The Brain and Nervous System

Instructor Manual

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This module covers a range of concepts, including understanding the development of two parts of the nervous system: peripheral and central nervous systems. The lion's share of the focus is on the latter as there are many terms and concepts related to the various divisions and structures of the central nervous system, including the brain. This module also briefly looks at neurons and neural networks. Finally, this module also offers information on the various techniques used to study the brain.

Learning Objectives

- **Relevant APA Learning Objectives (Version 2.0)**
  - Describe key concepts, principles, and overarching themes in psychology (1.1)
  - Develop a working knowledge of psychology's content domains (1.2)
  - Describe applications of psychology (1.3)
  - Use scientific reasoning to interpret psychological phenomena (2.1)
  - Demonstrate psychology information literacy (2.2)
  - Build and enhance interpersonal relationships (3.2)
  - Adopt values that build community at local, national, and global levels (3.3)
- **Content Specific Learning Objectives: The Brain**
  - Name and describe the basic function of the brain stem, cerebellum, and cerebral hemispheres.

- Name and describe the basic function of the four cerebral lobes: occipital, temporal, parietal, and frontal cortex.
- Describe a split-brain patient and at least two important aspects of brain function that these patients reveal.
- Name and describe the most common approaches to studying the human brain.
- Distinguish among four neuroimaging methods: PET, MRI, fMRI, EEG, and CAT.
- Describe the difference between spatial and temporal resolution with regard to brain function.

- **Content Specific Learning Objectives: The Nervous System**
  - Describe the reasons for studying different nervous systems in animals other than human beings.
  - Explain what lessons we learn from the evolutionary history of this organ.
  - Describe and understand the development of the nervous system.
  - Learn and understand the two important parts of the nervous system.
  - Explain the two systems in the peripheral nervous system and what you know about the different regions and areas of the central nervous system.
  - Learn and describe different techniques of studying the nervous system.
  - Understand which of these techniques are important for cognitive neuroscientists.

Abstract

1. THE BRAIN: The human brain is responsible for all behaviors, thoughts, and experiences described in this textbook. This module provides an introductory overview of the brain, including some basic neuroanatomy, some basic descriptions of functions of the brain, and brief descriptions of the neuroscience methods used to study it. 2. THE NERVOUS SYSTEM: The mammalian nervous system is a complex biological organ, which enables many animals including humans to function in a coordinated fashion. The original design of this system is preserved across many animals through evolution; thus, adaptive physiological and behavioral functions are similar across many animal species. Studying the development of the nervous system in a growing human provides a wealth of information about the change in its form and behaviors that result from this change. The nervous system is divided into central and

peripheral nervous systems, and the two heavily interact with one another. The peripheral nervous system controls volitional (somatic nervous system) and nonvolitional (autonomic nervous system) behaviors using cranial and spinal nerves. The central nervous system is divided into forebrain, midbrain, and hindbrain, and each division performs a variety of tasks; for example, the cerebral cortex in the forebrain houses sensory, motor, and associative areas that gather sensory information, process information for perception and memory, and produce responses based on incoming and inherent information. To study the brain, a number of methods have evolved over time; and each of these has certain strengths and limitations.

Class Design Recommendations

This module can be taught in one 60-minute class, or two shorter class periods (45 to 60 minutes). If it is taught in two class periods, we suggest using one period for overview and the peripheral nervous system and the other period for the central nervous system, neurons, and the anatomy and functions of various parts of the brain. Please also refer to the Noba PowerPoint slides that complement this instructor's manual.

Overview

- Warm-Up Activity: Just Noticeable Differences
- Brain Development
- The Central Nervous System:
- The Peripheral Nervous System
- Studying the Brain

Module Outline

What Can We Learn about the Human Brain From Other Animals?

- The human brain evolved from the brains of invertebrates and single-celled organisms. Many animals display non-verbal behaviors that are similar to humans. However, human non-verbal communication is more complex. The more complex the behavior, the more complex the nervous system. If we compare Homo habilis to Homo sapiens, we find that the former used crude stone tools compared to the tools used by Homo sapiens to build civilizations and cities.

How Does the Nervous System Develop?

- The nervous tissue that forms the brain develops over the course of gestation:

- As the embryo continues to develop, so does the neural tube. It balloons up *rostrally* (towards the head). At day 40, we can see clear distinctions of the **forebrain**, midbrain, hindbrain and the spinal cord. By 50 and 100 days the cerebral hemispheres are developing, and thereafter they cover the majority of the brain area.

