Chapter 12

The Cognitive Revolution

Outline

- The Decline of Behaviorism
- Early Theories in Cognitive Psychology
- The Rise of Cognitive Science
- The Nature of Cognitive Science
- Cognitive Science at Maturity: Debates and Developments
- The Study of the Mind at the New Millennium

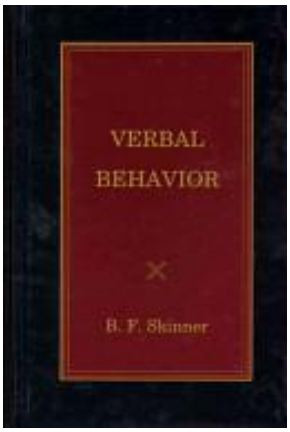
THE DECLINE OF BEHAVIORISM

The Decline of Behaviorism
Cartesian Linguistics

- Avram Noam Chomsky (1928-)
  - Radical in politics and linguistics
  - Revived Descartes rationalistic program
    - Language as the organ reason expresses itself
    - Resurrecting the notion of innate ideas
  - Conflict with behavioral treatments of language

The Attract on Verbal Behavior

- Chomsky's review of *Verbal Behavior*
  - Pure mythology
- His main criticism: Equivocation
  - Cannot be applied to human language
  - If metaphorically extended, they become vague
- Concepts criticized
  - Stimulus and reinforcement



The Attack on Verbal Behavior

- Stimulus
- Chomsky
  - To say that verbal behavior is under stimulus control is scientifically empty
  - Definition of stimulus is vague and metaphorical
    - Ex: suffix -ed

The Attack on Verbal Behavior

- Reinforcement
- Chomsky
  - Reinforced without emitting response
  - Reinforcing stimulus may not affect the reinforced person or even exist

The Attack on Verbal Behavior

- Did not accept Skinner's *Verbal Behavior* as a plausible scientific hypothesis
- Muddled and fundamentally wrong
- Overthrow behaviorism
  - cannot be built upon, only replaced

Chomsky's Influence

- Rationalist, Cartesian perspective
- Behaviorist approach to language cannot cope with its creativity or flexibility
- Language is a rule-governed system
  - Grammatical rules that allow for generation of new sentences by combining linguistic elements
- Behaviorists should not ignore these rules

Chomsky's Influence

- Nativist theory of language acquisition
- Language acquisition device
  - Guides the acquisition of native language
- Language is unique to humans
  - More nativist than Descartes

Chomsky's Influence

- Psychologists thought Behaviorist views were wrong
  - Chomskian
- More empirical research than Skinner
- George Miller
  - Abandoned behaviorism
- The mind

Erosions of Spencerian Foundation: Constraints of Animal Learning

- Principles from animal experiments would illuminate the way all organisms learn
- Constraints on what and how animals learns
  - animals evolutionary history
- Keller Breland
  - Pig study
  - Questioned behaviorism's assumptions

Erosions of Spencerian Foundation: Constraints of Animal Learning

- John Garcia
  - Conditioned nausea
- Evolution constrains which stimuli may be associated with which response
- Shortcomings of Spencerian paradigm
  - Generalizability is flawed
- Supports Chomsky's claim
  - Humans are not simply complicated rats

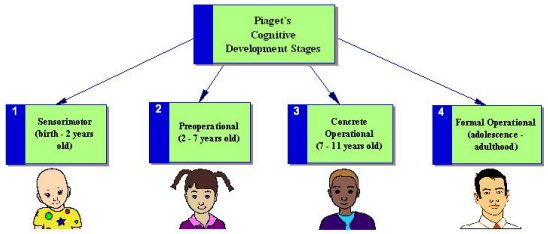
EARLY THEORIES IN COGNITIVE PSYCHOLOGY

The New Structuralism

- Movement in continental European philosophy, literary, criticism, and social science
  - Lévi-Strauss, Foucault, Piaget
- Carried on the Platonic-Cartesian rationalist attempt to describe the transcendent human mind
- Believed that human behavior patterns (individual or social) could be explained by reference to abstract structures of a logical or mathematical nature

Leading Structuralist – Jean Piaget (1896 – 1980)

- Swiss biologist and epistemologist
- Genetic epistemology to examine the development of knowledge in children
  - 4 stages of cognitive development



