In vivo electrophysiology

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In vivo Recordings

- Direct recording of animal neuronal activity
  - *In vivo* experiment takes place in a whole, living organism.
    - Most experiments performed *in vivo* submerge an electrode into the brain and record extracellularly.
    - However, it is possible to perform intracellular or even patch clamp recordings with specialized, dedicated equipment.
  - Acute vs Chronic Recordings
  - Anesthetized vs Awake Animals

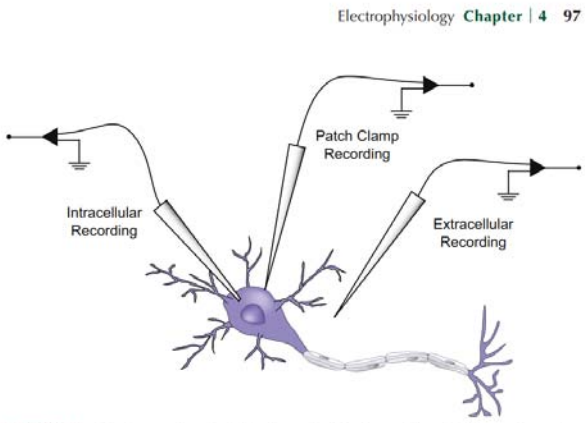

FIGURE 4.4 The three categories of electrophysiological recordings. Each type of recording is defined by where the scientist places the recording electrode: outside the neuron (extracellular recording), inside the neuron (intracellular recording), or adjacent to the membrane (patch clamp recording).

Carter, M., & Shieh, J. C. (2015). Guide to research techniques in neuroscience. Elsevier Science & Technology.

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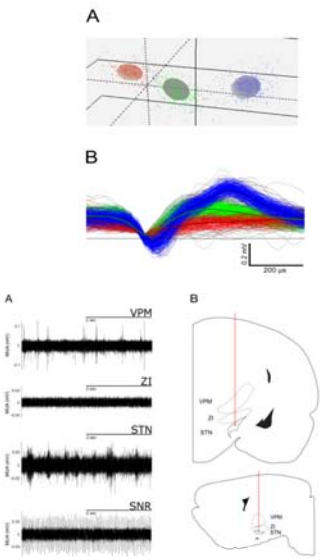
Commonly recorded Ephys signals

Intracellular:

- Synaptic events: signal which excites, inhibits or modulates cell activity.
- Spike activity: AP
- Postsynaptic potentials

Extracellular:

- field excitatory-postsynaptic potentials (fEPSPs or FP) evoked from dendritic areas
- Single unit (cell) activity (SUA) of spikes/action potentials: info from one cell
- Multi-unit activity (MUA) of spikes: better overall estimation of spike activity
- Non- spiking, graded potentials (EEG)



Haumesser, J.K., Kühn, J., Güttler, C., Nguyen, D.H., Beck, M.H., Kühn, A.A., van Riesen, C. Acute In Vivo Electrophysiological Recordings of Local Field Potentials and Multi-unit Activity from the Hyperdirect Pathway in Anesthetized Rats. J. Vis. Exp. (124), e55940, doi:10.3791/55940 (2017)

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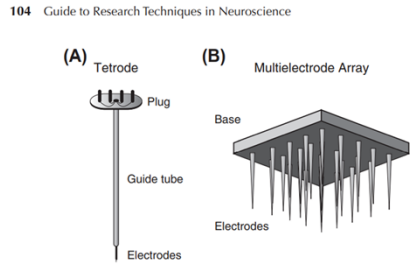
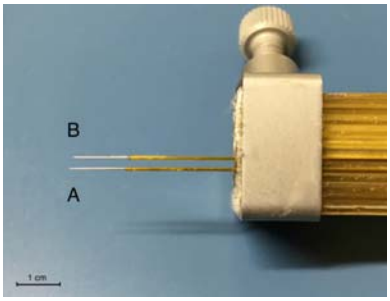
Measuring Neural Activity *In Vivo*

