The Nervous System

Instructor Manual

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We combined "The Nervous System" and "The Brain" modules in the instructor manual due to the overlap in material. Together, these first two content-heavy modules cover a range of concepts, including understanding the development of two parts of the nervous system: peripheral and central nervous systems. The focus should be on the latter as there is much to cover in terms of the various divisions and structures of the central nervous system. These two modules also offer 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 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.

- **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.
  - Distinguish between gray and white matter of the cerebral hemispheres.
  - Name and describe the most common approaches to studying the human brain.
  - Distinguish among four neuroimaging methods: PET, fMRI, EEG, and DOI.
  - Describe the difference between spatial and temporal resolution with regard to brain function.

Abstract

1: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. Comparative study of physiological functioning in the nervous systems of different animals lend insights to their behavior and their mental processing and make it easier for us to

understand the human brain and behavior. In addition, 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 nervous system, a number of methods have evolved over time; these methods include examining brain lesions, microscopy, electrophysiology, electroencephalography, and many scanning technologies. 2: 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, and brief descriptions of the neuroscience methods used to study it.

Class Design Recommendations

Due to the content overlap between "The Nervous System" and "The Brain", we recommend that the instructor combine the information in the two modules and teach it across two class periods. Please also refer to the Noba PowerPoint slides that compliment this outline.

First class period (50-75 min):

- Activity: Mythbusters – 8 myths about the human brain
- Explain the evolution and development of the human brain
- Describe the different parts of the peripheral nervous system
- Special topic: Two common nomenclature systems for the central nervous system
- Class demonstration: A Crumpled Cortex

Second class period (50-75 min):

- Describe the various areas of the central nervous system
- Learn how scientists study the nervous system

- Activity: Showercap Mindmap
- Special topic: Is half a brain ever better than a whole 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 emerges from the **ectoderm**through **neural induction**. This process forms the neural tube in a **rostrocaudal**, which is another way of saying head-to-tail, plane. The neural tube then closes up in the same direction.
- As the embryo continues to develop, so does the neural tube. It balloons up rostrally (towards the head). At day 40, we can see the **forebrain,**midbrain, hindbrain and the spinal cord.
- Inside the lining of the neural tube, the **neuroepithelium,**there exist two special groups ofcells. Neuroblasts are responsible for the creation of all the neurons and glial cells of the central nervous system. The other special group of cells travels outside of the neural tube and forms the **neural**crest, which allows for the development of sensory and autonomic neurons in the peripheral nervous system.

What is the Structure of the Nervous System?

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

Central Nervous System (CNS). There are many ways of conceptualizing and dividing the CNS. Below is one of the developmental categorizations of the various CNS structures.

1. Telencephalon (Cerebral Hemispheres) **–** The telencephalon is a part of the forebrain and is the newest development in the evolution of our brain. It is composed of the cerebral cortex and accompanying white matter (also known as the cerebrum) and subcortical structures (e. g., basal ganglia, amygdala, hippocampus). The cerebral cortex is distinctive in appearance due to its grooves (i.e., gyri) and ridges (i.e., sulci). The cerebrum is divided into the right and left hemisphere, which are further divided into four lobes:

- **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**. Additionally, the frontal lobe contains the **primary motor cortex**, which is like a representation of the entire body, and is responsible for voluntary movement.
- **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 **primary somatosensory cortex** , 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 secondary **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.

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.

2. Diencephalon – The diencephalon is part of the forebrain and consists of the thalamus and the hypothalamus.

- **Thalamus –** The thalamus acts as a gateway for incoming and outgoing information from the body and cerebral cortex. It also contains the **lateral geniculate nucleus**, which is a nucleus that receives visual information from the optic nerve and sends signals to the primary visual cortex in the occipital lobe. The thalamus also plays a role in the limbic system.
- **Hypothalamus**- The hypothalamus is responsible for the regulation of endocrine hormones and biological drives. The hypothalamus is also one of the structures in the limbic system.

3. Mesencephalon – The midbrain is located below the thalamus and consists of the superior and inferior colliculi and substantia nigra. In conjunction with reticular formation located in the brain stem, these structures process visual and auditory information.

