

## Syllabus Brain and Thought Cog Sci 201a Fall 2007

### Thursday Sept 6 1. Introduction

This lecture will describe the organization of the course, and provide a broad overview of brain function. We will discuss the different parts and functions of brain cells (neurons) and how they communicate with each other.

### Tuesday Sept 11 2. "How the brain works"

The brain will be compared to a corporation, in order to provide a general understanding of how different regions specialize and work together to control our behavior. Students will learn the terminology used to describe brain regions. The program *Sylvius* (available with the textbook) will be used to help visualize brain systems.

### Thursday Sept 13 3. The cortex- the architecture of thought

The neocortex is an intricate, six-layered structure that underlies our ability to perceive and think. This lecture will discuss the organization and anatomical connections of the cortex as a foundation for future lectures.

**Discussion Group 1:** Learning neuroanatomy using plastic brains

### Tuesday Sept 18 4. How neurons communicate- Part 1- *Dr. Vincent Pieribone*

Neurons have specialized membranes that control the entry and exit of ions such as sodium, potassium, and calcium. Movement of these ions across the membrane creates voltage changes, which allow neurons to transmit information to each other via action potentials. This lecture will provide the foundation for understanding experiments in which investigators record from neurons in animals performing cognitive tasks.

### Thursday Sept 20 5. How neurons communicate- Part 2- *Dr. Vincent Pieribone*

This lecture will focus on neurotransmission: the ways in which neurons are able to talk to each other at specialized contacts called synapses. Neurons communicate with each other at synapses by using either chemical messengers (neurotransmitters), or through electrical means at specialized connections called gap junctions.

**Discussion Group 2:** Review neurophysiology for Test 1

### Tuesday Sept 25 6. Modern imaging methods- *Dr. Godfrey Pearlson*

A great deal of what we are learning about the neuroscience of higher cognitive functions comes from functional imaging studies in humans. This lecture will describe how these methods are able to reveal changes in blood flow and metabolism in the living, thinking human brain.

### Thursday Sept 27 7. Movement

How does our nervous system control our movements, from simple reflexes to playing Chopin? This lecture will describe the anatomy and function of the motor system, and how lower spinal reflexes are controlled by higher cortical influences in a very plastic manner.

**Discussion Group 3: TEST 1 on lectures 1-6**

### Tuesday Oct 2 8. Somatosensory System

This lecture will describe how we are able to feel touch: pressure, pain, temperature and a sense of where our limbs are (proprioception). We will learn how the nervous system uses specialized nerve endings to detect different kinds of somatosensory signals, and how the somatosensory cortex processes this information in specialized ways.

**Thursday Oct 4      9. Olfaction- Dr. Charles Greer**

The chemical senses of smell and taste give our life much of its pleasure, and yet only recently have we begun to understand how the olfactory system is organized. This lecture will focus on how odors are processed by the nervous system, by combining inputs from different receptors.

**Discussion Group 4:** Discuss paper: [Neuronal ensemble control of prosthetic devices by a human with tetraplegia](http://www.nature.com/nature/journal/v442/n7099/supinfo/nature04970.html). Leigh R. Hochberg, Mijail D. Serruya, Gerhard M. Friehs, Jon A. Mukand, Maryam Saleh, Abraham H. Caplan, Almut Branner, David Chen, Richard D. Penn and John P. Donoghue. *Nature* 442, 164-171(13 July 2006)  
<http://www.nature.com/nature/journal/v442/n7099/supinfo/nature04970.html>

**Tuesday Oct 9      10. Taste- Dr. Dana Small**

This lecture will focus on taste, and how to perform psychophysical experiments in humans to determine what it is that subjects actually perceive. The anatomical organization and function of this system will be described.

**Thursday Oct 11      11. Audition- Dr. Joseph Santos-Sacchi**

How are sounds turned into signals that the brain can understand? How do we know where a sound is coming from, and what a sound is? This lecture will focus on how stimuli are transduced in the auditory system.

