

# Curriculum Vitae

## David Hoyt Brainard

### Personal Information

David Hoyt Brainard  
Department of Psychology  
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### Education

1982, Harvard University, A.B. Magna Cum Laude, Physics.  
1989, Stanford University, M.S., Electrical Engineering.  
1989, Stanford University, Ph.D., Psychology.

### Employment

1982-83, Aox Incorporated, Hopkinton, MA, Systems Programmer.  
1984, Fudan University, Physics, Visiting Scholar (Unpaid Summer Position).  
1990-91, University of Rochester, Center for Visual Science, Post-Doctoral Fellow.  
1991-1995, University of California at Santa Barbara, Psychology, Assistant Professor.  
1995-1999, University of California at Santa Barbara, Psychology, Associate Professor.  
1999-2001, University of California at Santa Barbara, Psychology, Professor.  
2005-2010, University of Pennsylvania, Psychology, Department Chair.  
2001-2013, University of Pennsylvania, Psychology, Professor.  
2013-present, University of Pennsylvania, RRL Professor of Psychology.

### Awards and Honors

1978, National Merit Scholar.  
1985-88, NSF Graduate Fellowship.  
1987, ARVO Travel Fellowship.  
1987, Cold Spring Harbor Laboratory Short Course Fellowship.  
1990-91, NIH/NEI National Research Service Award, Individual Post-Doctoral Fellowship.  
1991, Best Student Paper, Society for Information Display Annual Meeting.  
1993, Honorable Mention, NSF Young Investigator Award Program.  
2000, Fellow, Optical Society (OSA).  
2006, Macbeth Award, Inter-Society Color Council.  
2009, Fellow, Association for Psychological Science (APS).  
2013, Ira H. Abrams Memorial Award for Distinguished Teaching, School of Arts and Sciences, University of Pennsylvania.  
2015, Stein Innovation Award, Research to Prevent Blindness (RPB).  
2016, Palmer Lecture, Colour Group of Great Britain.  
2017, Silver Fellow, Association for Research in Vision and Ophthalmology (ARVO).  
2017, Boynton Lecture, Optical Society (OSA).

## Extramural Support

1992-2018, NIH/NEI RO1 EY010016, Color constancy, PI.  
2015-2018, DoD MR141251, Melanopsin specific contributions to photophobia in brain trauma, Co-PI (Aguirre, PI).  
2015-2019, NIH/NEI RO1 EY024681. Melanopsin and cone signals in human visual processing, PI (MPI award, with Aguirre also PI).  
2009-2020, NIH/NEI P30 EY00158, Core grant for vision research, PI.  
2015-2018, Research to Prevent Blindness (RBP) Stein Innovation Award, Assessment of retinal function at a cellular scale, PI.  
2014-2017, Simons Foundation Global Brain Initiative, Large-scale data and computational framework for circuit investigation, PI (MPI award with Chichilnisky, Rieke, and Wandell also PIs).  
2015-2020, NIH/NEI U01 EY025477, Platform technologies for microscopic retinal imaging: development and translation, Co-I (Carroll and Dubra, PIs).  
2010-2016, NSF IGERT Training Grant, Complex scene perception, Co-I (Daniilidis, PI).  
2014-2015, Samsung Corporation, Regional tone mapping optimization in high-dynamic range display, PI.  
2010-2015, NIH, Test efficacy of retinal photoswitch molecules in a canine model, Co-I (Beltran, PI at Penn; Isacoff, PI).  
2014-2015, Reading center services for assessing redness clinically and photographically. Amakem Therapeutics, Co-I (Maguire, PI).  
2010-2014, PA Department of Health CURE 2010-06-01, Improving vision and preventing visual impairment in rural Amish and urban African Americans, Co-I (Stambolian, PI).  
2012-2013, Sponsored Research Agreement, Amakem Therapeutics, Co-I (Maguire, PI).  
2009-2011, NIH/NEI RO1 EY010016S1, Color constancy ARRA supplement, PI.  
2010, Sponsored Research Agreement, Inspire Pharmaceutical, Co-I (Maguire, PI).  
2005-2010, NIH/NIMH RO1 MH70850 Visual knowledge of objects, Co-I (Thompson-Schill, PI).  
2000-2001, Sponsor, NIH/NEI NRSA post-doctoral fellowship awarded to Manoel Rowe.  
2000-2001, Agilent Corporation, Research in digital imaging, PI.  
1995-2000, Hewlett-Packard Corporation, Research in digital imaging, PI.  
1996-99, Sponsor, NIH/NEI NRSA post-doctoral fellowship awarded to James Kraft.  
1993-95, NSF, Instructional Laboratory Instrumentation, Laboratory in human information processing, PI.

## Intramural Grant Support

1991-95, UCSB Academic Senate Travel Grants.  
1991, UCSB Academic Senate Research Grant.  
1992, UCSB Instructional Development Minigrant.  
1993, UCSB Academic Senate Research Grant.  
1994, UCSB Academic Senate Research Grant (with G. Jacobs).  
1994, UCSB Instructional Development Minigrant.  
2011, Penn University Research Foundation Grant.

## Publications

For updated list, see <http://color.psych.upenn.edu/brainard>

1. Brainard, D.H. and Wandell, B.A. (1986). Analysis of the retinex theory of color vision. *Journal of the Optical Society of America A*, **3**, 1651-1661. Reprinted in Color (Physics-based Vision/ Principles and Practice), Healey, G.E., Shafer, S. A. and Wolff, L.B. (eds.), Jones and Bartlett Publishers, Boston, MA, 1992.
2. Brainard, D.H. (1989). Calibration of a computer controlled color monitor. *Color Research and Application*, **14**, 23-34.
3. Brainard, D.H., Wandell, B.A., and Cowan, W. (1989). Black light: how sensors filter spectral variations of the illuminant. *IEEE Transactions on Biomedical Engineering*, **36**, 140-149. Erratum published in *IEEE Transactions on Biomedical Engineering*, **36**, 572.
4. Wandell, B.A. and Brainard, D.H. (1989). Towards cross-media color reproduction. *Proceedings of the OSA Applied Vision Topical Meeting*, San Francisco, CA.
5. Brainard, D.H. (1989). Letter to the editor. *Color Research and Application*, **15**, 270.
6. Brainard, D.H. and Wandell, B.A. (1990). Calibrated processing of image color. *Color Research and Application*, **15**, 266-271.
7. Brainard, D.H. (1990). Calibrated color image processing. *Proceedings of SPSE's 43rd Annual Conference*, 171-173.
8. Poirson, A.B., Wandell, B.A., Varner, D. and Brainard, D.H. (1990). Surface characterizations of color thresholds. *Journal of the Optical Society of America A*, **7**, 783-789.
9. Brainard, D.H. and Wandell, B.A. (1990). The effect of the illuminant on color appearance. *Proceedings of the SPIE/SPSE Symposium on Electronic Imaging*, **1250**, 119-130.
10. Brainard, D.H. and Wandell, B.A. (1991). Evaluation of CIE Luv and CIE Lab as perceptual image representations. *Society for Information Display International Symposium Technical Digest*, **22**, 799-801.
11. Brainard, D.H. and Wandell, B.A. (1991). A bilinear model of the illuminant's effect on color appearance. In Computational Models of Visual Processing, Landy, M. and Movshon, J. A. (eds.), MIT Press.
12. Williams, D.R., Sekiguchi, N., Haake, W., Brainard, D.H., and Packer O. (1991). The cost of trichromacy for spatial vision. In Advances in Understanding Visual Processes: Convergence of Neurophysiological and Psychophysical Evidence, Lee, B. and Valberg, A. (ed.), Plenum Press.
13. Brainard, D.H. and Wandell, B.A. (1992). Asymmetric color matching: how color appearance depends on the illuminant. *Journal of the Optical Society of America A*, **9**, 1433-1448.
14. Brainard, D.H. and Williams, D.R. (1992). Spatial reconstruction of signals from short-wavelength cones. *Optical Society of America Topical Meeting: Advances in Color Vision. Digest Series*, **4** (1992), 211-213.

