## Focus on the Mind: Cognitive Psychology

## I. INTRODUCTION
### A. Cognitive Psychology

- Cognitive Psychology is the school of thought which is interested in how people mentally represent and process information.
  - Include in topics such as memory, concept formation, attention, reasoning, problem solving, judgment, and language.
  - Historically, psychology has always been (a few exceptions) cognitively oriented except for the brief period between the 1930's and 1950's
    - This was a time when behaviorism was highly influential and interests in cognitive topics were low

## I. INTRODUCTION
### A. Cognitive Psychology

- Ulrich Neisser coined *cognitive psychology*
  - Did so in his influential 1967 book *Cognitive Psychology*
    - Book defined the paradigm for a generation.
  - He characterized people as dynamic information-processing systems whose mental operations might be described in computational terms.
    - ...the term *cognition* refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used. It is concerned with these processes even when they operate in the absence of relevant stimulation, as in images and hallucinations...

## I. INTRODUCTION
### B. Cognitive Psychology vs. Other Paradigms

- Cognitive psychology is easily distinguished from other paradigms
  - Assumes that people are designed to process information rather than other design assumptions (grow, learn, be socialized, etc.).
    - It embraces the use of the scientific method
  - It explicitly acknowledges the existence of internal mental states unlike behaviorist psychology.
    - These internal states are objective computational ones rather than subjective states like those explored in humanism or in everyday Folk Psychology.
    - It also rejects introspection as a valid method of investigation.

## I. INTRODUCTION
### B. Cognitive Psychology vs. Other Paradigms

- Cognitive explanations identify computational processes giving rise to behavior.
  - Think of cognitive explanations of the behavior as identifying the software of a computer
    - Knowing the software of a computer would help you understand and predict the computer's behavior.
    - You may understand the software of a computer without understanding how the software is implemented (computer language) or medium on which it is implemented (hardware)
  - Cognitive psychology highlights the *mind as a computer* analogy.

## I. INTRODUCTION
### C. The *mind as a computer* analogy.

- How can computers help us understand mind?
  - To explain, consider what happened on May 11, 1997
  - Here is the New York Times headline and opening paragraph.

**IBM Chess Machine Beats Humanity's Champ**

NEW YORK -- In brisk and brutal fashion, the IBM computer Deep Blue unseated humanity, at least temporarily, as the finest chess playing entity on the planet on Sunday, when Garry Kasparov, the world chess champion, resigned the sixth and final game of the match after just 19 moves, saying, "I lost my fighting spirit."

## I. INTRODUCTION
### C. The *mind as a computer* analogy.

- Big Blue is the software which makes explicit the computational processes underlying intelligent performance.
  - This is the central idea of the *mind as a computer* analogy: To understand the objective computational processes underlying various behaviors.
  - Cognitive psychology try to understand the computational processes involved in perceiving, storing, remembering, analyzing, and interpreting information.
- The *mind as a computer* analogy holds that there are similarities and differences between the entities.

## I. INTRODUCTION
### C. The *mind as a computer* analogy.

- 1. Differences:
- What differences exist between humans and computers?
  - Physical nature: Humans are carbon-based whereas computers are Silicon-based.
  - Reproductive process. Only human beings reproduce.
  - Experience: Only humans actually feel pain, emotions etc. although computers can simulate it.
  - Consciousness: Only human are aware of themselves as an agent in the world (free-will).

## I. INTRODUCTION
### C. The *mind as a computer* analogy.

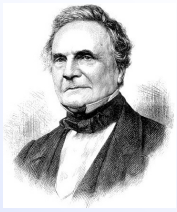
- 2. Similarities: What ways are they similar?
- Most of the similarities address the processing of information.
- Both Minds and computers…
  - *Input* information
  - *Output* information
  - *Access* information
  - *Store* information
  - *Retrieve* information
  - *Analyze* information

## I. INTRODUCTION
### C. The *mind as a computer* analogy.

- The Cognitive Approach denies that people are computers, only that people and computers both process information.
  - Information processing language lets us talk objectively about how the mind.
    - There is no "mental state" talk about the mind
  - In this view, the mind is full of dynamic and objective mental processes.
    - Use the same verbs when talking about the mind as when talking about computers.
    - The psychological question becomes how do we perform these operations.

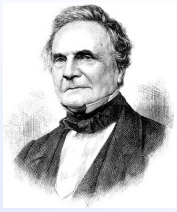
## II. BACKGROUND
### A. History of Computing

- Charles Babbage (1828 to 1839)
  - Held Cambridge University post formerly held by Isaac Newton.
  - Babbage's proposed Difference Engine
    - Special-purpose digital computing machine for the automatic production of mathematical tables (such as logarithm tables, tide tables, and astronomical tables).
    - The Difference Engine consisting entirely of mechanical parts (brass gear wheels, rods, etc



## II. BACKGROUND
### A. History of Computing

- Charles Babbage (1828 to 1839)
  - He also proposed an Analytical Engine
    - More ambitious machine than the Difference Engine
    - The Analytical Engine was to have had a memory store and a central processing unit.
    - It would select from alternative actions contingent on its previous actions.
  - A full-scale version of the AE was never built.



