

# INTRODUCTION TO COGNITIVE PSYCHOLOGY

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very gratefully contributed his material to this course in HCI*

# BRANCHES OF PSYCHOLOGY

- There are many branches of psychology; how you split them up will usually depend on which part of the world you are in, even which university or institution you were trained at. <http://www.medicalnewstoday.com/articles/154874.php>
- One the next slide is one delineation which I find particularly elucidating, particularly in how the different schools of psychology might deal with an issue such as alcoholism. <http://surviveapppsychology.weebly.com/prologue.htm>

# BRANCHES OF PSYCHOLOGY

Approach	Definition	Focus	Application Example: Alcoholism
PSYCHO-ANALYTIC	Behavior and personality is the product of unconscious sexual and aggressive forces	How does behavior spring from unconscious drives and conflicts?	Does excessive drinking indicate an unconscious problem or conflict? Does drinking reduce inhibitions allowing the unconscious to surface?
BEHAVIORAL	Behavior is the product of learning and associations	How do we learn observable responses (behaviors)?	Is alcoholism learned? Can it be unlearned? Can new habits replace the alcoholic habits?
COGNITIVE	Behavior is a consequence of internal thoughts. Humans use mental processes to solve problems or develop personality characteristics.	How do we encode, process, store and retrieve information?	What thought pattern precedes heavy drinking? Can the thoughts be analyzed and changed to curtail the drinking behavior?
HUMANISTIC	Behavior is a reflection of internal personal growth; we are not products of our environment. We all have free will	How do we reach our full potential to "self-actualize," and what prevents us from doing so?	For what inadequacy do people compensate by drinking? Does alcohol give people a false sense of relief from inadequacy or lack of self-worth?
NEURO-BIOLOGICAL	Behavior is a result of the interplay of functions of the nervous system and biology.	How do the body and brain enable behavior?	Is alcoholism a disease? What role does genetics play in the development of alcoholism? How does alcohol affect the brain?
SOCIO-CULTURAL	Behavior is influenced by the rules and expectations of social groups and cultures.	How do behavior and thinking vary across situations and cultures?	How does alcoholism differ between cultures? What unique pressures of a particular culture contribute to alcohol abuse?

# COGNITIVE PSYCHOLOGY

## ■ Cognition

- Describes mental activities such as acquisition, storage, transformation, and use of knowledge.
- Cognition operates every time you acquire information, place it in storage, transform that information, and use it.
- At this precise moment you are performing an impressive number of cognitive tasks.

## ■ Cognitive Psychology

- Sometimes it is a synonym for the word cognition, and so it refers to a variety of mental activities.
- Sometimes it refers to an approach/perspective in psychology that emphasizes the mental processes and knowledge that we use everyday.

# A BRIEF HISTORY OF COGNITIVE PSYCHOLOGY: EARLY BEGINNINGS

- Philosophers and other theorists have speculated about human thought processes for more than twenty-three centuries.
- Aristotle
  - Greek philosopher (384–322 BC) examined topics such as perception, memory, and mental imagery.
  - Discussed how humans acquire knowledge through experience and observation.
  - Emphasized the need for empirical evidence.
- Most experts agree that the discipline known as psychology started somewhere in the late 1800s.
- Wilhelm Wundt (1832-1920)
  - Historians often give credit to Wundt for creating the new discipline of psychology.
  - Credited with starting the first psychological laboratory in Leipzig, Germany.
  - Estimated to have taught approximately 28,000 students in his lifetime!

# A BRIEF HISTORY OF COGNITIVE PSYCHOLOGY

- Wundt proposed that psychology should study mental processes, using a technique called (trained) introspection.
- Trained Introspection
  - Carefully trained observers would systematically analyze their own sensations and report them as objectively as possible.
  - While it seems like a far cry from the rigor the field demands these days – It was a start!
- William James (1842-1910)
  - Known as the father of American Psychology.
  - Unimpressed by Wundt's introspection methods or current work on memory being done at the time.
  - Preferred to theorize about our own everyday psychological experiences.
  - Best known for his book, "The Principles of Psychology." which emphasized that the human mind is **active** and **inquiring**.