15. Sekiguchi, N. Williams, D.R. and Brainard, D.H. (1992) Contrast sensitivity for isoluminant and isochromatic interference fringes. *Optical Society of America Topical Meeting: Advances in Color Vision. Digest Series*, **4** (1992), 72-73.
16. Brainard, D.H. and Williams, D.R. (1992). Spatial reconstruction of signals from short-wavelength cones. *Vision Research*, **33**, 105-116.
17. Brainard, D.H. (1993). Perceptual variability as a fundamental axiom of perceptual science: comments on Ashby and Lee. In Foundations of Perceptual Theory, S. C. Masin (ed), Elsevier Science Publishers.
18. Brainard, D.H., Wandell, B.A., and Chichilnisky, E. J. (1993). Color constancy: from physics to appearance. *Current Directions in Psychological Science*, **2**, 165-170.
19. Sekiguchi, N., Williams, D.R., and Brainard, D.H. (1993). Aberration-free measurements of the visibility of isoluminant gratings. *Journal of the Optical Society of America A*, **10**, 2105-2117.
20. Sekiguchi, N., Williams, D.R., and Brainard, D.H. (1993). Efficiency for detecting isoluminant and isochromatic interference fringes. *Journal of the Optical Society of America A*, **10**, 2118-2133.
21. Williams, D.R., Sekiguchi, N., and Brainard, D.H. (1993). Color, contrast sensitivity, and the cone mosaic. *Proc. Nat. Acad. Sci. USA*, **90**, 9770-9777.
22. Brainard, D.H. and Freeman, W.T. (1994). Bayesian method for recovering surface and illuminant properties from photoreceptor responses. *Proceedings of the SPIE Conference on Human Vision, Visual Processing, and Display V*, **2179**, 364-376.
23. Brainard, D.H. (1994). Bayesian method for reconstructing color images from trichromatic samples. *Proceedings of the IS&T 47th Annual Meeting*, Rochester, NY, 375-380.
24. Williams, D.R., McMahon, M, Brainard, D.H., and Navarro, R. (1994). Comparison of noninvasive measures of the optical quality of the eye. *Proceedings of the OSA Topical Meeting: Vision Science and its Applications. Digest Series*, **2** (1994), 68-71.
25. Williams, D.R. Brainard, D.H., McMahon, M., and Navarro, R. (1994). Double pass and interferometric measures of the optical quality of the human eye. *Journal of the Optical Society of America A*, **11**, 3123-3135.
26. Brainard, D.H. (1995). Colorimetry. In OSA Handbook of Optics: Volume 1. Fundamentals, Techniques, and Design, Second Edition, M. Bass (ed), McGraw-Hill, Inc., New York, 26.1-26.54.
27. Freeman, W.T. and Brainard D.H. (1995). Bayesian decision theory, the maximum local mass estimate, and color constancy. *Proceedings of the Fifth International Conference on Computer Vision.*, 210-217.
28. Brainard, D. H. and Sherman, D. (1995). Reconstructing images from trichromatic samples: from basic research to practical applications. *Proceedings of the 3<sup>rd</sup> IS&T/SID Color Imaging Conference*, Scottsdale, AZ, pp. 4-10.
29. Brainard, D. H. and Ishigami, K. (1995). Factors influencing the appearance of CRT colors. *Proceedings of the 3<sup>rd</sup> IS&T/SID Color Imaging Conference*, Scottsdale, AZ, pp. 62-66.

30. Williams, D. R., Artal, P., Navarro, R., McMahon, M. J. and Brainard, D. H. (1996). Off-axis optical quality and retinal sampling in the human eye. *Vision Research* **36**, 1104-1114.
31. Speigle, J. M. and Brainard, D. H. (1996). Luminosity thresholds: effects of test chromaticity and ambient illumination. *Journal of the Optical Society of America A* **13**, 436-451.
32. Brainard, D. H. (1996). Cone contrast and opponent modulation color spaces. In Kaiser and Boynton, Human Color Vision, 2nd edition, Optical Society of America, Washington, DC.
33. Speigle, J. M. and Brainard, D. H. (1996). Is color constancy task independent? *Proceedings of the 4th IS&T/SID Color Imaging Conference*, Scottsdale, AZ, pp. 167-172.
34. Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, **10**, 433-436.
35. Chen, C. C., Foley, J. M. and Brainard, D. H. (1997). Detecting chromatic patterns on chromatic pattern pedestals. *IS&T Proceedings: Optics and Imaging in the Information Age*, 19-24.
36. Brainard, D. H. and Freeman, W. T. (1997). Bayesian color constancy. *Journal of the Optical Society of America A*, **14**, 1393-1411.
37. Brainard, D. H., Brunt, W. A., and Speigle, J.M. (1997). Color constancy in the nearly natural image. 1. Asymmetric matches. *Journal of the Optical Society of America A*, **14**, 2091-2110.
38. Vora, P. L., Harville, M. L., Farrell, J. E., Tietz, J. D., and Brainard, D. H. (1997). Image capture: synthesis of sensor responses from multispectral images. Proceedings of the 1997 IS&T/SPIE Conference on Electronic Imaging, (San Jose, CA, February 10-14, 1997), 3018, 2-11.
39. Vora, P. L., Farrell, J. E., Tietz, J. D., and Brainard, D. H. (1997). Linear models for digital cameras. Proceedings of the 1997 IS&T 50th Annual Conference, (Cambridge, MA, May 18-23, 1997), 377-382.
40. Brainard, D. H. (1998). Color constancy in the nearly natural image. 2. Achromatic loci. *Journal of the Optical Society of America A*, **15**, 307-325.
41. Fleishman, L. J., McClintock, W. J., D'Eath, R. B., Brainard, D. H. and Endler, J. A. (1998). Colour perception and the use of video playback experiments in animal behavior. *Animal Behavior*, **56**, 1035-1040.
42. Brainard, D. H. (1999). Color Vision. In the MIT Encyclopedia of the Cognitive Sciences, R. Wilson and F. Keil (eds.). See also <http://mitpress.mit.edu/MITECS/work/brainard.html>.
43. Kraft, J. M. and Brainard, D. H. (1999). Mechanisms of color constancy under nearly natural viewing. *Proceedings of the National Academy of Sciences USA.*, **96**, 307-312. PMID: PMC15135. [For a commentary on this paper, see Hurlbert, A. (1999). Is color constancy real? *Current Biology*, **12**, R558-R561.]
44. Speigle, J. M. and Brainard, D. H. (1999). Predicting color from gray: the relationship between achromatic adjustment and asymmetric matching, *Journal of the Optical Society of America A*, **16**, 2370-2376.
45. Brainard, D. H., Calderone, J. B., Nugent, A. K., and Jacobs, G. H. (1999). Flicker ERG responses to stimuli parametrically modulated in color space. *Investigative Ophthalmology and Visual Science*, **40**, 2840-2847.

46. Brainard, D. H., Roorda, A., Yamauchi, Y., Calderone, J. B., Metha, A., Neitz, M., Neitz, J., Williams, D. R., and Jacobs, G. H. (2000). Functional consequences of the relative numbers of L and M cones. *Journal of the Optical Society of America A*, 17, 607-614. Erratum published in *Journal of the Optical Society of America A*, 17, 607-614, 17, 1684.
47. Chen, C.C., Foley, J. M., and Brainard, D. H. (2000). Detection of chromoluminance patterns on chromoluminance pedestals I: Threshold Measurements. *Vision Research*, 40, 773-788.
48. Chen, C.C., Foley, J. M., and Brainard, D. H. (2000). Detection of chromoluminance patterns on chromoluminance pedestals II: Model. *Vision Research*, 40, 789-803.
49. Dacey, D., Packer, O.S., Diller, L., Brainard, D., Peterson, B., and Lee, B. (2000). Center surround receptive field structure of cone bipolar cells in primate retina. *Vision Research*, 40, 1801-1811.
50. Brainard, D.H. (2000). How to write an effective manuscript review. *Optics and Photonics News*, June 2000, 42-43.
51. Delahunt, P.B. & Brainard, D.H. (2000). Control of chromatic adaptation: signals from separate cone classes interact. *Vision Research*, 40, 2885-2903. Erratum published in 2008: *Vision Research*, 48, 1186.
52. Packer, O., Diller, L.C., Verweij, J., Lee, B.B., Pokorny, J., Williams, D.R., Dacey, D.M., and Brainard, D.H. (2001). Characterization and use of a digital light projector for vision research. *Vision Research*, 41, 427-439.
53. Vora, P.L., Farrell, J.E., Tietz, J.D., and Brainard, D.H. (2001). Image capture: simulation of sensor responses from hyperspectral images. *IEEE Transactions on Image Processing*, 10, 307-316.
54. Longere, P. and Brainard, D. H. (2001). Simulation of digital camera images from hyperspectral input. In *Vision Models and Applications to Image and Video Processing*. C. van den Branden Lambrecht (ed.), Kluwer. 123-150.
55. Brainard, D. H. (2001). Color vision theory. In *International Encyclopedia of the Social and Behavioral Sciences*, N. J. Smelser & P. B. Baltes (eds.), Elsevier, Oxford, UK, Vol.4, 2256-63.
56. Longere, P., Delahunt, P. B., Zhang, X., and Brainard, D. H. (2002). Perceptual assessment of demosaicing algorithm performance. *Proceedings of the IEEE*, 90, 123-132.
57. Rutherford, M. D. and Brainard, D. H. (2002). Lightness constancy: a direct test of the illumination estimation hypothesis. *Psychological Science*, 13, 142-149.
58. Kraft, J. M., Maloney, S. I., and Brainard, D. H. (2002). Surface-illuminant ambiguity and color constancy: effects of scene complexity and depth cues. *Perception*, 31, 247-263.
59. Brainard, D. H., Pelli, D.G., and Robson, T. (2002). Display characterization. In *Encyclopedia of Imaging Science and Technology*. J. Hornak (ed.), Wiley: 172-188.
60. Reese, L. A., Ashby, F. G. and Brainard, D. H. (2002). What makes a categorization task difficult? *Perception and Psychophysics*, 64, 570-583.
61. Yamauchi, Y., Williams D. R., Brainard D. H., Roorda, A., Carroll, J., Neitz, M., Neitz, J., Calderone, J. B., Jacobs, G. H. (2002). What determines unique yellow, L/M cone ratio or visual

