# DIY Neuroscience

Coming from an academic background of neuroscience into the art-science lab, I was confronted with the question of how to do neuroscience experiments yourself at home. This article is an exploration of the possibilities of doing neuroscience yourself. It is not intended to be an exhaustive list, but rather an explorations of the challenges of small scale/budget neuroscience experiments, and how you can get involved.

## What is Neuroscience?

Neuroscience is essentially the scientific study of the nervous system[1], which includes the brain and all the nerves that descend from it. While studies of the nerves in the body are relatively simple as they effectively are conveyors of information, things get a lot more complex when you get to the brain.

It is not an understatement to say that the human brain is the most complex object known in the universe. There are as many neurons (nerve cells) in the brain as there are stars in the milky way. Thats 100 billion neurons. However, thats not what makes the brain so complex. The complexity arises from the fact that each of these neurons are connected to up to 10,000 other neurons, adding up to over 1000 trillion points of contact[2]. The sheer combinatorial prowess of the brain puts to shame any computer we could ever dream of building.

But you shouldn't be surprised about all of this. After all, it's this same level of complexity that is letting you see these arbitrary markings on a screen, translate them to letters, add letters to form words, link words to meanings, and combine meanings into ideas. Not to mention that it is the human brain that designed the complex full-colour computer screen you are reading this on.

Its not a surprise then, that the study of the brain is a very difficult pursuit. Being a science, neuroscience is heavily data driven. At the end of the day, the experiment needs to be reproducible and needs to verify, create or make predictions of a given theory of how the brain (or a small part of it) works. Due to the brain's complexity, you can only focus on one aspect at time. Even then, theres no guarantee that your research will lead to anything. At it's current stage, I would say neuroscience is similar to Kant's idea of the scientific machine; several researchers working together to a body of research large enough to be able to put together more concrete ideas about how the brain works.

How can you as a DIYer contribute to this body of research? Maybe you are interested in the brain and would like to do a bit of poking around. Maybe you are a mad scientist trying to create an insectoid Frankenstein. Or maybe you are a teacher trying to get your kids interested in the nervous system.

Most experiments in neuroscience require either animal testing or very expensive and specialised equipment. This makes neuroscience a rather esoteric field that is not easily approachable by the masses. However, there are a few options which might allow you to do neuroscience at home.

## Backyard Brain

Backyard Brain is a direct effort to remedy the esoteric nature of neuroscience by selling kits for DIY neuroscience.

Backyard brain's sells kits for neuron spike testing, Myography, "mind control", and even a kit for making an artificial cyborg cockroach. A lot of Backyard Brain's kits involve "wetwork" (doing

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[1] https://en.wikipedia.org/wiki/Neuroscience#History

[2] http://www.human-memory.net/brain_neurons.html

surgery on wild animals), wherein you can insert electrodes into anaesthetised insects and directly measure signals from neurons, or stimulate neurons to control insects.

Their website has several experiments and lessons catered to teaching the layman about neuroscience. A few of the experiments don't even need specialised equipment to do, so it is definitely worth a visit.

You can find them here:

https://backyardbrains.com/experiments/

The spikerboxes are interesting because you can actually gather data from live firing neurons, and explore the different situations these neurons fire in. You might find something unique about the species you are looking at!

## Open BCI

Electroencephalography (EEG) is a non-invasive technique used to detect the electrical activity of the brain. When a large number of neurons fire together, they generate an electric field, which can be detected through electrodes on the skull's surface. EEG allows researchers to see which areas of the outer cortex is firing during specific activities, and is a popular tool in neuroscience research.

Research-grade EEGs can run upwards of 8 lakh rupees, making them quite expensive. Furthermore, most EEGs require proprietary software for data collection and analysis, and do not allow any interfacing with DIY projects. While most institutions have no problem with this, the EEG is a largely unhackable and unaffordable optopm for DIYers. As an answer to this problem, OpenBCI have created their own affordable EEG. OpenBCI stands for open-source Brain Computer Interface. Their boards and helmets run for 40,000 indian rupees for the most basic model, and are completely open-source. This means that they can be interfaced with other components such as the arduino, and the software is completely free and hackable.

OpenBCI's main attraction the ease with which you can interface it with other electronics. This allows you to easily create new ways of controlling electronic systems by interfacing the brain with your computer. However, the website touts it as a research-grade EEG so you can also do your own neuroscience experiments with the OpenBCI.

OpenBCI can be found here:

http://openbci.com

## tDCS

Moving on to the less ethical and less recommended DIY projects, we can start with tDCS.

