Interdepartmental Vision Course **Prof. George Sperling**

Psych 131A (68445) = BioSci N182 (06235) Discussion Sections (TA: Veronica Chu)

Fall, 2015. SSL 145. Tu, Th 11:00-12:20 Mon 4:00-4:50p Rm SSPA 1165 68448/06238

Class website: www.socsci.uci.edu/HIPLab/Vision_Class/

SYLLABUS

RECOMMENDED TEXTBOOK:

Title: Vision Science -- Photons to Phenomenology
Author: Stephen E. Palmer
Publisher: MIT Press, Cambridge, MA. 1999 (hardcover, 810 pp).

Other recommended (not required) textbooks:

Title: Sensation and Perception. 7th & 8th Editions are most current
Author: E. B. Goldstein.
Publisher: Belmont CA: Wadsworth Publ. Co.
Chapters on Vision. Earlier editions are better. Four copies of various editions are on reserve in Langson Library. Relevant pages in Goldstein S&P 5th and 6th Editions are listed on web page in "Notes and Annnouncements (Prior Years)"

Authors: R. Snowden, P. Thompson, T. Toscianko.
Title: Basic Vision an introduction to visual perception.
Publisher: Oxford, UK, Oxford University Press, 2006.

MORE ADVANCED (Shorter but highly detailed on selected topics)
Authors: Vicki Bruce, Patrick R. Green, & Mark A. Georgeson
Title: Visual Perception. Physiology, Psychology, and Ecology. 4th Ed.
Publisher: East Sussex, UK: Psychology Press (Erlbaum), 2003. (496 pp).

Other textbooks on Vision or on Sensation and Perception would also be OK.
Exams are based on materials presented IN CLASS and reviewed IN DISCUSSION SECTIONS. Notes outlining the lecture materials are provided on the class web page.

Lectures

1. Business items (blurb, 6 HW, 2 exams; login); Overview of course;
Brains, computers, complexity; Visual Angles.
Problem set 1: Visual angles.
Reading: Palmer: Chapter 1 (Introduction to Visual Science), pp. 4-15.

2. Physics of Light. Photons (waves & particles), wavelength, polarization angle, speed = wavelength x freq, refraction, absorbtion, reflection, chromatic aberration & prism, how to measure wavelength, pinhole camera, visual angles. Cameras, lenses, lens law, diopters.
Reading: Palmer, Ch. 1, Pp. 15-23, 616-618; Yellott, Optics and Visual Acuity, pp 1-10.
Problem set 2: More visual angles; measure blind spot

3. Structure of the eye. Refraction, camera and the human eye compared, structure of the eye, problems with the pinhole & pupil size; How to measure the power of lenses, diopters, accommodation, myopia, acquired myopia, presbyopia refraction and spectacles; aberrations. Demonstration: spherical and cylindrical corrections, additive +- lens powers (with overhead projector).
Reading: Palmer, pp 24-34; Yellott, Optics and Visual Acuity, 11 pp;
Problem set 2: Diopters, refraction; measure range of accommodation.

4. Photometry: point-source, illuminance, luminance, retinal illuminance. Rods & cones, light & dark adapta-

tion, experimental methods (brief introduction), Demonstration: Luminance is not brightness. Gelb (importance of surround).

Reading: Review Palmer Ch. 1; Photometry summary page (Sperling)

Problem set 3: Photometry

5. Visual anatomy and physiology 1. Review dark adaptation; Neurons (Hodgkin-Huxley), pumps, dendrites, axons, nerve impulse, saltatory conduction, synapses, transmitters (Acetyl cholne, GABA, ...) Optic nerve, optic tract, overview of anatomy (van Essen), what & where systems. How to experimentally determine receptive fields, receptive fields in retinal ganglion cells (Kuffler), LGN, V1-4c; simple cells (Hubel & Wiesel). M- P- K- cells, LGN structure, cortical unfolding, Retinotopic maps, cortical magnification, globe, Mercatur, conformal map (e+z)^-1; computational specialization (color, space, time).

