The Information Processing Approach to Cognition

Citation: Huitt, W. (2003). The information processing approach to cognition. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved [date] from, http://www.edpsycinteractive.org/topics/cognition/infoproc.html

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Overview

As stated in the introduction to this section, cognitive psychology represents the dominant approach in psychology today. A primary focus of this approach is on memory (the storage and retrieval of information), a subject that has been of interest for thousands of years. The most widely accepted theory is labeled the "stage theory," based on the work of Atkinson and Shriffin (1968). The focus of this model is on how information is stored in memory; the model proposes that information is processed and stored in 3 stages. In this theory, information is thought to be processed in a serial, discontinuous manner as it moves from one stage to the next. This theory is discussed in more detail below.

In addition to the stage theory model of information processing, there are three more that are widely accepted. The first is based on the work of Craik and Lockhart (1972) and is labeled the "**levels-of-processing**" theory. The major proposition is that learners utilize different levels of elaboration as they process information. This is done on a continuum from perception, through attention, to labeling, and finally, meaning. The key point is that all stimuli that activate a sensory receptor cell are permanently stored in memory, but that different levels of processing (i.e., elaboration) contribute to an ability to access, or retrieve, that memory. Evidence from hypnosis and forensic psychology provide some interesting support for this hypothesis. This approach has been extended by Bransford (1979) who suggests that it is not only how the information is processed, but how the information is accessed. When the demands for accessing information more closely match the methods used to elaborate or learn the information, more is remembered.

Two other models have been proposed as alternatives to the Atkinson-Shiffrin model: **parallel-distributed processing** and **connectionistic**. The parallel-distributed processing model states that information is processed simultaneously by several different parts of the memory system, rather than sequentially as hypothesized by Atkinson-Shiffrin as well as Craik and Lockhart. Work done on how we process emotional data somewhat supports this contention (see Goleman, 1995). The stage-theory model shown below differs slightly from the original Atkinson-Shriffin model in order to incorporate this feature.

The **connectionistic** model proposed by Rumelhart and McClelland (1986) extends the parallel-distributed processing model. It is one of the dominant forms of current research in cognitive psychology and is consistent with the most recent brain research (see Scientific American, 2000). This model emphasizes the fact that information is stored in multiple locations throughout the brain in the form of networks of connections. It is consistent with the levels-of-processing approach in that the more connections to a single idea or concept, the more likely it is to be remembered.

Even though there are widely varying views within cognitive psychology, there are a few basic principles that most cognitive psychologists agree with.

General principles

The first is the **assumption of a limited capacity** of the mental system. This means that the amount of information that can be processed by the system is constrained in some very important ways. Bottlenecks, or restrictions in the flow and processing of information, occur at very specific points.
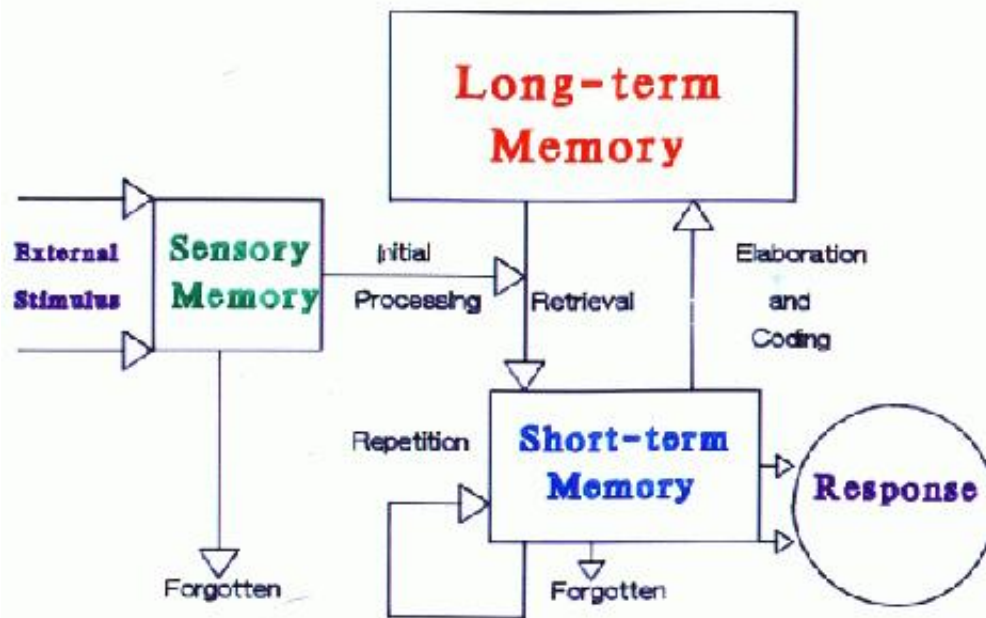
Like how a 64 gb iPod is actually a 58 gb iPod

A second principle is that a **control mechanism is required** to oversee the encoding, transformation, processing, storage, retrieval and utilization of information. That is, not all of the processing capacity of the system is available; an executive function that oversees this process will use up some of this capability. When one is learning a new task or is confronted with a new environment, the executive function requires more processing power than when one is doing a routine task or is in a familiar environment.

