



ELECTROPHYSIOLOGY: TAPPING INTO THE WONDERS OF THE BRAIN

Luqman Ojerinde^{1*}, Amy R. Pearce² and Christopher C. Lapis¹

¹Department of Anatomy & Cell Biology, Indiana University School of Medicine, Indianapolis, IN, United States

²Department of Psychology, Indiana University Indianapolis, Indianapolis, IN, United States

YOUNG REVIEWERS:



MALEEKA

AGE: 10



YUELING

AGE: 13

Electrophysiology is the study of the body's electricity. It is also one way that scientists study brain cells called neurons. *In vivo* electrophysiology is a technique that allows us to study what is happening among groups of neurons in living organisms. The "*in vivo*" part of the term means "in life". Measuring electrical activity from living organisms can uncover real-time communication between neurons, which helps us understand how the brain produces behavior. As we study the brain and learn more about how it works, we can get a better grasp of brain disorders and brain-related disabilities—and hopefully find new ways to treat them.

NEURONS

A brain cell that uses neurotransmitters and electricity to communicate with other brain cells and the body.

NEURO-TRANSMITTERS

Little chemical messengers that neurons send to each other to communicate.

ACTION POTENTIAL

A surge of electricity that travels down a neuron and allows it to communicate with other neurons.

Figure 1

Neurons communicate through a process involving neurotransmitters, ions, and electricity. While other types of communication also happen between neurons, and neurons come in other shapes and sizes, this figure shows the core idea of neural communication (Image created in Canva).

HOW DO NEURONS IN THE BRAIN WORK?

The brain is made up of many types of cells, and **neurons** are a major type. To communicate with each other, neurons send little chemical messengers, called **neurotransmitters**, from one neuron to the next (Figure 1, step 1). When a neurotransmitter is received by a neuron, positively or negatively charged substances called ions rush inside that neuron. If negative ions enter, then the signal stops. However, if enough positive ions build up in the receiving neuron, this triggers an **Action potential**. An action potential is like a surge of electricity that travels down the neuron. When the action potential reaches the end of the neuron, it causes neurotransmitters to be released again, which travel to the next neuron, and the cycle starts over (Figure 1, steps 2–4).

