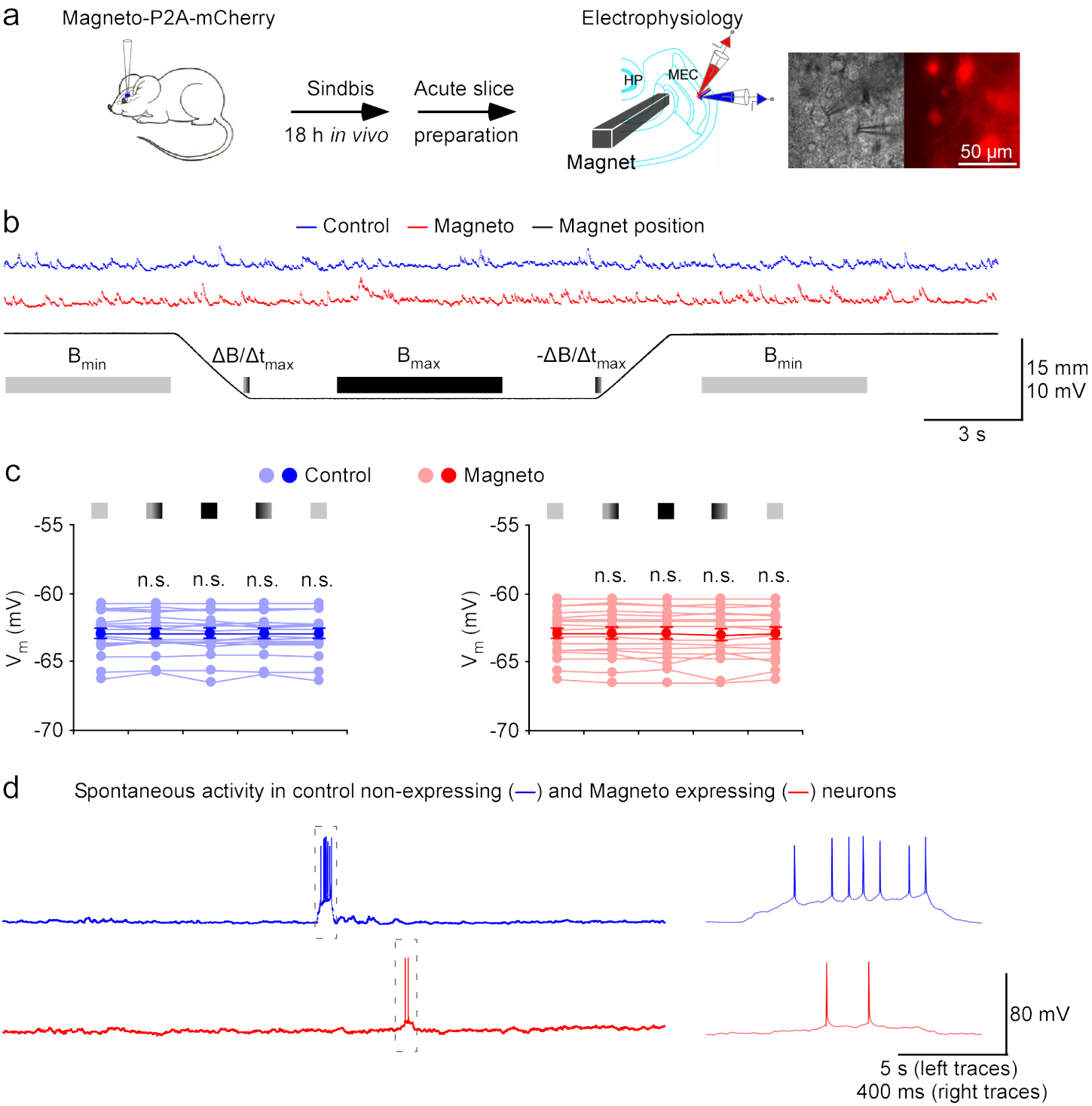

Figure S5. No magnetic effect in mouse MEC L2/3 neurons expressing Sindbis-delivered Magneto2.0.