What is the Structure of the Central Nervous System?

- What is the Brain Stem? Often referred to as the trunk of the brain, the brain stem is responsible for many of our basic survival functions (e.g., respiration, heart rate, digestion), sleep-wake cycles, growth and other hormonal behaviors as well as sensory and motor functions. Severe damage to a brain stem can necessitate the need for 'life support' as the patient is unable to breathe on his or her own. Collectively, the brain stem refers to the following structures: medulla, pons, midbrain, and diencephalon (which refers to thalamus and hypothalamus). Note that this depth of brain anatomy is not explicitly presented in the module.

Our nervous system is divided into main parts: the *peripheral* and *central* nervous system.

Central Nervous System (CNS).

This portion of the module is structured in a way that focuses on the "micro" and expands out toward the "macro." This means we begin our exploration with individual neurons and the communication of neurons across the synaptic gap. From there we "zoom out" to the anatomy of the brain and the various specific functions according to brain geography.

Neurons—are individual brain cells. They connect to one another to form "pathways" (or neural pathways) by which the brain sends electro-chemical signals. This activity is at the core of all thinking, remembering, processing, reacting and all of the other functions of the nervous system. Neurons work as electric-chemical charges build up until they reach a critical threshold; after which they “fire” down the axon to the next neuron.

The brain-- Below are two specific ways of understanding and organizaing the parts of the brain. First, the brain can be divided as follows (please note that the “-encephalon” vocabulary is not presented in the module; Noba has favored simpler vocabulary for this module. A more sophisticated view can be found in the individual modules on The Brain and on The Nervous System, respectively):

1. Forebrain – The forebrain is the forward-most portion of the brain. It consists of thetelencephalon and diencephalon.

2. Midbrain – The midbrain is the smallest region of the central nervous system and acts asa relay station for visual and auditory information. The midbrain is also referred to as the mesencephalon.

3. Hindbrain – The hindbrain is the rear lower portion of the brain and is comprised of themetencephalon and myelencephalon.

What is the Limbic System? Located beneath the cerebrum, the limbic system is a collective name for structures involved in emotion, motivation, and emotional associations with memory. It primarily refers to these structures: amygdala, hippocampus, thalamus, hypothalamus, basal ganglia and cingulate gyrus. The thalamus and hypothalamus have already been defined elsewhere.

- **Amygdala–** is an almond-shaped set of neurons that is part of the limbic system and located in the temporal lobe. It is involved in processing and expression of arousal and emotions like anger and fear.

- **Basal ganglia–** refers to a group of nuclei lying deep in the frontal lobes and is part of the limbic system. It is involved in voluntary movement and coordination.

- **Cingulate gyrus–** is a component of the limbic system that lies just above the corpus callosum. It is responsible for directing attention to emotionally significant events for associating memories to smells and pain.

Another way to parse apart the regions of the brain is by focusing on hemispheres and lobes:

1. Cerebral Hemispheres – The cerebral cortex is divided into left and right hemisphere and

connected by a dense bundle of white matter tracts known as the corpus callosum. There are some functions that are lateralized, or primarily under the control of one hemisphere. Both hemispheres, on the other hand, control motor and sensory functions, although the sensory and motor cortices have a contralateral representation. Split-brain patients are people whose two cerebral hemispheres are not connected via the corpus callosum as a result of surgery or genetic abnormality. Studying these patients helps us understand the function of the two hemispheres.

The cerebrum can further be divided into four lobes:

Parietal lobe– This is an area of the cerebrum at the top of the head, but towards the back, and is involved with somatosensory and gustatory sensation. The parietal lobe includes the somatosensory strip, which is like a map of the entire body and receives input from the skin and muscles. The parietal lobe also contains the gustation strip, or the second somatosensory cortex, which is involved with our experiences of taste.

Temporal lobe– This area contains the primary auditory and olfactory cortexes, brain regions devoted to hearing and smell, respectively. Proximally located to these areas is Wernicke's area, which is responsible for language comprehension and is connected to Broca's area. Damage to Wernicke's area can result in agnosia, or an inability to understand or recognize speech.

Occipital lobe– The occipital lobe is located in the back of the cerebrum and houses the primary visual cortex, which is responsible for vision.