4. Metencephalon – Located below the rear portion of the cerebrum and above the medulla, the metencephalon consists of pons and cerebellum.

- **Pons** - The pons processes sensory and motor information, connects the medulla to the cerebrum, and transfers information to and from the brain and spinal cord.
- **Cerebellum** - Often referred to as the “little brain,” the cerebellum controls muscle coordination, balance and muscle tone. Recently, it has been implicated in cognitive functions (e.g., language).

5. Myelencephalon – The myelencephalon is the most posterior part of the hindbrain and consists of the medulla oblongata.

- **Medulla oblongata–** The medulla is responsible for basic survival processes, such as breathing, digestion, heart and blood vessel functioning, swallowing, and sneezing. Together, the medulla, pons and cerebellum make up the hindbrain. The medulla, pons, cerebellum constitute the **brainstem**. The brain stem connects the brain and spinal cord.

The CNS can also be divided as follows:

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

2. Midbrain – The midbrain is the smallest region of the central nervous system and acts as a 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 the metencephalon 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.

What is the Difference between Gray and White Matter? The central nervous system has two types of tissue. Gray matter refers to the cell bodies of neurons, which contain genetic material. Gray matter covers the outer layer of the cerebral cortex and gives it its 'gray-ish' appearance. White matter, on the other hand refers to the axons of neurons. Axons are responsible for electrical conduction and are critical in cell communication.

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).

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

- **Event-related potentials**(ERPs) allow us to physiologically measure the electrical charge in the brain produced by sensory or motor events. ERPs are measured through **electroencephalography** (EEG). EEG has a high degree of **temporal resolution,** but poor **spatial resolution.**
- **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 Imagine 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.

Brain Stimulation Techniques

- Scientists have also studied the brain by stimulating it. **Lesion studies**evaluate the effect of a surgical removal of part of the animal brain to examine the effect on behavior. In humans, lesions are only observed in patients who have lost a brain region due to a medical reason (i.e., a stroke) or in those who have had brain surgery.

    - **Transcranial Magnetic Stimulation**(TMS) refers to a procedure during which a brief magnetic pulse is applied to the head to induce a mild electrical current in the brain. This technique allows scientists to study events that occur when ongoing cell communication and activity is interrupted in a particular brain area. Though it has great temporal resolution, a drawback of TMS is that it is limited to the surface of the cortex and does not extend to the deep areas of the brain. **Transcranial Direct Current Stimulation (tDCS)**is similar to TMS except that TDCS applies a direct low electrical current to the skull to stimulate the brain. When used in combination with cognitive training, tDCS has been shown to improve memory, attention, and coordination.

Difficult Terms

Agnosia
Autonomic nervous system
Basal ganglia
Brain stem
Broca's area
Cerebellum
Cerebral hemispheres
Cerebrum
Cingulate gyrus
Computerized axial tomography
Contralateral
Diencephalon
Diffuse optical imaging (DOI)
Ectoderm
Electroencephalography

Event-related potentials
Forebrain
Frontal lobe
Functional magnetic resonance imaging (fMRI)
Globus pallidus
Gray matter
Gyrus
Hindbrain
is the most rearmost part of the brain and consists of the pons and medulla oblongata. The hindbrain is one of three major developmental divisions of the brain; the other two are the midbrain and forebrain.

Hippocampus
Homo habilis
Homo sapiens
Hypothalamus
Lateral geniculate nucleus
Lateralized
Lesion studies
Limbic system
Magnetic resonance imaging (MRI)
Medulla oblongata
Mesencephalon
Metencephalon
Located below the rear portion of the cerebrum and above the medulla, the metencephalon consists of pons and cerebellum.

Midbrain
is the developmental division of the brain located between the forebrain and hindbrain, just below the thalamus. It consists of the superior and inferior colliculi and substantia nigra and forms part of the brain stem. The midbrain is associated with visual and auditory functions.

Myelencephalon
The myelencephalon is the most posterior part of the hindbrain and consists of the medulla oblongata.

