10
See Your Own Brain

If you were to ask your friends and colleagues what exactly neuroscientists do, they would probably answer: “They study the brain!” We’ve already seen that neuroscience is much broader than the brain alone, encompassing entire fields dedicated to the sensory systems discussed so far in our model organisms. But there is no denying that many feel the brain itself is an ocean of mystery. And in this chapter, we begin to wade in and understand a bit more about how the brain works.

To truly grasp how something functions, we need to measure it. The brain is no exception. In our last section, we measured the electrical neural activity of model organisms by placing small wires close to axons of living neurons. Using instruments like scissors, pins, and sharp recording needles, we were able to spy on the communication of neurons as they processed information. Recording neurons in invertebrates is possible and even relatively easy for a number of reasons. First, the neurons in insects lack the electrical insulation layer (called myelin) that our neurons have. This lack of myelin makes the current we measure much larger and easier to record. Second, our model invertebrates by definition have no bones. They have an outer shell that is readily penetrated by sharp electrodes. Once inside, the electrodes can cozy up right next to the electrically active axons, neurons, and muscles.

Humans, on the other hand, have thick skulls protecting their brains. The most obvious way to record from neurons in a human is to drill your way through the skull and place the electrodes inside the brain. This is what often happens during brain surgery (using power tools to drill the hole). Place some wires in—and voilà, it works! You could hear spikes just like in our previous experiments. But you cannot do this at home, obviously, as the results would most likely be deadly (not to mention messy)! So you will need to find a way to record electrical signals from your own brain without having to poke, cut, saw, or drill your way past your skull. What about from the outside of the body? That seems to work in hospitals where the heart signals are monitored without direct access to the heart. What if we were to just place the electrodes on the outside of the skull above the brain?

Experiment: Electroencephalography (EEG)

For this experiment, we will need to connect our head to the SpikerBox. A simple way to do this is to place two metal snap rivets into a sports sweatband, and place the sweatband on your head like you normally would. The reason for a headband (besides being a good look) is that it will be easy to position it in different areas around the head, plus it's better to clip the metal leads from the SpikerBox to the metal buttons on the headband than to clip them to your skin directly. (Ouch!) Once you have your headband, position it so that the metal clips are just above your forehead.

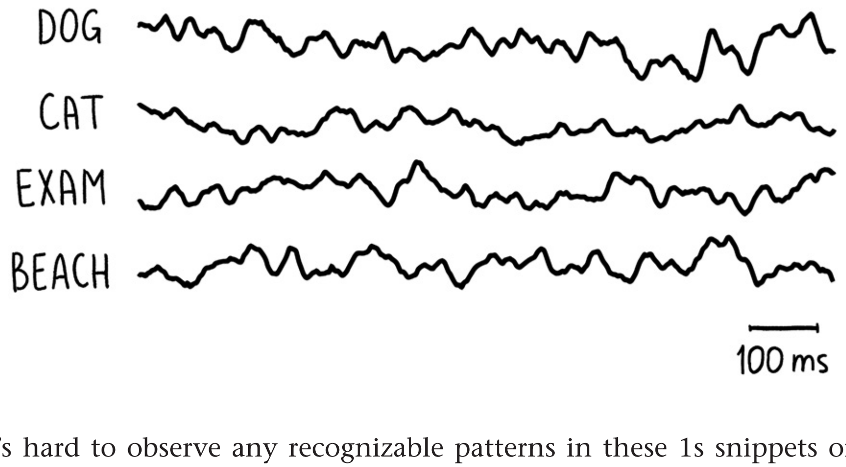
Next, place an EKG electrode sticker on the bone just behind your ear. This bone is called the mastoid process, and it is a nice, quiet spot without a lot of brain activity. Before we connect the headband to the SpikerBox, we will need to use a few globs of electrode gel underneath the metal clips so we can create an electrical connection between your scalp and the headband's electrodes. The electrode gel contains charged ions that allow any electricity on the head to flow more easily into the metal rivets. Once you are all set, you can clip the red recording clips onto your headband's metal clips, and the black ground clip onto the sticker electrode behind your ear. Connect all the leads to your SpikerBox.

It's time to start recording. Unlike in the cockroach labs from Part I, we will need to be a bit more careful with external noise in our system here. We recommend you perform your recordings on a battery-powered laptop, tablet, or phone—anything not plugged into the wall!

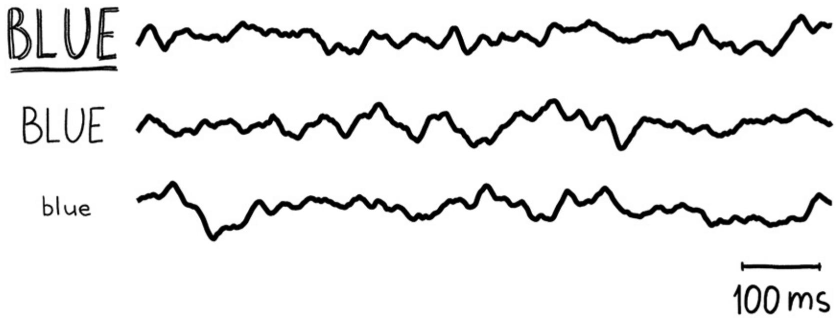
Connect your SpikerBox to your tablet or computer and open up the Spike-Recorder. Chances are you will see a flat, dormant line of inactivity, but don't let it frighten you! In all likelihood, you are not dead but rather have a bad electrical connection between the SpikerBox and your head. Try to add a bit more electrode gel and fiddle with the contact between your electrodes and scalp. If your connection is good, you will begin to see that the signal is ever so slowly moving:

This may seem rather odd at first. It appears to be very flat compared to the other recordings we have made so far. This is not an error. Recordings of the brain through the scalp, skin, and hair are considered to be a very "weak" signal, compared to internal recordings. To get a better look, let's increase the gain in software.

That's more like it! Now we can actually see that something is happening. Behold the electroencephalogram, or EEG! Notice that the EEG recording looks a lot more wavy than spiky. Maybe this slow-moving line is encoding our thoughts? Let's test this. Try thinking of two different things, back and forth. Do you notice any reliable differences between the two thoughts? It's best to envisage two completely unrelated notions, or different thoughts of stressful or relaxing situations.



It's hard to observe any recognizable patterns in these 1s snippets of the raw data EEG traces. Perhaps the EEG encodes the relative "strength" of the thoughts, like our neuron rate coding experiments of chapter 3. While watching your recording, think about the color blue. Think really hard! Think really, uh, soft?



Hmmmm . . . There are a few things to note here. First, it can be difficult to perform human experiments on conscious thoughts. We will need to make better stimuli. Also, the EEG signals seem almost random—again! But how can this be? We are pretty sure that we are recording from the brain. Doesn't the brain control our thoughts? Shouldn't we be able to see at least some difference between thinking of objects versus activities? To understand what is happening here, we will need to do more experiments.

Experiment: Alpha Rhythms of the Visual Cortex

While the quality of the EEG signal might seem disappointing when you compare it to the robust, information-rich action we saw with the spikes in our model organisms, this is the nature of EEG research. The signals are weak and slow, but do they contain information about what the brain is thinking?

To find out, let's set up a new experiment. This time, twist the headband around until the metal electrodes are facing the back of the head. We are now aiming for our brain's occipital lobe. In EEG research, electrode positions are given identifiers to make it easier to communicate with other scientists about your experiments. These identifiers often refer to the region they are sitting over. For example, we will now be recording from O1 and O2 from the occipital lobe.