Frontal lobe – This region of the cerebrum closest to the forehead. In the left frontal lobe, you will find Broca's area, a brain area responsible for language production. The frontal lobe is also involved with central and executive functions, such as working memory.

Primary Motor Cortex – Additionally, the frontal lobe contains the primary motor cortex, which is like a representation of the entire body, and is responsible for voluntary movement.

This may be a natural stopping point for a single class presentation.

Peripheral Nervous System

The peripheral nervous system (PNS) is divided into two systems:

- **Autonomic nervous systems (ANS)** – The ANS is primarily responsible for involuntary functions. It is further divided into the following systems, which work in tandem to regulate our "fight-or-flight" response:
    - Sympathetic– the sympathetic nervous system is responsible for energizing muscles and glands, causing the release of hormones and energy.
    - Parasympathetic– the parasympathetic nervous system is responsible for conserving energy and reducing the muscle and gland activity.

- **Somatic nervous system (SNS)**– The SNS is under the control of the individual, allowing humans to maneuver their own body muscles. The SNS consists of 12 pairs of cranial and 31 pairs of spinal nerves.

What Techniques Do Scientists Use to Study the Nervous System?

- The first scientific attempt to study brain functions began with phrenology in the 19th century, which posited that the various bumps and indentations on the skull reveal our mental abilities and personality traits. Phrenology has since been proven false, however, its birth led to the idea that different areas of the brain are responsible for varying functions.

Brain Imaging Techniques

- **Electroencephalograph (EEG)**measures electrical activity in the brain through the placement of a series of electrodes on the scalp.

- **Computerized axial tomography (CAT)** and **Magnetic Resonance Imaging (MRI)** are modern noninvasive techniques used to capture pictures of detailed structures in the brain by using X-rays or magnetic energy, respectively.

- **Positive Emission Tomography (PET)** is an invasive procedure in which an individual's brain is injected with radio-labeled isotopes. The isotopes enter the active nerve cells and emit positrons, which help record blood flow in various brain regions to help scientists assess which areas were active during a given task.

- **Functional Magnetic Resonance Imaging Techniques, (fMRIs)** are noninvasive brain imaging techniques that visibly document changes in blood flow to areas of the brain during a task. fMRIs and PET scans have decent spatial resolution, but cannot tell us when brain activity occurred.

- **Diffuse Optical Imaging (DOI)** directs infrared light into the brain and measures the light that comes back out. As the properties of light change when it passes through oxygenated blood or active neurons, they can indicate which brain areas were engaged in a particular task. Importantly, the DOI can be set-up to have high temporal and spatial resolution.

***Note on the Difficult Terms in this Module: This module is unusual for the sheer volume of new and often difficult vocabulary words. It may be especially helpful for students to create study aids such as flashcards to help learn this new vocabulary. They may find it helpful if you define each term repeatedly when using it in lecture. We recommend openly addressing the potentially daunting amount of vocabulary and reassuring students that with effort and repetition they can learn it.

Difficult Terms

Action potential
Autonomic nervous system
Axon
Brain stem
Broca's area
Central Nervous System
Cerebellum
Cerebral hemispheres
Cerebrum
Computerized axial tomography (CAT)
Contralateral
Corpus Callosum
Dendrites
Diffuse Optical Imaging (DOI)
Electroencephalography (EEG)
Forebrain

Frontal lobe
Functional magnetic resonance imaging (fMRI)
Hindbrain
Hippocampus
Homo habilis
Homo sapiens
Hypothalamus
Lateralized
Limbic system
Magnetic resonance imaging (MRI)
Midbrain
Myelin Sheath
Nervous System
Neurons
Neurotransmitters
Occipital lobe
Parasympathetic nervous system
Parietal lobe
Peripheral Nervous System
Positron Emission Tomography (PET)
Primary Motor Cortex
Soma
Somatic nervous system
Spatial resolution
Split-brain patient
Subcortical
Sympathetic nervous system
Synapses
Synaptic Gap
Temporal lobe
Temporal resolution
Thalamus
Wernicke's area
White matter

Lecture Frameworks

We recommend starting the class with a discussion that will make this heavily biological unit seem relevant to the daily lives of your students. Some students struggle to understand how the anatomy of the brain relates to psychological concepts such as attitudes, communication, and emotions. One simple way to do this is to begin by covering the evolution and development of the nervous system: it is clear that some mammals, such as cats and dogs cannot do all the things that chimpanzees and humans can do. Have your students list these differences and then suggest that some of these differences are related to differences in the nervous system (especially in the brain). Most of your first class will focus on the structure and working of neurons and the geography of the brain. Before diving into the central nervous system in the next class, emphasize that brain areas are organized in multiple ways and this can be confusing. The second class period can focus on the peripheral nervous system, methods used to study the brain, and also offer time for discussion or to reinforce learning from the previous session.

