

## **Syllabus for Psych 411: Neural Basis of Cognitive Control**

**Semester:** Spring, 2014.

**Professor:** Yuri Saalman; Email: saalman@wisc.edu; Telephone: 262-8671; Office: Room 518, Brogden Hall.

**Course Description:** Cognitive control refers to processes such as response inhibition, selective attention, working memory and mental set shifting, which allow you to flexibly adapt your behavior according to current goals and context. A number of psychological disorders, including schizophrenia, attention deficit disorder, obsessive-compulsive disorder and addictions, show impaired cognitive control. Although a wealth of evidence supports a vital role for the prefrontal cortex in cognitive control, neuroscience is only at an early stage of understanding neural processing in prefrontal cortical circuits and in larger-scale circuits that also incorporate parietal cortex and subcortical areas. In this course, we will critically evaluate evidence from electrophysiology, functional magnetic resonance imaging and brain lesion studies, to gain a better understanding of cognitive control across multiple levels of brain processing, from the cellular to the network and systems levels.

**Learning Objectives:** Overarching goal is for students to learn, develop and use the latest ideas about neural mechanisms of cognitive control, to explain and predict behavior in healthy individuals and individuals with impaired cognitive control. To achieve this goal, students will investigate the neuroscience of cognitive control through seminars, research articles, class discussions, a short written assignment, and an informal oral presentation.

**Class time:** Tuesday 9.30-10.45am and Thursday 9.30-10.45am. Tuesday classes usually will be seminars on the weekly theme. Thursday classes will include student presentations and discussion of the weekly readings.

**Location:** Room 115, Brogden Hall.

**Grading:** 20% class participation; 30% written assignment; 20% oral presentation; 30% in-class quizzes.

A=93-100%, AB=88-92%, B=83-87%, BC=78-82%, C=70-77%, D=60-69%, F=0-59%.

Students are expected to read the assigned articles and prepare two brief questions about these articles, in advance of class on Thursday each week (no prepared questions for week 1). Questions should be emailed to saalman@wisc.edu before Thursday's class.

Students sign up to present one of the listed articles during the semester. The student presenter highlights the major points of the article, with the aid of a few slides. This oral presentation of 10 minutes duration will be followed by a class-wide discussion of the article.

The written paper assignment (1,500 words maximum) is a focused review on one of the neuroscience research topics covered in class. The assignment is due May 8, 2014.

Students will take two short quizzes in class, one quiz in the middle of the semester and the other at the end of the semester.

Readings are available online from the Student Center at My UW.

**Weekly themes and readings** (readings to be discussed on Thursdays):

**1: January 21 and 23.** *Cognitive control overview.*

[Instead of student presentations in week 1, Yuri Saalman will provide instructions on how to prepare the oral presentation and written assignment.]

**2: January 28 and 30.** *Prefrontal cortex organization.*

- Badre D, Hoffman J, Cooney JW, D’Esposito M (2009) Hierarchical cognitive control deficits following damage to the human frontal lobe. *Nature Neuroscience* 12: 515-522.

**3: February 4 and 6.** *Prefrontal cortex models.*

- Smittenaar P, FitzGerald TH, Romei V, Wright ND, Dolan RJ (2013) Disruption of dorsolateral prefrontal cortex decreases model-based in favor of model-free control in humans. *Neuron* 80: 914-919.

**4: February 11/13.** *Attention I: Psychophysics and the fronto-parietal network.*

- Wolfe JM, Horowitz TS, Kenner NM (2005) Rare items often missed in visual searches. *Nature* 435: 439-440 (also see supplementary online information).
- Verdon V, Schwartz S, Lovblad KO, Hauert CA, Vuilleumier P (2010) Neuroanatomy of hemispatial neglect and its functional components: a study using voxel-based lesion-symptom mapping. *Brain* 133: 880-894.

