Lecture Notes

# Chapter 2: The Brain: An Overview of Structure and Function

## Learning Objectives

* Recognize the differences between psychologists’ interests in brain functioning in present and past cognitive psychology
* Describe the structures of the brain
* Explain the approaches to localization of function
* Compare and contrast the two cerebral hemispheres using lateralization of function
* Differentiate among various brain-imaging techniques
* Examine the differences among electrical brain-recording methods
* Argue whether or not the brain can be trained

## Outline

**I.** Setting the Stage

**A.** In the 1950s and 60s, cognitive psychologists believed that the workings of the brain were not necessarily relevant to their understanding of cognitive processes.

**1.** Many believed that a description of how each neuron in the brain worked would not help us to understand how a person decides what to order in a restaurant, for example.

**2.** Theorists believed that higher levels of abstraction, in terms of theoretical ideas such as memory storage areas, would be more useful in describing cognition.

**B.** There is still disagreement among psychologists, biologists, computer scientists, and philosophers regarding which level of explanation is most useful for understanding cognitive activity.

**C.** Many cognitive psychologists today, however, do feel that a working knowledge of the brain is essential for investigating cognition.

**II.** Structure of the Brain

**A.** The **hindbrain** and **midbrain** contain structures that regulate life support functions, muscular activity, and arousal, among other functions.

**1.** The **medulla,** located in the hindbrain, regulates life support functions such as breathing, heart rate, and blood pressure.

**2.** Also located in the hindbrain, the **pons** is involved in balance, sleep, and arousal.

**3.** The **cerebellum** is one of the most primitive brain structures, containing neurons that coordinate muscular activity.

**4.** The **midbrain** contains structures that relay information between other brain regions.

**B.** The **forebrain** includes the thalamus, the hypothalamus, the hippocampus, the amygdala, and the cerebrum.

**1.** The **thalamus** relays information to the cerebral cortex.

**2.** Hormones released by the **hypothalamus** help to regulate other glands in the body.

**3.** The **hippocampus** is involved in the formation of long-term memories.

**4.** The **amygdala** is involved in emotional learning and emotional memories.

**5.** The **cerebral cortex** is divided into four lobes.

**a)** The **frontal lobe** is located underneath the forehead, and has three separate regions.

**(1)** The **motor cortex** directs fine motor movements.

**(2)** The **prefrontal cortex** is involved with **executive functioning** (planning and decision-making, for example)

**b)** The **parietal lobe** is located underneath the top rear part of the skull and contains the somatosensory cortex, which processes sensory information such as pain and pressure.

**c)** At the back of the head are the **occipital lobes,** which process visual information**.**

**d)** The **temporal lobes** are located on the sides of the head and process auditory information.

**6.** Two hemispheres of the cerebral cortex are connected by the corpus callosum and anterior commissure; we actually have two lobes of each kind, one in the right hemisphere and one in the left.

**III.** Localization of Function

**A.** The idea of localization of function traces back to Austrian anatomist Franz Gall.

**1.** Gall believed in **faculty psychology,** the theory that different mental abilities were carried out in different parts of the brain.

**2.** Gall’s student, Johan Spurzheim, developed the study of **phrenology,** the incorrect idea that differences in psychological abilities could be seen in the relative size of different brain areas.

**B.** Modern approaches to localizing function in the brain date back to early studies of aphasias (disruptions of language) that result from damage to particular parts of the brain.

**1.** Paul Broca discovered that injuries to a part of the left frontal lobe (now known as Broca’s area) result in disruption of expressive language.

**2.** A decade later, Carl Wernicke discovered an area (now known as Wernicke’s area) in the superior, posterior temporal lobe that controls language understanding.

**3.** Work by other neuropsychologists established connections between lesions in particular brain regions and abilities such as specific motor control (in the motor cortex) and sensory reception (in the **primary somatosensory cortex**).

**C.** Higher-order cognitive processes, such as thinking and remembering, do not seem to be localized to one particular region.

**1.** Lashley’s studies of **ablation** (removal of parts of the brain) show that rats’ abilities to run mazes were related to the total amount of cortex removed, not the specific area removed.

**2.** Furthermore, some brain regions can take over the functions of damaged regions, particularly in the young—a phenomenon known as **plasticity.**

**IV.** Lateralization of Function

**A.** The term **lateralization** refers to the fact that the two cerebral hemispheres play different roles in cognitive functioning.

**1.** About 95% of people show a specialization for language in the left hemisphere.

**2.** The right hemisphere is dominant for spatial processing, musical ability, and other cognitive activities that involve synthesis of parts into a whole.

**B.** In most people, the two hemispheres are connected by a structure known as the **corpus callosum**.

**1.** In the late 1950s, epilepsy treatment sometimes involved severing the corpus callosum to stop the spread of seizures; people who underwent this surgery were known as **split-brained patients**.

**2.** Researchers studied these patients by quickly presenting pictures of objects to only one side of visual space, which sends messages to the opposite brain hemisphere.

**3.** Split-brained patients who view a pencil in the left visual field (information going to the right hemisphere) can search out a pencil with the left hand, but cannot say the name of what they saw.

**V.** Brain-Imaging Techniques

**A. Computerized axial tomography (CAT)** scans allow us to see “slices” of a living brain, helping physicians to diagnose brain injury.

**B.** CAT scans are not used as frequently today as **magnetic resonance imaging (MRI)**, which does not require radiation exposure and permits clearer pictures of the brain.

**C.** CAT scans and MRI show us a static picture of brain structure, but more recent techniques have allowed us to show brain activity when people perform different tasks.

**1. Positron emission tomography (PET)** techniques involve injecting a radioactively labeled compound and measuring the blood flow to different regions of the brain.

**2. Functional magnetic resonance imaging (fMRI)** uses the magnetic properties of the blood to achieve the same goals without radiation.

**VI.** Other Brain-Recording Techniques

**A.** To detect different states of consciousness, such as stages of sleep, **electroencephalography (EEG)** can be used.

**B. Magnetoencephalography (MEG)** measures changes in magnetic fields generated by electrical activity of neurons, giving a magnetic equivalent to an EEG, with more precise spatial localization of brain region activity.

**C.** The technique of **event-related potential (ERP)** measures an area of the brain’s response to a specific event.

**D.** A newer technique, **transcranial magnetic stimulation (TMS)** allows investigators to measure activity of specific brain circuits when an area of the brain is excited or inhibited.

**VII.** Training the Brain

**A.** Research with young animals suggests that experience can change the structure of the brain itself, as rats raised in enriched environments show better brain development than rats raised in standard cages.

**B.** Research on human adults, however, has shown mixed results of “brain training games” on cognitive functioning.