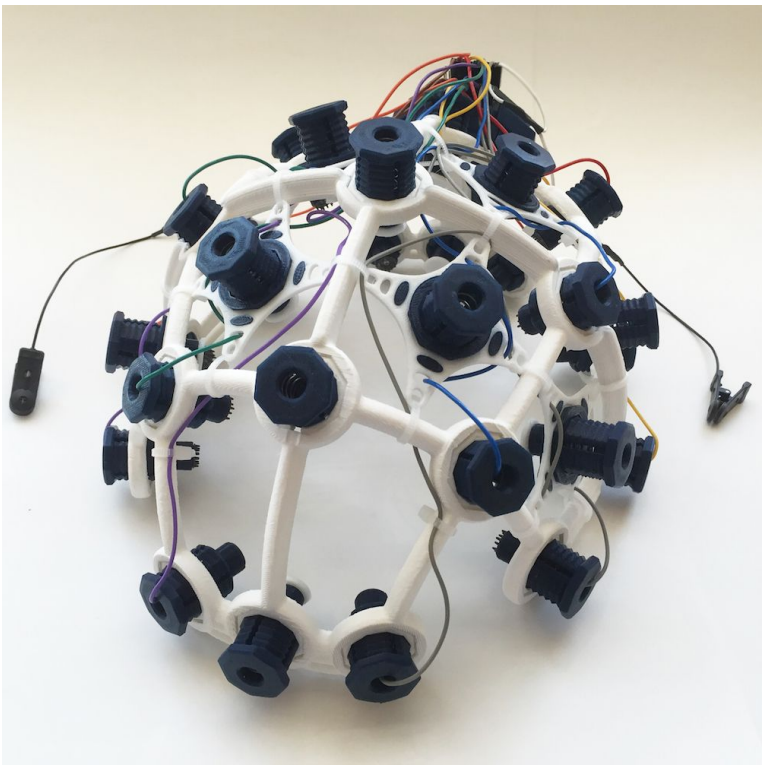
DIY Open Science Workshop: Hardware Guide

Build Your Own Eyetracker and EEG headset with open-source hardware, low-cost electronics, and 3D-printed parts

Building an EEG Headset

This is a modified version from OpenBCI Mark III Nova guide adopted for this workshop.



The Ultracortex is an open-source, 3D-printable headset intended to work with the OpenBCI system. The OpenBCI EEG board is capable of recording brain activity (EEG), muscle activity (EMG), and heart activity (ECG).

Parts

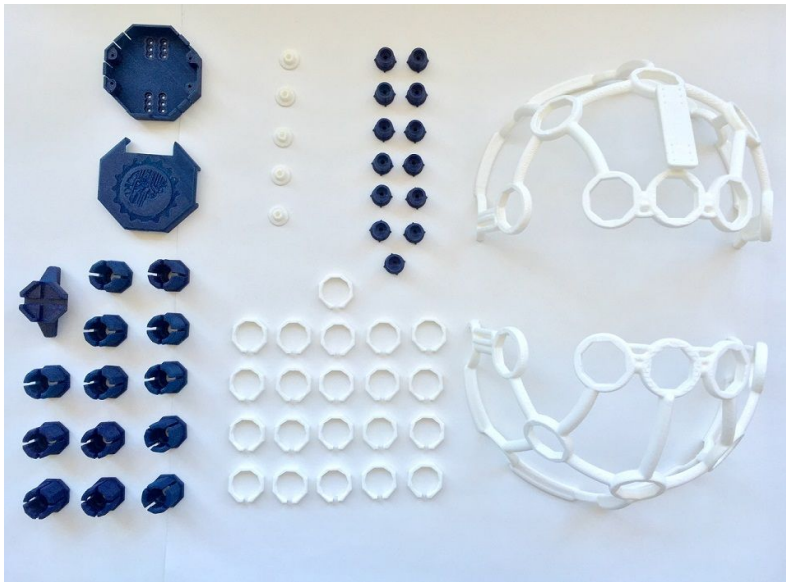


Figure 2. 3D printed parts for frame and electrode

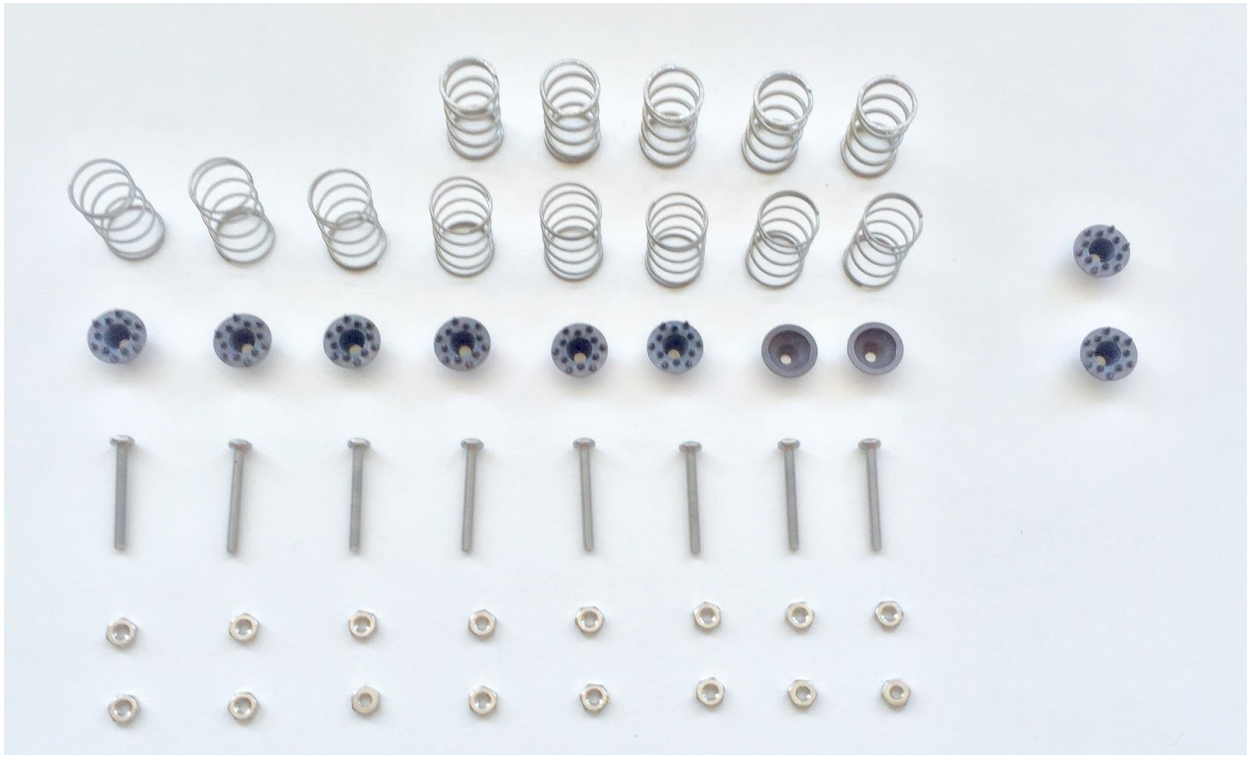


Figure 3. Internal electrode parts

Figure 4. Wiring

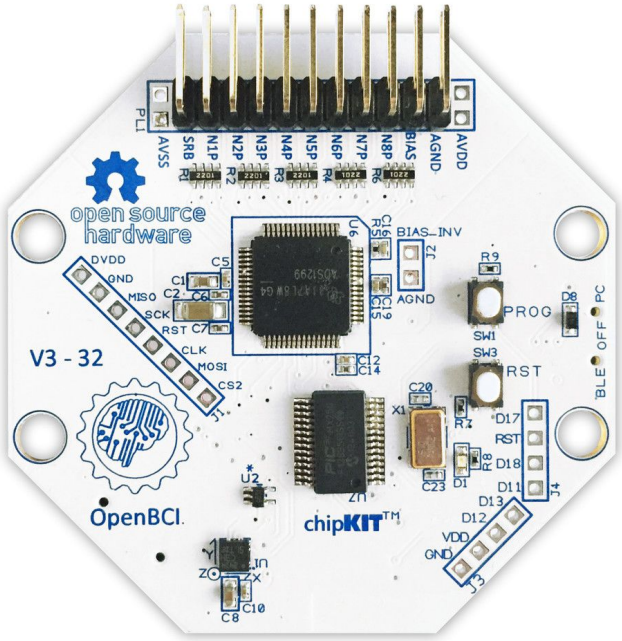


Figure 5. EEG board

Figure 6. Zip Ties

Description of Parts

Spring 1 (x8) — aka "Soft Spring" — Century Spring Corp. Stock #: U-4 — this spring is not as strong as spring 2. We use it to mount the electrodes. The low "Rate" (1.3 lbs/in) makes it more forgiving and comfortable when holding the spikey electrode against your head.
Spring 2 (x5) — aka "Strong Spring" — Century Spring Corp. Stock #: S-71315S — this spring has a much stronger "Rate" (14 lb/in). This makes is ideal to act as a standoff at locations where you do not have a spikey electrode.
We use small stainless steel screws and hex nuts to fasten the FRI electrodes (listed above) to the 3D-printed electrode mount components & wiring that connects the electrodes back to the OpenBCI board. We used stripped Gold Cup Electrodes as the cabling, by removing the gold cup with a wire cutter and looping the exposed wire around the screw between the two tightened hex nuts.