- **Single electrodes**: inserted through an implanted chamber
- **Multielectrode array (MEA)**: grid of dozens of electrodes capable of recording the activity of multiple neurons. Usually implanted on the outer surface of the brain.
  - allows for stimulation and extracellular recording from several neighboring sites at once.
- **Tetrodes**: has four active electrodes arranged into a single implant. Can be inserted into relatively deep brain structures





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Video Article

Acute *In Vivo* Electrophysiological Recordings of Local Field Potentials and Multi-unit Activity from the Hyperdirect Pathway in Anesthetized Rats

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Keywords: Neuroscience, Issue 124, *in vivo* electrophysiology, local field potentials, multi-unit activity, urethane anesthesia, basal ganglia, primary motor cortex, hyperdirect pathway

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Abstract

Converging evidence shows that many neuropsychiatric diseases should be understood as disorders of large-scale neuronal networks. To better understand the pathophysiological basis of these diseases, it is necessary to precisely characterize in which way the processing of information is disturbed between the different neuronal parts of the circuit. Using extracellular *in vivo* electrophysiological recordings, it is possible to accurately delineate neuronal activity within a neuronal network. The application of this method has several advantages over alternative techniques, *e.g.*, functional magnetic resonance imaging and calcium imaging, as it allows a unique temporal and spatial resolution and does not rely on genetically engineered organisms. However, the use of extracellular *in vivo* recordings is limited since it is an invasive technique that cannot be universally applied. In this article, a simple and easy to use method is presented with which it is possible to simultaneously record extracellular potentials such as local field potentials and multiunit activity at multiple sites of a network. It is detailed how a precise targeting of subcortical nuclei can be achieved using a combination of stereotactic surgery and online analysis of multi-unit recordings. Thus, it is demonstrated, how a complete network such as the hyperdirect cortico-basal ganglia loop can be studied in anesthetized animals *in vivo*.

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General Description of In Vivo Patch-Clamp Technique

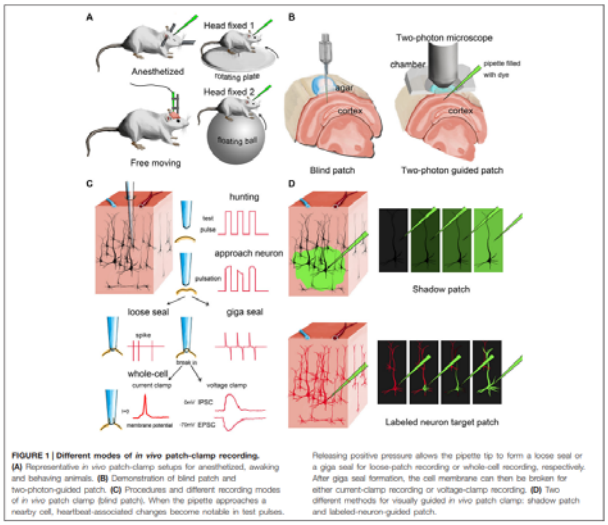

FIGURE 1 | Different modes of *in vivo* patch-clamp recording. **(A)** Representative *in vivo* patch-clamp setups for anesthetized, awaking and behaving animals. **(B)** Demonstration of blind patch and two-photon-guided patch. **(C)** Procedures and different recording modes of *in vivo* patch clamp (blind patch). When the pipette approaches a nearby cell, heartbeat-associated changes become notable in test pulses. Releasing positive pressure allows the pipette tip to form a loose seal or a giga seal for loose-patch recording or whole-cell recording, respectively. After giga seal formation, the cell membrane can then be broken for either current-clamp recording or voltage-clamp recording. **(D)** Two different methods for visually guided *in vivo* patch clamp: shadow patch and labeled-neuron-guided patch.