Neural crest
Neural induction
Neuroblasts

Neuroepithelium
Occipital lobe
Parasympathetic nervous system
Parietal lobe
Phrenology
Pons
Positron Emission Tomography (PET)
Primary Motor Cortex
Primary somatosensory cortex
Rostrocaudal
Secondary somatosensory cortex
Somatic nervous system
Spatial resolution
Split-brain patient
Subcortical
Sulcus
Sympathetic nervous system
Telencephalon
The telencephalon is a part of the forebrain and is the newest development in the evolution of our brain. It is composed of the cerebral cortex and accompanying white matter (also known as the cerebrum) and subcortical structures (e.g., basal ganglia, amygdala, hippocampus). The cerebrum is divided into the right and left hemisphere, which are further divided into four lobes: frontal, parietal, temporal and occipital.

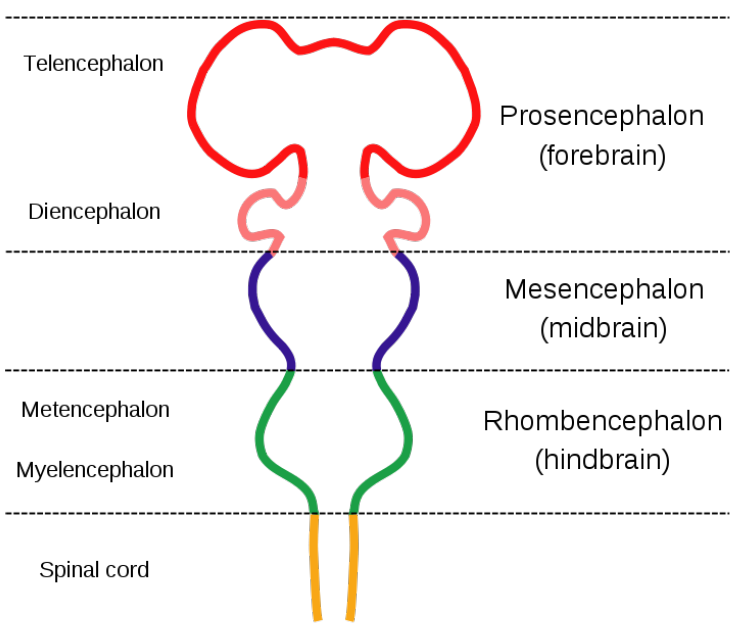
Temporal lobe
Temporal resolution
Thalamus
Transcranial direct magnetic stimulation
Transcranial magnetic stimulation
Wernicke's area
White matter
Working memory

Lecture Frameworks

We recommend starting the class with an activity to pique interest about the marvelous structure that is the human brain! Once you have covered the evolution and development of the nervous system, review the peripheral nervous system – this should all be relatively simple to comprehend for the students. However, 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. For this reason, we recommend ending the first class with a discussion on nomenclature and finishing off with a quick demonstration to segue into the second class, which reviews the central nervous system. The second class period is very content-heavy, so we propose interspersing the lecture with the suggested activity, video, and special topic to keep the students engaged.

First Class Period

- **Activity: Mythbusters** – 8 Myths about the Human Brain
    - A great way to generate interest in the fascinating topic of the brain is to evaluate what students actually know about it so far. They are sure to know some things, but we bet there are a lot of myths they might subscribe to as well. Dispelling some of these myths can be a fun activity for both you and the students. See the Activities and Demonstrations section for more detail.
- **Discussion/Warm-up**
    - Start by introducing how and why the nervous system in humans is important. Explain the evolution of the human brain. Continue by asking students to generate differences in cognitive and behavioral abilities between students and animals. Next, discuss



    - This would be a good segue into discussing how terminology is sometimes used interchangeably. Below are two common examples, but while teaching if you find more, sharing them with your students may prove extremely helpful to them.
        - (Very) Common Terminology with Multiple Names
            - Telencephalon > Cerebrum > Cerebral Cortex > Cerebral Hemispheres
            - Midbrain > Mesencephalon
    - Once you have explained the various ways scientists have "divided" the brain, continue on to a class demonstration before delving into the different structures and functions of these parts of the brain.
- **Demonstration: A Crumpled Cortex**
    - The defining feature in our brain and what sets us apart from other animals, is our cerebrum. Take a few minutes to present the demonstration called, "A Crumpled Cortex" (see Activities and Demonstrations section). Put simply, this is a quirky, simple illustration of the fascinating evolution of the brain.
- **Lecture:** Refer to slides up to the "Telencephalon" slide.
    - Slides cover the development of the nervous system including a brief matching activity.
    - Slides also cover the structure of the peripheral nervous system (PNS). This allows students to apply their knowledge of the PNS.

