INTRODUCTION TO COGNITIVE SCIENCE
2010 FALL

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Venue: OU207
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Topics:
Cognitive science is the interdisciplinary study of mind and the nature of intelligence. It is a rapidly evolving field that deals with information processing, intelligent systems, complex cognition, and large-scale computation. The scientific discipline encompasses the overlapping areas of neuroscience, psychology, computer science, linguistics and philosophy. Students will learn the basic physiological and psychological mechanisms and computational algorithms underlying different cognitive phenomena.

Goals:
The first goal is to teach WHY cognitive science became a popular and efficient discipline to investigate natural and artificial information processing devices. The second goal is to give an introduction to the historical development of the field. The third goal is to show HOW to analyze the performance of cognitive systems. The course is designed mostly for psychology and computer science students, but other students interested in interdisciplinary thinking might take the class.

Prerequisites:
PSYC 101 and COMP 105 or permission.

Course Structure:
Each week a topic will be discussed. There will be some weekly reading assignments. During the term it will be possible to give reports on readings.

Exams:
There will be a sixty minute long written midterm and a final oral examination. **Active participation in class activities are strongly encouraged. Class discussion is a vital part of learning in this style of course.** Reports on readings and discussion forums might determine the grades up to 40%. Written and oral reports on a group project are a pre-requirement for taking the final examination.

Book required:

Paul Thagard: Mind : Introduction to Cognitive Science.
Cambridge, MIT Press. (MIT Press, 1996), (2nd edition, 2005). (I will

refer to it as T:M)

Supporting literature:

Cognitive Science Resources
http://cogsci.uwaterloo.ca/courses/resources.html

Gazzaniga MS, Ivry RB and Mangun GR: Cognitive Neuroscience. The Biology of Mind. Third Edition, WW Norton Co. 2009

Mind Readings: Introductory Selections on Cognitive Science
by Paul Thagard (Editor) MIT Press, 1998)

Firth, Ch: Making up the Mind. How the Brain Creates our Mental World. Blackwell 2008

Weekly Topics:

1.Cognitive science: a true interdisciplinary field

A very good summary can be found at:
http://plato.stanford.edu/entries/cognitive-science/

Disciplines:
Philosophy
Psychology
Computer science and AI
Neuroscience
Linguistics
Anthropology

Overview:
History
Methods
Representation and computation
Theoretical approaches
Philosophical relevance

Why we are NOT using a single textbook?
Two different approaches exist:

I. Assumptions about the representation of the knowledge in the mind (logic, rules etc.)

II. Cognitive functions (learning, memory, emotions, decision making etc.)
Reading: T:M Chapter 1.

This class integrates the two approaches.

Key question: *how can the different disciplines interact to understand mind*?

2.Knowledge Representation: Logic, Rule-based systems and others

Mind might contain mental representations:

Formal logic
Rules
Concepts
Analogies
Images
Connections

Formal logic

- People have mental representations similar to sentences in predicate logic.
- People have deductive and inductive procedures that operate on those sentences.
- The deductive and inductive procedures, applied to the sentences, produce the inferences.

(You certainly should know the most important inferences:

Modus ponens: 1. If P, then Q . 2. P. Therefore, Q.
Modus tollens: 1. If P, then Q. 2. Q is false. Therefore, P is false. (indirect proof)*)*

The scope and limits of the approach of formal logic (and deductive reasoning. Two papers for group discussion:

Philip N. Johnson-Laird: Human reasoning and rationality:
www.pul.it/irafs/CD%20IRAFS'02/texts/Johnson%20Laird.pdf

Rips, L. J.:. Two kinds of reasoning. *Psychological Science, 12,* 129-134, 2001

to be downloaded from http://www.psych.northwestern.edu/~rips/

Readings: T:M Chapter 2 and 3.

Rules

- People have mental rules.
- People have procedures for using these rules to search a space of possible solutions, and procedures for generating new rules.
- Procedures for using and forming rules produce the behavior.