# A BRIEF HISTORY OF COGNITIVE PSYCHOLOGY: BEHAVIORISM

- **Behaviorism**
  - The most prominent theoretical perspective in the United States during the first half of the 19th century.
  - According to the behaviorist approach, psychology must focus on objective, observable reactions to stimuli in the environment.
  - The most prominent early behaviorist was the U.S. psychologist John B. Watson, who lived from 1878–1958.
  - Behaviorists thought of the mind as a sort of “black box” – no use in trying to pry into.
- Behaviorists rejected Wundt’s introspection methods and avoided terms such as thought, idea, or image because it was not possible to objectively measure such internal “things.”
- While behaviorists did not conduct research in the field of cognitive psychology they did indirectly affect cognitive psychology by:
  - Stressing the importance of clear and proper operational definitions.
  - Contributing to the field of contemporary research methods.
  - Contributing vast amounts to the field of learning.
- While behaviorism reigned in America for decades it had less influence in Europe.

# THE BIRTH OF MODERN COGNITIVE PSYCHOLOGY

- The birth of this discipline is generally the agreed upon year of 1956 because:
  - Researchers published numerous influential books and articles on attention, memory, language, concept formation, and problem solving that year.
  - Many researchers attended an important symposium at the Massachusetts Institute of Technology dealing with this emerging subject.
  - This time period following this year became known as the “cognitive revolution.”
- Psychologists were becoming disenchanted with behaviorism.
- Scientists were increasingly convinced that human behavior could not be fully explained using traditional behaviorist theory.
  - Behaviorists care only for observable stimuli, responses, and reinforcement! Human behavior is clearly more complex.
  - Behaviorists could not talk about something like a “problem solving strategy”
  - There were exciting new developments in areas like linguistics, memory, and developmental psychology.