I have to express strongly that I do not reccommend anyone do this at home themselves as there is no conclusive research about its effects. However, it is good to know about it as it is a relatively large movement among DIY "neuroscientists" and biohackers.

The idea is simple. While EEG detects signals produced by the brain, tDCS (which stands for transcranial direct current stimulation) does the opposite and attempts to zap the brain with mild electricity.

Clinically, tDCS has been shown to be a useful treatment for some cases of depression. The biohacker community on the other hand are testing the method as a means of improving cognitive performance. Companies like foc.us are even selling bespoke devices for tDCS.

Their website (www.foc.us) claims that tDCS allows you to “learn faster, train harder or remember more”, though they caution that you should be cautious as there is a lot of information both against and for tDCS.

However, there are a lot of tutorials online to make your own tDCS devices, which is what most DIYers do.

## Nootropics

Another movement that is taking place in DIY neuroscience is nootropics or so called “smart drugs”. Like tDCS, the use of nootropics is mainly for cognitive enhancement. Nootropics are a class of drugs that do not have substantial research behind them, but have been shown to improve cognitive ability.

The most well known example of nootropics are adderal and ritalin (ADHD medication that improves focus). There has recently been an increase in the number of students taking these drugs to improve their performance while studying.

However, the nootropics community online (mainly on the r/Nootropics subreddit) do not use nootropics only for studying, but as a daily supplement. Some even take them as “neuroprotective” supplements as there is research that shows some drugs decreasing the chance of developing alzheimers and other neurodegenerative diseases.

Nootropics are often taken in “stacks”, which are combinations of different nootropics in small doses paired with nutritional supplements such as choline. The online community performs “experiments” wherein they try different combinations and report the effects. The reports often include testimonials about their state of mind, health, and a description of the events during their day.

Testimonials are hardly a viable dataset for research, as each person can project their own ideas onto the stories they tell. However, the sheer amount of information on the forums present an interesting source of data for further research.

That being said, there is unsubstantial research about the negative effects of nootropics. Especially when taken in stacks. People who experiment with nootropics are therefore taking a substantial risk in their pursuit of increased cognitive ability.

A few companies have caught the nootropics train, and are marketing stacks in pill form that are allegedly thoroughly researched and natural. An example of this is AlphaBrain (www.onnit.com/alphabrain/).

Again I have to say that I do not recommend this as a DIY neuroscience project, but it is an interesting idea nonetheless.

## Open-Source Computational Tools

If you have computer skills, and would like to contribute to neuroscience research, there

## Techniques in Modern Neuroscience

Historically, neuroscience was rather gruesome science. It originally stemmed from the observation that people who had damaged certain parts of the brain could no longer perform certain tasks but were otherwise able to function. This led to a lot of purpose damaging of the brain and lobotomisation with the purpose of specifically damaging specific areas and seeing the end result.

While this practice was horrific by modern standards, it yielded a lot of information about what areas of the brain were involved in what process, and also what main processes add up to our human experience.

Today, neuroscience has moved on from neurosurgical experimentation of humans. Advances in modern technology allows scientists to look inside the brain without cutting it open, or to take measurements directly from specific cells in the brain.

Functional magnetic resonance imaging (fMRI) can be used to see what areas of the brain are being used during a task by monitoring the blood flow in the brain. A technique called diffusion tomography (dtMRI) can even show the main pathways of white matter (nerve axons) which shows which areas of the brain are physically connected to each other.

Another technique that is widely in use is electroencephalography (EEG). Nerves are essentially carriers of electricity. When a large number of nerves are “firing” (ie-conducting electricity) in a given area, an electric field can be detected on the surface of the skull. EEG works by placing electrodes at specific points on the skull and measuring these fields. From this data, it is possible to measure levels of attention and relaxation, certain emotions, and other useful information from the brain.

With the information gained from these non-invasive techniques, it is even possible to non-invasively influence the brain through stimulation of magnetic fields or electricity, for example to treat depression. These technologies are called transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS).

While non-invasive techniques provide adequate information about brain areas, they do not have the resolution to collect data from individual neurons or groups of neurons. It has been found that the working of the brain eventually boils down to how the cells in the brain are structured, and how they connect and interact with each other.  In order to look down at this level, neurosurgery and animal testing is required. However, it has evolved considerably since the days of pulling brains from people’s noses (as they did in ancient egypt).

“Wetwork” as it is called today, involves opening the brain of animals such as mice and inserting electrodes into specific cells in the brain to record information directly from them. As many as 200 cells can be sampled at the same time to see how they contribute to the overall functioning of the brain.