experience? Paper presented at the 9th Congress of the International Colour Association, *Proceedings of SPIE*, 4421, 275-278.

62. Brainard, D. H. (2003). Color appearance and color difference specification. In *The Science of Color*, 2nd edition, S. K. Shevell (ed.), Optical Society of America, Washington D.C., 191-216.

63. Brainard, D. H., Kraft, J. M., and Longere, P. (2003). Color constancy: developing empirical tests of computational models. In *Colour Perception: From Light To Object*, R. Mausfeld and D. Heyer (eds.), Oxford University Press, 307-334.

64. Brainard, D. H. (2003). Surface color appearance in nearly natural images: commentary on Maloney and Yang. In *Colour Perception: Mind and the Physical World*, R. Mausfeld and D. Heyer (eds.), Oxford University Press, 359-360.

65. Singh, B., Freeman, W. T., and Brainard, D. (2003). Exploiting spatial and spectral image regularities for color constancy. Paper presented at the 3rd Int'l Workshop on Statistical and Computational Theories of Vision, Nice France, October 12, 2003 ([http://department.stat.ucla.edu/~yuille/meetings/2003\\_workshop.php](http://department.stat.ucla.edu/~yuille/meetings/2003_workshop.php)).

66. Brainard, D. H. (2004). Color constancy. In *The Visual Neurosciences*, L. Chalupa and J. Werner (eds.), MIT Press, 948-961.

67. Delahunt, P. B. and Brainard, D. H. (2004). Does human color constancy incorporate the statistical regularity of natural daylight? *Journal of Vision*, 4, 57-81, <http://journalofvision.org/4/2/1/>, doi:10.1167/4.2.1.

68. Brainard, D. H. & Maloney, L. T. (2004). Perception of color and material properties in complex scenes. *Journal of Vision*, 4, issue 9, ii-iv, <http://journalofvision.org/4/9/i/>, doi:10.1167/4.9.i. [Feature issue introduction.]

69. Bloj, M., Ripamonti, C., Mitha, K., Hauck, R., Greenwald, S., & Brainard, D. H. (2004). An equivalent illuminant model for the effect of surface slant on perceived lightness. *Journal of Vision*, 4, 735-746, <http://journalofvision.org/4/9/6/>, doi:10.1167/4.9.6.

70. Ripamonti, C., Bloj, M., Hauck, R., Mitha, K., Greenwald, S., Maloney, S. I., & Brainard, D. H. (2004). Measurements of the effect of surface slant on perceived lightness. *Journal of Vision*, 4, 747-763, <http://journalofvision.org/4/9/7/>, doi:10.1167/4.9.7.

71. Delahunt, P. B. & Brainard, D. H. (2004). Color constancy under changes in reflected illumination. *Journal of Vision*, 4, 764-778, <http://journalofvision.org/4/9/8/>, doi:10.1167/4.9.8.

72. Zhang, X. and Brainard, D. H. (2004). Bayesian color correction method for non-colorimetric digital image sensors. *Proceedings of the 12th IS&T/SID Color Imaging Conference*, Scottsdale, AZ, 308-314.

73. Zhang, X. and Brainard, D. H. (2004). Estimation of saturated pixel values in digital color imaging. *Journal of the Optical Society of America A*, 21, 2301-2310. PMID: PMC1815481.

74. Delahunt, P. B., Zhang, X., and Brainard, D. H. (2005). Perceptual image quality: effects of tone characteristics. *Journal of Electronic Imaging*, 14, 023003, 1-12. PMID: PMC1773023.

75. Hillis, J. M. & Brainard, D. H. (2005). Do common mechanisms of adaptation mediate color discrimination and appearance? Uniform backgrounds. *Journal of the Optical Society of America A*, 22, 2090-2106. PMID: PMC1815483.
76. Xiao, B. and Brainard D. H. (2006). Color perception of 3D objects: constancy with respect to variation of surface gloss. *Proceedings of ACM Symposium on Applied Perception in Graphics and Visualization (APGV06)*, July 28-29, 2006, Boston, MA, 63-68.
77. Brainard, D. H., Longere, P., Delahunt, P. B., Freeman, W. T., Kraft, J. M., Xiao, B. (2006). Bayesian model of human color constancy. *Journal of Vision*, 6, 1267-1281, <http://journalofvision.org/6/11/10/>, doi:10.1167/6.11.10. PMID: PMC2396883.
78. Yin, L., Smith, R. G., Sterling, P. and Brainard, D. H. (2006). Chromatic properties of horizontal and ganglion cell responses follow a dual gradient in cone opsin expression, 26, 12351-12361, doi:10.1523/JNEUROSCI.1071-06.2006. PMID: PMC1815484.
79. Aguirre, G. K., Komaromy, A. M., Cideciyan, A. V., Brainard, D. H., Aleman, T. S., Roman, A. J., Avants, B. B., Gee, J. C., Korczykowski, M., Hauswirth, W. W., Acland, G. M., Aguirre, G. D., Jacobson, S. G. (2007). Canine and human visual cortex intact and responsive despite early retinal blindness from RPE65 mutation. *PLOS Medicine*, 4, 1117-1128, doi:10.1371/journal.pmed.0040186. PMID: PMC1896221.
80. Hillis, J. M. and Brainard, D. H. (2007). Do common mechanisms of adaptation mediate color discrimination and appearance? Contrast adaptation. *Journal of the Optical Society of America A*, 24, 2122-2133. PMID: PMC2773246.
81. Abrams, A. B., Hillis, J. M., and Brainard, D. H. (2007). The relation between color discrimination and color constancy: when is optimal adaptation task dependent? *Neural Computation*, 19, 2610-2637. PMID: 17716005; PMID: PMC2671007.
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84. Brainard, D. H., Williams, D. R., & Hofer, H. (2008). Trichromatic reconstruction from the interleaved cone mosaic: Bayesian model and the color appearance of small spots. *Journal of Vision*, 8(5):15, 1-23, <http://journalofvision.org/8/5/15/>, doi:10.1167/8.5.15. PMID: 18842086; PMID: PMC2671890.
85. Xiao, B. & Brainard, D. H. (2008). Surface gloss and color perception of 3D objects. *Visual Neuroscience*, 25, 371-385. doi:10.1017/S0952523808080267. PMID: 18598406; PMID: PMC2538579.
86. Manning, J. R. & Brainard, D. H. (2009). Optimal design of photoreceptor mosaics: Why we do not see color at night. *Visual Neuroscience*, 26, 5-19. doi:10.1017/S095252380808084X. PMID: 19193250; PMID: PMC2671005.
87. Yin, L., Smith, R. G., Sterling, P., & Brainard, D. H. (2009). Physiology and morphology of color-opponent ganglion cells in a retina expressing a dual gradient of S and M opsins. *Journal of Neuroscience*, 29, 2706-2724. PMID: 19261865; PMID: PMC2677103.