- **Warmup:** A great way to introduce the topic of the nervous system to students is by doing the Just Noticeable Differences Activity in the beginning of class.
- **Direct Instruction:**Refer to the PowerPoint slides for the following major topics: nervous system development, the central nervous system, and neurons: how the nervous system communicates
- **Activity/Demonstration:**To cover how the nervous system communicates, use the "Communication of Neurons Activity" described in the Activities and Demonstrations section. This will help solidify student's understanding of how neurons work and how they communicate on a micro level.
- **Direct Instruction:** Refer to the PowerPoint slides to talk about structures of the brain, the brainstem, corpus callosum and the lobes of the brain
- **Activity/Demonstration:**To help communicate the various functions of the 4 lobes of the brain and solidify the students' understanding of the brain, use the "Brain Quiz Activity" described in more detail in the Activities and Demonstrations section.
- **Direct Instruction:**Refer to the PowerPoint slides to talk about the peripheral nervous system
- **Activity/Demonstration:**To help better cover the various components and functions of the peripheral nervous system and help solidify students' understanding of this material, use the "Name that Peripheral Nervous System Activity" described in more detail in the Activities and Demonstrations section.
- **Direct Instruction:**Refer to the PowerPoint Slides to talk about the techniques scientists and researchers use to study the brain.

Activities & Demonstrations

Just Noticeable Differences Activity

- Time: 5-10 minutes
- Materials: any pointy object such as a hairpin, pencil, or pen
- Directions:

1. Here, the instructor can have students pair up or work in small groups to test "just noticeable differences." This can be accomplished by lightly touching two pointed objects, such as pens or pencils, against a part of the skin. You can try this on various areas such as the forearm or back of the hand. In each individual trial bring the points slightly closer together. At some point the subject will no longer be able to distinguish between the two points.
2. Discussion Questions:
    - What did you notice?
    - What did you learn?
3. Main Learning:
    - There is a limit, the just noticeable difference (JND), at which a person can distinguish the 2 points
    - The JND differs from one area of the body to another (eg. Neck, palm, forehead)
    - The JND is the result of different number of nerves cells in each area
    - Nerves cells are part of the nervous system (the students have just studied their own nervous system!).

Communication of Neurons

- Time: 5 minutes
- Materials:
- Directions:

1. Here you can use volunteers to act out the communication of neurons. Three volunteers will do. Have them stand side by side facing the audience. Their hand should be close but not touch. You can hand the first person (representing the first neuron) several cotton balls (representing neurotransmitters).
2. Explain as the person shifts them from one hand to another how they would actually be traveling from the soma (chest/body) down the sheath (arm) to the dendrites (hand). The cotton balls are then passed across the gap to the dendrites (hand) of neuron #2. This entire process then repeats between neuron #2 and neuron #3.
3. You might ask students to suggest the types of information that synapses communicate (thoughts, emotions, movement, memories, sensations and perceptions).

Brain Quiz

After going over the functions of each of the 4 Lobes of the Brain presented on the accompanying slide, administer a quick quiz to test the students' knowledge.

- Time:
- Materials:
- Directions:

1. Ask Students: Which area would be primarily responsible for processing:

- Realizing that the delicious smelling bread you are baking is nearly done (temporal)
- Tuning the dial and volume on a radio (occipital)- the same *fusiform face area* that reads facial features "puts together" other types of constellations of features such as the "face" of a radio.
- Buying refreshments and decorating your house for an upcoming party (frontal)
- Ducking when a friend throws a water balloon at you (occipital)
- The feeling of pain when someone pinches you (parietal)

Name that Peripheral Nervous System

The purpose of this activity is to allow students to apply their knowledge of the peripheral nervous system to activities common to them. There is a PowerPoint slide that accompanies this activity for the module.