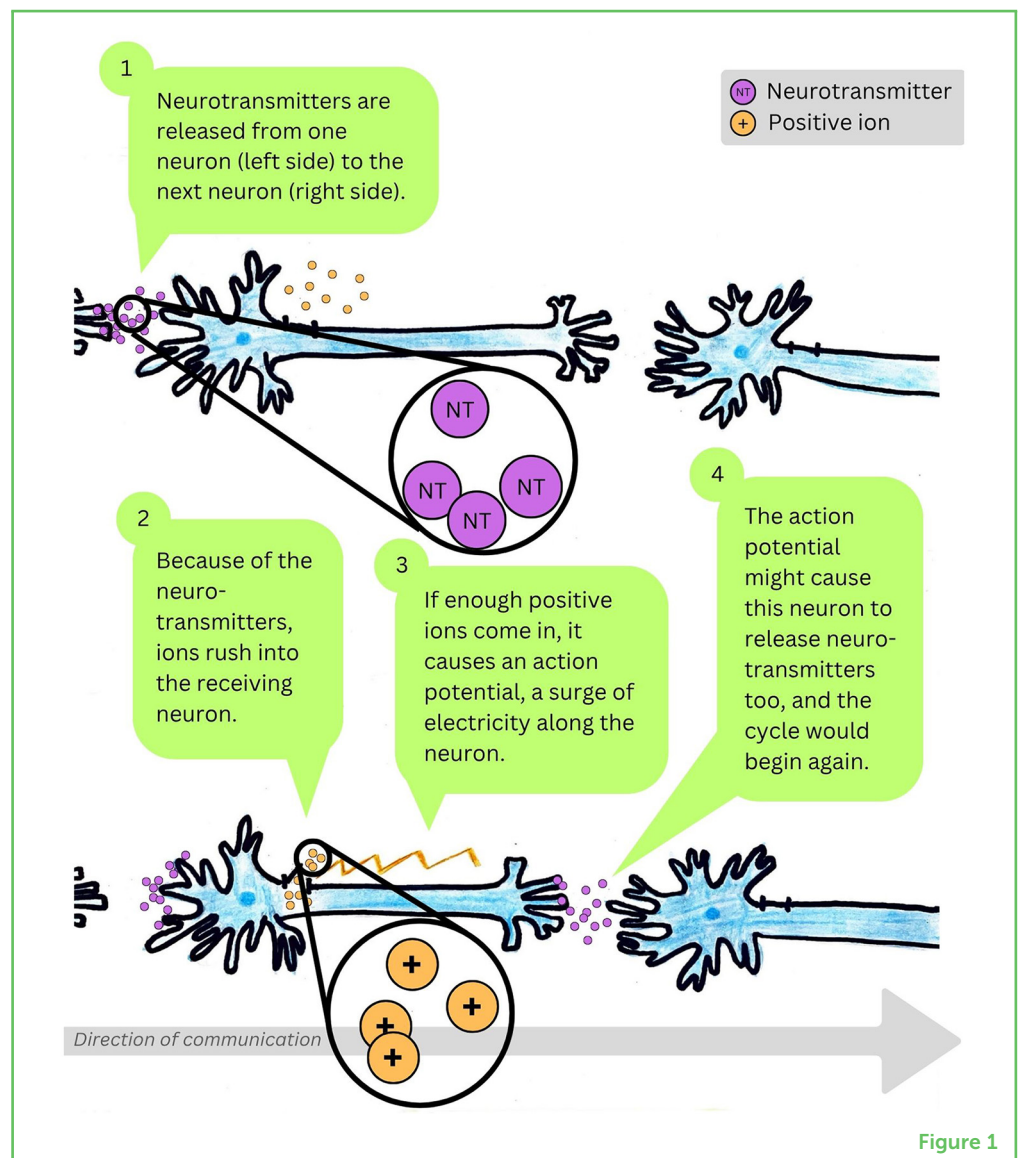


Figure 1

There are about 100 billion neurons in the brain. Neurons also connect with the body's muscles and glands and send signals from the body to the brain. At any moment, a lot of neurons are firing action potentials. By working together, neurons help us think, feel, move, breathe, and experience life events.

OUR BRAINS ARE COMPLICATED!

There is a lot going on in the human brain. Most of the time the brain works properly, but sometimes things can go wrong. For example, when someone is having a seizure, their neurons are overactive, and this might cause them to lose control of their movements. When our brains have problems like this, it can be very difficult for scientists to figure out why. Additionally, different brain disorders can be hard to tell apart from each other. Because of these factors, it might seem impossible to study the brain. How do we get past this obstacle? The answer lies in an interesting trait of neurons—their electricity can be measured.

WHAT IS ELECTROPHYSIOLOGY?

Electrophysiology is the study of electrical activity in different parts of the body. In the brain, electrophysiology can be used to measure the electrical communication of neurons. It is kind of like eavesdropping on neurons while they talk to each other. With the help of some advanced equipment, we can even record neurons while they are alive and functioning within a person's brain. This means we can get data about the brain that we might not be able to get by simply observing dead brain tissue or by observing the brain's blood flow. In addition, electricity is a key aspect of brain function, so tracking electricity means directly monitoring brain activity [1].

People have been engaging in electrophysiology for over a century. In the 1780s, a professor named Luigi Galvani electrically stimulated a dead frog's leg [2]. Upon stimulation, the leg muscles twitched. After the experiment, Galvani and other scientists began questioning what the muscle twitching meant about how muscles, **Nerves**, and electricity work in animals. Over many decades this led to various scientific advancements, including the discovery of the action potential. This knowledge also led to the development of modern electrophysiological techniques.

These techniques can involve stimulating a body part, like in Galvani's experiment, but they also include observing how tissues and organs naturally function with electricity. Particularly, electrophysiology is one of the best ways to get valuable information about the electrical activity of the brain. This includes how drugs can affect ions rushing into neurons, how the electrical activity of certain brain areas affects

ELECTRO- PHYSIOLOGY

The study of the body's electrical activity.