(**a**) Schematic drawing outlines the design of *in vivo* Sindbis viral expression, *ex vivo* magnetic stimulation and electrophysiological recordings in acutely prepared mouse MEC slices. The right images show simultaneous

whole-cell recordings from a pair of control non-expressing and Magneto-P2A-mCherry expressing MEC L2/3 pyramidal neurons under transmitted light (left) and fluorescence microscopy with RFP middle filter (right).

(**b**) Recordings of membrane potentials of the pair of control non-expressing and Magneto expressing MEC L2/3 neurons before, during and after magnetic stimuli delivered with a K&J N42 1/16" permanent block magnet mounted on a micromanipulator.

(**c**) Values of membrane potentials of control non-expressing (Initial B_{min}: -62.8±0.4 mV; $\Delta B/\Delta t_{max}$: -62.8±0.4 mV, *Z*=-0.024, *p*=0.98; B_{max}: -62.8±0.4 mV, *Z*=-0.828, *p*=0.41; $-\Delta B/\Delta t_{max}$: -62.8±0.4 mV, *Z*=-0.260, *p*=0.80; Ending B_{min}: -62.8±0.4 mV, *Z*=-0.923, *p*=0.36) and Magneto-P2A-mCherry (Initial B_{min}: -62.9±0.4 mV; $\Delta B/\Delta t_{max}$: -62.9±0.4 mV, *Z*=0.402, *p*=0.69; B_{max}: -63.0±0.4 mV, *Z*=-0.166, *p*=0.87; $-\Delta B/\Delta t_{max}$: -63.0±0.5 mV, *Z*=-1.065, *p*=0.29; Ending B_{min}: -63.0±0.4 mV, *Z*=0.166, *p*=0.87) expressing MEC L2/3 pyramidal and stellate neurons when the permanent magnet was away from (light), approaching to (light-dark transient color), close to (dark), retracting from (dark-light transient color), and away from (light) recorded neurons (*n*=17 from 13 animals). Note no difference in membrane potential in control non-expressing and Magneto-P2A-mCherry expressing MEC L2/3 neurons in all the experimental stages (*p*>0.05; Wilcoxon tests).

(**d**) Recordings of spontaneous events in the pair of control non-expressing and Magneto-P2A-mCherry expressing MEC layer 2/3 neurons. Note the spontaneous suprathreshold events in the gray dash line boxes shown again in an expanded time scale in the right.