A third principle is that there is a **two-way flow of information** as we try to make sense of the world around us. We constantly use information that we gather through the senses (often referred to as bottom-up processing) and information we have stored in memory (often called top-down processing) in a dynamic process as we construct meaning about our environment and our relations to it. This is somewhat analogous to the difference between inductive reasoning (going from specific instances to a general conclusion) and deductive reasoning (going from a general principle to specific examples.) A similar distinction can be made between using information we derive from the senses and that generated by our imaginations.

A fourth principle generally accepted by cognitive psychologists is that the human organism has been **genetically prepared to process and organize information in specific ways**. For example, a human infant is more likely to look at a human face than any other stimulus. Given that the field of focus of a human infant is 12 to 18 inches, one can surmise that this is an important aspect of the infant's survival. Other research has discovered additional biological predispositions to process information. For example, language development is similar in all human infants regardless of language spoken by adults or the area in which they live (e.g., rural versus urban, Africa versus Europe.) All human infants with normal hearing babble and coo, generate first words, begin the use of telegraphic speech (e.g., ball gone), and overgeneralize (e.g., using "goed to the store" when they had previously used "went to the store") at approximately the same ages. The issue of language development is an area where cognitive and behavioral psychologists as well as cognitive psychologists with different viewpoints have fought many battles regarding the processes underlying human behavior. Needless to say the disussion continues.

Stage Model of Information Processing

One of the major issues in cognitive psychology is the study of memory. The dominant view is labeled the "stage theory" and is based on the work of Atkinson and Shiffrin (1968).

This model proposes that information is processed and stored in 3 stages.

Sensory memory (STSS). Sensory memory is affiliated with the transduction of energy (change from one energy from to another). The environment makes available a variety of sources of information (light, sound, smell, heat, cold, etc.), but the brain only understands electrical energy. The body has special sensory receptor cells that transduce (change from one form of energy to another) this external energy to something the brain can understand. In the process of transduction, a memory is created. This memory is very short (less than 1/2 second for vision; about 3 seconds for hearing).

It is absolutely critical that the learner attend to the information at this initial stage in order to transfer it to the next one. There are two major concepts for getting information into STM:

> First, individuals are more likely to pay attention to a stimulus if it has an **interesting feature**. We are more likely to get an orienting response if this is present.

> Second, individuals are more likely to pay attention if the stimulus activates a **known pattern**. To the extent we have students call to mind relevant prior learning before we begin our presentations, we can take advantage of this principle.

Short-term memory (STM). Short-term memory is also called working memory and relates to what we are thinking about at any given moment in time. In Freudian terms, this is conscious memory. It is created by our paying attention to an external stimulus, an internal thought, or both. It will initially last somewhere around 15 to 20 seconds unless it is repeated (called maintenance rehearsal) at which point it may be available for up to 20 minutes. The hypothalamus is a brain structure thought to be involved in this shallow processing of information. The frontal lobes of the cerebral cortex is the structure associated with working memory. For example, you are processing the words you read on the screen in your frontal lobes. However, if I ask, "What is your telephone number?" your brain immediately calls that from

long-term memory and replaces what was previously there.

Another major limit on information processing in STM is in terms of the number of units that can be processed an any one time. Miller (1956) gave the number as 7 ± 2, but more recent research suggests the number may be more like 5 ± 2 for most things we are trying to remember. Because of the variability in how much individuals can work with (for some it may be three, for others seven) it is necessary to **point out important information**. If some students can only process three units of information at a time, let us make certain it is the most important three.

There are two major concepts for retaining information in STM: organization and repetition. There are four major types of organization that are most often used in instructional design:

- Component (part/whole)--classification by category or concept (e.g., the components of the teaching/learning model);
- Sequential -- chronological; cause/effect; building to climax (e.g., baking a cake, reporting on a research study);
- Relevance -- central unifying idea or criteria (e.g., most important principles of learning for boys and girls, appropriate management strategies for middle school and high school students);
- Transitional (connective) -- relational words or phrases used to indicate qualitative change over time (e.g., stages in Piaget's theory of cognitive development or Erikson's stages of socioemotional development)

A related issue to organization is the concept of chunking or grouping pieces of data into units. For example, the letters "b d e" constitute three units of information while the word "bed" represents one unit even though it is composed of the same number of letters. Chunking is a major technique for getting and keeping information in short-term memory; it is also a type of elaboration that will help get information into long-term memory.