NERVES

Bundles of long neuron extensions. Nerves branch out from the brain and spinal cord to make the nervous system.

EXTRACELLULAR RECORDING

One technique of electrophysiology in which one monitors the electricity from outside of neurons.

IN VIVO

A term that is used to describe experiments done on living creatures.

BRAIN COMPUTER INTERFACES

A technology that lets the brain and a computer send signals to each other. Some BCIs work from outside the body, while others involve devices placed inside.

other brain areas, and how the brain's overall electrical activity influences our actions. These days, electrophysiological techniques basically come in three categories. The first one is electrical monitoring *inside* a single neuron. The second is electrical monitoring from *outside* neurons, which is called **Extracellular recording**. The third category is monitoring from outside the brain. Let us take a look at the second category, extracellular recording. When this is done in the brain of a living creature, it is called **In vivo** electrophysiology. The "*in vivo*" part of the term means "in life".

OBSERVING NEURONS IN LIVING CREATURES!

During *in vivo* electrophysiology, small pieces of metal called electrodes are placed into one or more brain areas. They capture live electrical recordings, and this can be done on animals like rats and monkeys. Since there are no pain receptors in the brain, the animals do not feel pain from the procedure. However, these types of studies require lots of training, specialized equipment, and approval by an animal research ethics committee known as the **Institutional Animal Care and Use Committee**. Do not try this on your pet at home! When the neurons in the animal's brain fire action potentials, the electrodes pick up the electricity of those neurons. This electricity is displayed as waves visible on a computer screen.

Waves observed from neurons in different brain areas can inform scientists about neural activity. For example, the amygdala is a brain area associated with fear and aggression. High levels of electrical activity coming from this area might mean that the research animal is scared. *In vivo* electrophysiology can be used to understand other emotions too, and it even informs us about behavior.

HOW HAS IN VIVO ELECTROPHYSIOLOGY HELPED PEOPLE?

In vivo electrophysiology can help scientists get detailed information about neural activity, but the benefits do not stop there. When combined with other technologies, it can directly help people in need. **Brain computer interfaces (BCIs)** are a good example. BCIs allow direct communication between a brain and a computer. They come in many forms, but some use electrodes that pick up the electrical activity of neurons in a similar way to that shown in **Figure 2**. The basics are the same: electrodes sit among neurons and listen to their conversations. The difference is that BCIs then relay the conversation to a computer that performs an action, like translating the brain activity to speech [3]. This kind of BCI provides people with speech disabilities another way to communicate.

Figure 2

In *in vivo* (in life) electrophysiology, an animal has electrodes surgically inserted into its brain. It is then allowed to freely move around, sometimes in a box like the one shown. While the animal moves around, its brain electrical activity can be read on a computer screen in real time. This can help scientists get accurate information about what is happening in the animal's brain [Created in BioRender. Ojerinde, L. (2025) <https://BioRender.com/d24m158>].