Figure S6

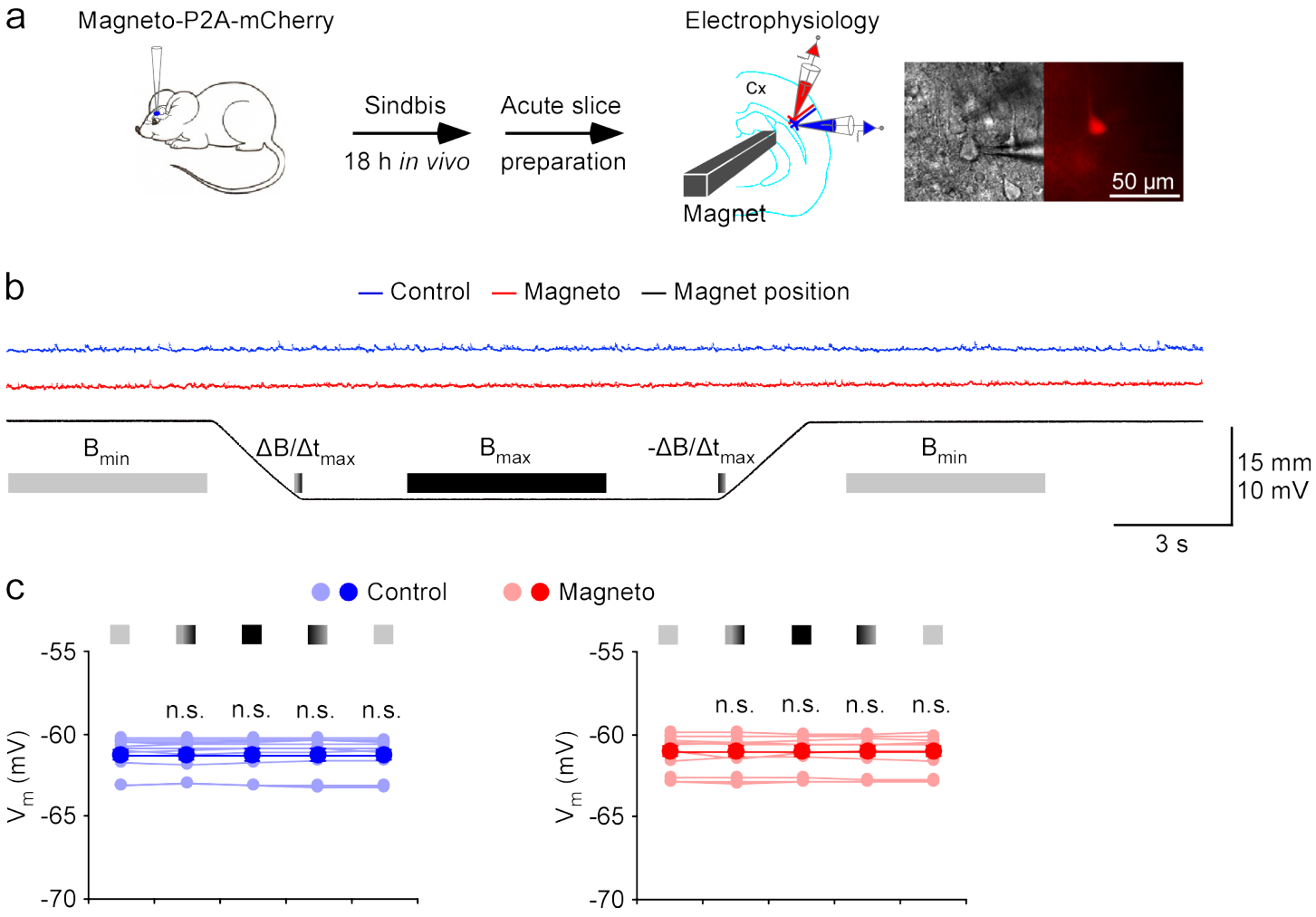

Figure S6. No magnetic effect in mouse barrel cortical L5 neurons expressing Magneto2.0.

(**a**) Schematic drawing outlines the design of *in vivo* Sindbis viral expression, *ex vivo* magnetic stimulation and electrophysiological recordings in acutely prepared mouse cortical slices. The right images show simultaneous whole-cell recordings from a pair of control non-expressing and Magneto-P2A-mCherry expressing barrel cortical L5 pyramidal neurons under transmitted light (left) and fluorescence microscopy with RFP middle filter (right). Cx: cerebral cortex.

(**b**) Recordings of membrane potentials of the pair of control non-expressing and Magneto-P2A-mCherry expressing barrel cortical L5 pyramidal neurons before, during and after magnetic stimuli delivered with a K&J N42 1/16" permanent block magnet mounted on a micromanipulator.

(**c**) Values of membrane potentials of control non-expressing (Initial B_{min}: -61.2±0.3 mV; $\Delta B/\Delta t_{max}$: -61.2±0.3 mV, Z=0.235, p=0.81; B_{max}: -61.2±0.3 mV, Z=0.000, p=1.00; $-\Delta B/\Delta t_{max}$: -61.2±0.3 mV, Z=0.628, p=0.53; Ending B_{min}: -61.2±0.3 mV, Z=0.392, p=0.70; Wilcoxon tests) and Magneto-P2A-mCherry (Initial B_{min}: -61.1±0.3 mV; $\Delta B/\Delta t_{max}$: -61.1±0.3 mV, Z=0.000, p=1.00; B_{max}: -61.1±0.3 mV, Z=-0.785, p=0.43; $-\Delta B/\Delta t_{max}$: -61.1±0.3 mV, Z=-0.235, p=0.81; Ending B_{min}: -61.1±0.3 mV, Z=0.000, p=1.00; Wilcoxon tests) expressing barrel cortical pyramidal neurons when the permanent magnet was away from (light), approaching to (light-dark transient color), close to (dark), retracting from (dark-light transient color), and away from (light) recorded neurons (n=12 from 6 animals). Note no difference in membrane potential in control non-expressing and Magneto-P2A-mCherry expressing barrel cortical L5 pyramidal neurons in all the experimental stages (p≥0.05; Wilcoxon tests).

