Psych 410/646: The Neuroscience of Smell

Fall Semester, 2009
Rutgers University Psychology Department

Course Information:

Undergraduate Course Number: 01:830:410:03
Graduate Course Number: 16:830:646:03
Meeting Time: Tuesday afternoons from 2-5 PM
Location: Psychology Department Room 301 (152 Frelinghuysen Road)

Professor:

John P. McGann, PhD
Email: jmcgann@rci.rutgers.edu
Office: Psych 308
Office Hours: Tuesdays from 5-6 PM (after class) or by appointment

Goals for the class: This course is designed to be an intensive seminar on the neuroscience of smell. My intention is to use the olfactory system as a model to teach how psychological phenomena (e.g. olfactory perceptions) can be related their neurobiological underpinnings at the molecular, cellular, and circuit levels. This course will include significant emphasis on neural and perceptual plasticity, and finally come around to clinical applications by the end of the semester. My hope is that students (both graduate and undergraduate) will not only learn a great deal of information about the neuroscience of smell, but also develop their abilities to evaluate and present data from the primary scientific literature.

Expectations: I expect every student to come to class having done the reading assigned for that week and prepared to discuss it (this includes during weeks with student presentations). The subjects covered in this class are diverse, ranging from molecular biology to electrophysiology to non-linear dynamical systems analysis to behavioral assays. All of you will eventually encounter material in the reading that you find challenging and slow. Please consider this a warning that some readings may take you much more time than you expect.

Course Materials: This course will be composed primarily of readings from the primary literature, which can be downloaded via pubmed.com from any Rutgers computer or downloaded from this course's Sakai site (under Resources). There will be one textbook used: Learning to Smell, by Wilson and Stevenson (2006, Johns Hopkins University Press). This book has been ordered through the campus Barnes and Noble bookstore. We will also read two chapters from The Synaptic Organization of the Brain, 5th edition (the edition DOES matter on this text), edited by Gordon Shepherd. The SOB is an encyclopedic book that is invaluable for any practicing neuroscientist, and I encourage all current and future graduate students to purchase it, but undergraduates may wish to simply copy the two chapters. It is on course reserve at the Library of Science and Medicine.

Evaluation:

You will be evaluated in this course based on three factors:
1) CLASS PARTICIPATION (about 20% contribution to final grade)

Each week I expect all students to have read all of the papers to be discussed that week and to be sufficiently familiar with them to discuss and critique each one. If you're not sure what to say, be able to either illustrate a weakness of the paper or to suggest a new direction or experiment that could build on the paper. Simply paying attention is not enough to get full marks for class participation – you need to speak up! Every student is expected to attend every class in order to earn full marks for class participation.

2) AN IN-CLASS PRESENTATION (about 30% contribution to final grade)

Each week one or more students will be assigned to present one of the assigned papers to the class. In most cases these presentations should go beyond the scope of the paper itself, including relevant background information on the scientific question being addressed, an explanation of the methods used and their advantages and disadvantages, and a discussion of the implications of the paper for the field. On days where three papers are being presented, the presentation should be no more than 50 minutes. When there are two, the presentation may be up to one hour and fifteen minutes. The evaluation will take into account both the content of the material presented and the quality of the presentation itself (i.e. your speaking and slide deck).

3) A TERM PAPER ON A CONTROVERSY IN OLFACTION (about 50% contribution to the final grade)

Each student will write a term paper on a controversial issue in olfaction (either a subject matter or a detailed critique of a specific paper or set of papers). This paper should be 20-30 pages long in double-spaced Times New Roman 12 pt font, and should clearly summarize the issues and the arguments on both sides of the controversy. Proposing experiments (feasible or not) that would settle the controversy is encouraged. Please submit a one-page summary of your topic on Friday Oct. 23 for approval, plus a list of the most important references. An outline of the term paper is due Friday, Nov. 20. I will give each outline general comments and indicate where I think it can be improved. The final version of the paper is due Friday, Dec. 11 at 5 PM, in hard copy, at my office in Psychology, Room 308. You have the entire semester to work on your paper, so I will not grant any extensions, nor will I accept late submissions.

Sample paper topics:

- What is the role of the olfactory bulb in odor perception?
- What is the relative importance of spatial vs temporal codes for odors?
- What is the best way to classify odorants (e.g. physical properties, perceptual quality, etc.)?
- Is there a speed-accuracy trade-off in olfaction?
- In a genetically hard-wired system, what is the role of plasticity?
- What role does neurogenesis play in the olfactory system?

Schedule:

<u>Tuesday Sept. 1 – Introduction to the Neuroscience of Smell</u>

Introduction to course plan

Introduction to the olfactory system and olfactory psychophysics

Gilbert and Firestein (2002) Dollars and Scents: Commercial Opportunities in Olfaction and Taste. *Nature Neuroscience* 5 Suppl: 1043-5.

Tuesday Sept. 8 – NO CLASS (Monday Classes meet instead)

Tuesday Sept. 15 – Human Olfaction: Psychophysics and Behavioral Influence

Doty and Laing (2003) Psychophysical measurement of human olfactory function, including odorant mixture assessment. In: Handbook of Olfaction and Gustation, ed. Richard Doty. New York: Marcel Dekker Inc. pp. 203-228.