**5: February 18/20.** *Attention II: Neural response modulation and top-down influences.*

- Gottlieb JP, Kusunoki M, Goldberg ME (1998) Representation of visual salience in monkey parietal cortex. *Nature* 229: 782-784.
- Moore T, Armstrong KM (2003) Selective gating of visual signals by microstimulation of frontal cortex. *Nature* 421: 370-373.

**6: February 25/27.** *Neural synchrony and information transmission.*

- Lakatos P, Karmos G, Mehta AD, Ulbert I, Schroeder CE (2008) Entrainment of Neuronal Oscillations as a Mechanism of Attentional Selection. *Science* 320: 110-113.
- Fiebelkorn IC, Saalman YB, Kastner S (2013) Rhythmic Sampling within and between Objects despite Sustained Attention at a Cued Location. *Current Biology* 23: 2553-2558.

**7: March 4/6. Working memory.**

- Vogel EK, McCollough AW, Machizawa MG (2005) Neural measures reveal individual differences in controlling access to working memory. *Nature* 438: 500-503.
- Xu Y, Chun MM (2006) Dissociable neural mechanisms supporting visual short-term memory for objects. *Nature* 440: 91-95.

**8: March 11/13. Quiz I.**

[March 18/20. Spring recess.]

**9: March 25/27. Categorization.**

- Shima K, Isoda M, Mushiake H, Tanji J (2007) Categorization of behavioral sequences in the prefrontal cortex. *Nature* 445: 315-318.
- Swaminathan SK, Freedman DJ (2012) Preferential encoding of visual categories in parietal cortex compared with prefrontal cortex. *Nature Neuroscience* 15: 315-320.

**10: April 1/3. Rules.**

- Badre D, Kayser AS, D'Esposito M (2010) Frontal cortex and the discovery of abstract action rules. *Neuron* 66: 315-326.
- Vallentin D, Bongard S, Nieder A (2012) Numerical rule coding in the prefrontal, premotor and posterior parietal cortices of macaques. *Journal of Neuroscience* 32: 6621-6630.

**11: April 8/10. Set shifting.**

- Isoda M, Hikosaka O (2007) Switching from automatic to controlled action by monkey medial frontal cortex. *Nature Neuroscience* 10: 240-248.
- Hyafil A, Summerfield C, Koechlin E (2009) Two mechanisms for task switching in the prefrontal cortex. *Journal of Neuroscience* 29: 5135-5142.

**12: April 15/17. Response inhibition.**

- Stuphorn V, Schall JD (2006) Executive control of countermanding saccades by the supplementary eye field. *Nature Neuroscience* 9: 925-931.

- Sharp DJ, Bonnelle V, De Boissezon X, Beckmann CF, James SG, Patel MC, Mehta MA (2010) Distinct frontal systems for response inhibition, attentional capture and error processing. *PNAS* 107: 6106-6111.

**13: April 22/24. Fluid intelligence.**

- Cole MW, Yarkoni T, Repovs G, Anticevic A, Braver TS (2012) Global connectivity of prefrontal cortex predicts cognitive control and intelligence. *Journal of Neuroscience* 32: 8988-8999.
- Middlebrooks PG, Sommer MA (2012) Neuronal correlates of metacognition in primate frontal cortex. *Neuron* 75: 517-530.

**14: April 29/May 1. Disorders of cognitive control.**

- Sigurdsson T, Stark KL, Karayiorgou M, Gogos JA, Gordon JA (2010) Impaired hippocampal-prefrontal synchrony in a genetic mouse model of schizophrenia. *Nature* 464: 763-767.
- Ersche KD, Jones PS, Williams GB, Turton AJ, Robbins TW, Bullmore ET (2012) Abnormal brain structure implicated in stimulant drug addiction. *Science* 335: 601-604.

**15: May 6/8. Quiz II.**

**Additional resources:**

Diamond A (2013) Executive functions. *Annual Review of Psychology* 64: 135-168.

Miller EK, Cohen JD (2001) Integrative theory of prefrontal cortex function. *Annual Review of Neuroscience* 24: 167-202.