Inputs and Outputs:

How the brain allows us to interact with the world

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Introduction

The simplest way to think about the brain is as a platform through which we can interact with the world. Highly specialized sensory structures in our peripheral nervous system detect information in our environment and send these sensory signals to the "information hub" of our bodies, the brain. Here, sensory information is processed to produce an internal precept of the external world. This internal representation is our brain's best guess at what's going on around us, but this picture is not a perfect one, and we'll discuss the limits of our own perception. The brain uses its interpretation of what is going on around us to then instruct remarkably precise and context appropriate behavior. Using motor movement as the key example, we will describe how cortex is involved in producing the 'ideas' of movement. A completely different system of the brain - the basal ganglia - is critically important for taking these 'ideas' from the cortex and refining them into precise and smooth behaviors. We'll show how abnormal activity in both cortex and basal ganglia result in aberrant behavior and disease. Ultimately, this lecture is about appreciating the most fundamental functions of the brain: accurately and appropriately interpreting the world and reacting to it, and what can happen when it fails. After the lecture please join us for a lab tour of Dr. David Ginty's laboratory where we can explore how research on sensory cells is conducted.

Speakers

Laura Driscoll is a fourth year PhD student in the Harvard Program in Neuroscience. In the lab of Chris Harvey, she studies the activity patterns of large neuronal populations in mice during learning of decision making tasks in virtual reality. She is passionate about the value of broad-based scientific knowledge in her community and is becoming increasingly interested in machine learning. In her free time, she enjoys imagining what the future will be like.

Shay Neufeld is a fourth year PhD student in the Harvard Program in Neuroscience. Armed with microscopes, lasers, and electrodes, he studies how circuit plasticity in the brain enables us to learn new behaviors that can be refined, remembered, and sometimes forgotten. Aside from doing experiments, he has a growing interest in how to effectively communicate science with the public – both through education and journalism. He also enjoys reading really old science papers and imagining how scientists figured things out hundreds of years ago. That being said, he is very thankful to be doing research now and not then.

Blind Spot Demo

Glossary of Important Terms

Central nervous system (CNS): the CNS is composed of the brain and spinal cord and it serves as the main "processing center" for the entire nervous system. It is connected to the limbs and organs via the nerves and ganglia of the **peripheral nervous system (PNS)**

Neuron: an electrically excitable cell that processes and transmits information through electrical and chemical signals. They have specialized structures to receive (**dendrites**) and transmit (**axon**) information. **Sensory neurons** convert external stimuli from the environment into internal electrical impulses and **motor neurons** control movement through contracting and relaxing muscles.

Synapse: a structure that permits a neuron to pass an electrical or chemical signal to another cell. It consists of a **pre-synaptic** structure on the neuron sending the signal and a **post-synaptic** structure on the cell receiving the signal. The **neuromuscular junction** is a specific type of synapse where a motor neuron activates a muscle to contract.

Neurotransmitters: chemicals naturally made by neurons that transmit signals across a synapse from one neuron to another "target" neuron. **Dopamine** is a neurotransmitter associated with thought, reward, and movement.

Electrical gradient: the difference in electrical charge across the membrane of a cell, this can be measured and manipulated using conductors of electricity called **electrodes**.

Retina: the back part of the eye that contains the cells that respond to light. These specialized cells are called **photoreceptors**. **Rod photoreceptors** are most sensitive to light and dark changes while **cone photoreceptors** are most sensitive to one of three different colors (green, red, or blue). The central part of the retina is called the **fovea**.

Reflex: an action or movement of the body that happens automatically as a reaction to something

Cortex: the outer layer of the brain associated with higher brain functions. The cortex is made up of regions with distinct functions. For example, **motor cortex** controls voluntary movements, **premotor cortex** is involved in the planning of movement, and **Broca's area** contains the motor neurons responsible for speech.

Basal ganglia: a region of the brain below the cortex associated with motor movements, habits, and emotion.

Circuit: a functional entity of interconnected neurons that is able to regulate its own activity

Resources to learn more

Talking Back to the Brain, http://sitn.hms.harvard.edu/seminars/2013, previous SITN lecture on how neurons communicate.

Types of neurons, http://education-portal.com/academy/lesson/types-of-neurons-sensory-afferent-motor-efferent-more.html

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