Figure S7

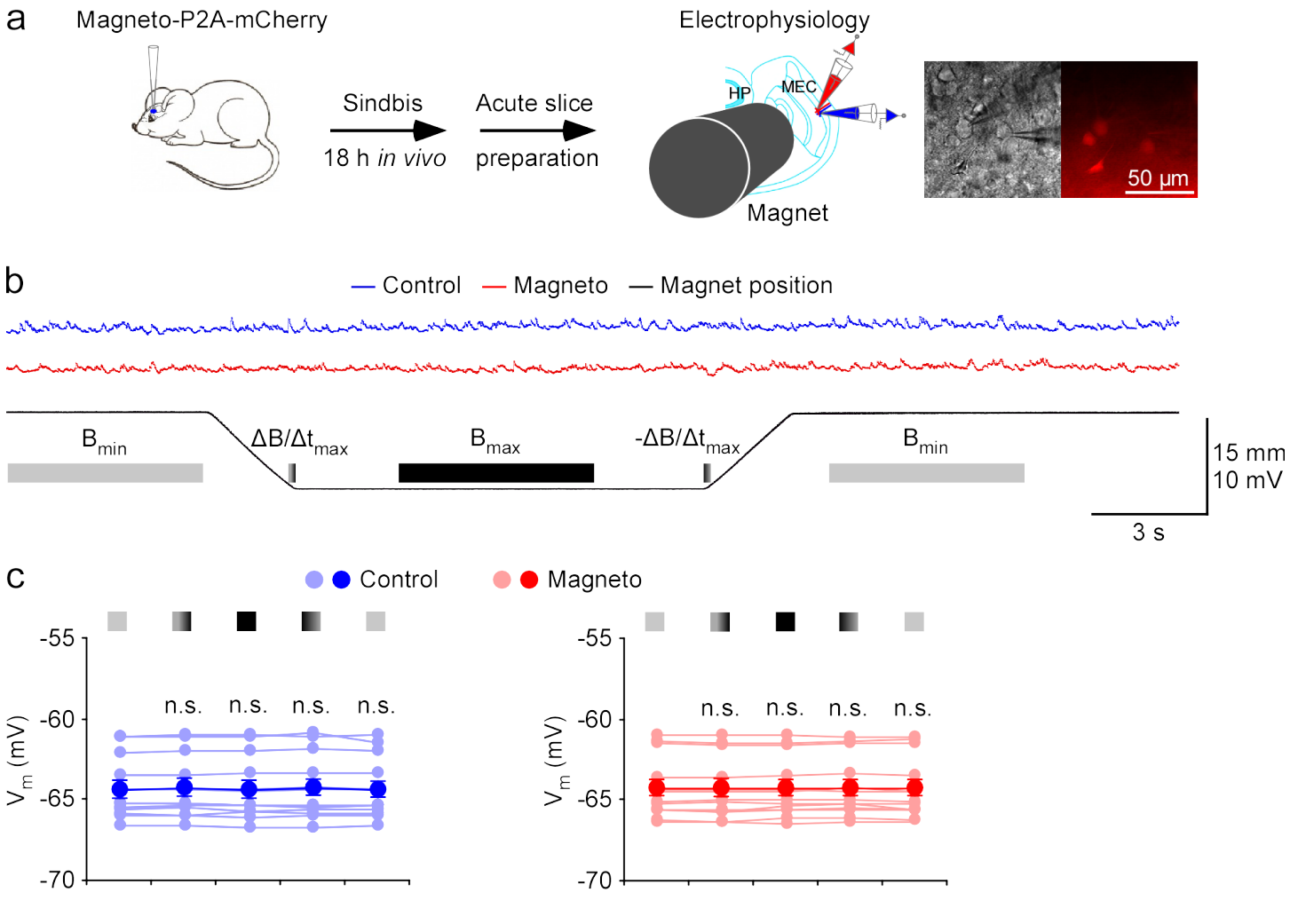

Figure S7. No 3/8" magnet-evoked effect in mouse entorhinal L2/3 neurons expressing Magneto2.0.