Second Class Period

- **Lecture: Refer to slides that focus on the following:**
    - An overview of the central nervous system.
    - The structures in the hindbrain, midbrain, and forebrain.
    - Techniques to study the human brain. Students are to match the technique with the correct description.
- **Activity: Showercap Mindmap**

- Given that this section often involves heavy memorization, when you feel you have covered enough content in the lecture, you might consider an activity that allows students to apply what they have learned about. The activity below, titled “Showercap Mindmap”, is a creative way to engage the students and simultaneously test their knowledge of the various structures and functions of the brain.

- **Special Topic: Is Half a Brain Ever Better Than A Whole Brain?**
  - We recommend using this intriguing topic as a way to not only generate discussion, but also to bring this content-heavy material to real life.
  - Ask the class if they know what a hemispherectomy is (a procedure that removes one hemisphere of the brain). Pose the question, does this procedure sounds radical, even archaic? Might there ever be a situation in which half a brain is better than a whole brain?
  - After a very brief discussion, consider playing the following video, titled: “Girl Living with Half Her Brain” at **https://www.youtube.com/watch?v=2MKNsI5CWoU.** The video is approximately 5:30 minutes and is about Cameron Mott, a little girl who was suffering from severe seizures...that is, before her hemispherectomy. Her only viable option, doctors suggested, was to remove the right side of her brain.
  - As the video demonstrates, Cameron’s operation was quite successful; she was able to go back to school and resume her life. She had trouble with movement on the left side of her brain, but was able to regain motor function with physical therapy. This video is an example of the resilience of a little child and the incredible neuroplasticity of the human brain; a young child’s brain is highly adaptable, so much so that under certain conditions and with the appropriate care, a child can function very well with only half of it! But, is Cameron’s case exceptional? What does the research say on this topic?
  - Researchers from Johns Hopkins Hospital found that just at their hospital alone, 86% of the 111 children who had hemispherectomies from 1975-2001, are either no longer experiencing seizures or have non-disabling seizures that do not require drug therapy (Kossoff et al., 2003; see Evidence-Based Teaching for more on this article).

Activities & Demonstrations

Mythbusters - 8 Myths about the Brain: In-Class Activity

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

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.

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

Answers

1. Einstein's brain is different than our brain. [FALSE] According to recent research, there are no 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.

2. We only use 10% of our brain. [FALSE] This is a very popular myth that has been around for 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.

3. Listening to Mozart makes you smarter. [FALSE]Currently, there are no findings establishing that 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.

4. People are either “right-brained” or “left-brained”. [FALSE]People use both their right and left 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.

5. Drinking alcohol always kills brain cells. [FALSE]Consuming moderate amounts of alcohol does 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.

6. Brain damage is always permanent. [FALSE]Recovery from brain injury depends on severity and 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.

7. The heart is more important for love than the brain. [FALSE]The brain has a lot (if not everything) 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.

8. The human brain is larger than any other animal brain. [FALSE] The absolute size of the human 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 now much 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 would approximately 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.

[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).

- Lobe labels are blue (occipital, temporal, parietal, and frontal)
- Specialized areas are green (the corpus callosum, Broca's area, and Wernicke's area).
- Labels relating to information processing are yellow (hearing; heat; pain and temperature; and interpretation and integration of information)
- Cortex labels are orange (motor, association, somatosensory, auditory, and visual).

Directions

- 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, 3*6(2): 125–130.

Outside Resources

Video: Pt. 1 video on the anatomy of the nervous system
http://www.youtube.com/watch?v=D1zkVBHPh5c

Video: Pt. 2 video on the anatomy of the nervous system

http://www.youtube.com/watch?v=8hC6NGQReL4

Video: To look at functions of the brain and neurons, watch
http://www.youtube.com/watch?v=9UukcdU258A

Web: To look at different kinds of brains, visit
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, 3*6(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. Stiegler-Balfour (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/ebooks/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/000/000/196/The%20Nervous%20System.ppt?1464203893.

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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