

Psychology 499 - Special Topics
Optical Illusions and Visual Computations

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Aside from being an endless source of amusements, optical illusions, which are benign failure modes of the brain, can be used to understand the neural computations that enable us to see.

This course will introduce students to a host of visual illusions and the neural machineries that underlie these phenomena. Students who are interested in the brain from a biological and/or computational perspective, and have completed introductory-level coursework in cognitive psychology or neuroscience/psychobiology will benefit maximally from this course. Computer programming experience, although not required, can be very helpful.

Text: (suggested)

Palmer SE. (1999) *Vision Sciences: Photons to Phenomenology*. MIT Press. {A comprehensive, up-to-date introduction to the vast areas of vision research, with breadth valued over depth.}

Frisby JP. (1980) *Seeing – Illusion, Brain and Mind*. Oxford University Press. {a very readable text on visual mechanisms. Still a classic, although some of the theories have since been augmented}.

Marr D. (1982) *Vision*. W.H. Freeman. {A must-read if you are serious about computational vision}

Seckel A. (2003) *Incredible Visual Illusions: You Won't Believe Your Eyes*. Arcturus Publishing. {A vast collection of visual illusions. Hopefully the book will hit the bookstores this semester.}

Reading materials: see lecture plan

Grades: participation 10 %; class presentation 15%; homework, short experiments, and computer programming exercises 35%; quizzes 20%; term paper/project 20%. Grade assignment: >90 A, >80 B, >70 C, >60 D, ≤ 60 F

Lecture Plan

(Class will meet once a week for 3.5 hours, divided into lecture, student presentation, and demo/discussion sections.)

Week 1: Preambles and logistics. A very brief introduction of the visual system. Why do visual illusions occur? Mechanistic and decision theoretic views.

Kersten D, Yuille A. (2003) Bayesian models of object perception. *Curr Opin Neurobiol.* Apr; 13(2):150-8.

Logothetis NK, Sheinberg DL. (1996) Visual object recognition. *Annu Rev Neurosci.* 19:577-621.

Week 2: The Moon-Crater illusion. Shape-from-shading computation, and Bayesian framework for understanding perception.

Ramachandran VS. (1988) Perceiving shape from shading. *Sci Am.* Aug; 259(2):76-83

Freeman WT. (1994) The generic viewpoint assumption in a framework for visual perception. *Nature.* Apr 7; 368(6471):542-5.

Week 3: Mach Card and Hallow Mask illusions. Is it shape-from-shading or shading-from-

shape? A generative model for perception.

Bloj MG, Kersten D, Hurlbert AC. (1999) Perception of three-dimensional shape influences colour perception through mutual illumination. *Nature*. Dec 23-30; 402(6764):877-9.

Friston KJ, Price CJ. (2001) Dynamic representations and generative models of brain function. *Brain Res Bull*. Feb; 54(3):275-85.

Week 4: Ball-in-a-box, and “common fate.” Occam’s Razor, minimal description length, and Bayesian inference.

Kersten D, Knill DC, Mamassian P, Bulthoff I. (1996) Illusory motion from shadows. *Nature*. Jan 4; 379(6560):31.

Kersten, D., Mamassian, P. & Knill, D.C. (1997) Moving cast shadows induce apparent motion in depth. *Perception*, 26 (2), 171-192.

Simoncelli EP. (2003) Vision and the statistics of the visual environment. *Curr Opin Neurobiol*. Apr; 13(2):144-9.

Week 5: Interlude I: introduction to the general schemes of visual computations

Reading: TBA

Week 6: Adelson’s lightness illusions. Intrinsic vs. extrinsic properties – a credit assignment problem.

Adelson EH. (1993) Perceptual organization and the judgment of brightness. *Science*. Dec 24; 262(5142):2042-4.

Week 7: Hermann Grid, Mach Band illusions, and the judgment of lightness. Lateral-inhibition – a bottom-up computation for perceiving invariant intrinsic properties.

Spillmann L. (1994) The Hermann grid illusion: a tool for studying human perspective field organization. *Perception*. 23(6):691-708.

Week 8: Orange or brown: interaction between color and lightness. Edge/region based computations for achieving color and lightness constancy.

Lotto RB, Purves D. (1999) The effects of color on brightness. *Nat Neurosci*. Nov; 2(11):1010-4.

Week 9: Munsterberg illusion and subject contour. From surfaces to contours – the all-important edge-detection and contour integration processes.

Morgan MJ, Moulden B. (1986) The Munsterberg figure and twisted cords. *Vision Res*. 26(11):1793-800.

Gregory RL, Heard P. (1979) Border locking and the Cafe Wall illusion. *Perception*. 8(4):365-80.

Week 10: Craik-O'Brien-Cornsweet illusion, and Shimojo’s edge-adaptation demo. From contours to surfaces, a “filling in” process.

Rossi AF, Rittenhouse CD, Paradiso MA. (1996) The representation of brightness in primary visual cortex. *Science*. Aug 23; 273(5278):1104-7.

Purves D, Shimpi A, Lotto RB. (1999) An empirical explanation of the cornsweet effect. *J Neurosci*. Oct 1; 19(19):8542-51.

Kingdom F, Moulden B. (1988) Border effects on brightness: a review of findings, models and issues. *Spat Vis*. 3(4):225-62.