**Discussion Group 5:** Review of class material: sound localization and audition lecture, comparison of labeled lines (audition, taste, somatosensory) vs combinatorial (olfaction)

**Tuesday Oct 16      12. Vision- The eye and primary visual cortex**

This is the first in a series of lectures on the visual system. This lecture will focus on the retina, and how these cells transform light into messages that are sent to the visual cortex for further processing. We will learn about the importance of contrast, and that even at these very early stages, information processing of What and Where is carried out in parallel streams.

**Thursday Oct 18      13. Vision- “What” things are: the inferior temporal cortex**

The inferior temporal processing stream analyzes visual features to tell us WHAT things are. This part of the cortex even has cells that respond only to certain faces. Loss of this cortex produces an “agnosia” where people can see things, but not know what they are.

**Discussion Group 6:** Review of V1 physiology, simple cells based on Kandel pages 534-535; *Recommended:* excerpts from [Hubel/Wiesel book "Brain and Visual Perception : The Story of a 25-Year Collaboration"](#)

**Tuesday Oct 23      14. Vision- “Where” things are: the parietal association cortex**

How do we draw, play chess, follow and create maps, represent quantity and perform mental rotations? The parietal association cortex is specialized for processing WHERE things are in visual space, for processing movement and alerting attention. Some researchers think that this cortex is essential for binding visual features and allowing perception itself.

**Thursday Oct 25      15. Long term memories and the medial temporal lobe**

How do we remember things over a day or over many years? A great deal of research has focused on brain processes occurring in the hippocampus and related structures in the medial temporal lobe. Higher cortical areas all have strong connections with the medial temporal lobes, in order to make new, long term memories.

**Discussion Group 7: TEST 2, lectures 7-14 (i.e. through V1).**

Tuesday Oct 30 **16. Alzheimer's Disease and Korsakoff's Amnesia – Dr. Christopher van Dyck**

This lecture will focus on how degenerative changes in the cortex result in memory loss and dementia in patients with Alzheimer's Disease. Recent memory loss is usually the earliest symptom of this disease, and degeneration of the medial temporal lobe early in the disease likely underlies this symptom. We will compare Alzheimer's Disease to Korsakoff's Amnesia, another memory disorder caused by vitamin B deficiency.

Thursday Nov 1 **17. "Thinking without thought"- Habit memory and the role of the basal ganglia**

Through repetition, we learn to ride bicycles and play the guitar "without having to think about it". This lecture will describe the cortex connects with the circuitry of the basal ganglia (and the cerebellum), and how critical these circuits are for the selection, initiation, execution, and on-line guidance of movements and thoughts. Degenerative changes in these circuits can lead to disorders of movement and thought, such as Tourette's Syndrome, Parkinson's Disease, and Huntington's Disease. Changes in some of these circuits also appear to underlie drug addiction.

**Discussion Group 8:** Discussion of Parkinson's Disease symptoms and research:

[Bankiewicz, K.S. et al. \(2006\) Long-term clinical improvement in MPTP-lesioned primates after gene therapy with AAV-hAADC. Mol. Ther. Epub](#)

[Bowers et al \(2006\) Faces of emotion in Parkinsons disease: Micro-expressivity and bradykinesia during voluntary facial expressions. JINS 12: 765–773.](#)

*Recommended reading:* excerpts from [The Case of the Frozen Addicts](#) by Langston and Palfreman.

Society for Neuroscience Nov 3-7; TA's away

Tuesday Nov 6 **18. Emotion and memory: the contribution of the amygdala-**

The so-called "limbic" structures of the brain are critical for regulating homeostasis and for associating stimuli with reward or punishment. In particular, the amygdala enhances memory consolidation for emotionally-relevant events, and mediates fear conditioning, processes critical to post-traumatic stress disorder (PTSD).

Thursday Nov 8 **19. Prefrontal Cortex: Overview and Regulation of emotion by the orbital prefrontal cortex**

The prefrontal cortex allows us to guide our actions, thoughts and emotions based on represented information. The orbital and medial parts of the prefrontal cortex regulate emotion and allow us to act appropriately in society. Weakness in this cortex has been implicated in sociopathic behaviors and in drug abuse, while overactivity of this cortex has been associated with depression (ventral medial PFC) and obsessive compulsive disorder (orbital PFC).

