PSYD50-08S: Current Topics in Memory and Cognition

Topic: ***The Cognitive Neuroscience of Knowledge Representation***

Class Meeting Time: Wednesday 10-12 Classroom: MW223

Contact Information for Instructor:
Instructor: Prof. George Cree
Office: S-559 Office Phone: (416) 287-7439 Email: george.cree@utoronto.ca

Introduction to the Course
This course deals with the cognitive neuroscience of knowledge representation, a 'hot topic' in cognitive neuroscience that has deep roots in classical philosophy. We will focus on two related content areas: object recognition and semantic memory. Knowledge representation is a large field of research, so we will focus specifically on the representation of object concepts (i.e., objects you can touch, such as dogs and hammers) and abstract concepts (e.g., truth and justice), two areas that border an important frontier in our understanding of how knowledge is represented in the human mind/brain. We will examine current psychological theories of both, evaluating supporting evidence drawn from many different approaches, including behavioral psychological testing, patient-based testing, functional brain imaging, computational modeling, single-unit recording, and philosophy.

Major emphasis will be placed on the constraints on theorizing that have come from the study of patients with category-specific deficits. These are object recognition and/or knowledge impairments observed in people who have suffered some form of brain injury or disease, such as a closed-head injury or herpes simplex encephalitis. Such brain damage sometimes results in a significant loss of knowledge in a specific domain (e.g., animals) with almost no loss in others (e.g., fruits and vegetables or tools). Over 100 case studies have been reported in the literature to date, and these case reports provide a rich source of data for constraining theories of knowledge representation.

There are several reasons why I believe this topic is ideal for study in a course at this level. First, the deficits are fascinating, and trying to make sense of the complex patterns of impairment provides a challenging intellectual puzzle. Second, there is no universally accepted account of how or why these patterns of deficits occur. There are currently three major classes of theories, all incomplete, jockeying for position as the all-encompassing theory that will explain how knowledge is stored in the brain. We will evaluate these theories, and it will be your job to decide which one you think is closest to the truth. Finally, many mistakes have been made by researchers along the way, including the use of poorly designed tests, use of questionable data analysis techniques, and pronouncement of inconsistent theoretical claims. The literature is thus replete with examples of what to do, and what not to do, when conducting research, and these will be used to illustrate a rigorous, yet appropriately skeptical, scientific approach to conducting research and developing theory.

By the end of this course you should have a deep understanding of the main issues in the field. You should also have a feel for the strengths and weaknesses of each the main approaches used

to study the topic, and you should have formed strong, justified opinions about how you think knowledge is stored in the mind/brain.

I will provide questions to help guide and focus your reading each week. The answers to these questions will subsequently be discussed in class.

Topics and Required Readings:

- ***Week 01: Introduction to the Cognitive Neuroscience of Knowledge Representation***
  - This week we will discuss the course content, methods of evaluation, and other related information. We will also very briefly discuss visual agnosia, category specific deficits, and perceptual symbol systems (PSS) theory (Barsalou, 1999), and consider the value of PSS as a theory of knowledge representation.
  - Readings for Week 2:
    - Sacks, O. (1970). The man who mistook his wife for a hat. In O. Sacks [ed.], *The Man Who Mistook His Wife for a Hat, and other Clinical Tales.* (pp. 8-22). New York, NY: Harper & Row Publishers.
    - Chapter 1 of: Farah, M. J. (2004). Visual Agnosia, 2nd Edition. Cambridge: MIT Press/Bradford Books.
    - Barsalou, L. W., Simmons, K., Barbey, A. K., & Wilson, C. D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences, 7(2),* 84-91.

- ***Week 02: Visual Agnosia and Object Recognition***
  - This week we will discuss visual agnosia in more detail, examine perceptual symbol system theory in more detail, and begin to discuss how objects might be represented in the ventral visual stream.
  - Readings for Week 3:
    - Quiroga, R. Q., Kreiman, G., Koch, C., & Fried, I. (2008). Sparse but not 'Grandmother-cell' coding in the medial temporal lobe. *Trends in Cognitive Sciences, 12(3),* 87-91.
    - Connor, C. E., Brincat, S. L., & Pasupathy, A. (2007). Transformation of shape information in the ventral pathway. *Current Opinion in Neurobiology, 17,* 140-147.

- ***Week 03: Grandmother Cells?***
  - This week we will discuss the forms of representation employed by the human visual system, and evaluate the evidence both for and against sparse and distributed visual representations.
  - Readings for Week 4:
    - Tarr, M. J., & Vuong, Q. C. (2002). Visual Object Recognition. In H. Pashler (Series Ed.) and S. Yantis (Ed.), *Stevens' Handbook of Experimental Psychology (Third Edition): Vol. 1. Sensation and Perception* (pp.287-314). New York, NY: John Wiley & Sons.