Rule-based systems:
manipulation and transformation of symbols

Rule-based programs for AI and cognitive science:

0. ELIZA http://en.wikipedia.org/wiki/ELIZA

1. Newell and Simon, GPS 1950s-60s

2. Expert systems, 1970s-90s. Most corporations.

3. ACT 1983. John Anderson.

4. SOAR, Newell and his students, 1980s, John E. Laird (Univ. Michigan)

5.Prolog: logic programming

Strength and weakness of the rule-based systems

Rules of Language: from Chomsky to Pinker

Noam Chomsky:
http://en.wikipedia.org/wiki/Noam_Chomsky

Steven Pinker: "Rules of Language

http://www.sciencemag.org/cgi/content/abstract/253/5019/530

3. Neural Networks and Connectionism

Logic and rules are the main forms of mental representations of the classical, symbolic approach. McCulloch-Pitts neurons connects logic to networks. How to calculate with MCP neurons and networks?

http://www.mind.ilstu.edu/curriculum/modOverview.php?modGUI=212

A learning machine: the Perceptron.

Connectionism offered and alternative to this symbolic approach. The most celebrated book of the connectionist alternative is:

A first reading on connectionism:
http://en.wikipedia.org/wiki/Connectionism

Second reading:

Connectionism: an introduction
http://www.mind.ilstu.edu/curriculum/modOverview.php?modGUI=76

Perceptron: a learning machine
http://www.csulb.edu/~cwallis/artificialn/History.htm
http://www.cis.hut.fi/ahonkela/dippa/node41.html

Read also: T:M Chapter 7.

4.The Brain

Experimental methods and disciplines

Levels

Neural representation: cells, networks, modules

Neural computation versus computational neuroscience

Brain states, mental states and the effect of molecules

Read T:M Chapter 9

http://geza.kzoo.edu/~erdi/brain.pdf

5. Memory and Learning: Concepts and Models

Theories of learning and memories

Models of short-term (working) memories

Models of long-term memories

Human memory, brain damage, and amnesia

Cellular bases of learning and memory

Long-term memory and hippocampus

T-M: Chapter 9.
Gazzaninga et al. Chapter 8.

6.Language: Acquisition and Evolution

Read:

Pinker: Language Acquisition
http://www.ecs.soton.ac.uk/~harnad/Papers/Py104/pinker.langacq.html

Mirror neurons and imitation learning

http://www.scholarpedia.org/article/Mirror_neurons

V.S. Ramachandran
http://www.edge.org/3rd_culture/ramachandran/ramachandran_p1.htm

7. Human Information Processing

Decoding and Interpreting signals

Information theory

Information-processing and cognition

Information updating: Bayesian theory

http://reverendbayes.wordpress.com/2008/05/29/bayesian-theory-in-new-scientist/

Firth p 119-124.

8-9. Consciousness, Emotions and Subconsciousness

Consciousness: from philosophy to experiments

Crick, F. and Koch, C A framework for consciousness. *Nature Neuroscience* (2003) **6**, 119-126
to be downloaded from
http://www.klab.caltech.edu/cgibin/publication/reference.pl?refdbname=paper

CONSCIOUSNESS EXPLAINED By Daniel C. Dennett
read a review from the New York Times:
George Johnson:
http://www.santafe.edu/~johnson/reviews.dennett.html

What are emotions?
How to represent emotions?
A useful website on emotion:

Emotional Circuits and Computational Neuroscience

http://www.snl.salk.edu/~fellous/pubs/Emotion-HBTNN2e-preprint.pdf

Can Computers Have Emotions?
http://www.inf.ed.ac.uk/events/hotseat/panel_statements.html#andy_position

Embodied cognition: Olaf Sporns

http://php.indiana.edu/~osporns/sporns.pdf

The neural basis of psychonalysis: from Sigmund Freud to Eric Kandel

Amit Etkin, M.Phil, Ph.D., Christopher Pittenger, M.D., Ph.D., H. Jonathan Polan, M.D. and Eric R. Kandel, M.D.**:** Toward a Neurobiology of Psychotherapy: Basic Science and Clinical Applications .

J Neuropsychiatry Clin Neurosci 17:145-158, May 2005

T:M Chapter 10. and 11.

10. **Summary and Outlook**

Cognitive science is an interdisciplinary study of mind and intelligence.

Levels, methods, the need of integration.
Open problems
Institutions, graduate programs
T:M Chapter 14.