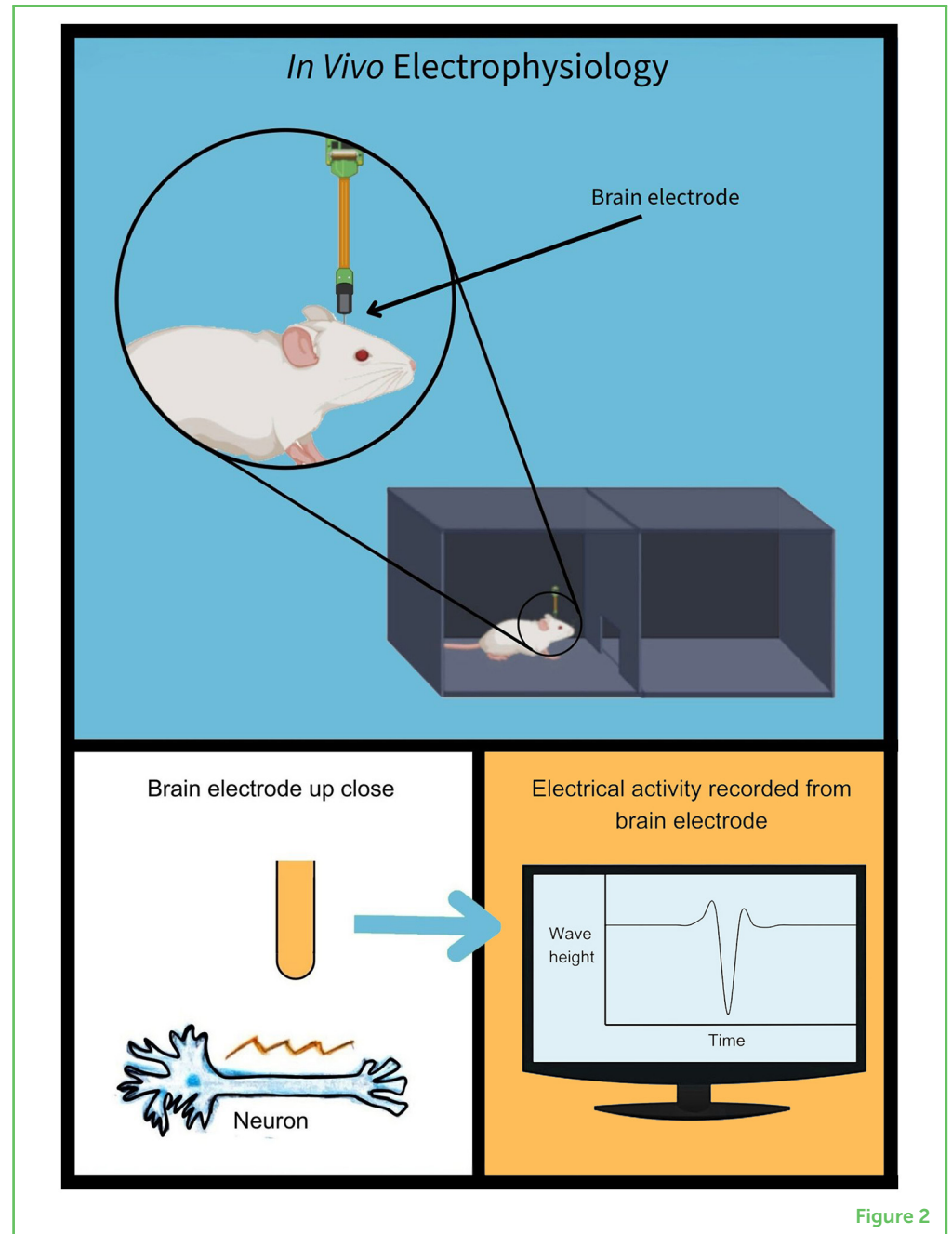


Figure 2

IN VIVO ELECTROPHYSIOLOGY CAN MAKE A DIFFERENCE

Observing neurons can be very helpful for studying the brain, and observing neural communication is even more helpful. After all, neurons are pretty cool on their own, but their group communication is what allows your brain to interpret the words you read in this article, for example. *In vivo* electrophysiology is a great way to analyze the communication of a group of neurons because it can give real-time data about neurons in several brain areas, helping scientists understand how those areas communicate and what it means. As seen

Figure 3

A BCI can be inserted onto the surface of a person's brain to record electrical activity. It uses the person's brain activity to produce the words they want on a screen (like "very good"). This BCI uses electrodes that measure electricity from groups of neurons, similarly to the *in vivo* electrophysiology shown in Figure 2 (Image created in Canva).