- ***Week 04: Cognitive Theories of Visual Object Recognition***

- This week we will continue our discussion of theories of visual object recognition to include cognitive theories that can be extended to all classes of objects.
- Readings for Week 5:
  - Kanwisher, N. (2000). Domain specificity in face perception. *Nature Neuroscience, 3(8),* 759-763.
  - Tarr, M. J., & Gauthier, I. (2000). FFA: a flexible fusiform area for subordinate-level visual processing automatized by expertise. *Nature Neuroscience, 3(8),* 764-769.

- ***Week 05: Domain Specificity in Face Perception?***
  - This week we will review the modularity debate as it applies to face perception, and decide whether the evidence best supports a module that has evolved due to evolutionary pressures to recognize faces, or rather, whether specialization for face processing arises due to the types of computations required to discriminate among highly visually similar objects.
  - Readings for Week 6:
    - Martin, A. (2007). The representation of object concepts in the brain. *Annual Review of Psychology, 58*, 25-45.

- ***Week 06: The Representation of Object Concepts in the Brain***
  - This week we will examine what has been learned about object concept representation through the use of fMRI.
  - Readings for Week 7:
    - Haxby, J. V., Gobbini, M. I., Furey, M. L., Ishai, A., Schouten, J. L., & Pietrini, P. (2001). Distributed and overlapping representations of faces and objects in ventral temporal cortex. *Science, 293*, 2425-2430.
    - Garreau, J. (2006). Brain on Fire. *Washington Post*, Monday, October 30, 2006.

- ***Week 07: Mind Reading***
  - This week we will examine how modern neuroimaging techniques can be used to 'read minds'. We will explore the frontiers of this research, and discuss both the feasibility of extending the approach to reading more complex representations, and the associated legal and ethic concerns.
  - Readings for Week 08:
    - Forde, E. M. E., & Humphreys, G. W. (1999). Category-specific recognition impairments: A review of important case studies and influential theories. *Aphasiology, 13(3)*, 169-193.
      - Focus on pp. 169-183 for the quiz. Pages 183-190 review the theories that we will be discussing over the next couple of weeks.

- ***Week 08: What are the Facts of Category Specific Semantic Deficits?***
  - This week we turn to a review of category-specific semantic deficits literature, with the goal of linking impairments to visual object recognition with impairments to semantic memory.
  - Readings for Week 9:

        - Caramazza, A., & Mahon, B. Z. (2003). The organization of conceptual knowledge: The evidence from category-specific semantic deficits. *Trends in Cognitive Sciences, 7(8)*, 354-361.

- ***Week 09: The Domain Specific Hypothesis***
    - This week we review one of the three major theories of semantic organization that have been developed to account for the patterns of impairment observed in cases of category-specific semantic deficits: the domain specific hypothesis.
    - Readings for Week 10:
        - Tyler, L. K., & Moss, H. E. (2001). Towards a distributed account of conceptual knowledge. *Trends in Cognitive Sciences, 5(6),* 244-252.

- ***Week 10: The Conceptual Structure Account***
    - This week we will discuss the second major theory designed to account for the patterns of impairment observed in cases of category specific semantic deficits: the conceptual structure account.
    - Readings for Week 11:
        - Simmons, W. K., & Barsalou, L. W. (2003). The similarity-in-topography principle: Reconciling theories of conceptual deficits. *Cognitive Neuropsychology, 20(3/4/5/6),* 451-486.

- ***Week 11: The Similarity in Topography Principle***
    - This week we discuss the third major type of theory designed to account for the patterns of impairment observed in cases of category-specific semantic deficits: sensory/functional theory. We will discuss connections to perceptual symbol systems theory, and return to evaluate perceptual symbol systems theory as a general theory of knowledge representation.
    - Readings for Week 12:
        - Crutch, S. J., & Warrington, E. K. (2005). Abstract and concrete concepts have structurally different representational frameworks. *Brain, 128*, 615-627.

- ***Week 12: Abstract Concepts***
    - This week we will explore how the lessons learned from the study of object concept representations, both visual and semantic, can be extended to help understand how abstract concepts might be represented.

Recommended Readings:

Knowledge Representation

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*, 577-660.

Markman, A. B. (2002). Knowledge Representation. In D.L. Medin & H. Pashler (Eds.) *Stevens' Handbook of Experimental Psychology (3rd Edition), Volume 2.* (pp. 165-208). New York: John Wiley and Sons.

Reviews of the Category-Specific Deficits Literature (and an important case report)

Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003). What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. *Cognitive Neuropsychology, 20(3/4/5/6)*, 213-261.