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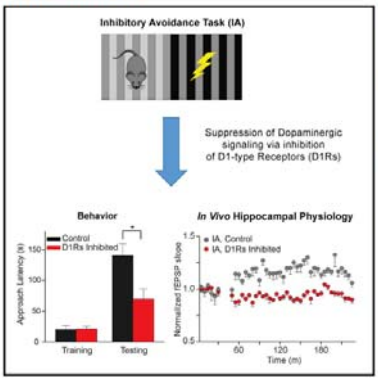
Article

Cell Reports

Dopamine Regulates Aversive Contextual Learning and Associated In Vivo Synaptic Plasticity in the Hippocampus

Graphical Abstract



Authors

John I. Broussard, Kechun Yang, Amber T. Levine, ..., Fu-Ming Zhou, Mariella De Biasi, John A. Dani

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In Brief

The role of dopamine in signaling rewards is well known, but here Broussard et al. show that dopamine D1-like receptor activity in the hippocampus is necessary for retention of aversive memories. The results indicate dopaminergic innervation and function within the hippocampus underlying long-term synaptic potentiation associated with aversive memory retention.

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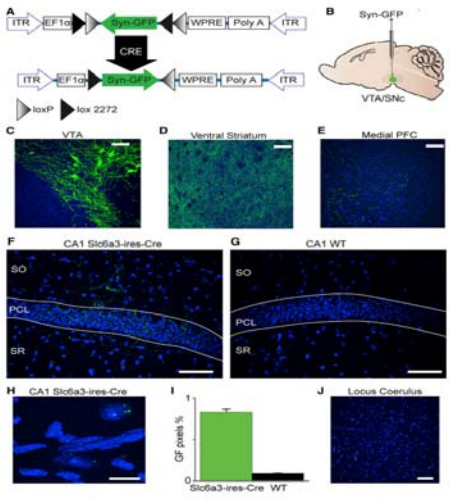
Fig 1. Midbrain DAT-Positive Neurons Project to the CA1



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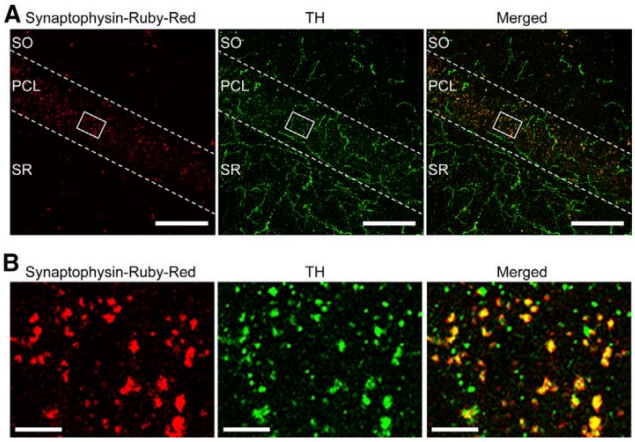

Figure 2. Dopaminergic Terminals and Axons in the CA1 Show High Co-localization with Tyrosine Hydroxylase

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Fig 3. Dopamine-Regulated Acquisition of a IA Long-Term Memory

a) Inhibitory Avoidance- Footshock

b) 24 hrs after training, mice injected with saline significantly delayed entering the dark, but SCH-treated mice was not delayed.

c) SCH did not impair STM, approach latency remained similar to controls at 1 and 3 hr after shock training

d) Implanted bilateral cannulas directly above CA1 and infused SCH (1 mg/ml) 15 mins before training. It shows a reduced approach latency.

e) high dose of SCH (0.2 mg/kg) immediately after IA training did not impair retention of the footshock at the 24-hr interval

f) SKF 81297 D1 agonist (0.9 mg/kg), enhanced IA retention 72 hr after a moderate (0.4 mA) footshock

g) Injected b2-adrenergic antagonist, Timolol (Tim), prior to IA training (10 mg/kg and 20 mg/kg, i.p.)