- Time:
- Materials:
- Directions:

1. Begin by going through each picture from top left to top right, and bottom left to bottom right. For each picture, ask students to identify which part of the nervous system is being used and to provide rationale for their answer. Each of the pictures is animated by clickers.
2. The first picture shows someone relaxing in a pool. Make certain to emphasize "relaxing"
    - For this picture students should indicate that the parasympathetic portion of the autonomic nervous system is activated which allows her to relax because there is no immediate threat or danger.
3. The second picture shows someone running away from a bull, which is a threat.
    - For this picture students should generate that the sympathetic portion of the autonomic nervous system is activated because of the stressful situation.
4. The third picture shows a boxing match.
    - In this picture, the sympathetic portion of the autonomic nervous system was likely activated in both individuals' because their bodies needed to be prepared for action.
5. The fourth picture is a bit trickier, but shows typing.
    - Students should indicate that typing uses the somatic portion of the nervous system because of the careful coordination of movements.

Additional Activities

Mythbusters - 8 Myths about the Brain

- Time: 16 minutes; 8 minutes for activity, 8 minutes for discussion
- Materials: If you decide to hand each person a true/false sheet, you will only need the sheet for the activity. You can also use clickers.
- Directions:

1. At the start of this unit, hand out a true/false sheet to the students with the general statements listed below. You can also put up each question on a slide sequentially, or use clickers. These statements are common misconceptions students may have about the brain. The instructor can pick or choose as many of these statements as desired. In some cases, the answers can generate interesting discussions.

- Einstein's brain is different than our brains.
- We only use 10% of our brain.
- Listening to Mozart makes you smarter.
- People are either "right-brained" or "left-brained".
- Drinking alcohol always kills brain cells.
- Brain damage is always permanent.
- The heart is more important for love than the brain.
- The human brain is larger than any other animal brain.

- Answers

- Einstein's brain is different than our brain. [FALSE] According to recent research, there areno neuroanatomical differences between our brain and Einstein's. Previous findings demonstrating that there may have been differences were quite likely due to confirmation biases and/or statistical errors, such as the multiple comparison problem.

- Hines, T. (2014). Neuromythology of Einstein's brain. Brain and Cognition, 88, 21–25.

- We only use 10% of our brain. [FALSE] This is a very popular myth that has been aroundfor a while. Recent brain imaging tools such as the fMRI demonstrated that though it is not necessary for all the areas of the brain to be active at once, for any given activity, there are usually a number of activated areas.
  - Lilienfeld, S. O., Lynn, S. J., Ruscio, J., & Beyerstein, B. L. (2009). 50 Great Myths of Popular Psychology: Shattering Widespread Misconceptions about Human Behavior. Chichester, England: Wiley-Blackwell.

- Listening to Mozart makes you smarter. [FALSE] Currently, there are no findings establishingthat listening to classical music makes people smarter. There may be evidence suggesting that learning a musical instrument improves attention, confidence and coordination. In short, listening to Mozart does not have any negative effects and may be pleasant to some, but it does not make people smarter.
  - Lilienfeld, S. O., Lynn, S. J., Ruscio, J., & Beyerstein, B. L. (2009). 50 Great Myths of Popular Psychology: Shattering Widespread Misconceptions about Human Behavior. Chichester, England: Wiley-Blackwell.

- People are either "right-brained" or "left-brained". [FALSE] People use both their right andleft hemispheres. Certain functions, such as speech production and facial recognition, etc., tend to be dominated by one side of the brain. However, even these tasks require input from both hemispheres. So, unless an individual's entire hemisphere is wholly removed or impaired, no one is considered to be completely "right"- or "left"-brained.
  - Gazzaniga, M. (2000). Cerebral specialization and interhemispheric communication. Brain, 7, 1293-1326.

- Drinking alcohol always kills brain cells. [FALSE] Consuming moderate amounts of alcoholdoes not harm brain cells. In fact, some studies have found that a glass or two of wine a day may reduce the risk of stroke. However, too much of anything is never a good thing! Years of alcohol abuse or “binge drinking” can damage neurons, change brain function, and shrink cells.

    - Anttila, T., Helkala, E.-L., Viitanen, M., Kåreholt, I., Fratiglioni, L., Winblad, B., … Kivipelto, M. (2004). Alcohol drinking in middle age and subsequent risk of mild cognitive impairment and dementia in old age: a prospective population based study. British Medical Journal, 329, 539
    - Bates, M., E., and Tracy, J., I. (1990) Cognitive functioning in young "social drinkers": Is there impairment to detect? Journal of Abnormal Psychology, 99, 242-249.