Screws (8x) — Stainless Steel Pan Head Phillips Machine Screw, 2-56 Thread, 3/4" Length
Nuts (16x) — Stainless Steel Hex Nut, 2-56 Thread Size, 3/16" Wide, 1/16" High
Screw for Board Case (4x) — #4 Drive Screw
Zip tie (10x)

Gold Cup Electrodes (1 bundle) — We strip apart eight electrodes from the Gold Cup Electrodes.
Dry (spikey) electrodes (6x) — Disposable / Reusable Dry EEG Electrode
Dry (non-spikey) electrodes (2x) — Disposable / Reusable Cup Wet/Dry EEG Electrode
Ear Clip reference electrodes (2x) — TDI-430 Silver-Silver Chloride Ear Clip Electrode

EEG Board (1x) — OpenBCI 32bit Board for 8 electrode channels

Battery Pack (1x) — ~500mAh lithium ion rechargeable battery pack

Suggested 3D Printing Settings

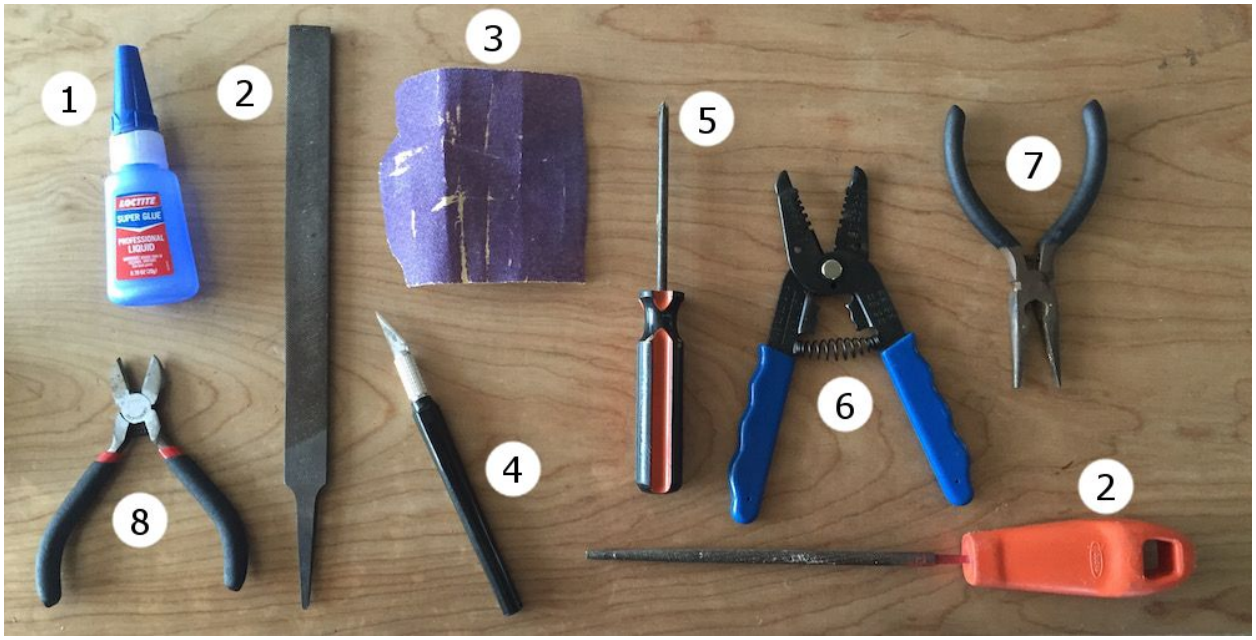
FRAME_FRONT & FRAME_BACK
- Material: PLA
- Supports: YES
- Raft: hopefully NO (but if supports aren't sticking, try the raft)
- Infill: 20%
- Layer Height: 0.2mm
- Number of Shells: 3
- Speed while extruding: 50-70% (slow it down if possible; these parts are detailed)

MECH_PARTS (OCTANUT / BOLT / SPRING_CASING / ELECTRODE_HOLDER)
- Material: PLA
- Supports: NO
- Raft: NO
- Infill: 20%
- Layer Height: 0.2mm
- Number of Shells: 3
- Speed while extruding: 50-70% (slow it down if possible; these parts are detailed)

BOARD_MOUNT, BOARD_COVER_STANDARD, & BOARD_COVER_ADVANCED
- Material: PLA
- Supports: NO
- Raft: NO
- Infill: 20%
- Layer Height: 0.2mm
- Number of Shells: 3
- Speed while extruding: 50-70% (slow it down if possible; these parts are detailed)

Assembly Tools

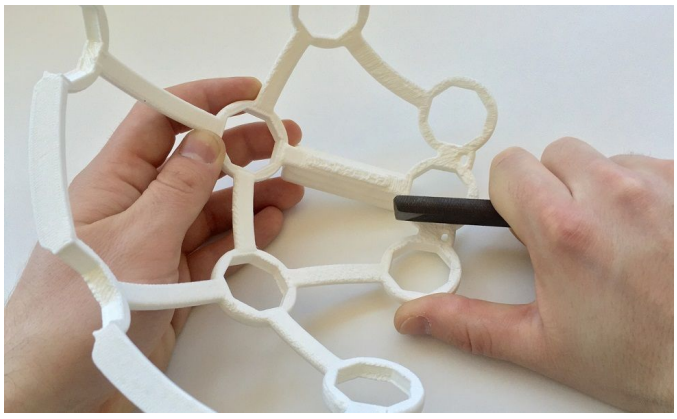
1. Super Glue
2. coarse flat & circular files (for removing support artifacts)
3. medium sand paper
4. exacto blade (optional)
5. philips head screw driver
6. wire cutters
7. needle-nose pliers (optional)
8. Snippers (optional)



Assembly Instructions

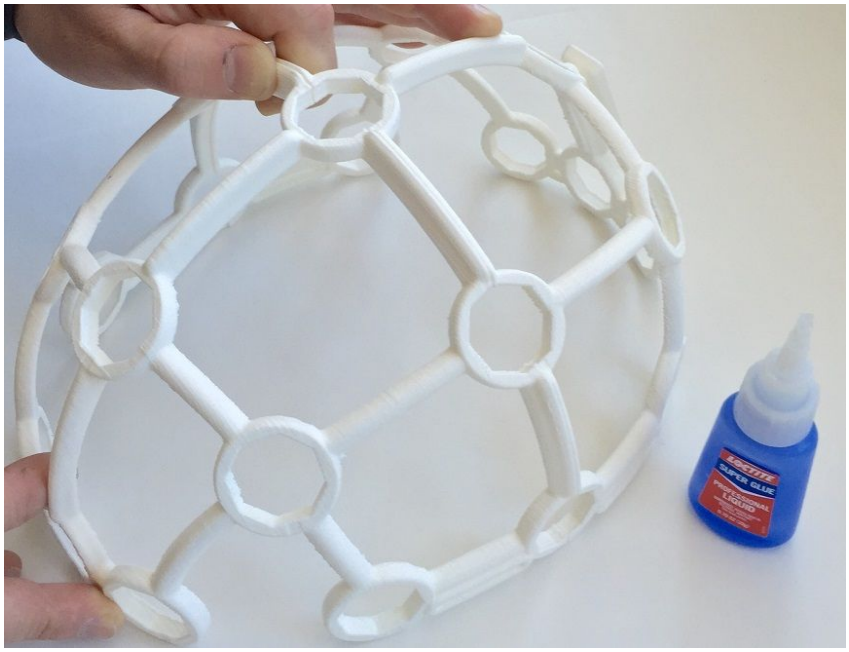
Remove residual support material & print flaws

Use sand paper, a file, and snippers to clean your FRAME and other 3D-printed parts. The most important part of this process is that you thoroughly clean out the frames nodes where you will place your OCTANUT pieces.



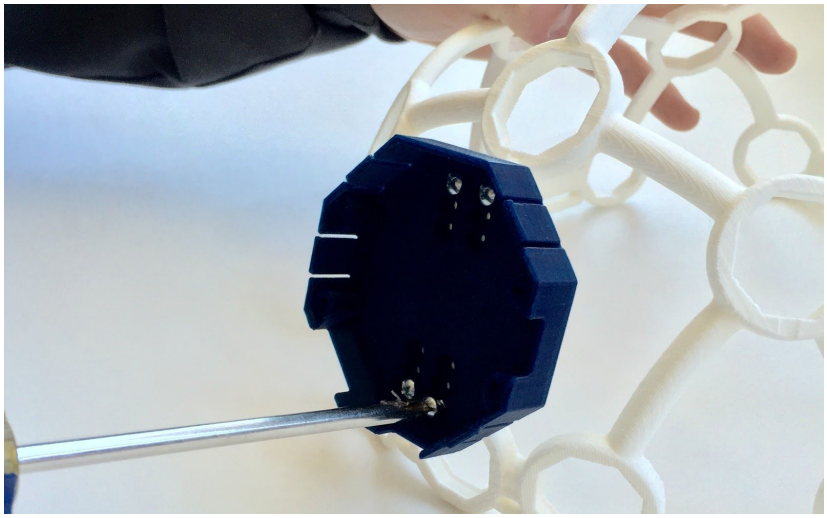
Glue the FRAME together

Carefully, glue the FRAME_FRONT and FRAME_BACK together with your super glue. The best way to do this is to place both halves of the frame on a level surface and carefully bring them together. Be sure to be precise; it's VERY difficult to pull the pieces apart once you've put them together.



Mount the OpenBCI BOARD_HOLDER

Use four #4 Drive Screws to mount the BOARD_HOLDER to the FRAME. Make sure that the orientation of the BOARD_HOLDER matches that of the pictures below:



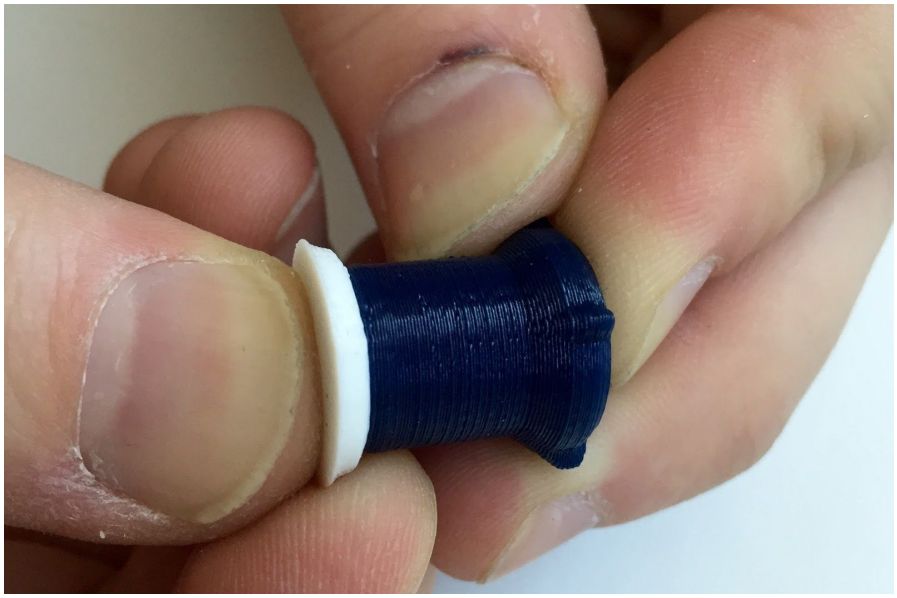
Assemble the Comfort Nodes

In order to fit the OCTANUT pieces into the frame, you will need the Comfort Nodes in order to securely glue the OCTANUTs in place.