**Discussion Group 9:** Discussion on ethics of psychopathic behavior following medial PFC lesions. Are people with ventral prefrontal cortical lesions responsible for their actions? Should they go to jail if they commit a crime? Background reading: [Anderson et al \(1999\) Nat Neurosci. 2:1032-7 Impairment of social and moral behavior related to early damage in human prefrontal cortex.](#)

## **Tuesday Nov 13 20. Working memory and the regulation of behavior: the dorsolateral prefrontal cortex-**

The prefrontal cortex is perhaps the most evolved region of the human brain, allowing us to guide and plan our behavior using representational knowledge. Neurons in this part of the brain can hold information on line in working memory, and then use this information to choose correctly, and to inhibit processing of irrelevant or inappropriate stimuli or responses.

Weaknesses in this cortex (particularly on the right side) are implicated with Attention Deficit Hyperactivity Disorder.

## **Thursday Nov 15 21. Language**

In humans, the cortex subserves the cognitive system we call Language. Based on evidence from studies on brain damaged patients and functional imaging studies in intact subjects we will discuss the basis for a "system approach" to the study of language-brain relations where organizational principles are not concerned with linguistic "activities" such as speaking, listening or reading, but with independently motivated linguistic components such as phonology (the structure of sound), syntax (the structure of sentences) and semantics (the structure of meaning). The evidence suggests that it is based on these components ( in interaction with other systems such as memory) that the brain determines the implementation of this important cognitive capacity. The lecture will focus on the syntactic aspect of language-brain relations.

**Discussion Group 10:** Discussion of uniquely different brains **Born On A Blue Day by Daniel Tammet, Chapter 1.** Ask your TA for the book itself if you are interested.

*Thanksgiving break*

## **Tuesday Nov 27 22. Sleep, dreaming and conciousness**

Neuromodulators such as norepinephrine and acetylcholine can dramatically change the state of the cortex, and determine whether we are awake or asleep. More subtle mechanisms may optimize or impair our cognitive abilities. Networks of higher cortical areas likely permit concious awareness.

## **Thursday Nov 29 Test 3 in class instead of lecture! on lectures 13-20**

**Discussion Group 11:** Go over test 3, Film clips from the Blumenthal lab showing patients with seizures that cause loss of conciousness.

## **Tuesday Dec 4 23. Creating the cortex during development - Dr. Pasko Rakic**

During development, glial cells form a scaffolding for neurons to climb and form the cortex. Differences between species in these basic mechanisms may show us how the cortex has evolved so tremendously in humans and other primates. Problems in the development of the cortex in the fetus may lead to future neuropsychiatric and cognitive disorders.

## **Thursday Dec 6 24. Mental Illness and the Cortex**

Deficits in higher cortical function contribute to a variety of neuropsychiatric disorders, including Attention Deficit Hyperactivity Disorder, depression, bipolar disorder and schizophrenia. This lecture will focus on how changes in the development or modulation of cortex may lead to symptoms in these disorders, with particular focus on the role of prefrontal cortex dysfunction in these illnesses.

**Discussion Group 12:** Discussing the neuropathology of schizophrenia, and how it relates to what you've learned in this course. [van Haren et al, \(2007\) Progressive brain volume loss in](#)

schizophrenia over the course of the illness: Evidence of maturational abnormalities in early adulthood. *Biol Psychiatry*. 2007 Jun 26; [Epub ahead of print]

**Tuesday Dec 11** **term paper due by 5:00 PM.** Please bring to 110 SSS, the Yale College Dean's Office, and put in the folder with your TAs name on it. Keep an extra copy of your paper just in case it gets lost! The Dean's Office is only open between 8:30 to 5:00; do NOT bring it other times. The box with folders should be there starting the afternoon of Monday Dec. 11 if you want to bring it early.

**Dec 17 2 PM Final Exam**