(**a**) Schematic drawing outlines the design of *in vivo* Sindbis viral expression, *ex vivo* magnetic stimulation and electrophysiological recordings in acutely prepared mouse MEC slices. The right images show simultaneous whole-cell recordings from a pair of control non-expressing and Magneto-P2A-mCherry expressing MEC L2/3 pyramidal neurons under transmitted light (left) and fluorescence microscopy with RFP middle filter (right). HP: hippocampus; MEC: medial entorhinal cortex.

(**b**) Recordings of membrane potentials of the pair of control non-expressing and Magneto-P2A-mCherry expressing MEC L2/3 pyramidal and stellate neurons before, during and after magnetic stimuli delivered with a 3/8" permanent block magnet mounted on a micromanipulator.

(**c**) Values of membrane potentials of control non-expressing (Initial B_{min}: -64.2±0.5 mV; $\Delta B/\Delta t_{max}$: -64.2±0.5 mV, Z=0.943, p=0.35; B_{max}: -64.2±0.5 mV, Z=-0.314, p=0.75; $-\Delta B/\Delta t_{max}$: -64.2±0.5 mV, Z=-1.363, p=0.17; Ending B_{min}: -64.3±0.5 mV, Z=-0.035, p=0.97; Wilcoxon tests) and Magneto-P2A-mCherry (Initial B_{min}: -64.3±0.5 mV; $\Delta B/\Delta t_{max}$: -64.3±0.5 mV, Z=-0.943, p=0.35; B_{max}: -64.3±0.5 mV, Z=0.594, p=0.55; $-\Delta B/\Delta t_{max}$: -64.3±0.5 mV, Z=1.223, p=0.22; Ending B_{min}: -64.3±0.5 mV, Z=0.524, p=0.60; Wilcoxon tests) expressing MEC L2/3 pyramidal and stellate neurons when the permanent magnet was away from (light), approaching to (light-dark transient color), close to (dark), retracting from (dark-light transient color), and away from (light) recorded neurons (n=13 from 4 animals). Note no difference in membrane potential in control non-expressing and Magneto-P2A-mCherry expressing MEC L2/3 neurons in all the experimental stages (p>0.05; Wilcoxon tests).

