

Open-Source Real-Time Closed-Loop Electrical Threshold Tracking for Translational Pain Research

Aidan P. Nickerson^{1,2}, Graeme W. T. Newton¹, James H. O'Sullivan³, Manuel Martinez-Perez⁴, Anna C. Sales¹, Gethin Williams⁵, Anthony E. Pickering¹, James P. Dunham¹

¹Anaesthesia, Pain, and Critical Care Sciences, School of Physiology, Pharmacology, & Neuroscience, University of Bristol ²Eli Lilly and Company

³Department of Computer Science, University of Bristol ⁴Department of Aerospace Engineering, University of Bristol ⁵Research Computing, University of Bristol

Corresponding Author

James P. Dunham

james.p.dunham@bristol.ac.uk

Citation

Nickerson, A.P., Newton, G.W.T., O'Sullivan, J.H., Martinez-Perez, M., Sales, A.C., Williams, G., Pickering, A.E., Dunham, J.P. Open-Source Real-Time Closed-Loop Electrical Threshold Tracking for Translational Pain Research. *J. Vis. Exp.* (194), e64898, doi:10.3791/64898 (2023).

Date Published

April 21, 2023

DOI

10.3791/64898

URL

jove.com/video/64898

Materials

Name	Company	Catalog Number	Comments
12V DC Power Supply	NA	NA	To power uStepper S-lite. Required for dial-controlled stimulators.
36 Pin Electrode Adapter Board	Intan Technology	C3410	APTrack Dependency. For connecting electrode input to headstage. \$255 USD as of March 2021.
APTrack Plugin	NA	NA	https://github.com/Microneurography/APTrack
Bipolar Ag/AgCl Recording Electrode	Custom	NA	Recording electrode for the skin-nerve preparation. Or equivalent.
Bipolar Concentric Stimulating Electrode	World Precision Instruments	SNE-100	For electrical stimulation in the mouse skin-nerve preparation. Or equivalent.
Bipolar Transcutaneous Stimulating Electrode	Custom	NA	For transcutaneous electrical stimulation while searching for single-neuron action potentials during microneurography.
BNC T Splitter (1+)	NA	NA	APTrack Dependency. Any standard BNC T splitter.
BNC to BNC cables (3+)	NA	NA	APTrack Dependency. Any standard BNC cables.
C6H11NaO7	Merck	S2054	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
CaCl2	Merck	C5670	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
Digitimer DS4 Constant Current Stimulator	Digitimer	DS4	Constant current stiuator for animal research. £1,695 GBP as of September 2022.

Digitimer DS7 Constant Current Stimulator	Digitimer	DS7A	Constant current stiuator for human research. £3,400 GBP as of September 2022.
Electroaccupuncture Classic Plus Stimulating Electrodes	Harmony Medical	NA	For fixed position intradermal electrical stimulation of the dorsal aspect of the foot during human microneurography.
Glucose	Fisher Scientific	G/0450/60	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
HDMI Cable	NA	NA	APTrack Dependency. Any standard passive HDMI cable. To connect OE I/O Board to OE Acquisition Board.
KCl	Merck	P9541	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
MgSO4	Acros Organics	213115000	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
Mineral Oil	Merck	330779	Electrical insulation for nerve recordings in th skin-nerve preparation. Or equivalent.
NaCl	Merck	S9888	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
NaHCO3	Merck	S6014	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
NaHCO3	Merck	S0751	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
Open Ephys Acquisition Board	Open Ephys	NA	APTrack Dependency. Includes USB cable to connect to computer and mains socket power supply. €2,955 EUR as of September 2022.
Open Ephys Graphical User Interface	Open Ephys	NA	https://github.com/open-ephys/plugin-GUI
Open Ephys I/O Board	Open Ephys	NA	APTrack Dependency. For ADC voltage inputs via BNC cables. €12.5 EUR without connectors, €85 EUR with connectors as of September 2022.
PulsePal V2	Sanworks	1102	APTrack Dependency. Open-source DAC and train generator. \$725 USD pre-assembled as of September 2022. Approx. \$275 USD for self-assembly.
RHD 6ft SPI Cable	Intan Technology	C3206	APTrack Dependency. For connecting headstage to OE Acquisition Board. \$295 USD as of March 2021
RHD2216 16ch Bipolar Headstage	Intan Technology	C3313	APTrack Dependency. For data acquisition and digitization. \$725 USD as of March 2021. Or equivalent RHD2000 series headstage.
Sucrose	Fisher Scientific	S/8560/60	Skin-nerve preparation synthetic interstitial fluid constituent. Or equivalent.
TCS-II Thermal Stimulator	QST.Lab	NA	For thermal stimualtion of nociceptor receptive fields during human microneurography.

Tungsten Microelectrode Pair (Active + Reference)	FHC	30085	For microneurography recordings. 35mm.
Ultrasound Scanner iQ+	Butterfly Network	NA	For ultrasound-guided electrode insertion during microneurography.
USB 3.0 5kV RMS Isolation	Inota Technology	7055-D	For isolating human microneurography participant from computer. €459 EUR as of September 2022.
USB-A to micro USB-B cable (2)	NA	NA	APTrack Dependency. To connect computer to PulsePal and to uStepper S-lite if using stepper-stimulator interfacing.
uStepper S-lite + NEMA17 motor	uStepper	NA	To interface with stimulators via a control dial. €50 EUR as of September 2022.
Von Frey Filaments	Ugo Basile	37450-275	For mechanical stimulation of receptive fields during sensory phenotyping of nociceptors.