Repetition or rote rehearsal is a technique we all use to try to "learn" something. However, in order to be effective this must be done after forgetting begins. Researchers advise that the learner should not repeat immediately the content (or skill), but wait a few minutes and then repeat. For the most part, simply memorizing something does not lead to learning (i.e., relatively permanent change). We all have anecdotal evidence that we can remember something we memorized (a poem for example), but just think about all the material we tried to learn this way and the little we are able to remember after six months or a year.

Long-term memory (LTM). Long-term memory is also called preconscious and unconscious memory in Freudian terms. Preconscious means that the information is relatively easily recalled (although it may take several minutes or even hours) while unconscious refers to data that is not available during normal consciousness. It is preconscious memory that is the focus of cognitive psychology as it relates to long-term memory. The levels-of-processing theory, however, has provided some research that attests to the fact that we "know" more than we can easily recall. The two processes most likely to move information into long-term memory are elaboration and distributed practice (referred to as periodic review in the direct instruction model).

There are several examples of elaboration that are commonly used in the teaching/learning process:

- imaging -- creating a mental picture;
- method of loci (locations)--ideas or things to be remembered are connected to objects located in a familiar location;
- pegword method (number, rhyming schemes)--ideas or things to be remembered are connected to specific words (e.g., one-bun, two-shoe, three-tree, etc.)
- Rhyming (songs, phrases)--information to be remembered is arranged in a rhyme (e.g., 30 days hath September, April, June, and November, etc.)
- Initial letter--the first letter of each word in a list is used to make a sentence (the sillier, the better).

Organization (types) of knowledge

As information is stored in long-term memory, it is organized using one or more structures: declarative, procedural, and/or imagery.

Declarative Memory (generally refers to information we can talk about)

- Semantic Memory-- facts and generalized information (concepts, principles, rules; problem-solving strategies; learning strategies)
    - Schema / Schemata -- networks of connected ideas or relationships; data structures or procedures for organizing the parts of a specific experience into a meaningful system (like a standard or stereotype)
    - Proposition -- interconnected set of concepts and relationships; if/then statements (smallest unit of information that can be judged true or false)
    - Script -- "declarative knowledge structure that captures general information about a routine series of events or a recurrent type of social event, such as eating in a restaurant or visiting the doctor" (Stillings et al., 1987)
    - Frame -- complex organization including concepts and visualizations that provide a reference within which stimuli and actions are judged (also called "Frame of Reference")
    - Scheme -- an organization of concepts, principles, rules, etc. that define a perspective and presents specific action patterns to follow
    - Program -- set of rules that define what to do in a particular situation
    - Paradigm -- the basic way of perceiving, thinking, valuing, and doing associated with a particular vision of reality (Harman, 1970)
    - Model -- a set of propositions or equations describing in simplified form some aspects of our experience. Every model is based upon a theory or paradigm, but the theory or paradigm may not be stated in concise form. (Umpleby in Principia Cybernetica Web, no date)

- Episodic Memory-- personal experience (information in stories and analogies)

Procedural Memory-- how to (driving a car, riding a bike)

Imagery -- pictures

Concept formation

One of the most important issues in cognitive psychology is the development or formation of concepts. A concept is the set of rules used to define the categories by which we group similar events, ideas or objects. There are several principles that lend themselves to concept development:

- name and define concept to be learned (advance organizer)
  a. reference to larger category
  b. define attributes
- identify relevant and irrelevant attributes (guided discovery)
- give examples and nonexamples (tie to what is already known -- elaboration)
- use both inductive (example/experience --> definition) and deductive reasoning (definition --> examples)
- Name distinctive attributes (guided discovery)

USING THE INFORMATION PROCESSING APPROACH IN THE CLASSROOM	
Principle	**Example**
1. Gain the students' attention.	• Use cues to signal when you are ready to begin. • Move around the room and use voice inflections.
2. Bring to mind relevant prior learning.	• Review previous day's lesson. • Have a discussion about previously covered content.
3. Point out important information.	• Provide handouts. • Write on the board or use transparencies.
4. Present information in an organized manner.	• Show a logical sequence to concepts and skills. • Go from simple to complex when presenting new material.
5. Show students how to categorize (chunk) related information.	• Present information in categories. • Teach inductive reasoning.
6. Provide opportunities for students to elaborate on new information.	• Connect new information to something already known. • Look for similarities and differences among concepts.
7. Show students how to use coding when memorizing lists.	• Make up silly sentence with first letter of each word in the list. • Use mental imagery techniques such as the keyword method.
8. Provide for repetition of learning.	• State important principles several times in different ways during presentation of information (STM). • Have items on each day's lesson from previous lesson (LTM). • Schedule periodic reviews of previously learned concepts and skills (LTM).

9. Provide opportunities for overlearning of fundamental concepts and skills.	• Use daily drills for arithmetic facts. • Play form of trivial pursuit with content related to class.

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