88. Allred, S. R. & Brainard, D. H. (2009). Contrast, constancy, and measurements of perceived lightness under parametric manipulation of surface slant and surface reflectance. *Journal of the Optical Society of America A*, 26, 949-961. PMID: 19340270; PMCID: PMC2714230.
89. Brainard, D. H. (2009). Bayesian approaches to color vision. *The Cognitive Neurosciences, Fourth Edition* (M. S. Gazzaniga, ed.). MIT Press, Cambridge, MA, 395-408.
90. Brainard, D. H. (2009). Color constancy. In *the Sage Encyclopedia of Perception* (B. Goldstein, ed.), SAGE Publications, Los Angeles, 253-257.
91. Brainard, D. H. & Stockman, A (2010). Colorimetry. In *OSA Handbook of Optics: Volume 3. Vision and Vision Optics*, Third Edition, M. Bass (ed), McGraw-Hill, Inc., New York, 10.1-10.56. [This is an updated and expanded version of publication 26 listed above.]
92. Stockman, A & Brainard D. H. (2010). Color vision mechanisms. In *OSA Handbook of Optics: Volume 3. Vision and Vision Optics*, Third Edition, M. Bass (ed), McGraw-Hill, Inc., New York, 11.1-11.104.
93. Garrigan, P., Ratliff, C. P., Klein, J. M., Sterling, P., Brainard, D. H., & Balasubramanian, V. (2010). Design of a trichromatic cone array. *PLoS Comput Biol.* 6(2): e1000677. doi: 10.1371/journal.pcbi.1000677. PMCID: PMC2820519.
94. Maloney, L. T. & Brainard, D. H. (2010). Perception of color and material in complex scenes. *Journal of Vision*, 10(9:i), doi:10.1167/10.9.i. [Feature issue introduction.]
95. Olkkonen, M. & Brainard, D. H. (2010). Perceived glossiness and lightness under real-world illumination. *Journal of Vision*, 10(9:5), doi 10.1167/10.9.5. PMCID: PMC2981171.
96. Demb, J. B. & Brainard, D. H. (2010). Neurons show their true colors. *Nature*, 477, 670-671. [News and Views].
97. Maloney, L. T. & Brainard, D. H. (2010). Color and material perception: Achievements and challenges. *Journal of Vision*, 10(9:19), doi:10.1167/10.9.19. [Feature issue overview.]
98. Brainard, D. H. & Maloney, L. T. (2011). Surface color perception and equivalent illumination models. *Journal of Vision*, 11(5:1), doi: 10.1167/11.5.1. PMCID: PMC3249236.
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63. Allred, S. R., & Brainard, D. H. (2007). Parametric measurements of lightness in the context of real illuminated objects. *Vision Sciences Society Annual Meeting*, Sarasota, FL, 234a, <http://journalofvision.org/7/9/234/>, doi:10.1167/7.9.234.
64. Maloney, L. T., Doerschner, K., & Brainard, D. H. (2007). Color constancy in 3D scenes: contrasting illumination-estimation and heuristic models. *Vision Sciences Society Annual Meeting*, Sarasota, FL, 458a, <http://journalofvision.org/7/9/458/>, doi:10.1167/7.9.458.
65. Brainard, D. H., Hofer, H., & Williams, D. R. (2007). Bayesian models of color appearance: Understanding the appearance of small spot colors. *Vision Sciences Society Annual Meeting*, Sarasota FL, 791a, <http://journalofvision.org/7/9/791/>, doi:10.1167/7.9.791.
66. Allred, S. R. & Brainard, D. H. (2007). Scene complexity affects lightness constancy with respect to changes in object slant and surround reflectance. *OSA Fall Vision Meeting*, Sept 16-19, Berkeley, CA, 51a, <http://journalofvision.org/7/15/51/>, doi:10.1167/7.15.51.
67. Xiao, B. & Brainard, D. H. (2007). Effect of test patch location on color appearance, in the context of 3D objects. *6<sup>th</sup> International Radiance and HDR Scientific Workshop*, Twin Cities, Minnesota, October 1-2, 2007.

68. Lichtman, D. P., Xiao, B. & Brainard, D. H. (2007). RenderToolbox: A MATLAB Toolkit for Hyperspectral Rendering with Radiance and PBRT. 6<sup>th</sup> International Radiance and HDR Scientific Workshop, Twin Cities, Minnesota, October 1-2, 2007.
69. Allred, S. R., Lohnas, L. J., & Brainard, D. H. (2008). Bayesian model of the staircase Gelb effect. Vision Sciences Society Annual Meeting, Naples, FL, 283a, <http://journalofvision.org/8/6/283/>, doi:10.1167/8.6.283.
70. Allred, S. R., Lohnas, L. J., & Brainard, D. H. (2008). Bayesian model of lightness perception. Gordon Research Conference on Sensory Coding and the Natural Environment, Lucca, Italy, July 27-August 1, 2008.
71. Gingras, G., Komaromy, A., Brainard, D. H., Tseng B., Acland, G. M., Aguirre, G. D., & Aguirre, G. K. (2008). Cortical responses to rod and cone-isolating flicker in a canine model of achromatopsia. Society for Advancement of Chicanos and Native Americans in Science, Salt Lake City, Utah, October 9-12, 2008.
72. Allred, S., Troiani, V., Lohnas, L., Jiang, L., Radonjić, A., Gilchrist, A. & Brainard D. (2009). An ideal observer model predicts lightness matches. Vision Sciences Society Annual Meeting, Naples, FL, May 8-13, 2009, 345a, <http://journalofvision.org/9/8/345/>, doi:10.1167/9.8.345.
73. Xiao B. & Brainard D. (2009). Surface material properties and color constancy of 3D objects. Vision Sciences Society Annual Meeting, Naples, FL, May 8-13, 2009, 359a, <http://journalofvision.org/9/8/359/>, doi:10.1167/9.8.359.
74. Gingras, G., Komaromy, A. M., Tseng, B., Alexander, J. J., Chiodo, V. V., Hauswirth, W. W., Acland, G. M., Aguirre, G. D., Brainard, D. H., & Aguirre, G. K. (2009). Cortical recovery following gene therapy in a canine model of achromatopsia. Vision Sciences Society Annual Meeting, Naples, FL, May 8-13, 2009, 311a, <http://journalofvision.org/9/8/311/>, doi:10.1167/9.8.311.
75. Das, S., Oliver, R., Avants, B., Radoeva, P., Brainard, D., Aguirre, G., Gee, J. (2009). A semi-automated solution for increasing the reliability of manually defined visual area boundaries. Vision Sciences Society Annual Meeting, Naples, FL, May 8-13, 2009, 771a, <http://journalofvision.org/9/8/771/>, doi:10.1167/9.8.771.
76. Das, S., Oliver, R., Avants, B., Radoeva, P., Brainard, D., Aguirre, G., Gee, J. (2009). Reliability of semi-automated visual area definitions in retinotopy. Organization for Human Brain Mapping Annual Meeting, San Francisco, CA, June 18-23, 2009, Neuroimage, 47, S1.
77. Oliver, R., MacIntyre, L., Doerschner, K., Maloney, L. T., Brainard, D. H. (2009). Interaction between stimulus depth and color appearance: in search of large effects. OSA Fall Vision Meeting, September 24-27, Seattle, WA.
78. Olkkonen, M. & Brainard, D. H. (2009). Perception of lightness and glossiness under natural light fields. OSA Fall Vision Meeting, September 24-27, Seattle, WA.
79. Lee, T. Y. & Brainard D. H. (2009). Spatial integration and lightness perception. OSA Fall Vision Meeting, September 24-27, Seattle, WA.
80. Reinstein, S. L., Gingras, G., Broussard, C. G., Aguirre, G. K., Brainard, D. H., & Komaromy, A. M. (2010). Behavioral measurement of photoreceptor-directed contrast sensitivity in canine, ARVO Annual Meeting, May 2-6, 2010, Ft. Lauderdale, FL.