Structuralism – Piaget

- Problems:
  - Stages too rigid/well defined
  - Underestimated children's abilities
  - No account of individual differences or the effects of experience/learning

Structuralism - Chomsky

- Innate universal grammar
- Emphasis on abstract structure and indifference to individual differences
- Language explained as rule-governed systems

Cognition in Social Psychology

- Theory of cognitive dissonance
  - Leon Festinger (1919 – 1989)
- Festinger and Carlsmith (1959) classic turning screws study
- Cognitive psychology growing outside behaviorism
  - Beliefs control behavior, not beliefs mediating responses (i.e., behaviorism)

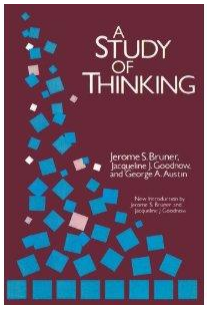
https://www.youtube.com/watch?v=korGK0yGIDo

The "New Look" in Perception

- Refuting that perception was a passive process
- Jerome S. Bruner (1915 –)
  - Psychoanalytic view
  - Perceiver plays an active role in perception
- Perceptual defense and subliminal perception studies
  - Bruner & Postman 1947; Postman, Bruner, & McGinnies, 1948
- Perception as an active mental process, with conscious and unconscious mental activities intervening between a sensation and a response

The Study of Thinking

- *A Study of Thinking* (1956)
  - Bruner
  - Formation of concepts and categories
- Concept formation = active process
  - Not associative process, meditational responses
  - Construct and follow strategies/decision procedures



THE RISE OF COGNITIVE SCIENCE

The Rise of Cognitive Science

- Scientific revolution → human vs. machine
  - E.g., Blaise Pascal and his calculator (1642)
- Methodological behaviorists
  - Tolman: cognitive maps
  - Physiological (Lashley): reducing mind to brain processes
  - Radical: dismissed the mind, mental was not a behavior

The Rise of Cognitive Science

- Problem of the mind
  - Hull (physicalism): physical cause-precedes-effect
  - Tolman – purposive behavior, in living things

VS.

Purposive Machines

- Industrial Revolution – mechanization of work
  - To replace humans and animals
- Problem: getting machines to produce energy and not blow-up
- E.g., steam engines
  - 1788 James Watt: centrifugal (Watt) governor
- Purposive, goal-directed machine
  - "Solved" the Tolman vs. Hull problem

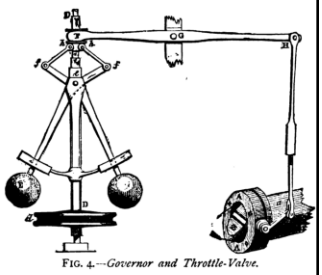
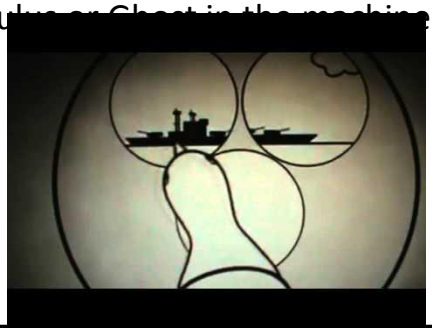


FIG. 4.—*Governor and Throttle-Valve.*

Purposive Machines:

Project OrCon

- Concept of feedback (in 1943) – not conceptualized/available to Watt
- Project OrCon (Organic Control) – B.F. Skinner
  - Developed a pigeon-guided missile
  - Homunculus or Ghost in the machine



Purposive Machines

- Informational feedback (1943)
  - Purpose + mechanism
  - Rosenblueth, Wiener, and Bigelow (1943/66)
- E.g., thermostats and heat pump
  - Feedback loop
  - Purposive device
  - Changed the mechanistic view of nature (e.g., clocks)

Purposive Machines

- Concept of information
  - E.g., thermostats and sensors
  - Two different physical devices, both controlled by information
- However, these devices are single-purpose behaviours
  - People are not; general-purpose

Reverse Engineering the Mind: Artificial Intelligence

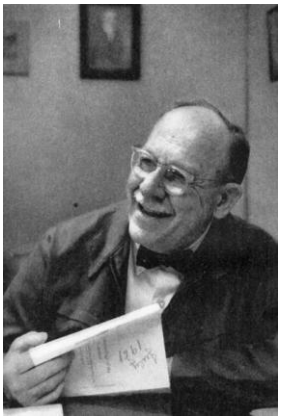
- A.M. Turing 1930s – concept of general-purpose computers
  - Imitation game
  - Turing Test – criterion for AI
- Defined the field artificial intelligence (AI) and established cognitive science