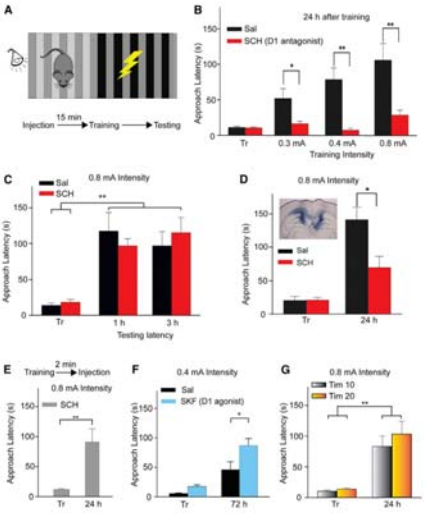

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Figure 4. IA Training Increased the AMPA/ NMDA Current Ratio in CA1 Pyramidal Neurons, but Not in Dentate Gyrus Granule Cell

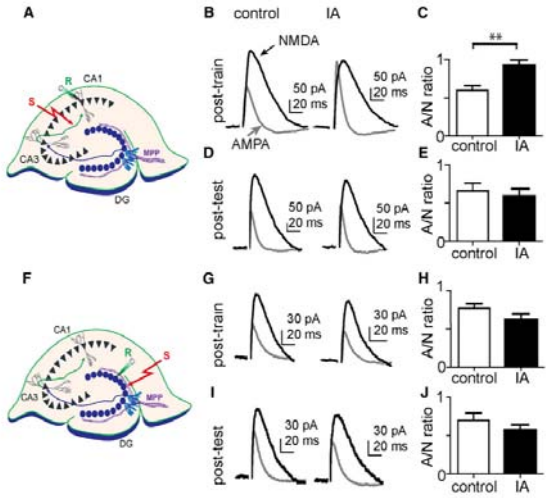

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Figure 5. IA Training Enhanced the Slope of the In Vivo fEPSP of the CA3-CA1 Circuit

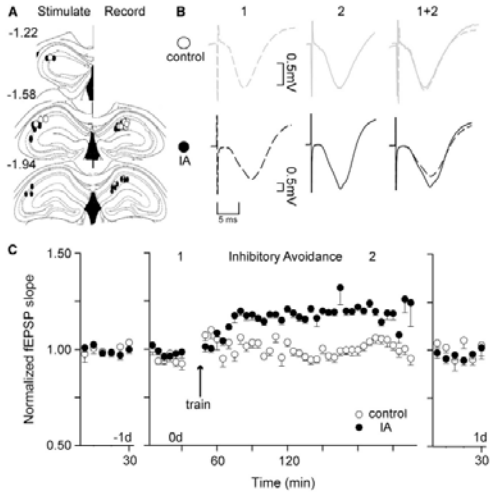

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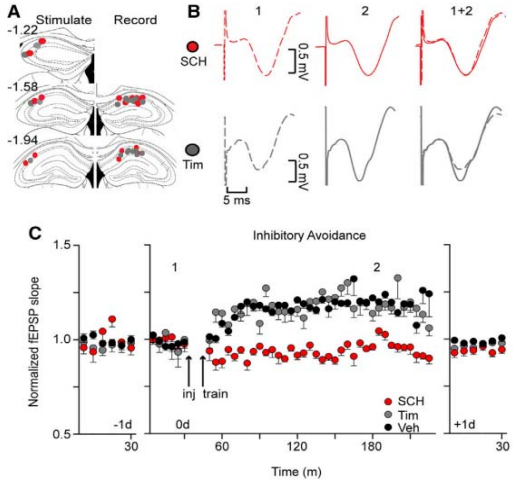
Figure 6. D1/D5 Receptor Antagonist, but Not b-adrenergic Receptor Antagonist, Blocked IA Training-Induced Increases in the In Vivo fEPSP Slope



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- Automated whole-cell patch clamp electrophysiology of neurons in vivo – YouTube
- Neuronal in vivo Assays | Creative Bioarray (creative-bioarray.com)

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