Cree, G. S., & McRae, K. (2003). Analyzing the factors underlying the structure and computation of the meaning of chipmunk, cherry, chisel, cheese and cello (and many other such concrete nouns). *Journal of Experimental Psychology: General, 132(2),* 163-201.

Farah, M. J. (2004). *Visual Agnosia*, 2nd Edition. Cambridge: MIT Press/Bradford Books.

Warrington, E. K., & Shallice, T. (1984). Category specific semantic impairments. *Brain, 107*, 829-854.

Computational Models of Semantic Memory

Cree, G. S., & Armstrong, B. (in press). Computational models of semantic memory. In M. Spivey, K. McRae, & M. Joanisse [Eds.], *The Cambridge Handbook of Psycholinguistics*. Cambridge University Press.

Rogers, T. T., & McClelland, J. L. (in press). Precis of Semantic Cognition: A Parallel Distributed Processing Approach. *Behavioral and Brain Sciences*.

Methods of Evaluation:

Weekly Quizzes (best 10 of 11) *	30%	Weeks 2-12
Class Participation	10%	Evaluated Over all 12 Weeks
3 Short Papers *	30%	Due Weeks 3, 6, & 9
Final Term Paper	30%	Due Week 12

This course is designed to help you develop your critical thinking, research, and communication skills. Hence writing assignments are designed to emphasize understanding and integration of concepts, rather than regurgitation of details. Quizzes, however, will focus on facts, details, and critical thinking, to test how well you have understood the readings.

Information about Quizzes

The quizzes will consist of short answer questions based on the reading(s) assigned the previous week. They are designed to take 10-15 minutes. They will occur at the beginning of class. Please arrive at class on time – extra time will not be granted to students that arrive late.

Information about 3 Short Papers

You will be asked to write 3 short (750 words) papers on topics provided in class. They will be due at the beginning of class in weeks 3, 6, and 9. You must bring a printed copy of your paper to class to be used for peer evaluation, and ultimately, to be submitted during class. Note that you must also submit an outline that highlights your thesis statement, and topic sentences, at the end of your paper. See the document: SampleShortD50Paper.doc for an example.

* You have the option to substitute one 10 minute presentation (worth 10% of your final grade) for one of the three short papers (drop the lowest grade) or for 10% of the quiz component of your final grade (i.e., quizzes count for only 20% of final grade). Note that you are still required to complete all papers and quizzes. I will allow a maximum of 2 presentations per class, and presentation time slots will be assigned on a first-come, first-served basis. Presentation topics must be cleared by me before I will allow you to reserve a time slot. If given the opportunity to present, you must consult with me during office hours to make sure that your presentation is of sufficient quality for it to be presented to the class.

Information about the Term Paper
Final term papers will be due the last day of classes. They will be a maximum of 2500 words long, and must be on a topic directly related to the course content. The topic must be approved by the instructor. Possible topics will be suggested throughout the course.

Information about Class Participation
Students are expected to participate actively in class. Attendance in class is expected, and will not be rewarded. In other words, class participation marks must be earned, by contributing to the class discussion, be this by asking relevant and probing questions, answering questions posed by others, or posting relevant and interesting information, along with appropriate analysis, on the class discussion board. Note that discussion board participation will not be sufficient to achieve a good participation mark; it will help your mark, but it should not be the sole basis of your mark.

Academic Writing
Writing assignments make-up a large component of this course. If you are not comfortable with your writing abilities, or would like a quick refresher on specific topics, then be sure to make use of the following two excellent resources:

UTSC Writing Centre: AC 210, http://www.utsc.utoronto.ca/~tlsweb/TWC/index.htm
-- offers 20 min. drop in sessions, or 50 min. 1-1 sessions.

U of T Advice on Academic Writing: http://www.utoronto.ca/writing/advise.html
-- a fantastic source of materials on writing.

Policies on missed exams and assignments.
If you miss a class due to illness, be sure to get appropriate medical documentation. If you miss class due to a funeral, be sure to get a copy of the death certificate. If you plan to travel during the course, and miss a class as a result, you must clear this with the instructor before you travel if you wish to be excused from the relevant quiz. In the case of missed quizzes, your mark will be computed out of the remaining number of quizzes (e.g., if you miss 1 quiz, then your best 9 of 10 will make up the quiz component of your grade).

Please be aware that I cannot, by U of T policy, accept assignments after the last day of classes.

Policies on academic integrity

Please review the UTSC Code on Academic Behaviour:
http://www.utsc.utoronto.ca/courses/calendar/University_of_Toronto_Policies.html#Code_of_Behaviour_on_Academic_Matters

Access*Ability*
Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the Access*Ability* Services Office as soon as possible. The UTSC Access*Ability* Services staff (located in S302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or ability@utsc.utoronto.ca. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

The above schedule, policies, procedures, and assignments in this course are subject to change in the event of extenuating circumstances.