Artificial Intelligence

- Coined by scientist John McCarthy (1927 – 2011)
- Pure AI – imitate behavior
  - E.g., modern chess-playing "brute force" programs
- Computer simulation – imitate the human and its mind

Disentangling Mind and Body, Program and Computer

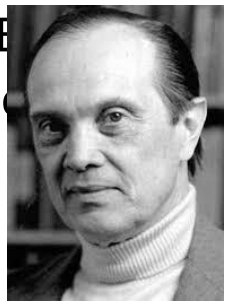
- Edwin G. Boring (1946)
  - What would a robot have to do to be called intelligent?
  - "Certainly a robot whom you could not distinguish from another student would be an extremely Convincing demonstration of the mechanical nature of man and the unity of science."



Disentangling Mind and Body, Program and Computer

- Jaroslav A. Deutsch (1953)
  - Created an electromechanical model capable of learning mazes and insightful reasoning
- Donald E. Broadbent (1958)
  - Proposed a mechanical model of attention and short-term memory
  - Argued that input to the senses should be thought of as information, not as physical stimuli

Disentangling Mind and B
Program and Computer



- George Miller
  - The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Information Processing (1956)
  - Moved away from an eclectic behaviorist position on human learning
  - Set the stage for research about information processing

Disentangling Mind and Body, Program and Computer

- In the 1950s, people began to think of the human brain as a computer, born with certain hardware and programmed by experience
- Psychologists turned to the goal of understanding how human beings process information

Disentangling Mind and Body, Program and Computer

- In 1956, a conference on the new field of "artificial intelligence" was held at Dartmouth College
- "Every aspect of learning or any other feature of intelligence can in principle be so precisely defined that a machine can be made to simulate it."

Simulating Thought

- Allan Newell, J.C. Shaw and Herbert Simon
  - "Elements of a Theory of Problem Solving" (1958)
  - Wrote programs that would solve problems
    - The Logic Theorist
    - General Problem Solver
  - Unlike AI, these *computer simulation programs* claim to simulate human thought, not just human behavior
  - Little immediate influence, GPS abandoned

Man the Machine

- During the 1960s, cognitive psychology was booming and its influence extended into clinical psychology
- Psychologists came to accept “the familiar parallel between man and computer”
- Theories about mental processes were thought of in the language of the computer – input, processing and output

Behaviorism Defeated or Marginalized

- 1960s and 70s – information-processing theory gradually replaced mediational theory as the language of cognitive psychology
- Radical behaviorism continued to exist, but was confined to a “publications ghetto”
- Herbert Simon (1980) declared that a revolution had occurred

The Myth of the Cognitive Revolution

- Was the cognitive revolution an illusion?
- Cognitive psychologists believe that a Kuhnian scientific revolution occurred in the 1960s
- Information-processing psychology could also be thought of as a new form of behaviorism
- Evolutionary period in psychology, but perhaps not revolutionary

THE NATURE OF COGNITIVE SCIENCE

The Nature of Cognitive Science Informavores: The Subjects of Cognitive Science

- Cognitive science: The science of informavores
- All information-processing systems operate according to the same principles
- Two goals:
  1. Complex behavior reduced to simple behavior
  2. Human thinking reduced to neurophysiology
- Functionalism

The Minds of Informavores: The New Functionalism

- Functionalism extends to include humans
- People use wetware
- Mind is a set of computational functions that runs the body
- Predict, control, explain by understanding the human “program”

The Minds of Informavores: The New Functionalism

- Solution to the behaviorists problem
  - How to explain intentionality of behavior without teleology
- Functionalism
  - preserves Hull and Tolman approach
  - Processes of computer programs
- Hull and Tolman were right
  - Computational approach put their insights together

COGNITIVE SCIENCE AT MATURITY: DEBATES AND DEVELOPMENTS

Uncertainties in 1980's

- Herbert Simon oversold the promise of AI
  - E.g., computers will be the world's chess champion
  - E.g., machines will be able to do anything man can do
- Signs on unhappiness
  - Lack of direction, looking at trivial things
  - Field is not advancing or developing
  - No major developments since 1971
  - Narrow field

Debates: The Challenge of Intentionality

- Mental states refer to something beyond themselves, they represent something
- Representations have both semantics and syntax
- Example: the written word "desk"
- Example: playing chess with a computer

Debates: Is the Turing Test Valid?