81. Olkkonen, M. & Brainard, D. H. (2010). Interaction of diffuse and specular reflectance in the perception of object lightness and glossiness. VSS Annual Meeting, May 7-12, 2010, Naples, FL. <http://journalofvision.org/10/7/389>, doi: 10.1167/10.7.389.
82. Madigan, S. C. & Brainard, D. H. (2010). Dissimilarity scaling of lightness across changes of illumination and surface slant. VSS Annual Meeting, May 7-12, 2010, Naples, FL. <http://journalofvision.org/10/7/447>, doi: 10.1167/10.7.447.
83. Manning, J. R., Hurst, B. & Brainard, D. H. (2011). Learning receptor types from receptor responses. COSYNE 2011, February 24-27, 2011, Salt Lake City, Utah.
84. Benson, N. C., Butt, O. H., Datta, R., Brainard, D. H. & Aguirre G. K. (2011). A universal retinotopic mapping of V1 with respect to anatomy. VSS Annual Meeting, Naples, FL, May 6-11, 2011. <http://journalofvision.org/11/11/1067>, doi: 10.1167/11.11.1067.
85. Butt, O. H., Benson, N. C., Datta, R., Brainard, D. H. & Aguirre G. K. (2011). Multi-focal and phase-encoded retinotopy compared. VSS Annual Meeting, Naples, FL, May 6-11, 2011. <http://journalofvision.org/11/11/1069>, doi: 10.1167/11.11.1069.
86. Radonjić, A., Gilchrist, A., Allred, S. and Brainard, D. (2011). Lightness perception in high-dynamic range contexts. VSS Annual Meeting, Naples, FL, May 6-11, 2011. <http://journalofvision.org/11/11/375>, doi: 10.1167/11.11.375.
87. Kanematsu, E. & Brainard, D. H. (2011). Effects of familiar objects on color perception. VSS Annual Meeting, Naples, FL, May 6-11, 2011. <http://journalofvision.org/11/11/384>, doi: 10.1167/11.11.384.
88. Olkkonen, M. & Brainard, D. (2011). Shape modulates the effect of lightfield on perceived glossiness. VSS Annual Meeting, Naples, FL, May 6-11, 2011. <http://journalofvision.org/11/11/398>, doi: 10.1167/11.11.398.
89. Tan, G. & Brainard, D. H. (2011). Bayesian reconstruction of trichromatic images using Cauchy priors in the wavelet domain. IEEE Symposium on Signal Processing in Medicine and Biology, December 10, 2011, Brooklyn, NY.
90. Radonjić, A & Brainard, D. H. (2012). Eye movements reveal inter-observer processing differences in a color appearance task. VSS Annual Meeting, Naples, FL, 2012. <http://www.journalofvision.org/content/12/9/864>, doi: 10.1167/12.9.864.
91. Benson, N. C. & Brainard, D. H. (2012). An Unsupervised Learning Technique for Typing Cones in the Retinal Mosaic. VSS Annual Meeting, Naples, FL, 2012. <http://www.journalofvision.org/content/12/9/1167>, doi: 10.1167/12.9.1167.
92. Lee, T. Y. & Brainard, D. H. (2012). Both 3D Orientation and Local Contrast Affect Surface Lightness. VSS Annual Meeting, Naples, FL, 2012. <http://www.journalofvision.org/content/12/9/1215>, doi: 10.1167/12.9.1215.
93. Persichetti, A. S., Thompson-Schill, S. L., Brainard, D. H., Butt, O. H., Hsu, N S., & Aguirre, G. K. (2012). Application of fMRI adaptation to characterize the neural representation of color. VSS Annual Meeting, Naples, FL, 2012. <http://www.journalofvision.org/content/12/9/851>, doi: 10.1167/12.9.51.

94. Benson, N. C., Butt, O. H, Jain, S., Brainard, D. H. & Aguirre G. K. (2013). Cortical surface structure predicts extrastriate retinotopic function, VSS Annual Meeting, Naples, FL, 2013. <http://journalofvision.org/13/9/271>, doi:10.1167/13.9.271.
95. Radonjić, A., DiClemente, K., & Brainard, D. H. (2013). Do asymmetric color matches predict cross-illumination color selection. VSS Annual Meeting, Naples, FL, 2013. <http://journalofvision.org/13/9/462>, doi:10.1167/13.9.462.
96. Spitschan, M., Jain, S., Brainard, D. H., and Aguirre, G. K. (2013) Temporal properties of photopigment contributions to the pupillary light reflect. OSA Fall Vision Meeting, Houston, TX, 2013, <http://www.journalofvision.org/content/13/15/P4.short>, doi: 10.1167/13.15.39.
97. Ruff, D. A., Brainard, D. H. & Cohen, M. R. (2014) Neuronal population decoding can account for perceptual lightness illusions. COSYNE, Salt Lake City, Utah, 2014.
98. Spitschan, M., Luu, L., Datta, R., Brainard, D. H., and Aguirre G. K. (2014). Melanopsin-driven responses in the human brain. VSS Annual Meeting, St. Petes Beach, FL, 2014. <http://www.journalofvision.org/content/14/10/594>.
99. Brainard, D. H., Ruff, D. A. & Cohen, M. R. (2014). Neuronal population decoding can account for perceptual lightness illusions. VSS Annual Meeting, St. Petes Beach, FL, 2014. <http://www.journalofvision.org/content/14/10/597>.
100. Pearce, B., Radonjić, A., Dubin, H., Cottaris, N. P., Mackiewicz, M., Finlayson, G., Brainard, D. H. & Hurlbert A. (2014). Illumination discrimination reveals "blue" bias of colour constancy in real and simulated Scenes. VSS Annual Meeting, St. Petes Beach, FL, 2014. <http://www.journalofvision.org/content/14/10/599>.
101. Radonjić, A., Cottaris, N. P., & Brainard, D. H. (2014). Color constancy in a natural task is high VSS Annual Meeting, St. Petes Beach, FL, 2014. <http://www.journalofvision.org/content/14/10/798>.
102. Luu, L., Spitschan, M., Aguirre G. K., and Brainard, D. H. (2014). Melanopsin and cone specific temporal filtering revealed by non-linear pupil responses. VSS Annual Meeting, St. Petes Beach, FL, 2014. <http://www.journalofvision.org/content/14/10/988>.
103. Lindsey, D., Brown, A., Brainard, D., & Apicella, C. (2014). Hadza color naming and the origins of basic color categories. VSS Annual Meeting, St. Petes Beach, FL, 2014. <http://www.journalofvision.org/content/14/10/1001>.
104. Spitschan, M., Aguirre, G. K., & Brainard D. H. (2014). Penumbra cones and Purkinje Trees. OSA Fall Vision Meeting, Philadelphia, PA, 2014. <http://www.journalofvision.org/content/14/15/22>.
105. Radonjić, A. & Brainard, D. H. (2014). Color constancy in action. OSA Fall Vision Meeting, Philadelphia, PA, 2014. <http://www.journalofvision.org/content/14/15/84>.
106. Krieger, A. Dubin, H., Pearce, B., Aston, S., Hurlburt, A., Brainard, D. & Radonjić, A (2015). Illumination discrimination depends on scene surface ensemble. VSS Annual Meeting, St. Petes Beach, FL, 2015. <http://jov.arvojournals.org/article.aspx?articleid=2433511>.
107. Lindsey, D., Brown, A., Brainard, D. & Apicella, C (2015). The color communication game. VSS Annual Meeting, St. Petes Beach, FL, 2015, <http://jov.arvojournals.org/article.aspx?articleid=2433064>.

108. Spitschan, M., Ryan, J., Brainard D. H., & Aguirre, G. K. (2016). Dependence of melanopsin-mediated human pupil responses upon light level and stimulus masking. ARVO Annual Meeting, Seattle, WA, May 1-5, 2017.
109. Chen, M., Cooper, R. F., Han, G. K., Gee J., Brainard, D. H., Morgan, J. I. (2016). Multi-modal montaging of adaptive optics retinal images. ARVO Annual Meeting, Seattle, WA, May 1-5, 2017.
110. Ding, X., Krieger, A., Pearce, B., Aston, S., Hurbert, A., Brainard, D., & Radonjić, A. (2016). Illumination discrimination in the absence of a fixed surface reflectance layout. VSS Annual Meeting, May 13-18, St. Pete's Beach, FL. Journal of Vision, Vol.16, 219. doi:10.1167/16.12.219.
111. Radonjic, A. & Brainard, D. H. (2016). Lightness perception in real and simulated scenes. ECVF, August 28-September 1, 2016. Barcelona, Spain.
112. Cooper R. F., Tuten W. S., Brainard, D. H. & Morgan, J. I. W. (2017). Irradiance and duration dependence of the cone photoreceptor intrinsic reflectance response. OSA Fall Vision Meeting, October 13-15, Rochester, NY. [Winner, Young Investigator Award.]
113. Spitschan, M., Bock, A. S., Frazzetta, G., Brainard, D. H., & Aguirre, G. K. (2017). Human visual cortex responds to isolated melanopsin-directed stimulation. OSA Fall Vision Meeting, October 13-15, Rochester, NY.