# THE ROLE OF COMPUTER SCIENCE

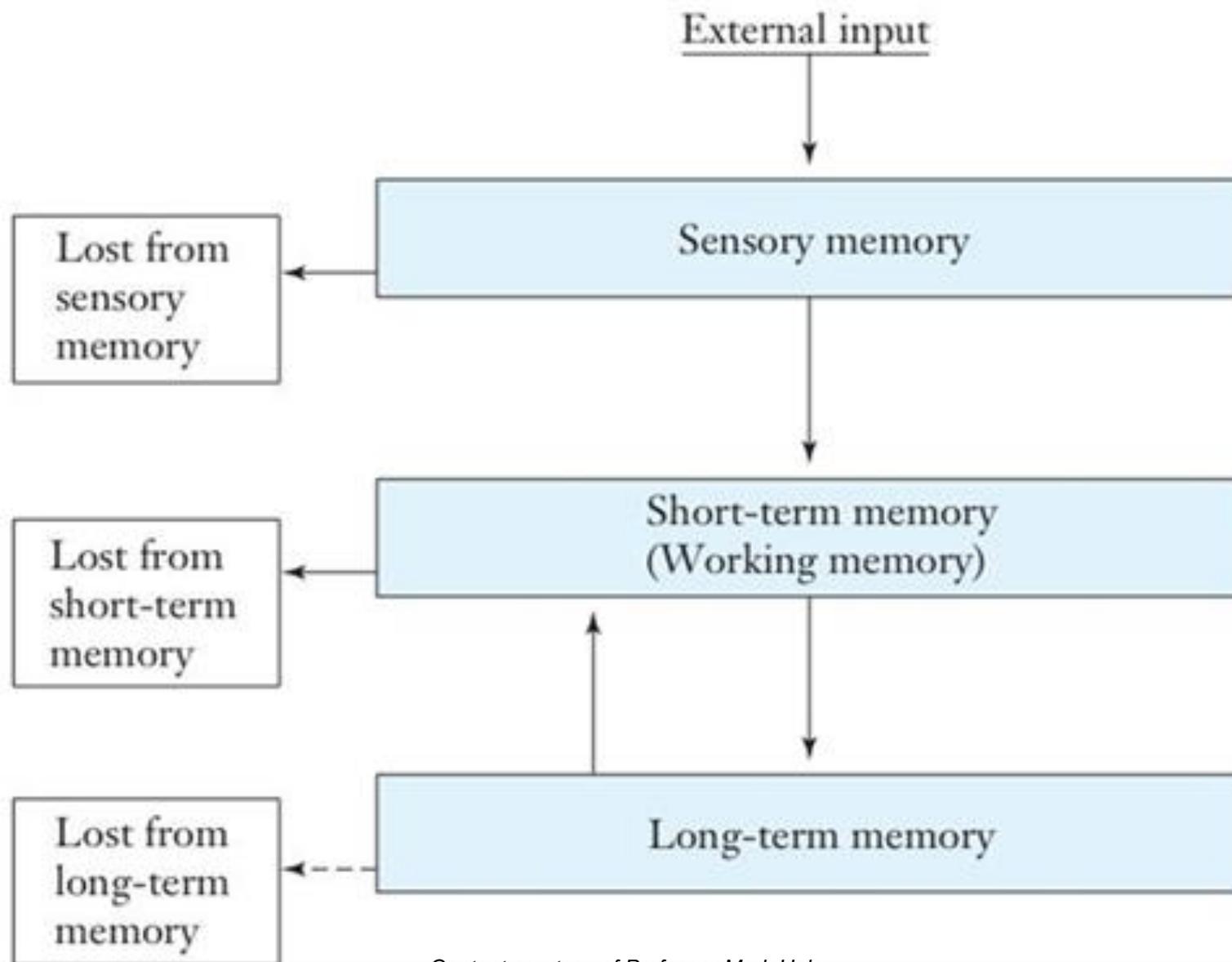
- The Information Processing Approach (IPA)
  - As computer science began to develop in the 1950s psychologists began speculating that human thought processes could be analyzed from a similar perspective.
  - Helped to define the new “cognitive revolution” and served as the most popular theory in the new discipline.
- Consists of two important components:
  - A mental process can be compared with the operations of a computer.
  - A mental process can be interpreted as information progressing through the system in a series of stages, one step at a time.

# THE INFORMATION PROCESSING APPROACH

- The most important early theory using the Information Processing Approach was the Atkinson-Shiffrin model of human memory.
  - Highly influential in persuading research psychologists to adopt the emerging cognitive psychology perspective.
  - Proposed that memory can be understood as a sequence of discrete steps, in which information is transferred from one storage area to another or is lost.
  - Remained a dominant theory for many years and still serves as a basis for more preferred theories.

**FIGURE 1.1**

**Atkinson and Shiffrin's Model of Memory.**



# COGNITIVE SCIENCE SCIENTIFIC TECHNIQUES

# SCIENTIFIC TECHNIQUES

## ■ Neuroscience techniques

- - Brain Lesions
- - Positron Emission Tomography
- - Functional Magnetic Resonance Imaging
- - Event-Related Potential Technique (EEG)
- - Single Cell Recording Technique

## ■ Brain Lesions

- Refers to destruction of tissue in the brain.
- Usually scientists examine damage caused by natural events (strokes, tumors, or accidents).
- Try to determine how this damage relates to behavior and functioning in the individual.

# STUDYING BRAIN LESIONS

## ■ Brain Lesions

- Refers to destruction of tissue in the brain.
- Usually scientists examine damage caused by natural events (strokes, tumors, or accidents).
- Try to determine how this damage relates to behavior and functioning in the individual.