Stevenson and Boakes (2003) A mnemonic theory of odor perception. *Psychological Review* 110:340-64.

Zhou and Chen (2009) Fear-related chemosignals modulate recognition of fear in ambiguous facial expressions. *Psychological Science* 20: 177-183.

Tuesday, Sept. 22. Neurobiology Overview & Transduction of Chemical Signals

Buck and Axel (1991) A novel multigene family may encode odorant receptors: a molecular basis for odor recognition. *Cell* 65:175-87

Mombaerts et al. (1996) Visualizing an olfactory sensory map. Cell 87:675-86.

Wilson and Mainen (2006) Early events in olfactory processing. *Annual Review of Neuroscience* 29:163-201.

Tuesday Sept. 29 - Representation of Odorants in the Olfactory Bulb Inputs

Malnic et al. (1999) Combinatorial Receptor Codes for Odors. Cell 96:713-723.

Reisert and Restreppo (2009) Molecular Tuning of Odorant Receptors and Its Implication for Odor Signal Processing. Chemical Senses. In Press.

Soucy et al. (2009) Precision and diversity in an odor map on the olfactory bulb. Nature Neuroscience 12:210-20.

Tuesday Oct. 6 Neurobiology of the Olfactory Bulb and Olfactory Cortex

The chapter on the Olfactory Bulb. In: The Synaptic Organization of the Brain. Ed: Gordon Shepherd. 5th edition. (don't read the wrong edition!)

The chapter on the Olfactory Cortex. In: The Synaptic Organization of the Brain. Ed: Gordon Shepherd. 5th edition (don't read the wrong edition!)

Tuesday Oct. 13 Odor Representation & Processing I

Yokoi et al (1995) Refinement of odor molecule tuning by dendrodendritic synaptic inhibition in the olfactory bulb. Proceedings of the National Academy of Sciences 92:3371-5.

McGann et al. (2005) Odorant Representations are modulated by intra- but not interglomerular presynaptic inhibition of olfactory sensory neurons. *Neuron* 48:1039-53.

Fantana et al. (2008) Rat Olfactory Bulb Mitral Cells Receive Sparse Glomerular Inputs. Neuron 59:802-814.

Tuesday Oct. 20 - NO CLASS (Society for Neuroscience Annual Meeting)

Friday Oct. 23 – TERM PAPER TOPICS DUE BY 5 PM IN HARD COPY

Tuesday Oct. 27 Odor Representation & Processing II

Kay and Laurent (1999) Odor- and context-dependent modulation of mitral cell activity in behaving rats. *Nature Neuroscience* 86:2823-33.

Stopfer et al. (2003) Intensity versus identity coding in an olfactory system. *Neuron* 39:991-1004.

Rinberg et al. (2006) Sparse odor coding in awake behaving mice. *Journal of Neuroscience* 26:8857-65.

Tuesday Nov. 3 - Learning to Smell I

Wilson and Stevenson, Chapters 1 – 4 (75 pages)

Chapter 1: The Function of the Olfactory System in Animals and Humans
Chapter 2: A Historical and Comparative Perspective on Theoretical Approaches
Chapter 3: Receptive Mechanisms
Chapter 4: The Relationship Between Stimulus Intensity and Perceptual Quality

Tuesday Nov. 10 - Learning to Smell II

Wilson and Stevenson, Chapters 5 & 6 (113 pages)

Chapter 5: Odor Quality Discrimination in Nonhuman Animals
Chapter 6: Odor Quality Discrimination in Humans

Tuesday Nov. 17 - Learning to Smell III

Wilson and Stevenson, Chapters 7 & 8 (77 pages)

Chapter 7: Odor Memory
Chapter 8: Implications

Friday Nov. 20 – TERM PAPER OUTLINES/DRAFTS DUE BY 5 PM IN HARD COPY

Tuesday Nov. 24 – Plasticity and Learning in the Olfactory System

Mandairon and Linster (2009) Odor perception and olfactory bulb plasticity in adult mammals. Journal of Neurophysiology 101:2204-9.

Bazhenov et al. (2005) Fast odor learning improves reliability of odor responses in the locust antennal lobe. Neuron 46: 483-92.

Sevelinges et al. (2009) The basolateral amygdala is necessary for the encoding and the expression of odor memory. *Learning & Memory*16:235-42.

Tuesday Dec. 1 - Influence of Sniffing and Attention

Mainland and Sobel (2006) The sniff is part of the olfactory percept. *Chemical Senses* 31:181-96.

Wesson et al. (2009) Why sniff fast? The relationship between sniff frequency, odor discrimination, and receptor neuron activation in the rat. *Journal of Neurophysiology* 101:1089-102.

Zelano et al. (2005) Attentional modulation in human primary olfactory cortex. *Nature Neuroscience* 8:114-20.

Tuesday Dec. 8 Human Olfaction

Haddad et al. (2008) Measuring smells. *Current Opinion in Neurobiology* 18:438-44.

Haehner et al. (2007) Olfactory loss may be a first sign of idiopathic Parkinson's disease. *Movement Disorders* 22: 839-42.

Course wrap-up and conclusions.

Friday Dec. 11 – FINAL PAPERS DUE AT 5 PM IN HARD COPY