## II. BACKGROUND
### A. History of Computing

- Alan Turing (1912-1954)
  - In 1936, Turing invented the principle of the modern computer.
    - He described an abstract digital computing machine consisting of a limitless memory and a scanner that moves back and forth through the memory, symbol by symbol, reading what it finds and writing further
  - Turing was a cryptanalyst during WWII and broke the German code helping to win the war.
    - Created the Turing test for deciding whether computers *think*.

## II. BACKGROUND
### A. History of Computing

- Claude Shannon (1916-2001)
  - Electronic engineer and mathematician,.
    - Author of the landmark 1948 paper *A Mathematical Theory of Communication* which developed information theory
      - Information Theory involves the quantification of information (the signal contained thousands of bits of information)
    - He is credited with founding both digital computers and digital circuit design theory in 1937.

## II. BACKGROUND
### B. Intellectual History

- Cognitive abilities have been studied philosophically before the founding of psychology
  - J. S. Mill (British Empiricist)
  - Gustav Fechner (Physiologist; Psychophysics)
  - Hermann Ebbinghaus (Experimentalist)
  - William James (Functionalist)
  - But there were important founders of the cogntive approach

## II. BACKGROUND
### B. Intellectual History

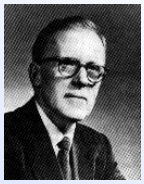
- Jean Piaget (1996 – 1980)
  - Swiss Psychologist and a founder of cognitive development in the 1920s
    - His work focused on child's interactions with the environment
      - Identified structures becomes more complex (reflected through stages) through maturation and experience.
    - His extensive work on cognitive development in the 1930's and 1940's contributed to the revived interest in cognitive issues in the 1950's

## II. BACKGROUND
### B. Intellectual History

- Edward Tolman and Clark Hull
  - Challenged Behaviorist assumptions by examining internal mental process
  - These processes were called *Intervening Variables*
    - For Hull, these variables were mainly physiological (needs)
    - For Tolman they were mainly cognitive variables (mental maps).


## III. Founding of Cognitive Psychology
### A. Key Ideas

- Carl Rogers and Donald Hebb
  - Both challenged radical behaviorism and psychoanalysis.
  - Rogers emphasized the importance of internal conscious processes and its role on behavior.
  - Hebb contributed to the rise of cognitive interests with his book *The Organization of Behavior* which encouraged an interest both biological explanations and cognitive processes.



## III. Founding of Cognitive Psychology
### A. Key Ideas

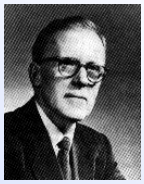
- Cognitive Psychology founding due to a confluence of people presenting key ideas.
- Herbert Simon and Allen Newell
  - Colleagues at Carnegie-Mellon University
    - Were founding fathers of several of today's important scientific domains, including artificial Intelligence, information processing, decision-making, problem-solving,

## III. Founding of Cognitive Psychology
### A. Key Ideas

- George Miller
  - Princeton Professor whose ideas are fundamental to cognitive psychology.
    - Miller (1956) claimed that were are constraints on STM
      - STM could only hold 7 (+/-2) chunks of information, where a chunk is any meaningful unit including digits, words, chess positions,
    - Miller, Galanter, and Pribram (1960) proposed TOTE (Test-Operate-Test-Exit)
      - Suggested that TOTE should replace the stimulus-response as the basic unit of behavior explanations.
      - Concept central in goal-directed behavior.

## III. Founding of Cognitive Psychology
### A. Key Ideas

- A critical event was the IEEE (*Institute of Electrical and Electronics Engineers*) Symposium on Information Theory at MIT (Sept. 11, 1956)
- Papers by:
  - Allen Newell and Herbert Simon
    - Presented papers on computer logic
  - Noam Chomsky
    - Presented his views on language
  - George Miller
    - Presented his research on short-term memory its capacity.



## III. Founding of Cognitive Psychology
### A. Key Ideas

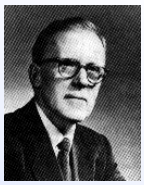
- Jerome Bruner
  - Professor at Harvard and NYU
    - Published *The Study of Thinking* (1956) and the *Process of Education* (1960 )
      - Considered central in the cognitive approach to thinking and learning.
  - Key ideas:
    - Learning is an active process where learners construct new ideas
    - Cognitive structure (schema, models) provides meaning and organization to experiences.