You will need the following pieces:

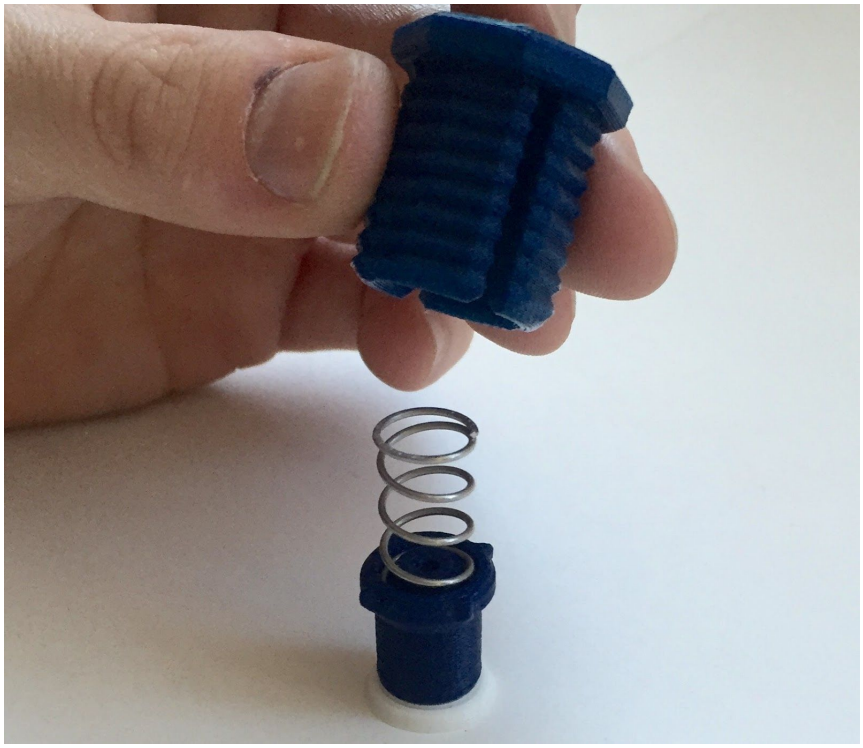
- OCTABOLT
- Strong Spring
- ELECTRODE_HOLDER
- Comfort insert

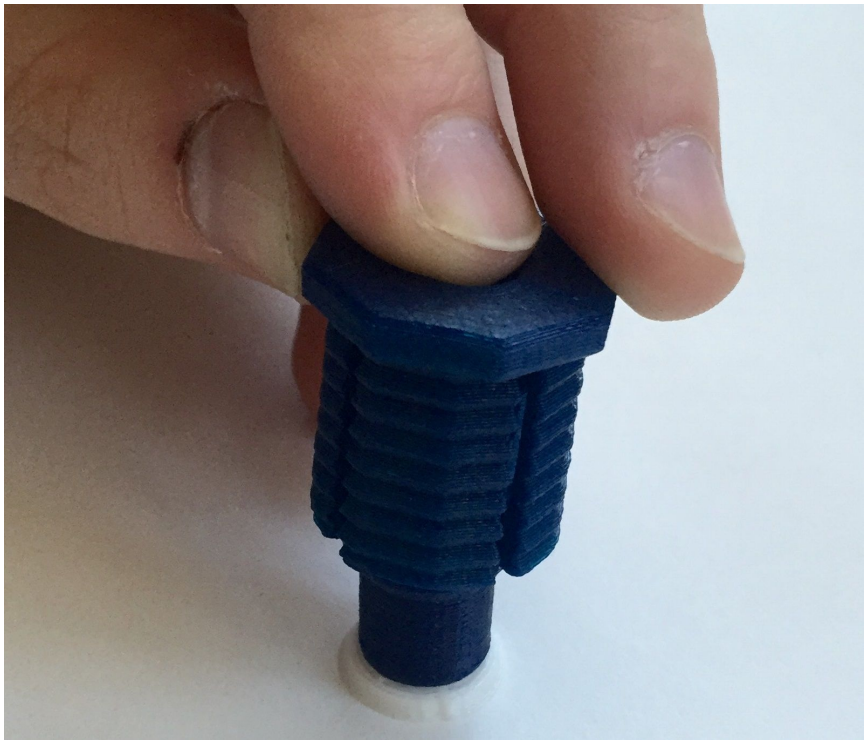
First, put the comfort insert into front of the ELECTRODE_HOLDER.



Next, insert the spring into the back of the ELECTRODE_HOLDER.
![image](../assets/ultracortex-nova-images/spring_electrodeholder.jpg)

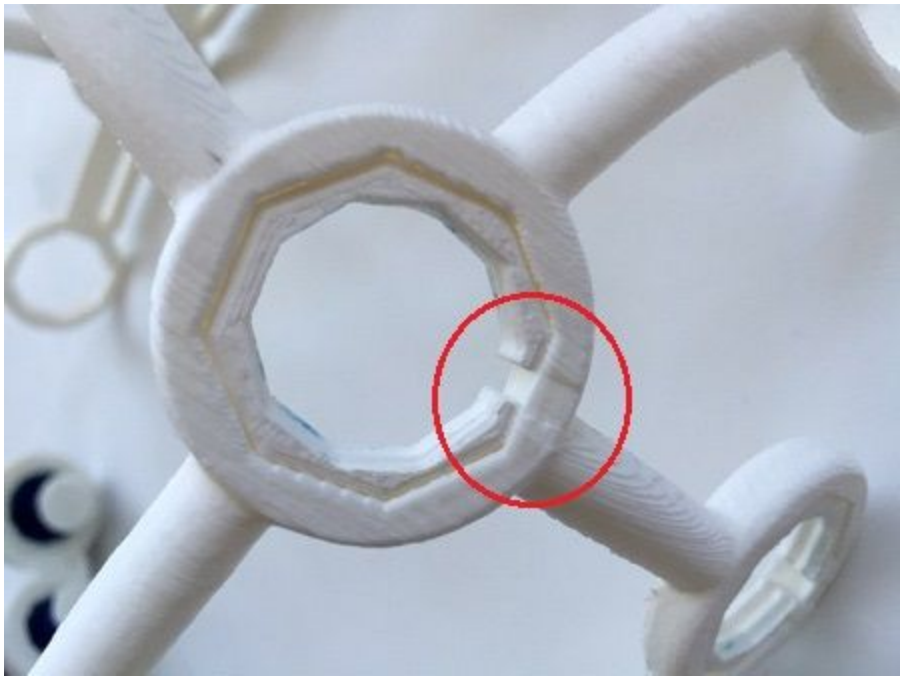

Then, slide the OCTABOLT over the top:



