Psychology 354
The Cognitive Sciences: One Or Many?

Brief Course Overview

A Fragmented Psychology

A Unified Cognitive Science

Cognitive Science Or The Cognitive Sciences?

Michael R.W. Dawson

- PhD from University of Western Ontario
- Research interests in foundations of cognitive science, artificial neural networks, embodied cognitive science
- Research methods include computer simulation and LEGO robot fabrication
- For details about my research, **go to my home web page**

Course Objectives

- To introduce the foundational assumptions of cognitive science
- To expose students to the elements of three major positions in cognitive science: classical, connectionist and embodied
- To determine whether there is one cognitive science, or many

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Course WWW Support

- **There is an eClass site for this course**
- **Also, there is extensive web site support for this course.**
  - Syllabus
  - Slide handouts
  - Textbook for 2019
  - Quiz and midterm feedback
  - Slides
  - Notices to class (on home page)
 - Links to relevant material on other sites

www.bcp.psych.ualberta.ca/~mike/Pearl_Street/PSYCO354/

Course Evaluation

- **Midterm exam worth 30%**
  - Exam format: 10 written definitions + one 3-4 page essay, with some choice
- **Cumulative final exam worth 50%**
  - Exam format: same as midterm, cumulative essay, definitions post-midterm
- **Ten 10-minute quizzes worth 20%**
    - Quiz format: Short answer essay based on required readings
- **Check the syllabus for the schedule!**

Required Textbook

- **Dawson, M.R.W. (2013).** *Mind, Body, World: Foundations of Cognitive Science*
- **Link to book information from course website takes you to a site that also provides a free pdf of the book**
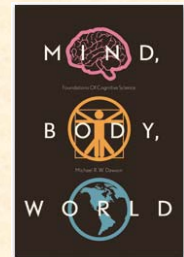
Discussion Topic

What is cognitive science?

The UCSD Definition

"The Department of Cognitive Science emphasizes three main areas of study: the brain-the understanding of neurobiological processes and phenomena; behavior-the experimental methods and findings from the study of psychology, language, and the sociocultural environment; and computation-the powers and limits of various representational formats, coupled with studies of computational mechanisms. This approach involves a multidisciplinary study of cognition with emphasis on computer science, linguistics, neuroscience, psychology, and related aspects of anthropology, biology, mathematics, philosophy, and sociology."

-- from the UCSD web site

University of California
San Diego
InfoPath

The Rutgers Definition

" The approach in cognitive science, in contrast with the approach taken by other investigators interested in similar issues, is essentially computational. The goal is to understand such aspects of intelligent performance as perception, language processing, planning, problem solving, reasoning, and learning, in terms of the computational processes that underwrite these skills, as well as the computational mechanisms (be they silicon hardware, or neural tissue) that may instantiate them. The pursuit is essentially multi-disciplinary and involves techniques and knowledge drawn from experimental psychology, computer science, neuroscience, philosophy, linguistics, mathematics, and engineering."

Welcome to
Rutgers
The State University of New Jersey

The Waterloo Definition

"Cognitive Science is the interdisciplinary study of mind and intelligence, embracing psychology, philosophy, linguistics, neuroscience, anthropology, computer science and engineering. The study of mind is exciting for theoretical reasons, since the attempt to investigate the nature of thinking is as challenging as anything attempted by science. […] The study of mind is inherently interdisciplinary, requiring the diverse insights and methodologies of psychologists, philosophers, computer scientists, linguists, neuroscientists, anthropologists, and other thinkers."

-- from the University of Waterloo web site

University of
Waterloo

A Shared Foundation

- The Sloan Foundation "provided grants to several universities with the condition that the funds be used to promote communication between disciplines" (Miller, 2003, p.143)
- Each discipline "had progressed far enough to recognize that the solution to some of its problems depended crucially on the solution of problems traditionally allocated to other disciplines" (Miller, 2003)
- Communication difficulties within single disciplines like psychology. How can interdisciplinary communication, required in cognitive science, be possible?