## III. Founding of Cognitive Psychology
### A. Key Ideas

- Leon Festinger
  - Noted that ideas that one may have might be compatible with or incompatible with one another.
    - When ideas are incompatible, a state of cognitive dissonance exists that motivates a person to change beliefs or behavior.
  - His description made no reference to behavioristic ideas.
  - Cognitive Dissonance one of the major accomplishments of all of Psychology

## III. Founding of Cognitive Psychology
### A. Key Ideas

- Hebb (again!)
  - Continued to discuss physiology and behavioral phenomena and cognitive processes.
    - His APA Presidential address urged the use of the scientific rigor of the behavioral researchers to study cognitive processes.
    - He noted the work of Festinger and Miller, Galanter, & Pribram as good starts toward this rigorous cognitive psychology.
  - He was also encouraged by the possibility of using computer models for studying cognitive processes.



## IV. Growth of Cognitive Psychology
### A. Introduction

- Notable movements in Cognitive Psychology
  - Artificial Intelligence
    - The branch of computer science which aims to understand intelligent behavior.
  - Information Processing
    - The approach within Psychology to study the cognitive operations underlying human behavior
  - Cognitive Science
    - Interdisciplinary study of the nature of intelligence.
  - Connectionism
    - Models mental or behavioral phenomena as emergent processes of *interconnected networks of simple units*.

## IV. Growth of Cognitive Psychology
### B. AI

- AI: Machines capture powers of human mind.
  - Alan Turing: Raised the question about and developed a test of whether or not machines think
  - Weak vs. strong artificial intelligence.
    - Proponents of weak AI claim that, at best, a computer can only simulate human mental attributes.
    - Proponents of strong AI claim that the computer (when appropriately programmed) really is a mind capable of understanding and having mental states.
  - John Searle notes computer programs have syntax (formal rules), not semantics (meaning).
    - Human thought has intentionality, but computers do not.

## IV. Growth of Cognitive Psychology
### B. AI

- Are humans machines?
  - The question reintroduces important questions into modern times, such as what is the nature of human nature?
    - This type of question posed in relation to machines brings into play many issues such as the mind-body question and the lawfulness of human behavior and free will.
  - Other philosophical issues concerns rationality vs. irrationality of human thought
    - Heuristics vs. algorithms.

## IV. Growth of Cognitive Psychology
### C. Information Processing

- Uses the computer as a model for human information processing.
  - One major issues is the role of domain general vs. specific processing systems
    - Domain General processing systems advocated by Piaget and Simon (weak problem-solving strategies).
      - The role of general cognitive systems has fallen out of favor.
    - Domain Specific processing systems advocated by Chomsky and Miller to account for language
      - Information processing marks a return to faculty psychology, as does the recent discovery that the brain is organized into many "modules" (groups of cells) each associated with some specific function.

## IV. Growth of Cognitive Psychology
### C. Information Processing

- Return of the Mind-Body Problem
  - Radical behaviorists denied the existence of a mind, but cognitive psychology assumes the existence of a mind.
  - In each case, bodily events and cognitive events are assumed
    - Therefore the relationship between the two must be explained.
  - The problem of realizing cognitive processes into a medium (brain or computer) seen largely as an engineering problem.
    - Not as simple as once thought.

## IV. Growth of Cognitive Psychology
### D. Cognitive Science

- In the 1970's, information-processing psychologists combined efforts with philosophers, anthropologists, linguists, neuroscientists, engineers, and computer scientists to create the area of cognitive science (1970s)
- Cognitive science uses a variety of methodologies,
  - The methods include those of psychology, neuroscience, linguistics, anthropology, computer science

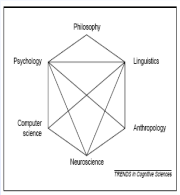


Fig. 1. Cognitive science in 1978. Each line joining two disciplines represents inter-disciplinary inquiry that already existed in 1978.

## IV. Growth of Cognitive Psychology
### E. Connectionism

- In the 1980s new forms of cognitive modeling was developed – Connectionism; PDP models
  - The cornerstone of this model is Hebb's Rule
    - If neurons are successively or simultaneously active, the strength of the connections among them increases.
  - Associations among units in a network change as a function of experience.
    - Synaptic changes simulated by modifiable mathematical weights, or loadings among units in the network.
    - Learning is explained in terms of changing patterns of excitation and inhibition (represented by mathematical weights) within the network.

## IV. Growth of Cognitive Psychology
### E. Connectionism

- Back propagation systems
  - Connectionist system that requires a "teacher" to provide feedback concerning the program's performance.
    - NETtalk (http://www.cnl.salk.edu/ParallelNetsPronounce/nettalk.mp3) is an example of this type of system in which words are fed into the system and their influence travels through the hidden units until they are coded into phonemes.
  - Training consists of adjusting the weights within the network so that the discrepancy between the input and the desired output is systematically reduced.