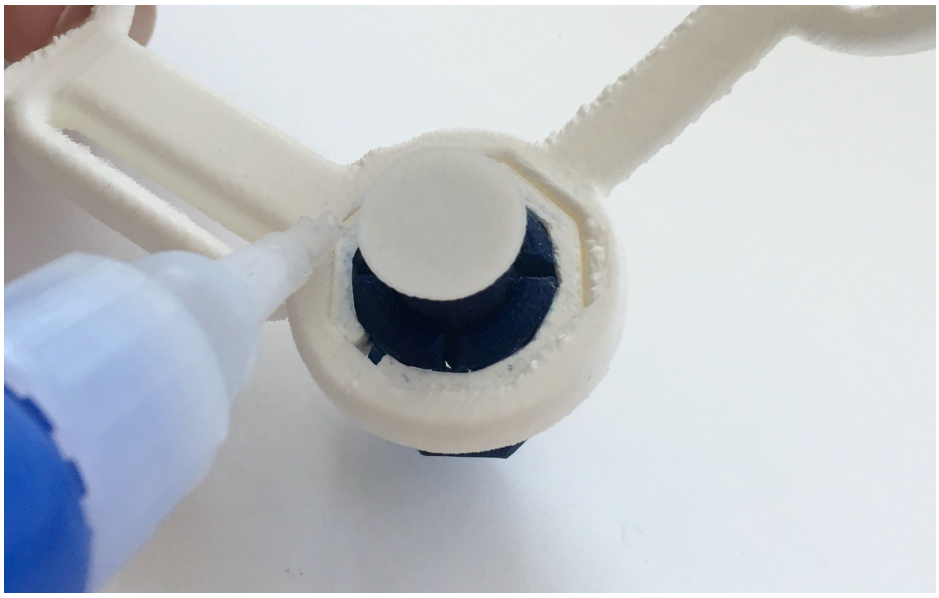


Insert OCTANUT pieces (x21) into frame

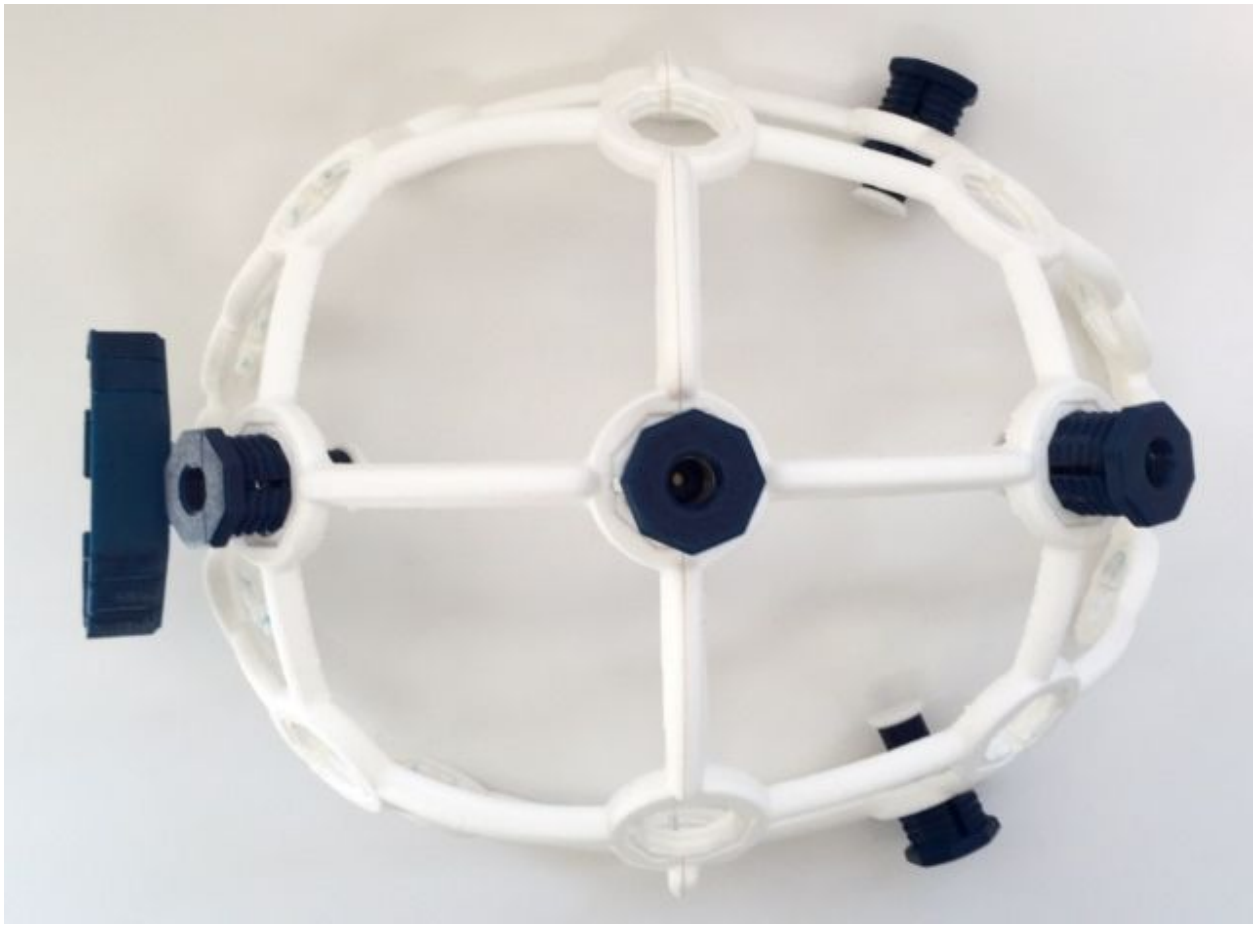
Note: at each node, you must line up the cut in the OCTANUT with the indentation on the frame as indicated in the picture below.



For each OCTANUT, insert the OCTABOLT so that the OCTANUT is held into the frame. Now you can glue the OCTANUT to the frame like this:

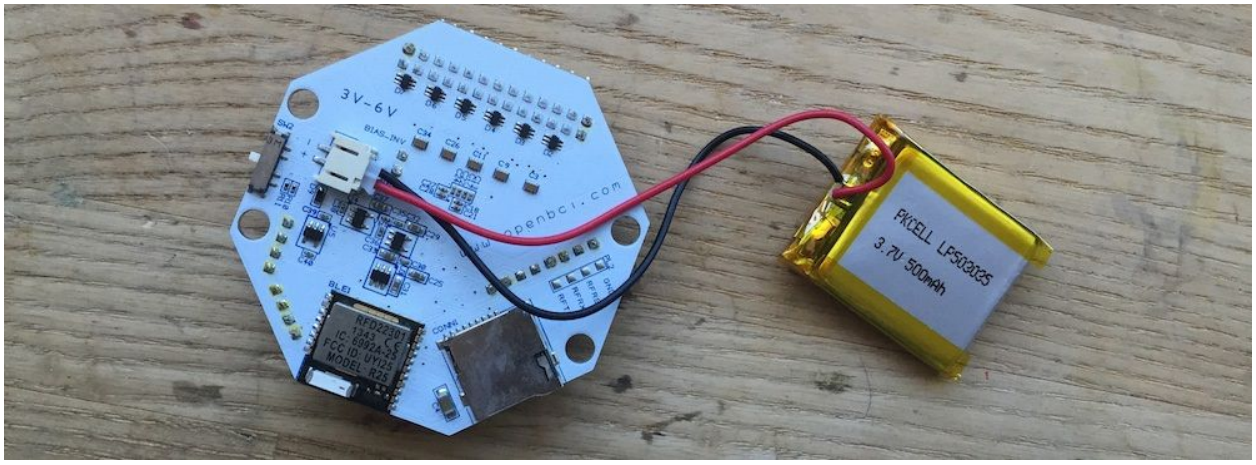


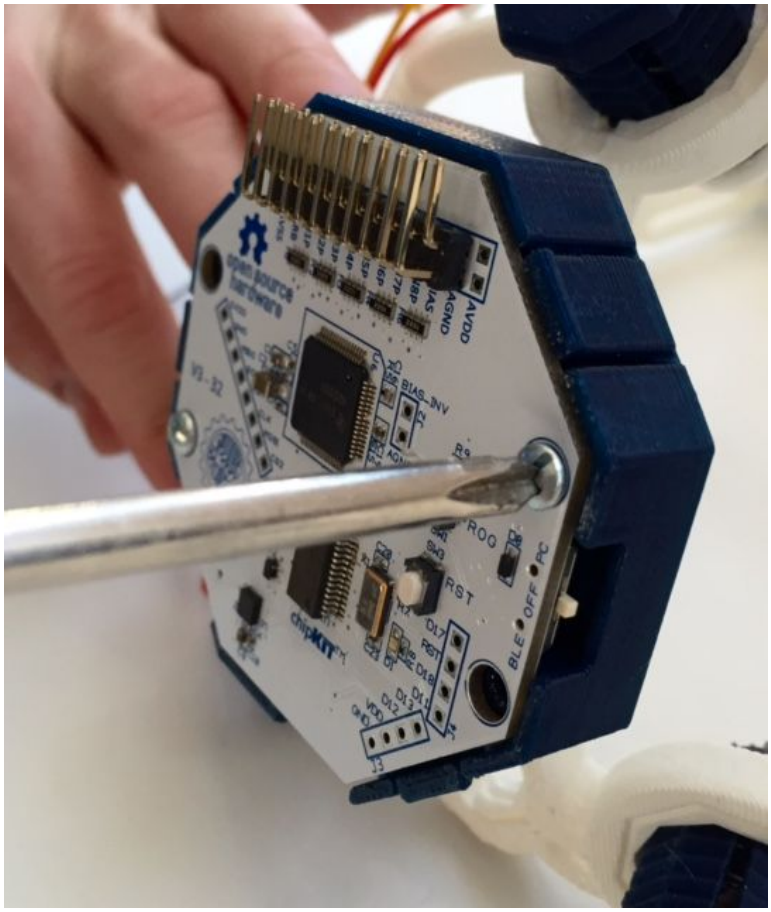
Your Ultracortex should now look like this:



Embed OpenBCI into the Ultracortex

Connect your ~500 mAh lithium ion rechargeable batter to the back of your 32bit OpenBCI Board. Then fold the battery and its wires neatly behind the board before inserting the board into the BOARD_MOUNT. You can then use one of your #4 Drive Screws to secure the OpenBCI Board to the BOARD_MOUNT. Typically you don't need to use any #4 Drive Screws because the BOARD_COVER locks the OpenBCI Board in place, but in this case it's a good idea because you'll want to see where you're connecting your wires.





Identify electrode locations

Before creating your electrode mounts, it's a good idea to think about where you may want to place the electrodes on the Ultracortex FRAME. The placement of the electrode may affect how

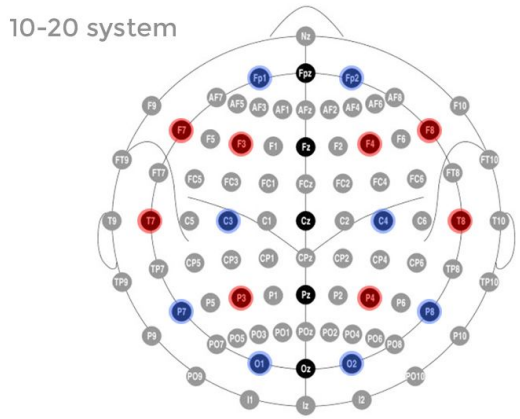
long you make the wire between the electrode and where the OpenBCI is mounted, at the back of the frame.

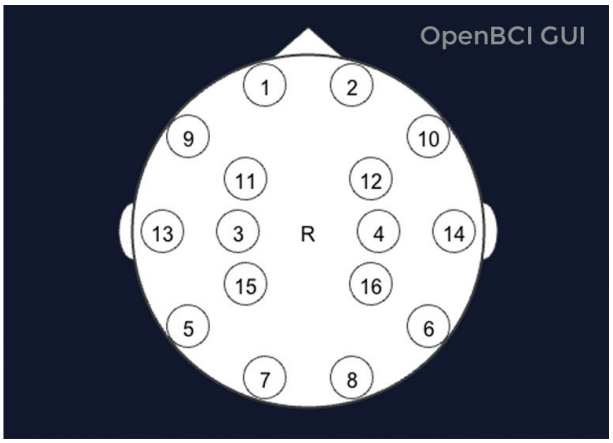
The Ultracortex node locations are based on the [10-20 system](https://goo.gl/gSwYw), which is the internationally accepted standard for electrode placement in the context of EEG.

The images below indicates the default 10-20 electrode locations that the OpenBCI Graphical User Interface expects. This application is great for viewing/recording your EEG and can be found in our [OpenBCI_Processing](http://) repo. The blue nodes indicate the 8 default 10-20 locations (channels 1-8) of the 32bit Board. The red nodes indicate the default 10-20 locations of channels 9-16 when using the OpenBCI 16-channel R&D Kit.