ALFRED P. SLOAN FOUNDATION
S
1934

Psychology Is Born

- Modern experimental psychology is rooted in two seminal publications from the second half of the 19th century, Fechner's 1860 *Elements of Psychophysics* and Wundt's (1873) *Principles of Physiological Psychology*
- At the time of these publications, psychology arose as a broad, unified science

ELEMENTE
PSYCHOPHYSIK

Wilhelm Wundt
Grundzüge der physiologischen Psychologie
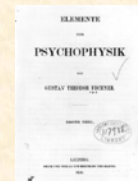
Unified At Birth

"This general significance of the experimental method is being more and more widely recognized in current psychological investigation; and the definition of experimental psychology has been correspondingly extended beyond its original limits. We now understand by 'experimental psychology' not simply those portions of psychology which are directly accessible to experimentation, but the whole of individual psychology" (Wundt & Titchner, 1873/1904, p. 8)

Wilhelm Wundt

Edward Titchner

Crisis In Psychology

- Not long after its creation, psychology fractured, producing what Bühler called in 1927 a crisis in psychology
- For Sigmund Koch (1993, p. 902) "psychology is misconceived when seen as a coherent science or as any kind of coherent discipline devoted to the empirical study of human beings. Psychology, in my view, is not a single discipline but a collection of studies of varied cast, some few of which may qualify as science, whereas most do not."

Karl Bühler

Psychology Is Fractured

- Leahey (1987, p. 3) calls psychology a "large, sprawling, confusing human undertaking."
- "It is as though opposing armies were fighting battles in order to win the right to define the nature of the war" (Boden, 1981, p. 71)
- Psychology is "a bunch of men standing on piles of their own crap, waving their hands and yelling 'look at me, look at me'" (Gilbert, 2002).

Thomas H. Leahey

Margaret Boden

A Narrow Vision

- Specialization and fracturing within psychology narrows its vision
- "Psychologists often ignore work outside their own laboratories, usually ignore work outside their own sub-specialties, and almost always ignore work outside their own discipline" (Gilbert, 2002, p. 3).
- In short, psychology is not interdisciplinary

Daniel Gilbert

From Content To Foundations

- One problem with being trained in psychology is that we are mostly exposed to content areas, and not to foundational assumptions. Indeed, psychology may not have any foundational assumptions to be shared!
- In contrast, cognitive science may permit diverse researchers to communicate with one another *because they share foundational assumptions!*

Cognitive Science Is Born

- Cybernetics arose in the 1940s when researchers from different disciplines used information theory and feedback as foundational ideas
- Cybernetics evolved into cognitive science by the end of the 1950s
- "I date the moment of conception of cognitive science as 11 September, 1956, the second day of a symposium organized by the 'Special Interest Group in Information Theory' at the Massachusetts Institute of Technology" (Miller, 2003, p. 142)
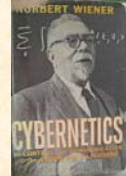
George Miller

Unity In Cognitive Science?

- Cognitive science **might** be less fractured than psychology
- "I went away from the symposium with the strong conviction, more intuitive than rational, that human experimental psychology, theoretical linguistics, and computer simulation of cognitive processes were all part of a larger whole" (Miller's reaction to the 1956 Symposium On Information Theory).

George Miller

A Shared Foundation

The Information Processing Hypothesis

The human mind is a complex system that receives, stores, retrieves, transforms and transmits information

What are the implications of this assumption?

- Communication
- Research methods
- Research questions
- Interdisciplinary studies

Classical Cognitive Science

- The information processing hypothesis united cognitive science because 'information processing' was taken by most to mean 'the kind of processing digital computers do'
- This led to incredible breakthroughs in the study of problem solving and language
- This also led to the development of computer simulations of high-level cognition

Allen Newell and Herbert Simon

Noam Chomsky

Classical Foundations

- Classical cognitive science sees cognition as the rule-governed manipulation of symbols
- It is inspired by the digital computers of the 20th century
- It's key idea is the physical symbol system
- Its key architectures are the Turing machine, the von Neumann machine, and the production system
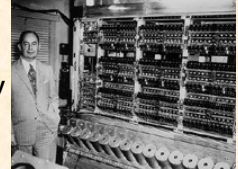
Von Neumann and the EDVAC