Reading: Palmer, pp 35-43, 64-70, 115-117, 143-158

6. Visual anatomy and physiology 2. models (mathematical, computational, physical, neural) neuronal computation, (neuron = Mississippi). Channels: characterizing a neuron by the spatial frequency of the sinewave to which it is maximally sensitive, tiling a space with neurons of a particular kind, push-pull, Cortical architecture, columns, visual system anatomy/architecture. Brain imaging (EEG, MEG, PET, fMRI). parallel computation.

7. Color Vision 1. Color, color matching. Trichromacy, dimensionality, metameres, Grassman's Laws; demonstrating quanta psychophysically. Absorption, difference, and action spectra, spectral sensitivity. Color versus reflectance. CIE Color space. The algorithmic problem: Extracting surface reflectance and illumination in natural scenes.

Reading: Palmer, Ch. 3, Color Vision, pp. 94-139; Appendix C. Color Technology, pp 689-699.

8. Color Vision 2. Young-Helmholtz vs Hering, physiological representation, color blindness, How to make color films, prints, achieve perfect reproductions (feedback). Review.

10 & 11. Spatial vision. Contrast senstivity functions, sinewaves, channels: [Superposition, sinewaves, impulses], Fourier theorem; application to receptive fields; channels, and the algorithmic consequences of multiresolution representation; Mach bands and related illusions; failures of simple center-surrouond computations; lightness illusions (Mach card; Craik-O'Brian, Gilchrist, Adelson). Review visual angles and logarithms, if necessary.

Reading: Palmer, pp 125-132 (review), 158-171.

12. Psychophysical methods and sensory scaling. Constant stimuli, method of limits, adjustment, adaptive methods, JND. Sensory scaling, magnitude estimation, power law, scale types. Weber, Fechner, psychophysical laws; objective versus subjective methods; Type 1 and Type 2 experiments. Perceptual experience (consciousness) within a scientific framework. Signal detection theory, 2AFC.[Noise as the ultimate limiting factor].

Reading: Palmer, Appendix A. Psychophysical Methods, 666-673; Sperling: Type 1 and 2 Experiments, 2 pp

MIDTERM. Closed book: no calculators, cell phones, or notes in class. Exam questions are to be answered on the exam paper itself (no bluebooks).

13. Depth Perception 1. Convergence, accommodation, binocular disparity. Pictoral cues: Retinal image size, linear perspective, texture gradients, shading, occlusion, atmospheric perspective, familiarity. Movement Parallax. Kepler diagram, horopter, Panum.

Reading: Palmer, Ch. 5. Perceiving Surfaces Oriented in Depth, pp 200-253.

14. Depth Perception 2. Random-dot stereograms, making a "seeing eye" picture. Size as combination of retinal size and perceived distance, cue combination & early decision processes. Illusions. Perceptual recalibration, prism expts. Begin Motion Perception 1. Space-time representation, computational equivalence to depth and texture; sampled versus continuous motion.

15. Motion Perception 2 (concluded). Second- and third-order motion. correlation model, motion aftereffects, traditional observations. Structure from motion, flowfields, algorithms. Relation to texture and recep-

tive fields.

Reading: Palmer, Ch. 10. Perceiving Motion and Events, pp. 467-517

17. Object recognition. Computer vs human memory--LTM, STM. template vs feature matching; pandemonium system; figure-ground = segmentation: Rules, Gestalt grouping phenomena, shadows, T-junctions (again), Reading, eye movements in reading, texture segregation and visual search; pop-out, parallel versus serial search; Mach card, Necker cube, binary perceptions, generic viewpoints. top-down versus bottom up--inverted faces. Why don't we see motion when the eye moves? Why doesn't the world seem blurred with poor peripheral vision. Why does the world seem complete all around us. Computational approaches: cartooning versus gray scale;

18. Perceptual development; neurological disorders. The retinal image is upside down, why doesn't the world appear upside down? Cone redirection; critical period, deprivation, sign language, V1 re-organization Visual cliff, snakes, restored sight, Descarte's paradox (cube, sphere), Prism and inverting lens adaptation (Stratton, Harris, Ramachandran). Blindsight, split brain, Balint syndrome, prosopagnosia, parallel visual computation. chess board skills, 10^4 hrs, letter-word phenomenon. Miscellaneous issues in object perception.

Readings. Palmer, pp 249-253 (review), pp 631-638.