For the remainder of this tutorial, the blue nodes on the 10-20 system diagram (channels 1-8 of the OpenBCI default settings) will be used. The channel to 10-20 system correlations are as follows:

* Channel 1 - Fp1
* Channel 2 - Fp2
* Channel 3 - C3
* Channel 4 - C4
* Channel 5 - P7
* Channel 6 - P8
* Channel 7 - O1
* Channel 8 - O2

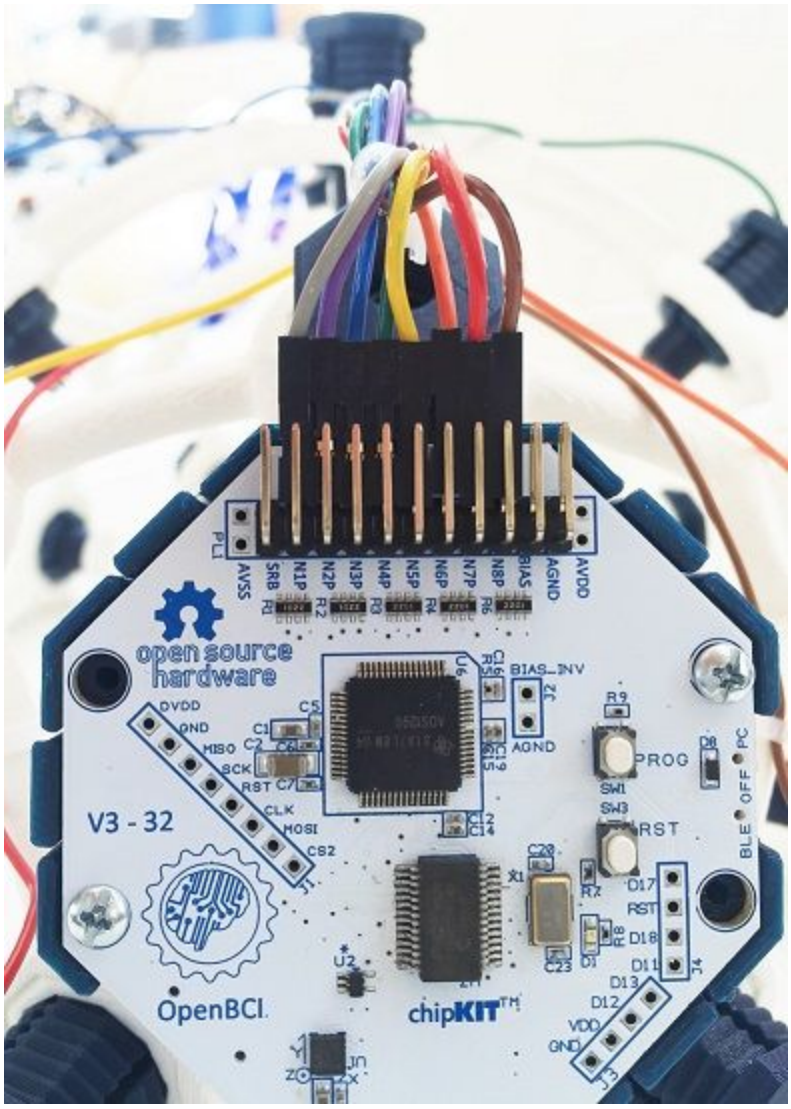




Connect wiring to OpenBCI

Before shortening any of your wires, connect the female header of each wire to the N pin of channels 1-8, as indicated in the image to the lower right. The N pins are the ones closer to the

OpenBCI Board. By default, the OpenBCI Board references these 8 pins with the SRB 2 pin (the bottom SRB pin).



Measure, cut, and strip wires

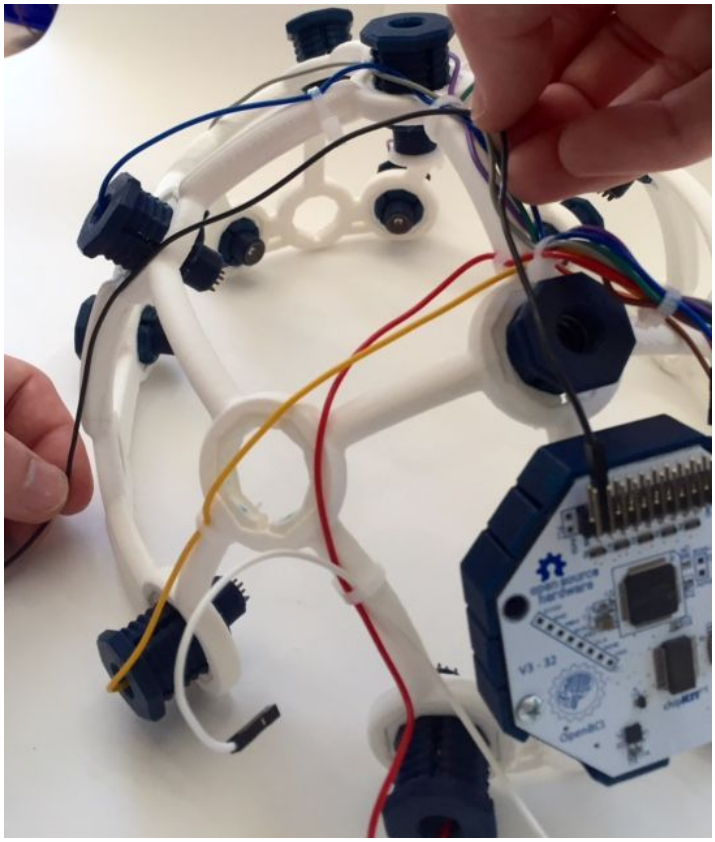
For each wire, measure the distance between where it is connected to the OpenBCI Board and the node that it will terminate at on the Ultracortex frame. Give yourself 2-3 inches of slack (extra length), because you're going to strip the end of the wire, and you may want the extra slack to zip-tie/tape the wiring to the frame later on.

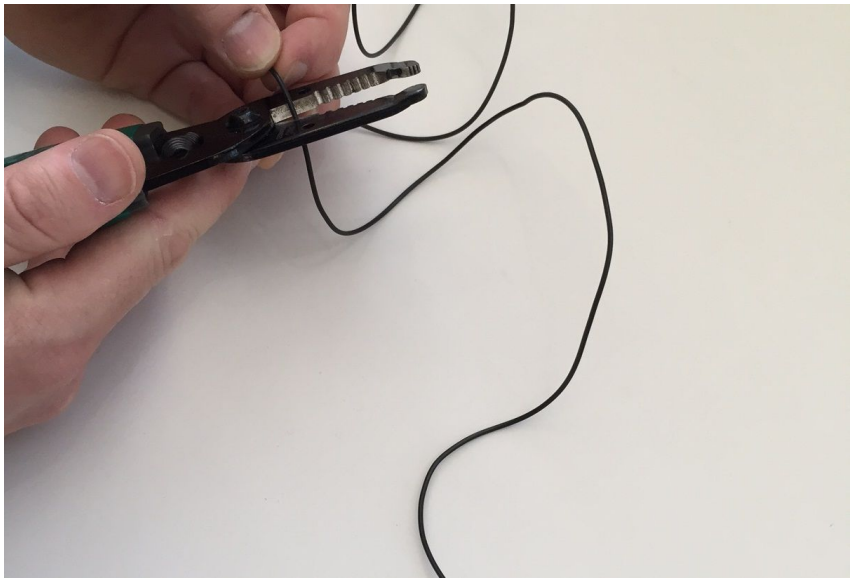
As mentioned above, if you're using the default OpenBCI electrode configuration, cut the wires so that they terminate at the following nodes:

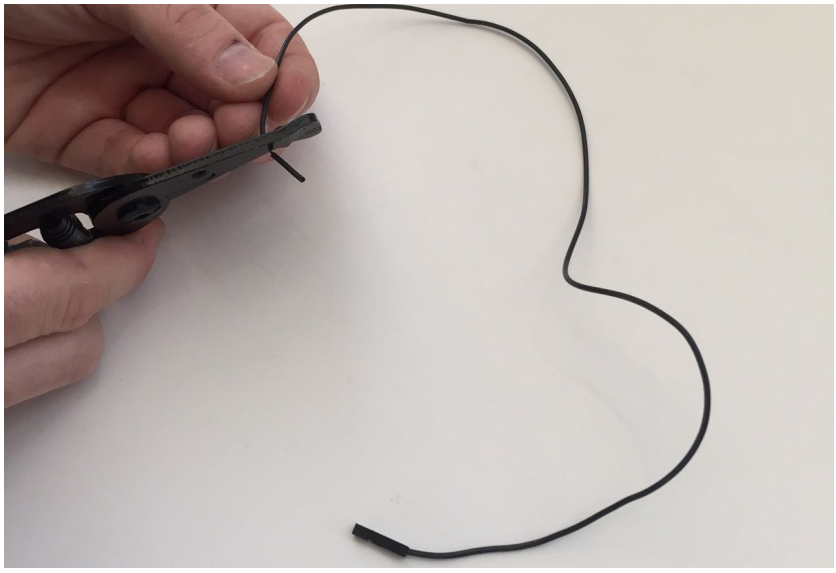
* Channel 1 - Fp1
* Channel 2 - Fp2

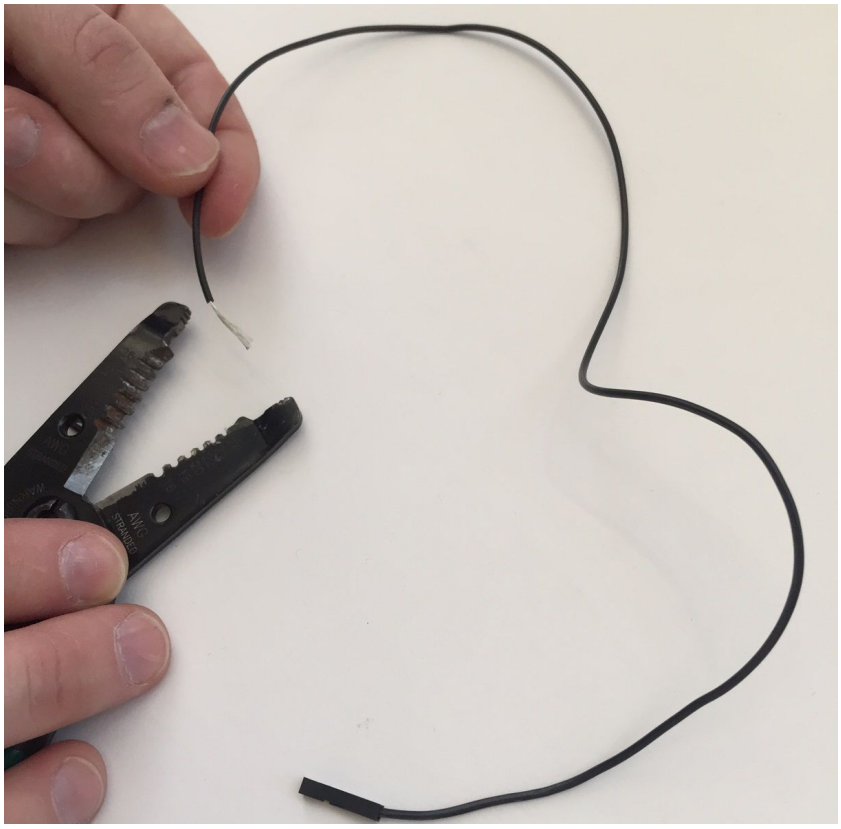
* Channel 3 - C3
* Channel 4 - C4
* Channel 5 - P7
* Channel 6 - P8
* Channel 7 - O1
* Channel 8 - O2

After you're done measuring, cutting, and stripping your wires, disconnect them from the OpenBCI board. You will need the female header free so you can guide the springs and OCTANUT pieces into place in the following step. But remember which wire goes where!