Week 11: Interlude II: introduction of the neural mechanisms for the early stages of vision.

Reading: TBA

Week 12: Afterimages. Visual adaptation as a tool for probing feature-selectivity of neurons in early vision.

Shimojo S, Kamitani Y, Nishida S. (2001) Afterimage of perceptually filled-in surface. *Science*. Aug 31; 293(5535):1677-80.

He S, MacLeod DI. (2001) Orientation-selective adaptation and tilt after-effect from invisible

patterns. Nature. May 24; 411(6836):473-6.

Week 13: Anomalous-motion illusions. Early mechanisms for motion computation.

Adelson, E. H., & Bergen, J. R. (1985). Spatiotemporal energy models for the perception of motion. *J Opt Soc Am A*, 2(2), 284-299.

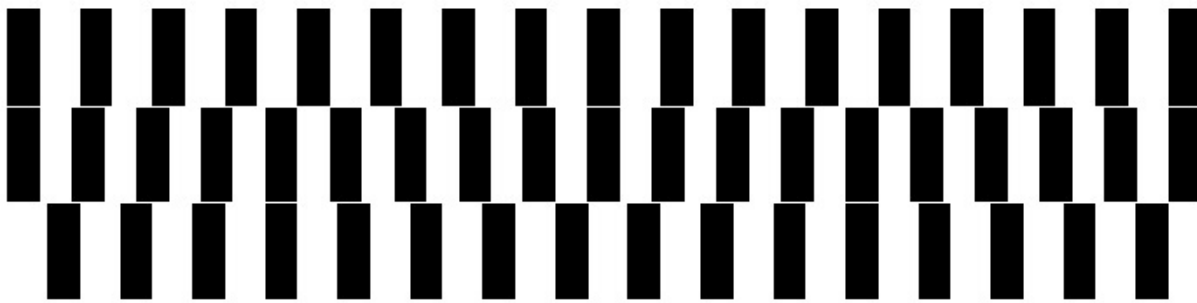
Pinna B, Brelstaff GJ. (2000) A new visual illusion of relative motion. *Vision Res.* 40(16):2091-6.

Week 14: When far-away contours cancelled out Craik-O'Brien-Cornsweet. Interactions between visual mechanisms.

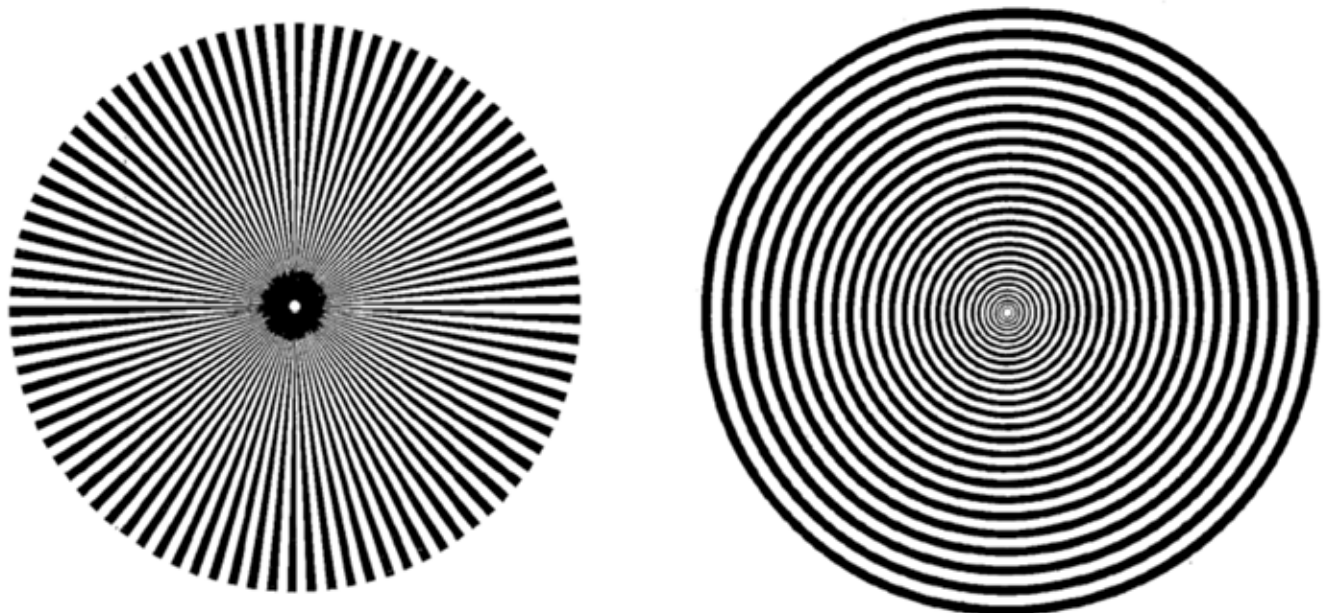
Knill DC, Kersten D. (1991) Apparent surface curvature affects lightness perception. *Nature.* May 16; 351(6323):228-30.

Week 15: A grant summary: structuring neural computations within a Bayesian framework.

Project presentation



(The horizontal lines are straight. A version of the Munsterberg illusion by Akiyoshi Kitaoka)



(From: Wade. *The art and science of visual illusions*)