- Brain damage is always permanent. [FALSE]Recovery from brain injury depends on severityand location of the trauma. For instance, concussions are mild brain injuries, usually resulting in only short-term disruptions of brain functioning. With rehabilitation, even a severe brain injury, such as a stroke, can allow for the brain to develop new networks and “redirect” signals through the healthy regions of the brain.

    - Brown J., A. (2006). Recovery of motor function after stroke. Progress in Brain Research. 157, 223–228.

- The heart is more important for love than the brain. [FALSE]The brain has a lot (if noteverything) to do with love. When two people are in love, neuroimaging techniques show that many areas of the brain “light up” and various hormones (e.g., dopamine, norepinephrine, etc.) are released. These chemicals are associated with feelings of excitement and pleasure.

    - Fisher, H., Aron, A., & Brown, L. L. (2005). Romantic love: An fMRI study of a neural mechanism for mate choice. The Journal of Comparative Neurology, 493(1), 58–62.

- The human brain is larger than any other animal brain. [FALSE] The absolute size of thehuman brain, though larger than some animal brains, is most definitely not the largest of all animal brains. The brains of animals like elephants and whales are significantly larger than ours.
    - Roth, G., & Dicke, U. (2005). Evolution of the brain and intelligence. Trends in Cognitive Sciences, 9(5), 250–257.

A Crumpled Cortex: In-Class Demonstration

This demo would be a great fit when explaining how the human brain has evolved over time, with the newest addition being the cerebral cortex, which incidentally happens to be the largest region of the brain. Ask the students to explain why the cerebral cortex is wrinkled. There may be a few students who correctly answer that the wrinkled appearance of the cerebral cortex allows for greater surface area while fitting in the confined space of an individual's head. Use the activity to punctuate this point to the students.

- Time: 5 minutes
- Materials: You will need a sheet of paper, preferably a newspaper sheet as it has larger dimensions than legal-sized paper.
- Directions:

1. Take a plain sheet of paper and crumple it into a small, wrinkled ball.
2. Point out to the students that though the paper retains the same surface area, it is nowmuch smaller and can now even fit in your hand. From an evolutionary perspective, it made more sense to fold the cortical layer like a crumpled piece of paper rather than enlarging the entire head!
3. You can then inform the students that if the cerebral cortex were flattened out, it wouldapproximately be the size of a newspaper page (Myers, 1995). Alternatively, you could do this entire exercise with a newspaper page rather than a plain white sheet of paper.
4. [Adapted from Randy Smith's Instructor Manual for the David Myers' Introductory Textbook]

Showercap Mindmap: In-Class Activity

Learning about the different areas of the brain can be a daunting task for anyone, let alone a first-year undergraduate student in introduction to psychology. Though the example below is comprehensive, this spatial activity can be adapted for as many or few parts of the brain the instructor desires. Researchers found that students who used this activity saw improved spatial recall of this physiological terminology as compared to students who learned the material verbally.

- Time: 15-20 min
- Materials: You will need a pack that contains: a clear, unmarked plastic shower cap, a whiteboard marker, and sticky, 15 color-coded labels (blue, green, yellow, and orange).
- Directions:

1. Divide students into groups of 4 and assign one student on each team to wear the shower cap. • Provide 10 minutes to other students to attach the labels to correct parts of the "brain". You might allow them to use a textbook for reference (or not!).

- Vanags, Thea, Mira Budimlic, Elissa Herbert, Melena M. Montgomery, and Tracy Vickers. (2012).
- Showercap Mindmap: A Spatial Activity for Learning Physiology Terminology and Location.
- Advances in Physiology Education, 36(2): 125–130.

Discussion Points

1. "What real world differences in behavior and intelligence do we see between primates and other animals such as dogs, cats, and mice?" This is a chance to point out that some of these differences may be housed in the front portion of the brain.
    - Possible student answers include (but are not limited to):
        - Use of fire and technologies
        - Group/family organization such as helping behaviors and more sophisticated communication (eg. Sign language, hoots warning a "friend" of possible danger, speech

2. Show students a half minute video: an animation of prenatal brain development: **https://www.youtube.com/watch?v=86NDMfxU4ZU**

    - At approximately 30 seconds into the video, point out the ballooning up of structures in the brain. After playing the video, ask for students' reaction. Students will likely be surprised at the rapid development that occurs.

3. For each of the structures of the limbic system, listed below, ask students to think of everyday activities that might involve using each of these structures.