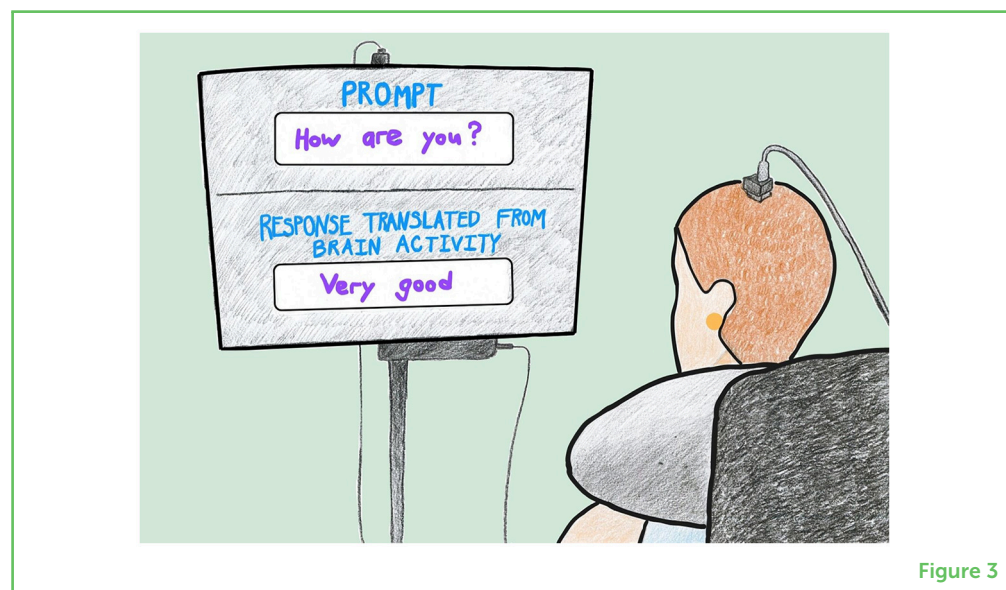


Figure 3

Although *in vivo* electrophysiology has many benefits, it is not perfect. The equipment can be expensive and troublesome. Understanding data extracted from its procedures can be difficult. Although it is very useful, sometimes *in vivo* electrophysiology is best used in combination with other techniques or not used at all. Members of my laboratory use *in vivo* electrophysiology to analyze the neural activity involved in the addictive behavior associated with drug use. People all around the world who study the brain, like neuroscientists, use the technique to advance many other types of brain research [4]. Now that you know the basics of how it works, maybe one day you can join in using this technique to study the wonders of the brain!

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**MALEEKA, AGE: 10**

I am Maleeka and I go to Highgate Primary School in London. I love science, swimming, arts and crafts, and spending time with my family and friends. When I was in year 2, I took part in a BBC science episode about slugs! I have been playing the violin for a long time, and I enjoy learning new things. In the future, I want to be a scientist and make amazing discoveries that help people and improve the world.

**YUELING, AGE: 13**

My name is Yueling. In my free time I enjoy creative writing, hanging out with friends, and reading. I am also very curious when I am outside exploring the neighborhood. In creative writing, I have written several short stories that have been noticed by child magazines.

**LUQMAN OJERINDE**

Luqman is a laboratory technician in the department of Anatomy & Cell Biology at Indiana University School of Medicine. He is also a post baccalaureate student studying the mind and body through the lens of behavioral neuroscience, and he hopes to enter a neuroscience Ph.D. program soon. Outside of the lab Luqman reads, exercises, spends time with family, and spoils himself with YouTube videos, often from Veritasium. *luquoj@gmail.com

**AMY R. PEARCE**

Amy R. Pearce is a teaching professor in the Department of Psychology and a STEM education innovation and research institute associate at Indiana University Indianapolis. She earned her Ph.D. in neuroscience, plus a certificate in science communication from The Australian National University and her B.S. in psychology from Arkansas State University. Amy teaches neuroscience courses at her university and promotes STEM education through school and community events, including fun things like science comedy and science festivals.

**CHRISTOPHER C. LAPISH**

Christopher C. Lapish is a professor of anatomy, cell biology and physiology at IU School of Medicine and director of addiction research at the Stark Neurosciences Research Institute. He earned his Ph.D. in neuroscience from the Medical University of South Carolina. He heads a lab that investigates the neural mechanisms that underlie cognitive dysfunction in disorders of the brain.