- The "Chinese Room" test demonstrates that the Turing test is not a good measure of intelligence because it passes the test without any understanding
- One of the most contentious papers in the history of cognitive science

Debates: Is Formalism Plausible?

- The idea that computers can do "anything a man can do" assumes that anything a person does is a formal procedure
- Computer programs are not able to make decisions that humans make without formal thought a are caught in the frame proble
  - Daniel Dennett's robot story

Developments
The New Games in Town: The New Connectionism

- Connectionism
- Revived parallel processing
  - computer science and psychology converged
  - Hardware
- 2 important issues for new connectionist
  - Parallel machines could learn
  - Brain is not a sequential device

The New Games in Town: The New Connectionism

- Connectionist is computational
  - Write computer models that emulate behavior
- Uses different rules and representations
- Computation theory to understand the differences

Developments: Level of computation

- 3 hierarchal levels of the analysis of intelligent action
  - Cognitive level
  - Algorithm level
  - Implementation level
- Should psychological theories of learning and cognition be concerned with implementation?
- What psychological change occurs when consciousness is no longer needed?

Developments: The Conscious and Intuitive Processors

- Smolensky:
  - Conscious processor: engaged when consciously think of a task/problem
  - Intuitive processor: do it without conscious thought
- What happens during the transition?
  - Difficult to resolve
  - Rule-following versus rule-governed behavior

The Conscious and Intuitive Processors

- The issue is whether or when human behavior is rule-following
- Symbol system
  - The conscious and intuitive processor are rule-following and rule-governed systems
- Connectionist
  - Rule following only at conscious level

Developments: Cognitive Neuroscience

- Human mind is a hybrid of symbol system and connectionist
  - At the neural level, learning and cognition carried out by connectionist processes
  - The rational aspects of the mind are a serial processor
- Daniel Dennett
  - Multiple drafts model consciousness
  - Consciousness is a serial machine implemented in the brain's parallel architecture which is the intuitive processor

Cognitive Neuroscience

- Aided by the Decade of the Brain
- Revived the path through physiology
  - Cognitive Neuroscience

Developments: Rejecting the Cartesian Paradigm: Embodied Cognition

- Embodied cognition
  - Rejects symbol-system conception
- Suspicious over 4 tenets of the Cartesian paradigm
  - Computationalism
  - Neurocentrism
  - Bodily indifference
  - Separability thesis

Rejecting the Cartesian Paradigm: Embodied Cognition

- Intelligence is rooted in bodily interactions
  - Aglioti et al. (2008)
- Extended mind
- Developed in the field of AI
  - Robotics
  - Rodney Brooks

Rejecting the Cartesian Paradigm: Embodied Cognition

- Embodied cognition and behaviorism are similar
  - Realistic perception
  - Interaction between organism and world
- The difference
  - Embodied cognition assume minds are the natural kind
  - Radical behaviorist think the concept of the "mind" should be dropped
- Same idea of psychology
  - The study of the organism interacting with the world

THE STUDY OF THE MIND AT THE BEGINNING OF THE NEW MILLENNIUM

The New Millennium

- Scientific study of the mind (cognitive neuroscience) flourished
- Breakthrough after breakthrough

- Dissenter (John Horgan)
  - Breakthroughs, but no overarching picture of the human mind
  - Human mind/brain cannot understand itself
  - No applications

American journalist, science writer

Conclusion & Summary

- Cognitive sciences replaced behaviorism as the dominant approach to psychology
- Psychologists began to think of the human brain as a machine, and turned their research toward information processing
- The cognitive revolution laid the groundwork for a new approach to the study of the mind – cognitive neuroscience

Study Questions

- What did Chomsky have to say about Skinner's *Verbal Behaviorism?*
- What are the two shortcomings that lead to the development of connectionist?
- What are the three hierarchal levels proposed by Marr and how do they explain the difference between connectionist and symbol system?
- How was symbol system and connectionist reconciled?
- Describe three important ideas of embodied cognition.
- How did the invention of machines influence the study of cognitive processes?
- What is the difference between artificial intelligence and computer simulation? How does this relationship mimic that of behaviorism and cognitive science?