Figure S8

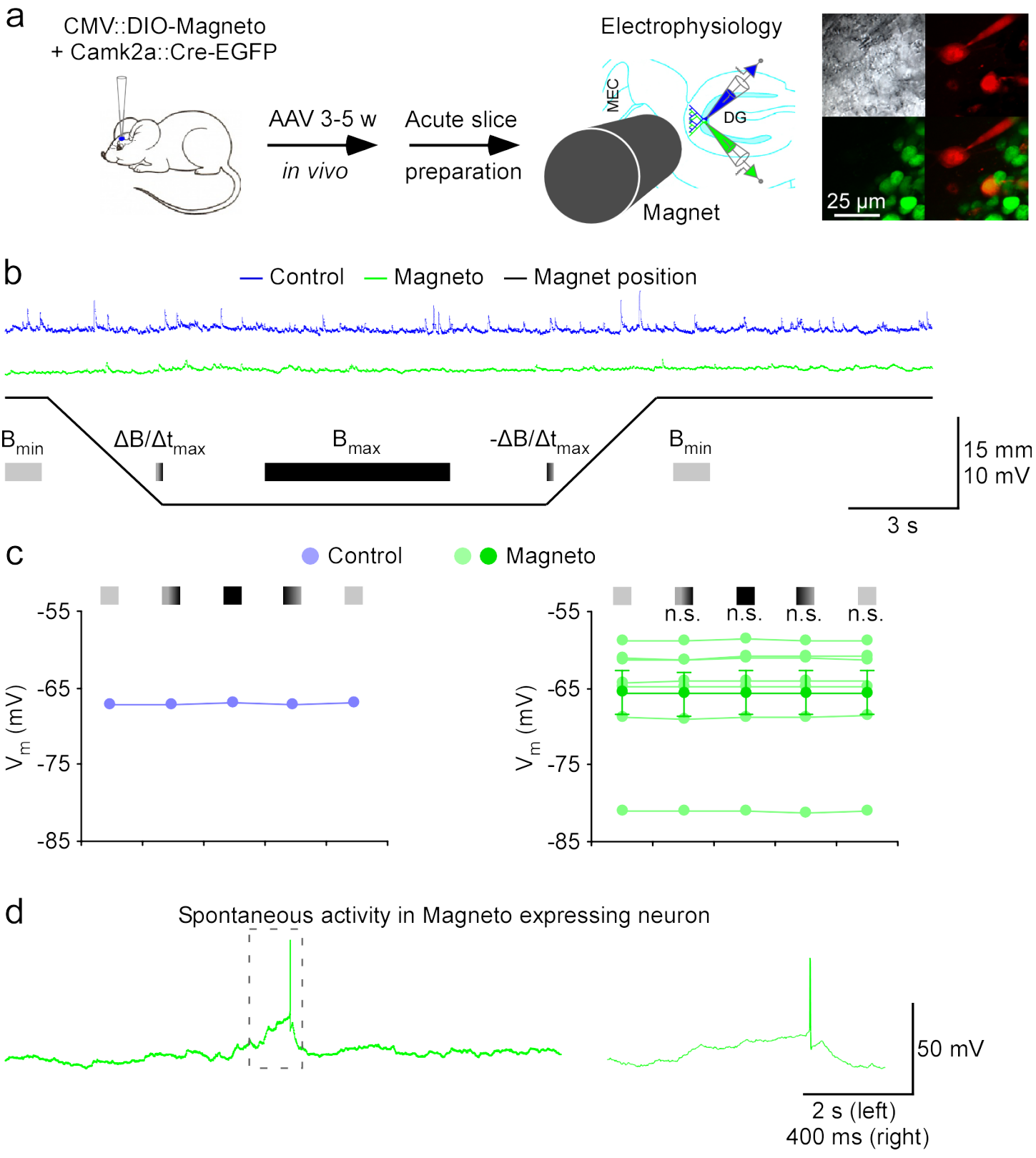

Figure S8. No magnetic effect in mouse hippocampal dentate gyrus neurons expressing Magneto2.0.

(**a**) Schematic drawing outlines the design of *in vivo* AAV viral expression of CMV::DIO-Magneto and Camk2a::Cre-EGFP, *ex vivo* magnetic stimulation and electrophysiological recordings in acutely prepared mouse hippocampal slices. The right images show simultaneous whole-cell recordings from a pair of control non-expressing and DIO-Magneto/Cre-EGFP expressing hippocampal dentate gyrus (**DG**) neurons under transmitted light (upper left) and fluorescence microscopy with RFP (upper right) and GFP (lower left) filters and their overlay (lower right). DG: dentate gyrus; MEC: medial entorhinal cortex. Note that the viral expression and acute slice preparation were carried out by Drs Ronald Gaykema and Manoj Patel.

(**b**) Recordings of membrane potentials of the pair of control non-expressing and DIO-Magneto/Cre-EGFP expressing DG neurons before, during and after magnetic stimuli delivered with a 3/8" permanent block magnet mounted on a micromanipulator.

(**c**) Values of membrane potentials of control non-expressing (Initial B_{min}: -66.9 mV; $\Delta B/\Delta t_{max}$: -66.8 mV; B_{max}: -66.8 mV; $-\Delta B/\Delta t_{max}$: -66.9 mV; Ending B_{min}: -66.8 mV; n=1) and DIO-Magneto/Cre-EGFP (Initial B_{min}: -65.6±2.8 mV; $\Delta B/\Delta t_{max}$: -65.7±2.8 mV, Z=-1.352, p=0.18; B_{max}: -65.6±2.9 mV, Z=1.181, p=0.24; $-\Delta B/\Delta t_{max}$: -65.6±2.9 mV, Z=0.854, p=0.40; Ending B_{min}: -65.6±2.8 mV, Z=0.854, p=0.40; n=7) expressing DG neurons when the permanent magnet was away from (light), approaching to (light-dark transient color), close to (dark), retracting from (dark-light transient color), and away from (light) recorded neurons. Note that in this experiment only one control non-expressing neurons was recorded and analyzed with seven DIO-Magneto/GFP-Cre expressing neurons because the majority of dentate gyrus neurons exhibited green fluorescence (**see insets**).