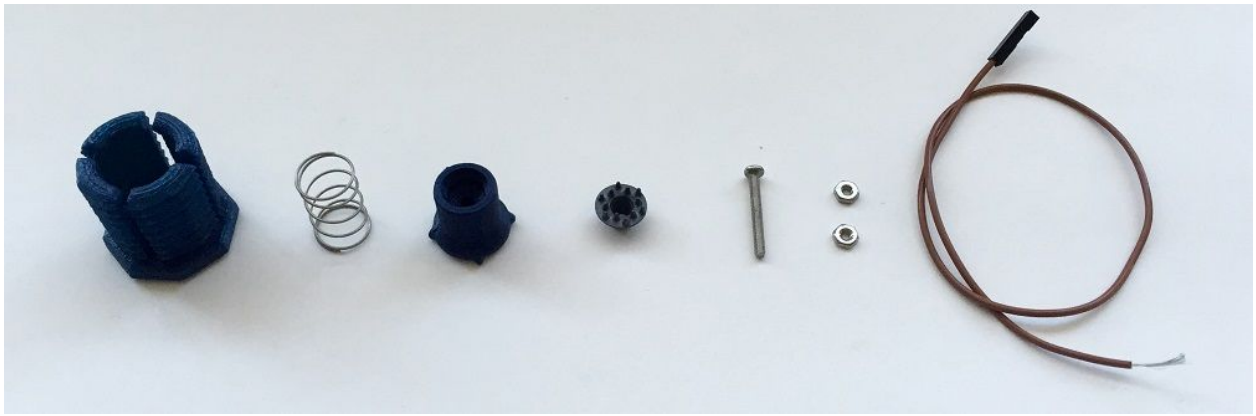






Assemble electrode mounts (x8)

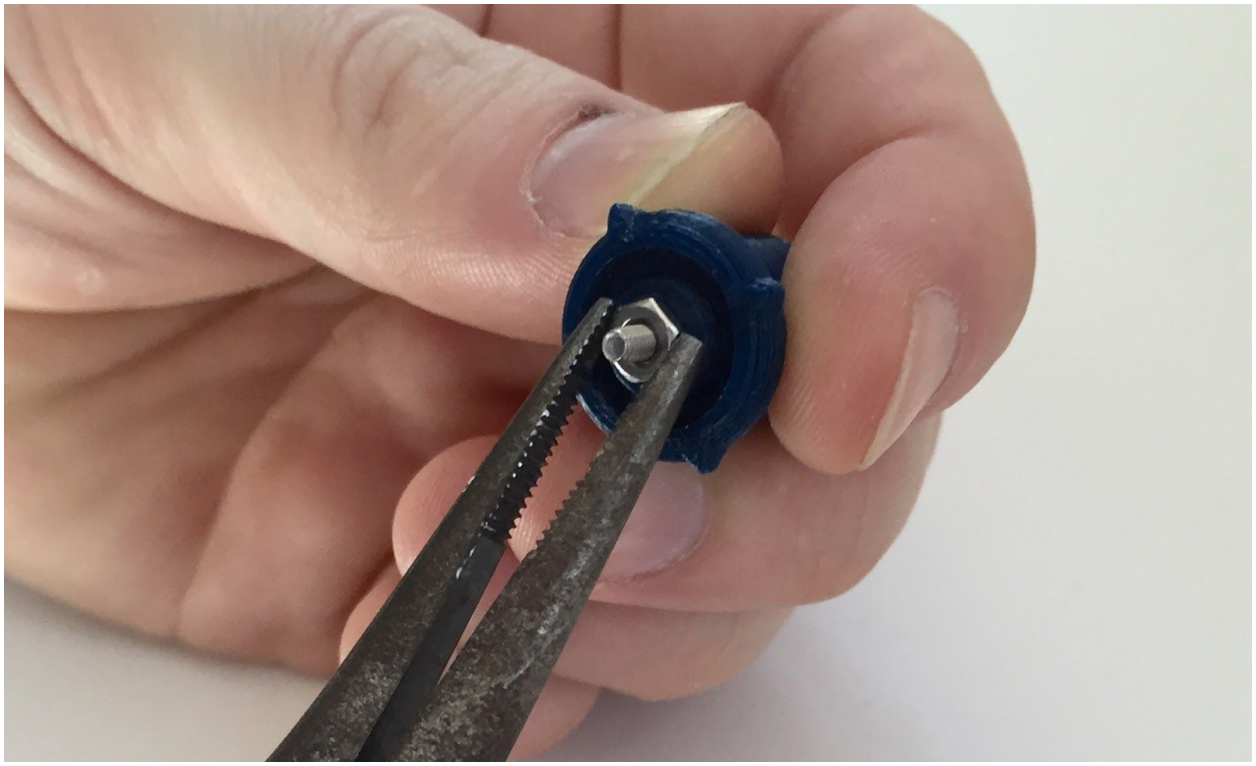
These are the pieces that comprise one full electrode unit:



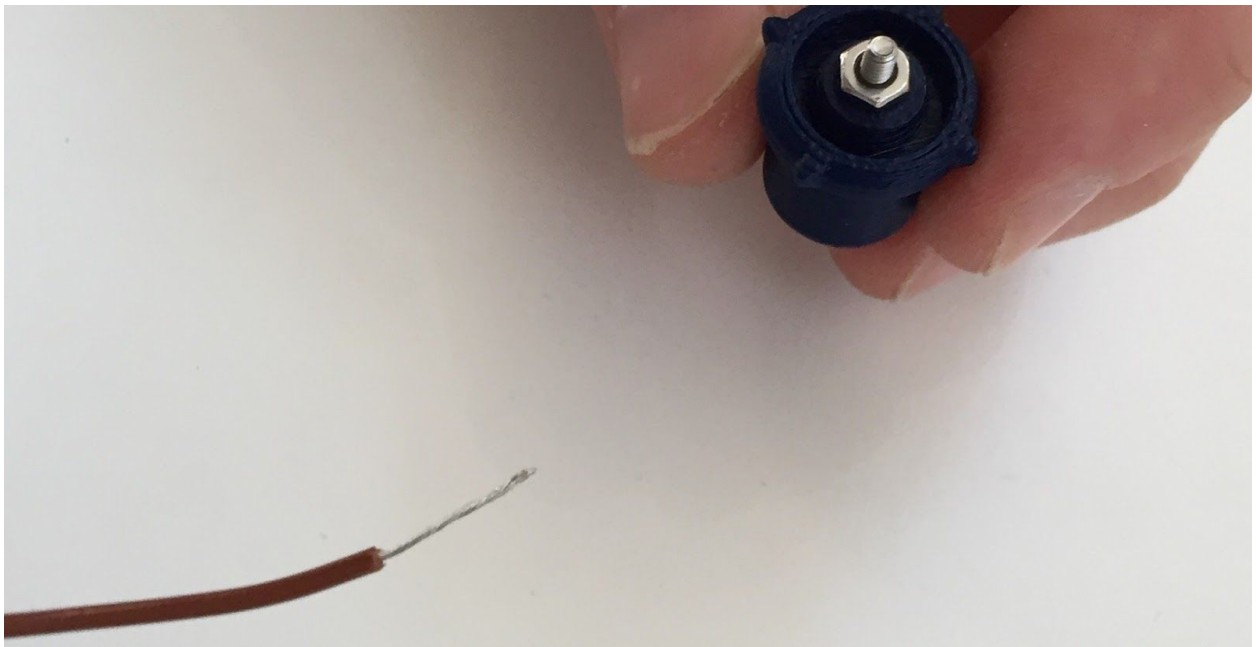
First, slide a **Machine Screw (2-56 Thread, 3/4" Length)** through the FRI electrode and guide it into the ELECTRODE_HOLDER.

Then, slide the screw and electrode into the ELECTRODE_HOLDER

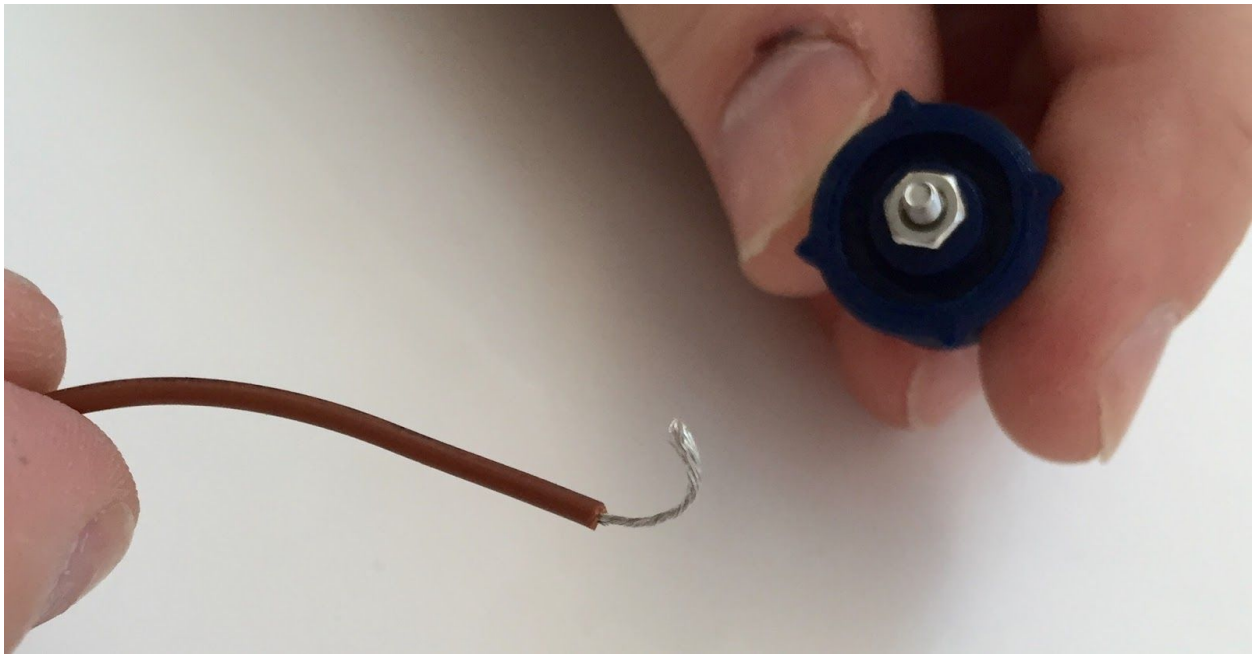
Next, twist a *Hex Nut (2-56 Thread Size, 3/16" Wide, 1/16" High)* onto the screw, securing the electrode to the holder.