## Theses Supervised

- C. C. Chen (1996). Chromatic pattern vision mechanisms: masking experiments and divisive inhibition models. Ph.D. Thesis. Department of Psychology, UC Santa Barbara. Co-advised with John Foley.
- W. A. Brunt (1996). Simultaneous color constancy measured using asymmetric color matching under naturalistic conditions. Master Thesis. Department of Psychology, UC Santa Barbara.
- J. M. Speigle (1998). Testing whether a common representation explains the effect of viewing context on color appearance. Ph.D. Thesis, Department of Psychology, UC Santa Barbara.
- P. B. Egan (1998). The relationship between lightness and color appearance: are context effects calculated independently for each cone type? Master Thesis. Department of Psychology, UC Santa Barbara.
- M. D. Rutherford (2000). The role of illumination perception in color constancy. Ph.D. Thesis, Department of Psychology, UC Santa Barbara.
- P. B. Delahunt (nee Egan) (2001). An evaluation of color constancy across illumination and mutual reflection changes. Ph.D. Thesis, Department of Psychology, UC Santa Barbara
- L. Yin (2008). Retinal processing of achromatic and chromatic signals in guinea pig along the dual gradient in cone opsin expression. Ph.D. Thesis, Neuroscience Graduate Program, University of Pennsylvania. Co-advised with Peter Sterling.
- B. Xiao (2009). Color perception and constancy of objects in 3D complex scenes. Ph.D. Thesis, Neuroscience Graduate Program, University of Pennsylvania.
- S. C. Madigan (2011). The effect of object orientation on lightness representation. Ph.D. Thesis, Department of Psychology, University of Pennsylvania.

T. Y. Lee (2012). Integration and segregation in audition and vision. Ph.D. Thesis, Department of Psychology, University of Pennsylvania. Audition work supervised by Virginia Richards.

M. Spitschan (2016). Melanopsin sensitivity in the human visual system. Ph.D. Thesis, Department of Psychology, University of Pennsylvania. Co-advised with Geoff Aguirre.

## **Post-Doctoral Advisees**

J. M. Kraft, 1996-1999.  
M. P. Rowe, 2000-2001.  
P. Longere, 2000-2001.  
K. Ripamonti, 2002-2004.  
J. M. Hillis, 2002-2005.  
J. A. Wilson, 2004-2006.  
S. R. Allred, 2006-2009.  
R. T. Oliver, 2007-2009.  
M. Olkkonen, 2009-2011.  
N. C. Benson, co-advised with G. K. Aguirre, 2011-2014.  
A. Radonjić, 2010-present.  
R. F. Cooper, 2016-present.  
W. S. Tuten, 2016-present.

## **Graduate Rotation Supervision (Penn)**

Lu Yin, Neuroscience, 2001  
Bei Xiao, Neuroscience, 2003  
Patrick Williams, Neuroscience, 2003  
Guang Chen, Bioengineering, 2003  
Jeremy Manning, Neuroscience, 2006  
Lynn Lohnas, Neuroscience, 2007  
Kristy Simmons, Neuroscience, 2007  
Vanessa Troiani, Neuroscience, 2008  
Jiang Li, Neuroscience, 2008  
Grace Tan, Bioengineering, 2011  
Manuel Spitschan, Psychology, 2012  
Long Luu, Psychology, 2013  
Jessica Hsu, Bioengineering, 2015

## **PhD Thesis Committees (Penn)**

Crystal Lutz, Psychology, 2003 PhD  
Jason Liu, Radiology, 2005 PhD  
Hjiang Qi, Bioengineering, 2007 PhD  
Patrick Connolly, Neuroscience, 2008 PhD  
Joshua Jacobs, Neuroscience, 2008 PhD  
Daniel Drucker, Psychology, 2009 PhD  
Rishi Kalwani, Neuroscience, 2011 PhD  
Jeremy Manning, Neuroscience, 2011 PhD  
Nina Hsu, Neuroscience, 2012 PhD  
Jason Prentice, Physics, 2012 PhD

Lynn Lohnas, Neuroscience, 2012 PhD  
Kristy Simmons, Neuroscience, 2013 PhD  
John Burke, Neuroscience, 2013 PhD  
David Kahn, Neuroscience, 2015 PhD  
Xuexin Wei, Psychology, 2015, PhD  
Kate Christison-Lagay, Neuroscience, 2015, PhD  
Adam Gifford, Neuroscience, 2016, PhD  
Alex Burka, Electrical and Systems Engineering, in progress  
Matt Churgin, Bioengineering, in progress  
David Isele, Electrical and Systems Engineering, in progress

## **Undergraduate/MA Research Supervision (Penn)**

Kiran Mitra, 2002, Independent Study  
Robin Hauck, 2002, Independent Study  
Joel Gutierrez, 2003, Summer Intern  
Scott Greenwald, 2003, Paid Research Assistant  
Paul Kanyuk, 2003, Paid Research Assistant  
Sarah Kearney, 2005, Senior Thesis  
Michal Parness, 2005, Senior Thesis  
Cara O'Boyle, 2005, Paid Research Assistant  
Catherine Sharrar, 2006, Senior Thesis  
Jennifer Klein, 2006, Senior Thesis  
David Harwood, 2007, Summer Intern  
Ah Rim Shin, 2008, Senior Thesis  
Brendan Hurst, 2008, Summer Intern  
Elizabeth Megas, 2009, Independent Study  
Lauren MacIntyre, 2009-11, Paid Research Assistant  
Danielle Daitch, 2010, Senior Thesis  
Angelica Godinez, 2011, Summer Intern  
Manuel Spitschan, 2011, Summer Intern  
Kira DiClemente, 2012, Independent Study, Paid Research Assistant  
Aylin Daldal, 2012, Independent Study  
Emma France, 2012, Summer Intern  
Ayaka Nonaka, 2013, Senior Design Project  
Josh Wilson, 2013, Senior Design Project  
Jordan Kodner, 2013, Senior Design Project  
Robin Choi, 2013, Independent Study  
Jack Allen, 2013, Independent Study  
Hillary Dubin, 2013-15, Paid Research Assistant  
Ben Bolnick, 2014, Independent Study  
Richa Agrawal, 2014, MA Thesis Committee Member (Robotics)  
Avery Krieger, 2014-16, Paid Research Assistant, Senior Thesis  
Alexander Graf, 2014-15, Senior Thesis  
Maneka Mirchandaney, 2015, Independent Study  
Xiaomao Ding, 2015, Paid Research Assistant  
Rashad Abdulla, 2016, Independent Study  
Susan Hao, 2016, Independent Study, Senior Thesis  
Tamara Balderas, 2016, Independent Study  
Xiaomao Ding, 2016-17, Senior Thesis

## **Invited Talks**

1991, UC Irvine, "Reconstruction of signals from short-wavelength cones."

1992, UC San Diego, "Reconstruction of signals from short-wavelength cones."

1993, University of Rochester, "Bayes estimator for reconstruction from samples."

1993, UCLA, "Bayes estimator for reconstruction from samples."

1993, Conference on Geometrical Representations of Mathematical Phenomena, "Reconstructing a trichromatic percept from univariate samples"

1993, UC Berkeley, "Ideal observer for reconstruction from trichromatic samples."

1993, Stanford University, "Ideal observer for reconstruction from trichromatic samples."

1993, UCSB, Department of Statistics, "Bayesian method for reconstruction from trichromatic samples: applications to human vision."

1994, Society for Illumination Engineering, Santa Barbara Chapter, "How the illumination affects color appearance."

1994, UCSB, Department of Physics, "Non-linear inverse problems: applications to color vision."

1994, UCSB, Department of Electrical and Computer Engineering, "Bayesian method for recovering surface and illuminant properties from photosensor responses."

1994, IS&T 47th Annual Meeting, "Bayesian method for reconstructing color images from trichromatic samples."

1994, Goldstar Corporation Image and Media Lab, Seoul, Korea, "Color constancy in human and machine vision."

