Published in A Beginner's Guide to Brain-Computer Interfaces

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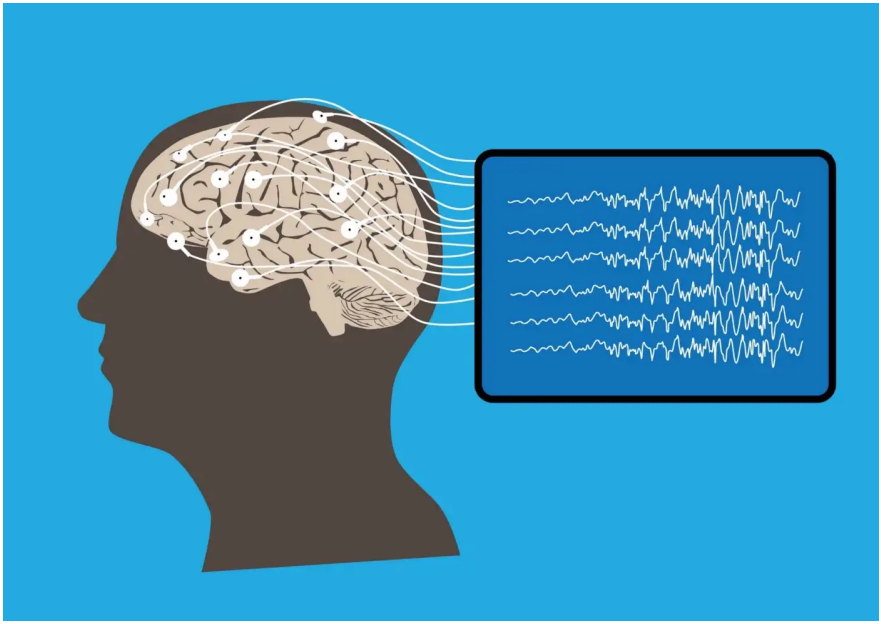
The EEG Device For Your Project: Choosing between NeuroSky MindWave, Muse 2, g.tec Unicorn, OpenBCI, Emotiv EPOC+...

Location can make or break your project — Beginner's Guide to Brain-Computer Interfaces (part 2)



The NeuroSky MindWave, Muse 2, g.tec Unicorn, OpenBCI, Emotiv EPOC+.... Nowadays, a lot of commercial EEG devices are on the market. The devices differ in terms of size, electrode amount, electrode placement, wires, charging time, dry or wet electrodes, and more. As a beginner in the BCI field, choosing your first device is very difficult, especially when prices can be more than €1000...

With this blog post, I hope to explain you the single most important feature to look for: location of the electrodes!

Why Location Matters

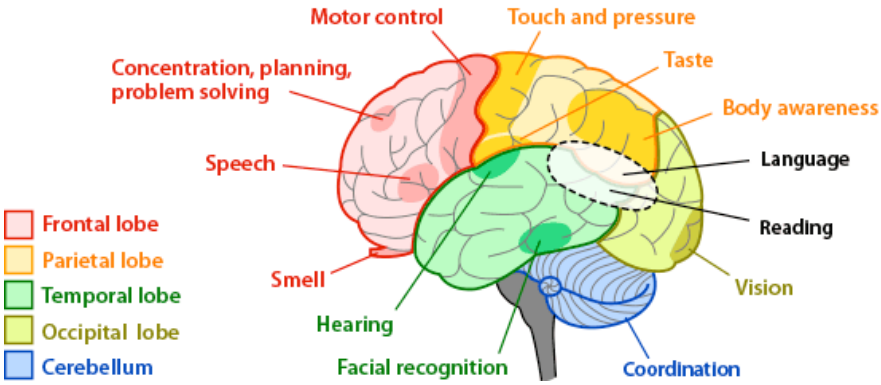


Figure 1: Areas of the brain and their function. Adapted from this site.

Tl;dr: different tasks require different parts of the brain.

To illustrate this, let me talk about my 2 motor imagery projects: a failed one, and a successful one.

Last summer, I tried to build my first bedroom BCI for motor imagery prediction. For this project, I used the Muse 2 headset. Little did I know, that by choosing the Muse 2, I made it nearly impossible to succeed in this task, even before I wrote any code!

As seen in Figure 1, the area for motor control lays around the middle of the center part of the brain, in the area of the frontal lobe called the motor cortex. To capture brain activity around this area, one needs to place electrodes around this area. The 10–20

international system is a system used for electrode placement to ensure comparable placement across studies, but also to identify which areas of the brain lay are captured by each electrode.