    - *Amygdala* – is an almond-shaped set of neurons that is part of the limbic system and located in the temporal lobe. It is involved in processing and expression of arousal and emotions like anger and fear.
    - *Basal ganglia* – refers to a group of nuclei lying deep in the frontal lobes and is part of the limbic system. It involves involuntary movement and coordination.
    - *Cingulate gyrus* – is the area of the limbic system that lies just above the corpus callosum. It is responsible for coordinating sensory input with emotionally significant events in order to create memories and regulate behavior.

4. Here there is an opportunity to discuss the corpus callosum, and the so-called "split brain" patients who have undergone surgery to sever their corpus callosum. Specifically, it is a chance to discuss the contralateral nature of the brain in which each hemisphere process motor and sensory information for the opposite half of the body. You may want to show or discuss the video of a split brain patient, found here: **https://youtu.be/ZMLzP1VCANo**

    - *Additional option:* This is also a potential opportunity to introduce students to one of the historical ways that brain function was studied– through brain damage. One of the most famous early examples is Phineas Gage, a railroad worker who survived an accident in which a steel rod was driven through his head. Common reports detail that Gage suffered personality changes, such as being irritable and using profanity, as well as epilepsy, which eventually killed him. You can learn more here: **https://en.wikipedia.org/wiki/Phineas_Gage**

5. Discussion questions on studying the brain:

    - What are some of the advantages and disadvantages of modern imaging techniques compared with historic case studies of people with brain lesions (brain damage)?

    - Possible answers include: expensive, not portable, not invasive, can identify very specific brain areas, etc.

- How much more likely are you to be convinced of the results of a psychology study if it includes a brain scan versus self-report data? Why?

Outside Resources

Video: Animation of Neurons
http://www.youtube.com/watch?v=-SHBnExxub8

Video: Split Brain Patient
http://www.youtube.com/watch?v=ZMLzP1VCANo

Web: Animation of the Magnetic Resonance Imaging (MRI)
http://sites.sinauer.com/neuroscience5e/animations01.01.html

Web: Animation of the Positron Emission Tomography (PET)
http://sites.sinauer.com/neuroscience5e/animations01.02.html

Web: Teaching resources and videos for teaching about the brain, from Colorado State University:
http://www.learner.org/resources/series142.html

Web: The Brain Museum
http://brainmuseum.org/

Evidence-Based Teaching

Kossoff, E. H., Vining, E. P. G., Pillas, D. J., Pyzik, P. L., Avellino, A. M., Carson, B. S., & Freeman,

J. M. (2003). Hemispherectomy for intractable unihemispheric epilepsy: Etiology vs. outcome. Neurology, 61(7), 887–890.

- This article reviews the success of hemispherectomies in 111 patients treated at the Pediatric Epilepsy Center at Johns Hopkins Hospital between 1975-2001. The authors report that 86% of these surgeries resulted in a seizure-free or non-handicapping seizures prognosis, dramatically improving these children's quality of life. These findings suggest that hemispherectomy may be a viable medical option in some cases of epilepsy or other severe seizure-inducing conditions.

Hines, T. (2014). Neuromythology of Einstein's brain. Brain and Cognition, 88, 21–25.

- Albert Einstein is widely recognized as having one of the most brilliant minds of all time. His brain has received a lot of attention, in that since his passing there have been four published studies suggesting that his brain is different from other human brains in different ways. Hines stringently reviews the evidence from these published studies and finds that in fact many of the results are due to illusory correlations and inaccurate use of statistics, as well as selective reporting. These findings suggest that future studies use more rigorous procedures and analyses in order to avoid biased results.

Richmond, A. S., Carney, R. N., & Levin, J. R. (2011). Got Neurons? Teaching Neuroscience Mnemonically Promotes Retention and Higher-Order Thinking. Psychology Learning & Teaching, 10(1), 40-45.

- Richmond and colleagues examined if the mnemonic keyword method was effective in helping students: 1) learn 26 neuroscience terms; 2) remember this information over time; and 3) use what they learned in a higher-order application exercise. Some examples of terms include: aphasia, cerebral cortex, hippocampus, etc. The researchers found that in their sample of 58 students, those who used the mnemonic method did better than those who used their own best strategies in all of three of the above objectives. These results suggest that there is a utility to using this method in psychology classes, especially in those involving lots of terminology.

Vanags, Thea, Mira Budimlic, Elissa Herbert, Melena M. Montgomery, and Tracy Vickers. (2012).