Broken Promises

- By the mid-1970s, however, cognitive science began to fracture
- First, the promise of the classical approach had failed to materialize
- "An overall pattern had begun to take shape…: an early, dramatic success based on the easy performance of simple tasks, or low-quality work on complex tasks, and then diminishing returns, disenchantment, and, in some cases, pessimism" (Dreyfus, 1992, p. 99).
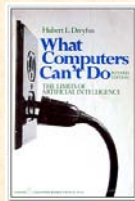
Hubert L. Dreyfus

Connectionist Cognitive Science

- Second, alternative and antagonistic approaches emerged
- Connectionism abandoned the notion of rules, symbols, and digital information processing
- It replaced them with fuzzy, parallel distributed processing models inspired by the brain
- This led to advances in complex pattern recognition and machine learning


David Rumelhart

Jay McClelland

Connectionist Foundations

- **Connectionist cognitive science views cognition as emerging from multiple, simultaneous and simple processes**
- **It is inspired by the architecture of the brain**
- **It's key idea is parallel distributed processing**
- **Its key architectures are the perceptron, the multi-layered perceptron, and the autoassociative network**
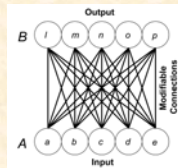
Standard Pattern Associator

Embodied Cognitive Science

- **Another reaction against classical cognitive science was embodied cognitive science**
- **It replaced classical emphasis on planning with a new emphasis on action, and feedback between the world and the agent that depended on the agent's embodiment**
- **This led to the development of the "new robotics" and the notion of the extended mind**

James J. Gibson

Terry Winograd

Embodied Foundations

- **Embodied cognitive science views cognition as emerging from structured relations between an agent and its world**
- **It is inspired by replacing planning with acting**
- **It's key ideas are situatedness and embodiment**
- **Its key architectures are behavior-based robots**

Machina speculatrix

Domo

Three Schools Of Thought

- **Between September 11, 1956 and today cognitive science appears to have splintered into three schools of thought**
  - **Classical cognitive science**
  - **Connectionist cognitive science**
  - **Embodied cognitive science**
- **Each school of thought appears to use a very different language to explain cognition**
- **The three schools of thought are frequently at odds with one another**

Tension Between Positions

- "The problem with connectionist models is that all the reasons for thinking that they might be true are reasons for thinking that they couldn't be psychology" (Fodor & Pylyshyn, 1988, p. 66)

Zenon Pylyshyn

- "The idea that human activity is determined by rules is not very plausible when one considers that most of what we do is not naturally thought of as problem solving" (Horgan & Tienson, 1996, p. 31)

Terry Horgan

- "Models of the world simply get in the way. It turns out to be better to use the world as its own model" (Brooks, 1991, p.139)

Rodney Brooks

Language And Science

- Many would agree with Borges' claim in 'The Library of Babel' that a language exists to express ultimate knowledge
  - "It is verisimilar that these grave mysteries could be explained in words: if the language of philosophers is not sufficient, the multiform Library will have produced the unprecedented language required, with its vocabularies and grammars"

Jorge Luis Borges

- For philosophers like Kuhn, fragmentation – different paradigms – are revealed in communication breakdowns between competing schools of thought (i.e. paradigms)

Thomas Kuhn

The Cognitive Sciences

- One possibility is that cognitive science is paradigmatic, and that the fractionation that we have discussed indicates qualitatively distinct approaches to explaining cognition

- "The modern fragmentation of cognitive science might be an example of communication breakdowns produced by the existence of incommensurable theories. For instance, it is not uncommon to see connectionist cognitive science described as a Kuhnian paradigm shift away from classical cognitive science (Horgan & Tienson, 1996; Schneider, 1987). When embodied cognitive science is discussed in Chapter 5, we will see that it too might be described as a new paradigm."

Cognitive Science

- A second possibility is that cognitive science is pre-paradigmatic, and that the fractionation that we have discussed indicates variety – to be later unified – in determining the core elements of cognitive theory

- "In the early stages of the development of any science different men confronting the same range of phenomena, but not usually all the same particular phenomena, describe and interpret them in different ways" (Kuhn, 1970, p. 17).

- "My suspicion is that cognitive science has achieved some general agreement about the kinds of phenomena that it believes it should be explaining. However, it is pre-paradigmatic with respect to the kinds of technical details that it believes are necessary to provide the desired explanations."