(**d**) Recordings of spontaneous events in a DIO-Magneto/Cre-EGFP expressing DG neuron. Note the spontaneous suprathreshold event in the gray dash line box shown again in an expanded time scale in the right.

Figure S9

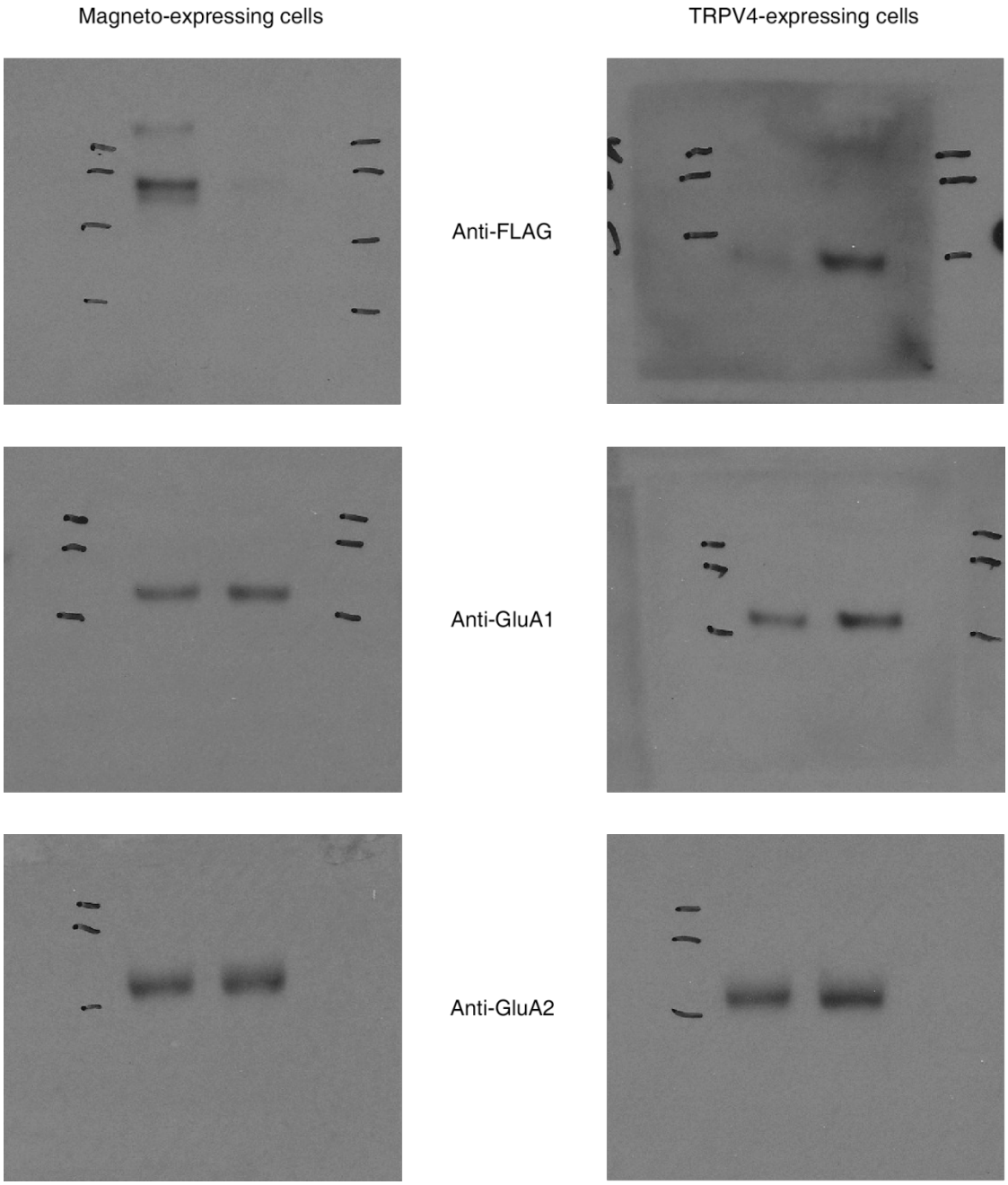

Figure S9. Images of original uncropped Western blots used for preparation of figure 1f-g.