## ■ However, sometimes scientists may cause the lesions. (Remember this is irrevocable damage!)

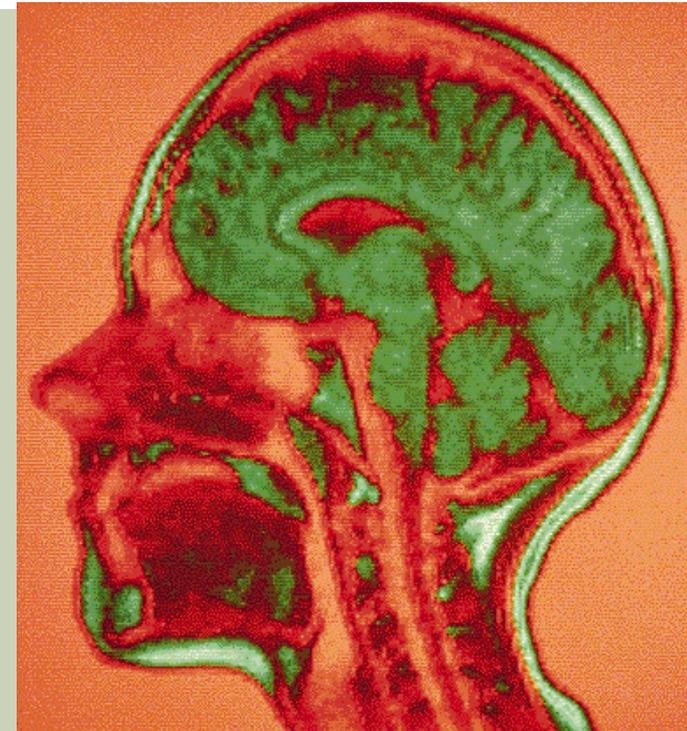
- Why might we go to this extreme?
- Can be used to treat epilepsy and other disorders.
- Scientists have also purposefully lesioned areas in the brains of lab rats for purposes of research.
- The biggest problem with this type of research is that it is very seldom that people have damage that is localized to just one region or structure.
- This often makes it very hard to draw specific conclusions.

# POSITRON EMISSION TOMOGRAPHY (PET)

- Measures brain activity indirectly by examining the properties of the blood flow in regions of the brain as you perform cognitive tasks.
- When you perform cognitive tasks, your brain needs oxygen to support the neural activity.
- Blood flow increases in the activated part of the brain in order to carry oxygen to that site.
- Researchers measure blood flow by injecting the participant with a radioactive chemical just before they perform a task and then measuring the accumulation of the chemical in areas of interest.
- A downside to this method is that it does not have the kind of temporal resolution to allow us to make causal statements.
  - i.e., it is not precise with regards to time!
- PET scans require several seconds to produce data!
- PET scans essentially record average activity level over time.
  - If your task takes only a few seconds then a PET scan may be of very little interest.
- PET scans are not used as often as other methods because they are expensive and they expose people to radioactive chemicals.

# FUNCTIONAL MAGNETIC RESONANCE IMAGING (fMRI)

- fMRIs directly measure the amount of oxygen in the blood based on the principle that oxygen-rich blood is an index of brain activity.
- Less invasive than PET and has a higher temporal resolution.
- Still not precise enough to study the sequence of events in cognitive tasks performed very quickly.
- For Example:
  - You can read a word out loud in about  $\frac{1}{2}$  second
  - fMRI measures would show simultaneous neural activity in both the visual and the motor parts of your brain.
  - The resolution is not high enough to separate the activities.