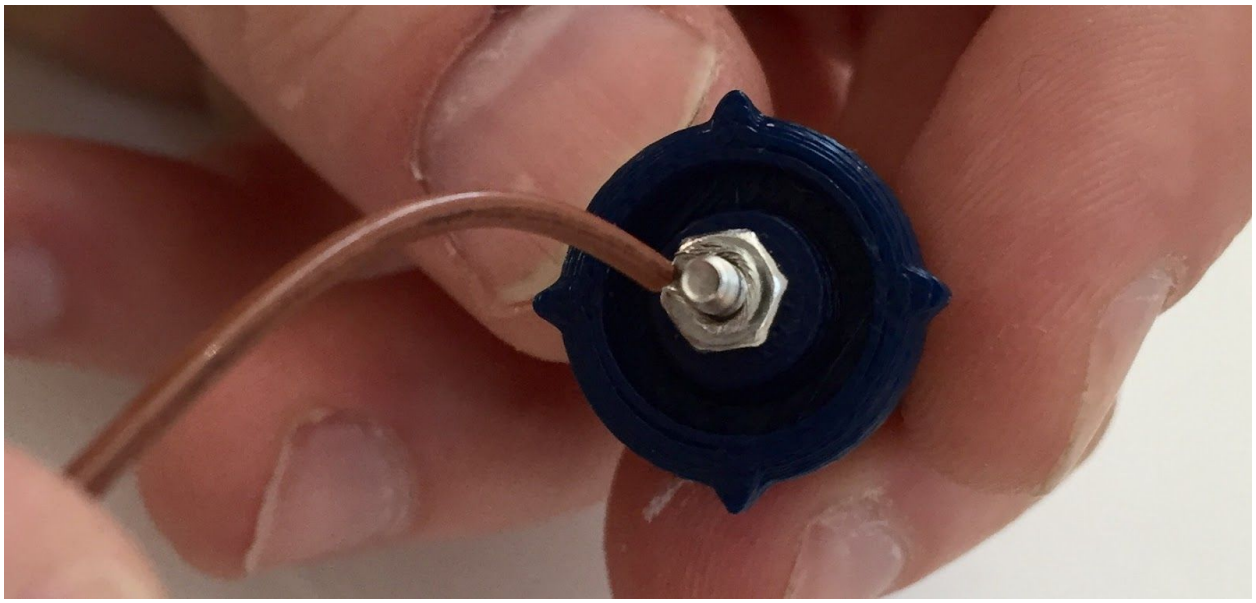


Next, twist the exposed metal of your wire so that it is tight and clean.



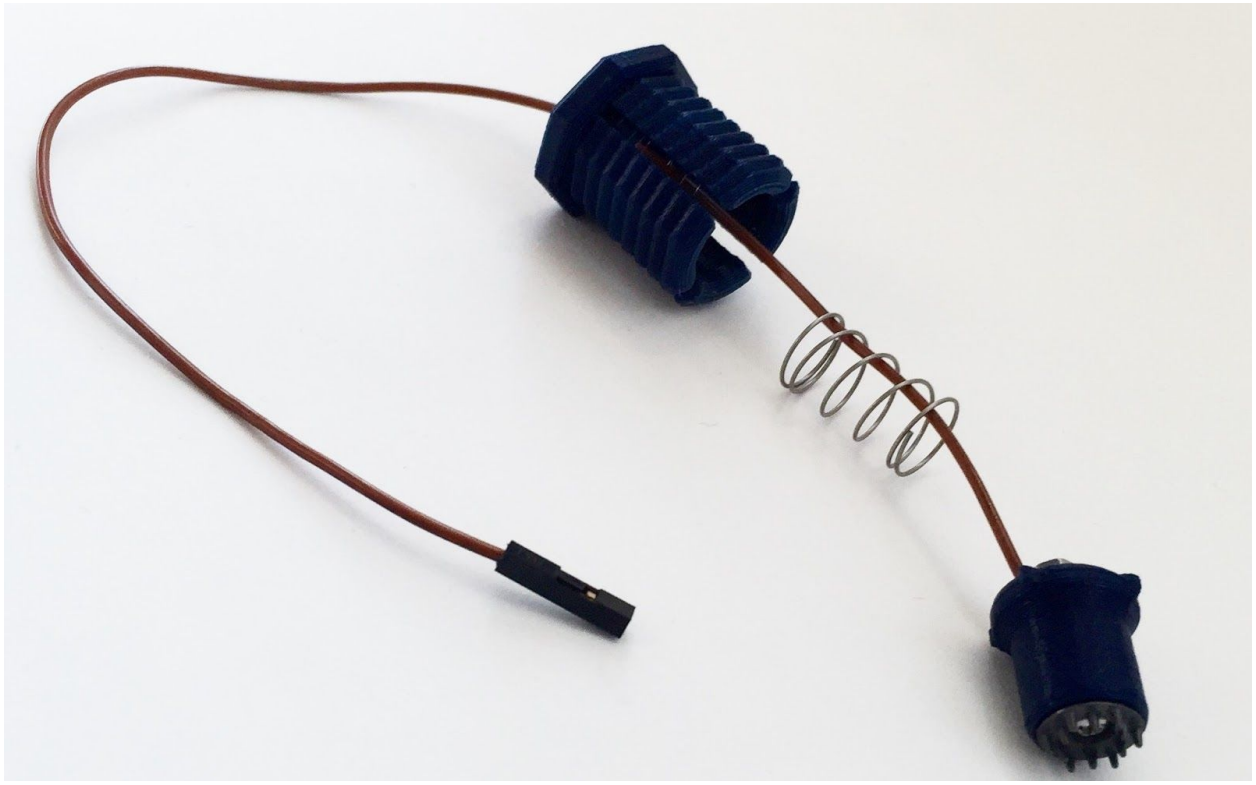
This part is a little bit tricky! Wrap the exposed metal of your wire once around the remaining thread of the screw. You can use your finger nail to pinch the wire down against the nut, while wrapping.



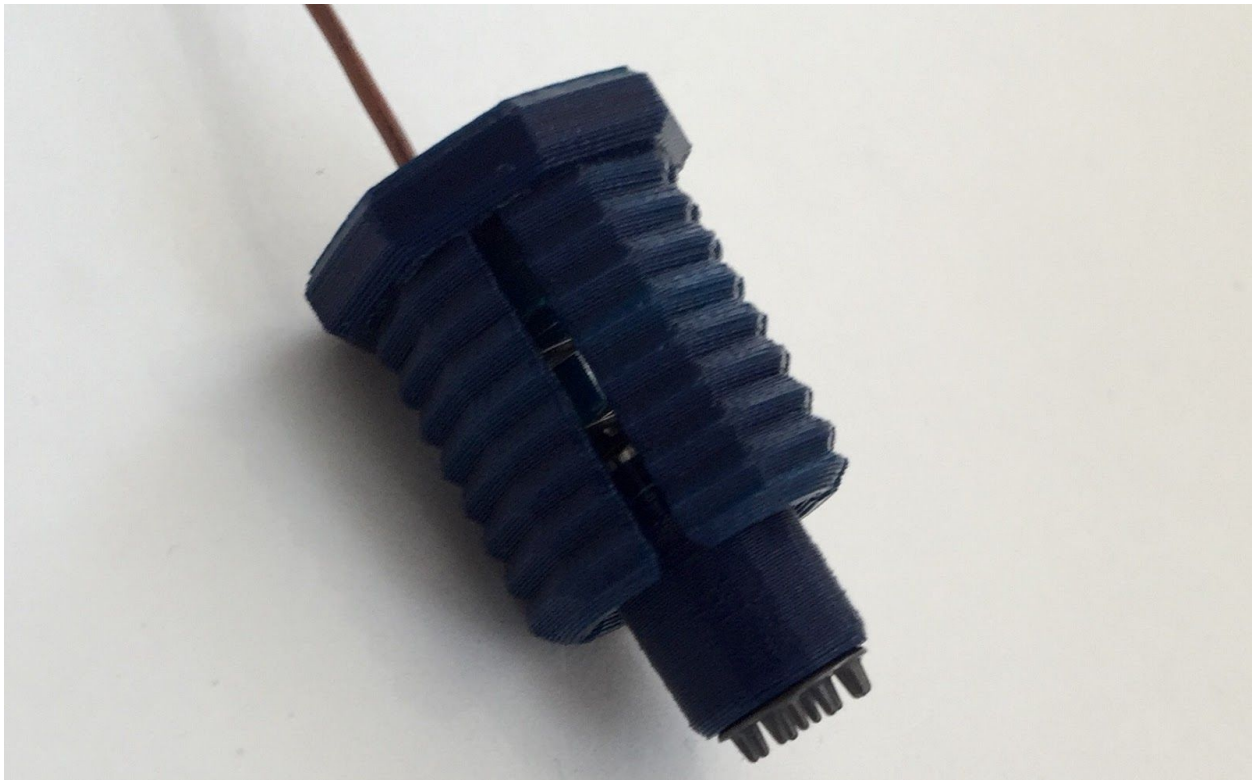


Then, twist your second Hex Nut onto the screw, securing the wire between the two nuts. You can use wire cutters to firmly screw the nut into place.

Slide a **Suggested Spring 1 (aka "Weak Spring")** and then the OCTABOLT around the wire as shown below.