- Showercap Mindmap: A Spatial Activity for Learning Physiology Terminology and Location. Advances in Physiology Education, 36(2): 125–130.
- See activities and demonstration for description of this article.

Suggestions from the Society for Teaching's Introductory Psychology Primer

Rhodes, M. E. (2013). Biopsychology. In S.E. Afful, J. J. Good, J. Keeley, S. Leder, & J. J. StieglerBalfour (Eds.). Introductory Psychology teaching primer: A guide for new teachers of Psych 101.

Retrieved from the Society for the Teaching of Psychology web site: http://teachpsych.org/e-books/intro2013/index.php

POSSIBLE ASSESSMENTS (Out of Class) Levels of Analysis: Using their textbooks, have students write a short paper comparing the different ways in which the nervous system can be studied (e.g., clinical observations, experimental techniques, neuroimaging techniques).

Neuroanatomy:Provide students with diagrams and have them label the lobes and other major areas of the brain and describe their primary function(s).

Myths of the Brain: Have students read and respond to the Top Ten Myths of the Brain (http://www.smithsonianmag.com/science-nature/Top-T...

Have students choose an animal study that is described in their text (e.g., Harlow) and write a short paper about the knowledge that was gained from the study contrasted with the costs to the animal subjects.

ACTIVITIES & TECHNIQUES (In Class) Action Potential: Have students act out an action potential as described in Felsten, 1998 (see annotated bibliography). This is an integral part of understanding how the nervous system works, but is often an area that students have difficulty with. Engaging students in an interactive process for understanding the action potential usually enhances their understanding of the process.

Synaptic Transmission: Have students demonstrate synaptic transmission as described in Reardon et al., 1994 (see annotated bibliography). This is another area that is vitally important for understanding later material, but that students have difficulty grasping.

Brain anatomy: Have students construct a clay brain that depicts the lobes and the brainstem. (http://faculty.washington.edu/chudler/chmodel.html... This is a fun activity that helps students remember the lobes of the brain.

RELEVANT TOP ARTICLES (Annotated Bibliography)

Felsten, G. (1998). Propagation of action potentials: An active participation exercise. Teaching of Psychology, 25, 109-111.

This article describes an exercise that demonstrates the propagation of action potentials. Results suggest that this activity may enhance students' understanding of action potentials.

Herzog, H. A. (1990). Discussing animal rights and animal research in the classroom. Teaching of Psychology, 17, 90-94.

This article describes an exercise to engage students in a discussion about animal research. Students role-play participation on an Institutional Animal Care and Use Committee and make decisions about whether hypothetical experiments will be approved.

Reardon, R., Durso, F. T., & Wilson, D. A. (1994). Neural coding and synaptic transmission: Participation exercises for introductory psychology. Teaching of Psychology, 21, 96-99.

This article describes two exercises to help students understand neural coding and synaptic transmission. Anecdotal reports suggest that these activities aid students' understanding of these processes.

Sheldon, J. P. (2000). A neuroanatomy teaching activity using case studies and collaboration. Teaching of Psychology, 27, 126-128.

This article describes a collaborative activity using case studies to consolidate information about neuroanatomy. Data suggest that this activity is both enjoyable and helpful to students.

PowerPoint Presentation

This module has an associated PowerPoint presentation. Download it at https://nobaproject.com//images/shared/supplement_editions/000/000/193/The%20Brain%20and%20Nervous%20System.ppt?1464116094.

About Noba

The Diener Education Fund (DEF) is a non-profit organization founded with the mission of re-inventing higher education to serve the changing needs of students and professors. The initial focus of the DEF is on making information, especially of the type found in textbooks, widely available to people of all backgrounds. This mission is embodied in the Noba project.

Noba is an open and free online platform that provides high-quality, flexibly structured textbooks and educational materials. The goals of Noba are three-fold:

- To reduce financial burden on students by providing access to free educational content
- To provide instructors with a platform to customize educational content to better suit their curriculum
- To present material written by a collection of experts and authorities in the field

The Diener Education Fund is co-founded by Drs. Ed and Carol Diener. Ed is the Joseph Smiley Distinguished Professor of Psychology (Emeritus) at the University of Illinois. Carol Diener is the former director of the Mental Health Worker and the Juvenile Justice Programs at the University of Illinois. Both Ed and Carol are award- winning university teachers.

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