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


- 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=korGK0yGI0](https://www.youtube.com/watch?v=korGK0yGI0)

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

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.”

• 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 Body, 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 and are caught in the frame problem
  – 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?