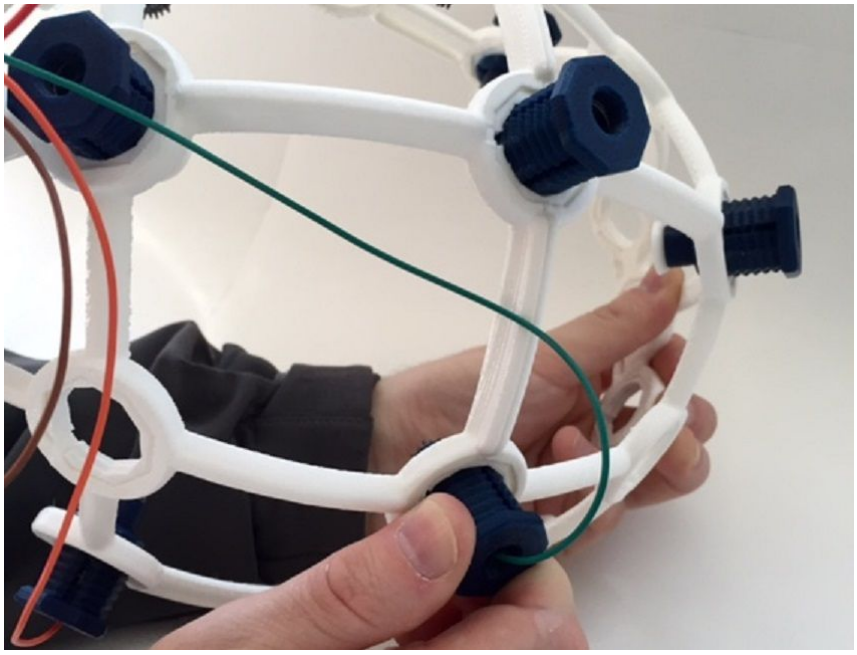
Snap the full electrode unit together, guiding the semi-spherical protrusions on the outside of the SPRING_CASING into the relief cuts of the OCTABOLT.



Voila!

Insert electrode units into your Ultracortex

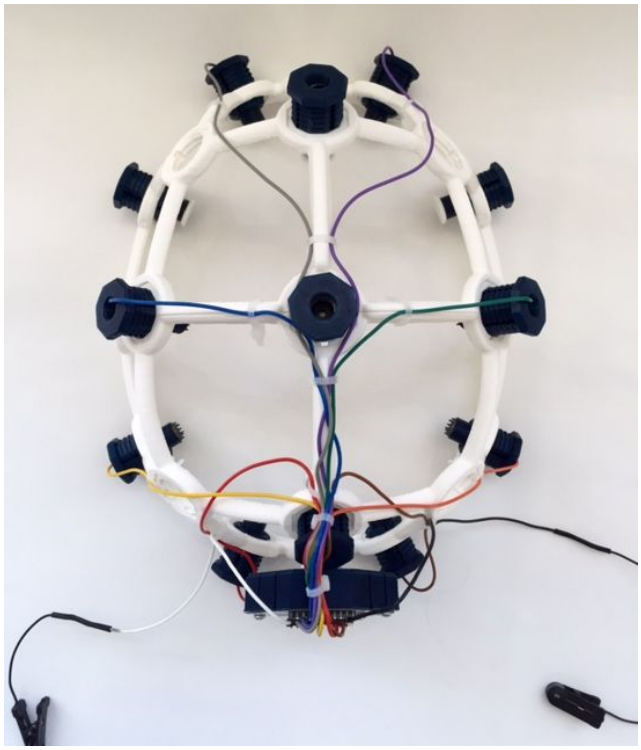
Once you've asesembled all of your electrode units, twist them into their respective Ultracortex frame nodes. If the parts are tough to twist into place by hand, use the OCTATOOL that comes with your kit as shown in the picture below. Over time the resistance between the OCTANUT and OCTABOLT will diminish, and the pieces will twist into place more easily.



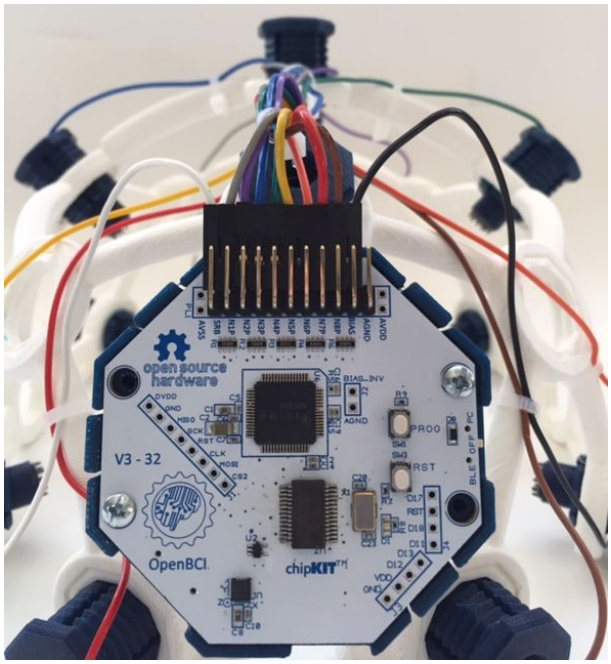
Connect wires to OpenBCI & connect ear clip electrodes (Reference & Ground)

Now that all of your electrode units are connected to your Ultracortex frame, reconnect the electrode wires to the OpenBCI board as detailed above. If you have some handy, you may

want to use zip ties to secure the loose wiring to the Ultracortex frame.

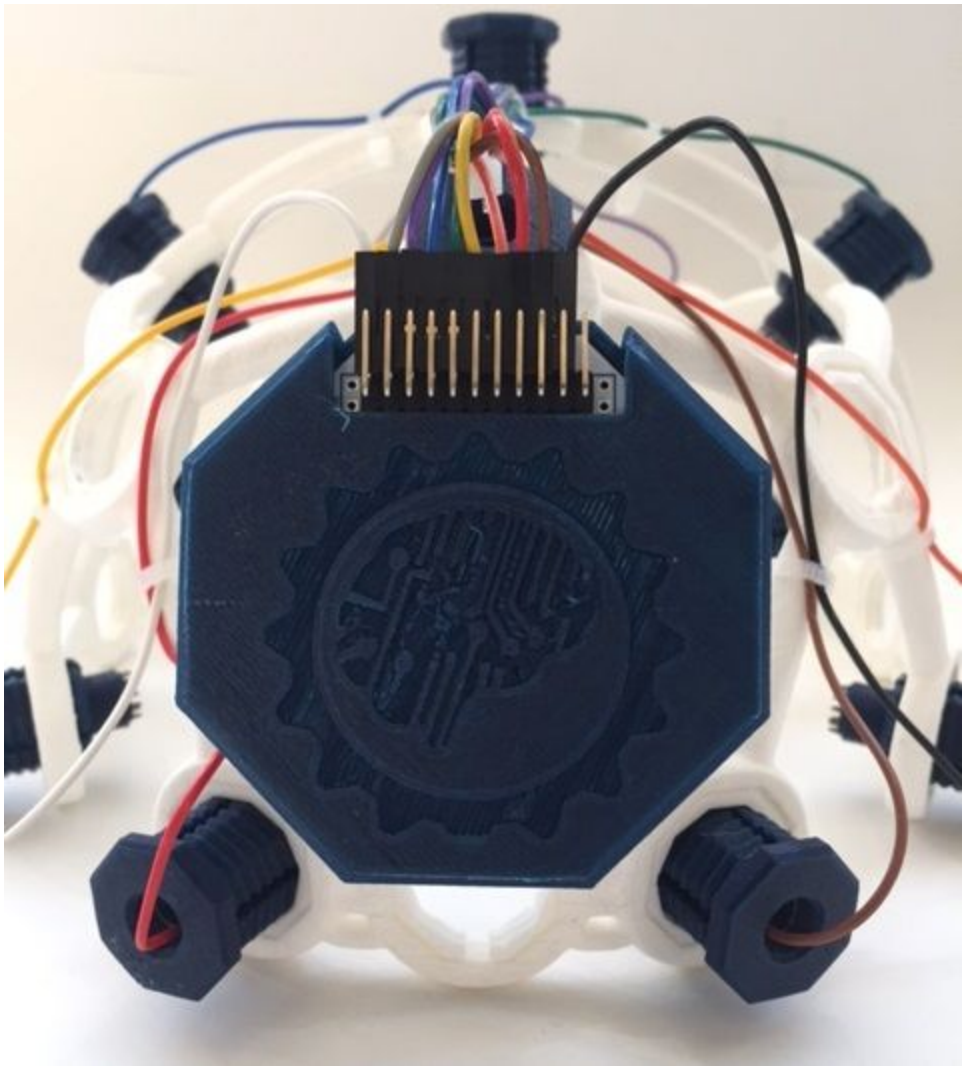


Next, connect two touch-proof adapter cables to SRB2 and bottom BIAS pin (white and black respectively in the image below). You can use the touch-proof adapter that comes with the OpenBCI 32bit Board or OpenBCI 16-channel R&D Kit. Then connect your [ear clip electrodes](http://fri-fl-shop.com/product/td-430-silver-disc-electrode-ear-clip/) to these touch-proof adapters. These ear clip electrodes serve as the reference and bias (ground with common-mode noise rejection) for your EEG system.



Fasten the BOARD_COVER

Now clip your board cover into place. If you've soldered any of the header rows onto your OpenBCI board, you'll need to use the BOARD_COVER_ADVANCED, as seen in the picture below. Otherwise, you can use the BOARD_COVER_STANDARD with the OpenBCI logo.



Building an Eyetracker

This is a modified version from Pupil Lab's DIY Eyetracking guide adopted for this workshop.

Parts

Cheap pair of sunglasses
Playstation Eye
2 IR-LEDs
Exposed (black) film negative
Aluminum 9-gauge wire
Wire Ties
Alligator Clips
200 ohms resistor

Tools

Solder station, wick, flux (in lieu of alligator clips)
Small philips screwdriver
Prying tool to help un-case the webcams
Box cutter

Assembly Instructions

Prepare Webcams

The first step is to modify the cameras so we can use them for eye-tracking.

De-case Cameras

Take out the rubber holders in the back of the webcam casing.


4 MICROPHONE ARRAY SYSTEM


U3
U5A
R4
R2
R1
R23
Q2
R18
X1
P_ALK
P_ACLR
P-ADOUT1
P-ADOUT0
C11
C14
C12


4 MICROPHONE ARRAY SYSTEM

Remove the camera lens

Unscrew the camera lens from the circuit board.