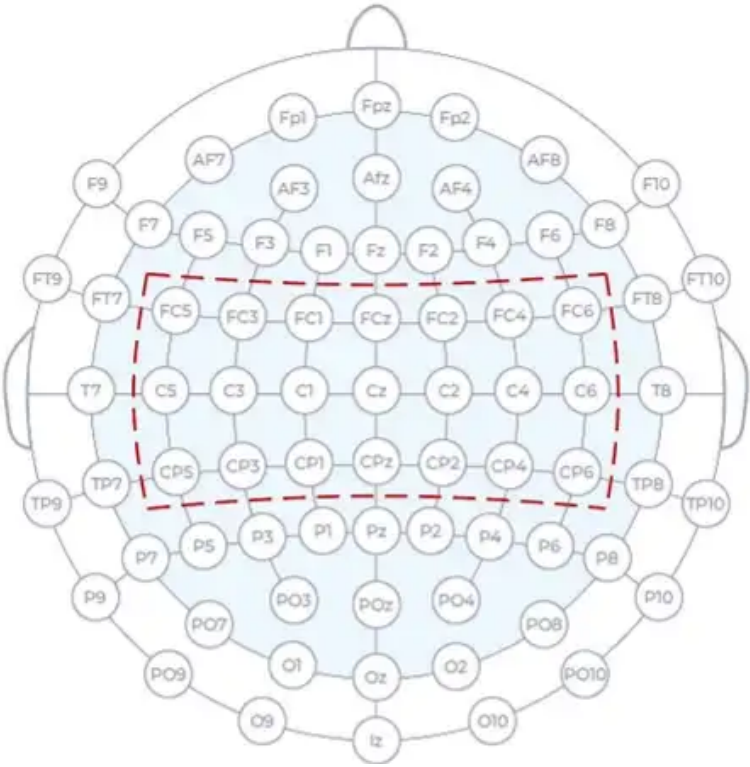


Figure 2: The 10–20 international system. The electrodes in the highlighted area are placed on top of the motor cortex area. Figure adapted from this paper.

In Figure 2 above, we see the 10–20 international system, with a dotted area indicating the motor cortex

area. Now, let's look at the electrode placement of the Muse 2.

Figure 3: The Muse 2 (left), and the electrode placement of the Muse 2 (right).

No wonder this project failed... The electrodes are far off from the motor cortex!

Fast forward to this year.

The last six months, I have been working on a motor imagery BCI project using the g.tec Unicorn. This device has 8 electrodes.

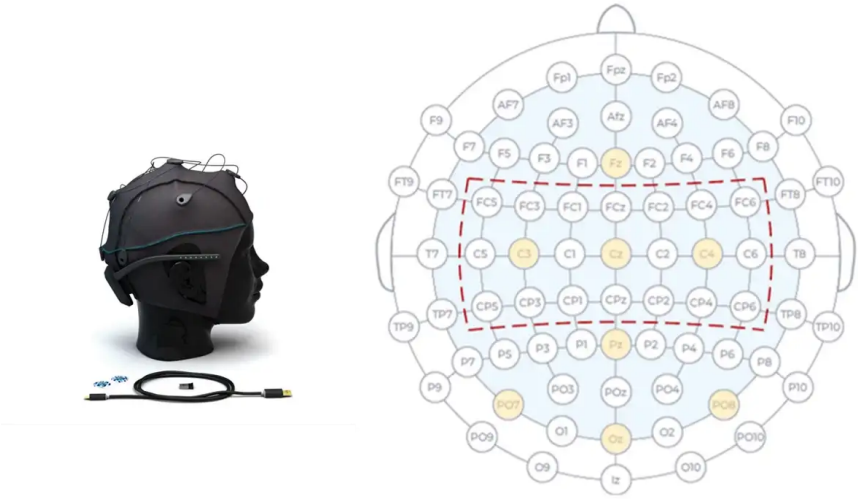


Figure 4: The g.tec Unicorn (left), and the electrode placement of the Unicorn (right).

Well, this seems more promising! The Unicorn has 3 electrodes in the motor cortex area.

To underline the importance of having electrodes around the motor cortex area for motor imagery classification, let's look into what happens to the classification accuracy of upper-limb motor imagery (classifying left arm motor imagery versus right arm motor imagery), when we change the electrode placement.

Results of different types of electrode placements

For this mini-experiment, we will compare 3 different types of electrode placement of the Unicorn: using all

For this comparison, I build a pipeline using Riemannian Geometry (more on this algorithm in later blog posts!). The data is from 2 subjects, both containing 10 trials, with each trials having 26 segments of 2 seconds for each of our classes. Our model will be tested by leave-one-out cross validation: put 9 of the trials in the training set, and 1 trial in the test set, repeat this for every trial, and then take the average. For now, I will spare you more of the details, and go straight into the results!

Subject	All	C3, Cz, C4	Fz, Pz, Oz, PO7, PO8
1	83.6%	84.2%	76.8%
2	73.8%	73.5%	57.7%

Table 1: Results of the different electrode configurations.

The results clearly show that using none of the electrodes around the motor cortex leads to worse results: showing a 7% decrease for subjects 1 and even a 16% decrease for subject 2 when compared to the other 2 configuratio 26 s that having the information from the C3, Cz and C4 electrodes is

sufficient for the motor imagery classification, as the performance when having all the electrodes does not differ much from the C3, Cz and C4 performance.

Conclusion

Before you buy any EEG device, look into electrode placement! Of course, the correct electrode placement will differ for which project you want to do. For event-related potential detection, main activity has been found around electrodes Fz, Cz, and Pz. Focus-related activity originates from the prefrontal cortex, and can be measured by sensors on your forehead (like my Muse 2 has!).

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