1994, Osaka Electro-Communication University, Osaka, Japan, "Color constancy in human and machine vision."

1995, UC Irvine, Department of Cognitive Science, "Color constancy in the nearly natural image."

1995, MIT, Department of Brain and Cognitive Sciences, "Color constancy in the nearly natural image."

1995, IBM Almaden Research Center, "Color constancy: perceptual computations in humans and computers."

1995, Keynote address, "Reconstructing images from trichromatic samples: from basic research to practical applications." IS&T Color Imaging Conference, Scottsdale, AZ.

1995, Trieste Encounters in Cognitive Science, Trieste, Italy. "Color constancy in the nearly natural image."

1996, Second NECI Vision Workshop, "Color constancy in the nearly natural image."

1996, FASEB Meeting on Retinal Neurobiology and Visual Performance, "Behavioral consequences of retinal sampling: interactions between space and color."

1996, University of California Workshop on Vision Modeling, "Bayesian modeling of human performance."

1996, UCLA, Department of Psychology, "Color constancy in the nearly natural image."

1997, Second Annual Hewlett-Packard Session on University Research in Imaging, "Hyperspectral color imaging."

1997, Optical Society of America Annual Meeting, Workshop on Visual Modeling Environments.

1997, Workshop on Natural Scene Statistics, Jimminy Peak, MA. "Chromatic structure in natural images."

1997, California Institute of Technology, CNS, "Color constancy in the nearly natural image."

1998, UC Berkeley, "Color constancy in the nearly natural image."

1998, Smith-Kettlewell Eye Research Institute, "Color constancy in the nearly natural image."

1998, University of Chicago, "Color constancy in the nearly natural image."

1998, University of Rochester, Center for Visual Science Symposium: Environmental Structure, Statistical Learning, and Visual Perception, "Color constancy in the nearly natural image."

1998, University of Oregon, "Color constancy in the nearly natural image."

1999, University of Washington, "Color constancy in the nearly natural image."

1999, SIGGRAPH, Panel Presentation, "How realistic are monitor images?"



2000, University of Pennsylvania, "Color constancy in the nearly natural image."

2000, Keynote address: ISSC Panchromatic 2000 Conference, "Color constancy and color context effects."

2001, Smith-Kettlewell Eye Research Institute, Workshop, Bayes 2001, "Bayesian modeling of human color constancy."

2001, NYU, "Computational mechanisms of color constancy."

2002, Rutgers (New Brunswick), "Computational mechanisms of color constancy."

2003, Brown University, "Computational mechanisms of color constancy."

2003, Schepens Eye Research Institute, Broadhurst Distinguished Lecture Series, "Computational mechanisms of color constancy."

2003, Penn Institute of Neural Science Retreat, "Mechanisms of color constancy."

2003, University of Rochester, "That was then, this is now: 40 years of color vision."

2003, NYU, Workshop on Perception of Color and Material Properties in Three-Dimensional Scenes, "Lightness constancy: the effect of surface slant."

2003, Keynote address, IS&T Color Imaging Conference, Scottsdale, AZ, "Computational mechanisms of human color constancy"

2004, Rutgers (Newark), "Lightness constancy: the effect of surface slant."

2004, UT Austin, "Computational mechanisms of color constancy."

2005, Keynote address, 10<sup>th</sup> Congress of the International Colour Association, "Computational mechanisms of color constancy", May 8-13, Granada, Spain.

2006, Cambridge Research Systems Invited Lecture, Vision Meeting of the Colour Group of Great Britain, "Bayesian models of color appearance: understanding the appearance of small spot colors", January 12, London, England.

2006, Macbeth Award Invited Lecture, "Bayesian models of color appearance", Annual Meeting of the ISCC, May 14-15, 2006, Ottawa, Canada.

2006, Columbia University, "Color from a single cone? Understanding the appearance of small spot colors."

2007, Invited Lecture, "Gloss, color, and 3D objects", 19<sup>th</sup> Symposium of the International Colour Vision Society, July 27-31, 2007, Belem, Brazil.

2007, New York University, "Color, Bayes, and the trichromatic mosaic: understanding the appearance of small spot colors."

2007, IMBS Conference on Mathematics and Vision, "Color, cones, and Bayesian modeling: understanding the appearance of small spot colors," UC Irvine, November 9-11, 2007, Irvine, CA.

2008, Workshop on Natural Environments, Tasks, and Intelligence, "Bayes and the trichromatic cone mosaic," UT Austin, March 28-30, 2008, Austin, TX.

2008, Workshop on Perception of Material Properties in 3D Scenes, "Material, color, and complex scenes," University of Pennsylvania, October 17-19, 2008, Philadelphia, PA.

2009, Workshop on Cognitive and Developmental Factors in Perceptual Constancy, Discussant, University of Pennsylvania, February 20-22, 2009, Philadelphia, PA.

2009, Visual Processing in Insects II, "Bayes, color, and the trichromatic cone mosaic," Janelia Farm, May 17-20, 2009, Ashburn, VA.

2009, OSA Fall Vision Meeting, "Bayesian Models of Object Color Perception," September 24-27, 2009, Seattle, WA.

2009, Rutgers University, "Color, cones, and Bayesian modeling: understanding the appearance of small spot colors," October 12, 2009, New Brunswick, NJ.

2010, SUNY College of Optometry, "Color, cones, and Bayesian modeling: understanding the appearance of small spot colors," February 5, 2010, New York, NY.

2010, University of Pennsylvania, "Color, cones, and Bayesian modeling: understanding the appearance of small spot colors," April 5, 2010, Philadelphia, PA.

2010, ARVO Annual Meeting, VSS Symposium on Understanding the Function Mechanisms of Visual Performance, "Bayes and the cone mosaic: understanding the color appearance of very small spots", May 5, 2010, Ft. Lauderdale, FL.

2010, Stanford University, "Bayes, color, and visual perception," June 2, 2010, Palo Alto, CA.

2010, FASEB Meeting on Retinal Neurobiology and Visual Processing, "Bayes and the cone mosaic," July 11-16, Saxtons River, VT.

2011, Department of Ophthalmology, Harvard University, "Color perception in complex scenes," January 20, 2011, Boston, MA.

2011, Department of Psychology, Northeastern University, "Bayes and color vision," March 31, 2011, Boston, MA.

2011, Workshop on Perception of Material Properties, "Space and spectrum: color constancy in the third dimension," June 1-5, Schloss Rauischholzhausen, Germany.

2011, OSA Imaging Systems Applications Topical Meeting . "Learning the mosaic: unsupervised identification of sensor spectral types," July 10-14, Toronto, Canada.

2011, GRASP Lab, University of Pennsylvania . "The human demosaicing algorithm," September 8, 2011, Philadelphia, PA.

2011, Keynote Address, IS&T Color Imaging Conference, San Jose, CA. "The human demosaicing algorithm"

2011, Center for Image Systems Engineering, Stanford University, "The human demosaicing algorithm," November 11, 2011, Stanford, CA.

2012, Center for Visual Science, University of Rochester, "Decoding the cone mosaic," June 11, 2012, Rochester, NY.

2012, Sensory Coding and the Natural Environment 2012, "Decoding the cone mosaic," September 9-12, 2012, IST, Klosterneuburg, Austria.

2013, College of Optometry, University of Houston, "Temporal properties of cone and ipRGC contributions to the pupillary light reflex," October 7, 2013, Houston, TX.

2013, CVS 50<sup>th</sup> Anniversary Symposium, Center for Visual Science, University of Rochester, "Color vision and the natural Image," October 19, 2013, Rochester, NY.

2014, NETI Workshop, University of Texas at Austin, "Color constancy in natural tasks," April 11-13, 2014, Austin, TX.

2014, Janelia Conference on Signal Transforms in the Early Visual System, "Population coding of lightness in early visual cortex", September 14-17, 2014.

2014, 3M Corporation, "Color in Natural Tasks", October 27, 2014, St. Paul, Minnesota.

2015, University of Giessen, "Population coding of lightness in primate visual cortex", January 21, 2015, Giessen, Germany.

2015, University of Washington, "Population coding of lightness in primate visual cortex", February 2, 2015, Seattle, WA.

2015, ARVO Annual Meeting Minisymposium on Exploring the Distribution and Expression of L-, M- and S-cone Photoreceptors, "Learning the mosaic: Unsupervised typing of L and M cones from natural image input", May 5, 2015, Denver, CO.