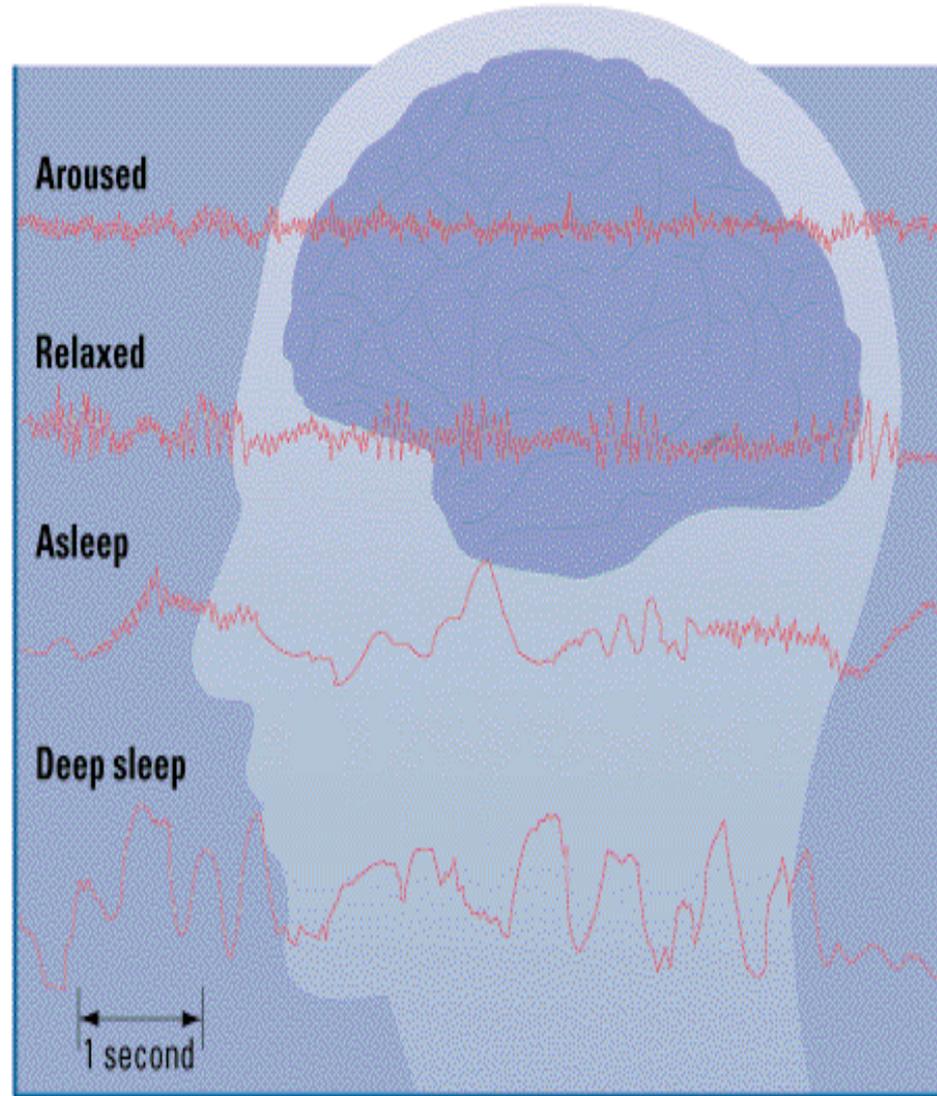


- Magnetic fields align certain ions and compounds.
- When field is removed, these molecules release energy as radio waves.
- Computer calculates tissue density from radio waves.
- Provides clear 3D images

# EVENT-RELATED POTENTIAL TECHNIQUE

- The event-related potential (ERP) technique records the brief fluctuations (milliseconds) in the brain's electrical activity in response to a stimulus.
  - This neural activity is recorded by an electroencephalogram (EEG) device containing many small electrodes attached to the scalp.
- The ERP technique cannot identify the response of a single neuron.
- However, it can identify electrical changes over a very brief period in a specific region of the brain.
- ERP produces reasonably precise picture about changes in the brain's electrical potential during a cognitive task.
- High temporal resolution in that it can detect changes in signal within a millisecond as opposed to other methods which require seconds or even minutes.
- The downside to this is that there are often many artifacts or “noise” in the recordings due to the highly sensitive recording equipment.

# ELECTROENCEPHALOGRAPH (EEG)



# FUNCTIONAL NEAR INFRARED (FNIR)

- Functional state of tissue influences the optical properties of the tissue.
- Specifically measures oxygenation of the frontal lobe as an indicator of cognitive workload.