Figure S10

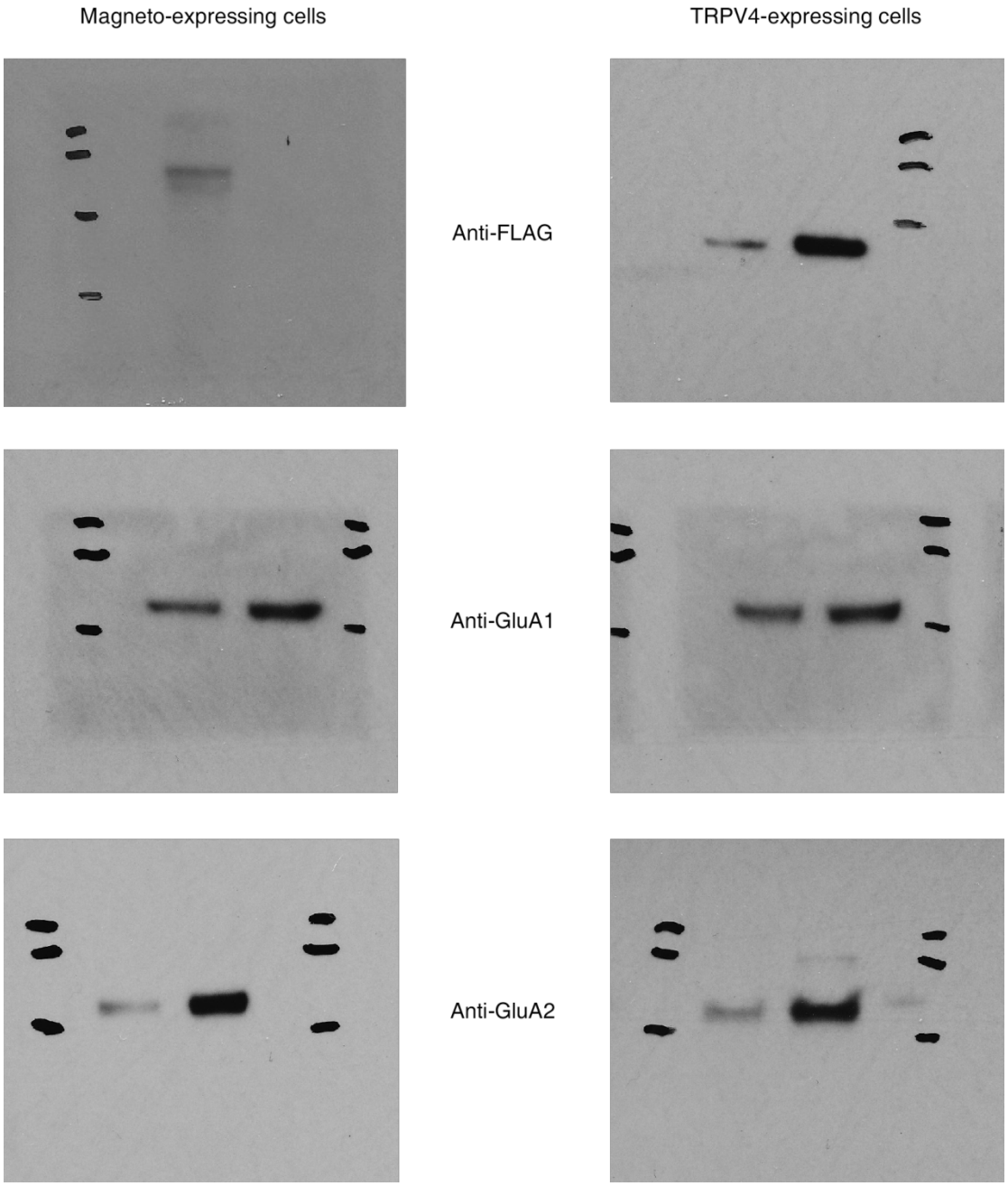

Figure S10. Images of original uncropped Western blots used for preparation of figure S3.