19. Catch up and review. Finally, a 15 minute review as in "15-Minute Hamlet" (Tom Stoppard, 1979).

UCI Fall, 2015 Psych 131A, Bio N182

Sep 24 (Thu) 11:00a SE2-1304 Vision 01 Business, Intro, overview, photons, visual angles
Sep 30 (Mon) 4:00-4:50 DiscSection_1 Visual angles
Sep 29 (Tue) 11:00a SE2-1304 Vision 02 Physics of light, dark adaptation, start anatomy
Problem 1 due (visual angles)
Oct 1 (Thu) 11:00a SE2-1304 Vision 03 Perimetry, measure blind spot, visual anatomy
Oct 5 (Mon) 4:00-4:50 DiscSection_2 visual angles w/spatial freq; measuring blind spot
Oct 6 (Tue) 11:00a SE2-1304 Vision 04 review, receptive fields, V1
Problem 2 due (blind spots)
Oct 8 (Thu) 11:00a SE2-1304 Vision 05 V1, complex cells, hypercolumns; start photometry (Prob 3)
Oct 12 (Mon) 4:00-4:50 DiscSection_3 photometry
Oct 13 (Tue) 11:00a SE2-1304 Vision 06 Review receptive fields--how many in V1, complex cells, tiling, pushpull, Spatial F
Problem 3 due (photometry)
Oct 15 (Thu) 11:00a SE2-1304 Vision 07 review complex cells, inverse receptive field is impulse response, sinewaves, Fourier, linear system, HW is linear systems. Receptive field problem 4 (graphical convolution)
Oct 19 (Mon) 4:00-4:50 DiscSection_4 computing convolution HW
Oct 20 (Tue) 11:00a SE2-1304 Vision 08 receptive field equals impulse response. Mach bands. sine waves, start color.
Problem 4 due (receptive fields)
Oct 22 (Thu) 11:00a SE2-1304 Vision 09 Review HW, lin sys, Fourier (contrast sensitivity fc), then continue color vision.Begin color, RGB, xyz, retina
Oct 26 (Mon) 4:00-4:50 DiscSection_5 midterm review, gs goes over CSF
Oct 27 (Tue) 11:00a SE2-1304 Vision 10 Midterm1
Oct 29 (Thu) 11:00a SE2-1304 Vision 11 Lenses - Type 1 & 2 for HW 5 (range of accommodation)
Nov 2 (Mon) 4:00-4:50 DiscSection_6 diopters, lenses, acquired myopia, type 1 & 2
Nov 3 (Tue) 11:00a SE2-1304 Vision 12 Wrap up lens and image formation. Resume color vision X,Y,Z, metamers
Problem 5 due (lens)
Nov 5 (Thu) 11:00a SE2-1304 Vision 13 Finish color vision: black bodies, color space wrt monitor guns, color blindness; start psychophysics (gun, constant stimuli, ... method of adjustment missed,
Nov 9 (Mon) 4:00-4:50 DiscSection_7 SFN
Nov 10 (Tue) 11:00a SE2-1304 Vision 14 Psychophysics, consider different psychophysical methods, Weber, Fechner, Steve
Nov 12 (Thu) 11:00a SE2-1304 Vision 15 Motion from beginning to end, including Figure ground

Nov 16 (Mon) 4:00-4:50 DiscSection_8
Nov 17 (Tue) 11:00a SE2-1304 Vision 16 Midterm2
Nov 19 (Thu) 11:00a SE2-1304 Vision 17
Nov 23 (Mon) 4:00-4:50 DiscSection_9
Nov 24 (Tue) 11:00a SE2-1304 Vision 18
Problem 6 due (stereograms)
Nov 26 (Thu) 11:00a SE2-1304 Vision THANKSGIVING
Dec 0 (Mon) 4:00-4:50 DiscSection_10
Dec 1 (Tue) 11:00a SE2-1304 Vision 19
Problem 7 due (signal detection theory)
Dec 3 (Thu) 11:00a SE2-1304 Vision 20

Dec 7 (Mon) Finals week 4:00-4:50 DiscSection_11
Dec 8 (Tue) 10:30a-12:30p Vision FINAL