The screenshot shows the website for the CONQUER collaborative at Drexel University. The page features the Drexel University logo and a navigation menu with links for Welcome, People, Translational activities, Optical Brain Imaging, and News. The main heading is "Functional Optical Brain Imaging" with "fNIR" in a red font. Below the heading is a photograph of a man wearing a head-mounted device. To the right of the photo are two links: "See our RESEARCH PROJECTS" and "See our SELECTED PUBLICATIONS". Below these links is a color-coded heatmap and a grid of small images. The bottom section is titled "Functional Optical Brain Imaging at Drexel University" and contains a paragraph of text describing the laboratory's interdisciplinary efforts. To the right of the text is a diagram of a human brain with a "Source" and "Detector" labeled on the surface.

**Functional Optical Brain Imaging at Drexel University**

Drexel's Optical Brain Imaging Laboratory is part of the Neuroengineering Resource Center, an interdisciplinary effort which brings together faculty, students and resources from the School of Biomedical Engineering, Psychology, Psychiatry, Nursing and Health Professions, Neurology, Neurobiology, Neurosciences, Visualization, Gaming, Computer Science, Education and others partner units. The laboratory is focused on the development, systems integration and field/clinical deployment of optical brain imaging techniques to monitor human brain activity of healthy individuals and patients. The team has been at the

# SINGLE CELL RECORDING TECHNIQUE

- Researchers study characteristics of an animal's brain or nervous system by inserting a thin electrode into or next to a single neuron.
  - This method obviously can't be used with humans!
- The most famous example of this technique was found in Hubel and Wiesel's work in discovering feature detector cells in cats.
  - Researchers found that there were cells in the cortex that responded maximally to lines of specific orientation when the stimulus was placed in the cats visual field.

# ARTIFICIAL INTELLIGENCE & COMPUTER SIMULATION AND MODELING

- A branch of computer science that seeks to explore human cognitive processes by creating computer models that accomplish the same tasks that humans do.
- Researchers in these domains have tried to model things like face recognition and human problem solving. *(More coming in Lesson 7!)*
- AI and computer simulation tend to be extremely specialized, powerful, fast, and reliable in terms of processing.
- Even chess experts make a minor mistake every 10 moves or so and that is why a program can be developed that can beat the greatest chess masters.
- However, the domain space can be very narrow with AI. This limits its scope of usefulness. Lower generalizability!
- Even though computer simulation and AI may excel at VERY complex things...
  - There are still tasks that humans accomplish quite easily that defy computer simulation.
  - Consider the task of scanning your room for your text book only to remember that it was in your gym bag - in your car (left at your friends house last night).
- Computers can't match humans' sophistication in:
  - - Learning language, Identifying objects in everyday scenes, Solving problems creatively

# PARALLEL DISTRIBUTED PROCESSING APPROACH (PDP)

- Also called connectionism and/or neural networks.
- Grew out of neuroscience research techniques where scientists were able to observe the numerous connections among neurons in the cerebral cortex.
- The (PDP) approach argues that cognitive processes can be understood in terms of networks that link together neuron-like units.
- Many operations can proceed simultaneously—rather than serially (one step at a time). This is the “parallel” part of PDP!
- This network pattern suggests that an item stored in your brain cannot be localized in a specific pinpoint-sized region of your cortex.
- Instead activity seems to be distributed throughout a section or sections of the brain. This is the “distributed” part in PDP.

# "PROOF" OF THE PDP THEORY?

- Try the following exercise on the next slide:

# EXERCISE

- To begin this exercise start reading this sentence.
- Now turn your head to the left and look at the wall, and then immediately return to the next paragraph.
- When you looked at the visual scene (the wall), your retina presented about one million signals to your cortex—all at the same time. If your visual system had used serial processing in order to interpret these one million signals, you would still be processing that visual scene, rather than reading this sentence!

*Adapted from Matlin's Cognition 7th ed.*

# CONCLUSION

- Scientists welcomed the PDP approach because it was more a robust approach to thinking about the way the brain functions.
- Keep in mind that the PDP approach uses the human brain to describe processing—rather than the serial-computer analogy.
- Cognitive Science – Large field that includes various disciplines such as:
  - Cognitive psychology
  - Artificial intelligence
  - Linguistics
  - Sociology
  - Neuroscience
  - Philosophy
  - Anthropology
  - Computer Science