2015, OSA Imaging and Applied Optics Congress, "ISETBIO: Computational tools for modeling early human vision", June 9, 2015, Arlington, VA.

2015, Computational Eye and Brain Workshop, "Modeling in ISETBIO: Unsupervised typing of L and M cones from natural image input", August 20, 2015, Stanford, CA.

2015, European Conference on Visual Perception, Symposium on Color Constancy, "Confessions of a constancy index junkie", August 23-27, 2015, Liverpool, UK.

2015, Fifth PRISM Network Workshop, "The use of color and material perception to accomplish naturalistic tasks", October 6-9, 2015, Leuven, Belgium.

2016, Meeting of the Colour Group of Great Britain, Palmer Lecture, "Psychophysics in the distal stimulus: color and material perception in the service of natural tasks", January 13, 2016, London.

2016, Vanderbilt University, Vision Science Talk Series, "Color and material perception in the service of natural tasks", March 3, 2016, Nashville, TN.

2016, Vision Sciences Society Annual Meeting, Symposium on Artifice versus realism as an experimental methodology, "The use of graphics simulations in the study of object color appearance", May 13, 2016, St. Petes Beach, FL.

2016, European Conference on Visual Perception, Symposium on Color: Cone Opponency and Beyond, "Color psychophysics in the distal stimulus", August 28-September 1, Barcelona, Spain.

2016, OSA Fall Vision Meeting, "100 years of vision and color in OSA", October 13-15, Rochester, NY.

2017, University of Maryland, "Color and material perception in the service of naturalistic tasks", April 14, 2017, College Park, MD.

2017, AI-apalooza, "Learning Cone Types: An Ahumada Inspired Adventure in the Fundamentals of Color Vision", May 24, 2017, St. Pete Beach, FL.

## Reviewing

Applied Optics; Brain; Color Research and Application; Current Biology, Graphics Interface '94 Conference; IEEE Transactions on Image Processing; Journal of Comparative Neurology; Journal of the Optical Society; Journal of Mathematical Psychology; Journal of Neuroscience; Journal of Vision; Nature; Nature Neuroscience; Neuron; NIPS; NSF; Optical Engineering; Perception; Perception and Psychophysics; Proceedings of the National Academy of Sciences USA; PLOS Computational Biology; PLOS One; Psychological Science; Siggraph; Spatial Vision; Vision Research; Wellcome Trust.

## Teaching

Courses taught:

- Introduction to Cognitive Science (undergraduate)
- Perception: Vision (undergraduate)
- Laboratory in Perception (undergraduate)
- Visual Neuroscience (undergraduate)
- Eye, Mind, and Image (undergraduate)
- Visual Systems Analysis (undergraduate/graduate)
- Mathematical Psychology (graduate)
- Perception (graduate)
- Advanced Visual Neuroscience (graduate)
- Experimental Methods in Perception (graduate)
- Assorted Graduate Seminars

1995, Invited Faculty, McDonnell Foundation Summer Institute in Cognitive Neuroscience.

1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, Invited Faculty, Cold Spring Harbor Lab, Short Course in Computational Neurobiology: Vision.

1998, Society for Information Display Short Course in Color Science.

1998, Outside Member, Dissertation Committee of Elaine Jin, University of Chicago.

1998, Reader for Habilitation of Heinz Bauml, University of Regensburg.

1998, Optical Society of America Annual Meeting, Short Course in Color Spaces.

1999, Outside Member, Dissertation Committee of Barnard Kobus, Simon Fraser University.

2001-2003, 2005, Lecturer, IRCS Summer Undergraduate Workshop in Cognitive Science.

2002, Outside Member, Dissertation Committee of Elizabeth Johnson, New York University.

2005, Outside Member, Dissertation Committee of Katja Doerschner, New York University.

2008-2012, Co-organizer, IRCS Summer Undergraduate Workshop in Cognitive Science.

2008, Invited Faculty, Sage Center Summer Institute in Cognitive Neuroscience.

2007-2010, Lecturer, Penn Summer Undergraduate Program in Computational Neuroscience.

2008, Outside Member, Dissertation Committee of Ana Radonjić, Rutgers University.

2009, Lecturer, Penn Biomedical Graduate Studies Summer Undergraduate Internship Program.

2010, Outside Member, Dissertation Committee of Holly Gerhard, New York University.

2011, 2013, Facilitator, Penn Biomedical Graduate Studies Workshop on Responsible Conduct of Research.

2011, Judge, NSF IGERT Poster Competition.

2012-2015 Co-Organizer, Complex Scene Perception Journal Club.

2016, Outside Reader, PhD Thesis of Alexandra Schmidt, University of Sydney.

## Professional Service

1991, Technical Committee, OSA Annual Meeting.  
1995, Technical Committee, OSA Annual Meeting.  
1996, Temporary Member, NIH Vision Sciences B Study Section (twice)  
1997-2003, Topical Editor for Color, Journal of the Optical Society A.  
2000-2002, NIH Visual Sciences B Study Section.  
2001-2003, OSA Tillyer Award Committee.  
2001-2007, Vision Sciences Society Abstract Review Board  
2003, Chair, NIH Special Emphasis Study Section (July)  
2003-present, Board of Editors, Journal of Vision.  
2003, Organizer (with L. T. Maloney), Workshop on Perception of Color and Material Properties in Complex Scenes, New York University, October 2003.  
2004, NIH Special Emphasis Study Section (March)  
2004, Chair, NIH Special Emphasis Study Section (July)  
2005, Chair, NIH Special Emphasis Study Section (March)  
2006, NIH Special Emphasis Study Section (June)  
2006, NIH Special Emphasis Study Section (November)  
2007, Program Committee, SIGGRAPH Meeting on Applied Perception and Computer Graphics  
2008, Session Chair and Discussant, Gordon Research Conference on Sensory Coding and the Natural Environment, Lucca, Italy.  
2008, Organizer (with L. T. Maloney, A. Hurlbert), Workshop on Perception of Material Properties in 3D Scenes, University of Pennsylvania, October 2008.  
2008, Chair, NIH Special Emphasis Study Section (December)  
2009-12, Vice-Chair, Color Technical Group, OSA Vision and Color Division.  
2013-2015, Chair, Color Technical Group, OSA Vision and Color Division.  
2010, NIH Special Emphasis Study Section (January).  
2011, NIH Special Emphasis Study Section (February).  
2012, NIH Special Emphasis Study Section (May).  
2013-14, Vision Sciences Society Young Investigator Award Selection Committee.  
2014, Char, Local Organizing Committee, OSA Fall Vision Meeting.  
2015, Temporary Member, NIH SPC Study Section (September).  
2016-present, Board of Directors, Vision Sciences Society.  
2017, NIH Special Emphasis Study Section (March).  
2017-present, OSA Tillyer Award Committee.

## Departmental and University Service (UCSB)

1991-97, Life Sciences Computing Facility Steering Committee.  
1991-92, Department Computer Committee.  
1992-93, Department Graduate Admissions Committee.  
1992-93, Department Mathematics/Statistics Curriculum Committee.  
1992-94, College Computing Task Force.  
1992-97, Organizer of Vision Science Seminar Series.  
1993, 1996, 1997, Faculty Participant, Freshman Orientation Program.  
1993, Ad-hoc group to meet with UC Provost Walter Massey.  
1993-94, Department Executive Committee.  
1993-94, Department Mathematics/Statistics Curriculum Committee (Chair).  
1994-98, Department Technical Policy Committee (Chair, 95-98).  
1995, University Small Department Graduate Fellowship Committee.  
1996-97, College Computer Coordinator Search Committee.

1996-98, University Faculty Welfare Committee.  
1996-98, University Child Care Advisory Committee (Co-Chair, 1997-98).  
1997-98, Vision Science Search Committee (Chair).  
1998-99, On sabbatical leave.  
1999-00, Vision Science Search Committee (Chair).  
1999-00, Life Sciences Computing Facility Steering Committee.  
1999-01, Department Technical Policy Committee (Chair, 2000-01).  
2000-01, University Committee on Capital Projects.  
2000-01, Neuroscience Research Institute Advisory Board  
2000-01, Psychology Department Executive Committee.

## **Department and University Service (Penn)**

2001-03, Chair's Advisory Group, Department of Psychology.  
2002-04, Psychology Department Space Committee  
2001-05, Committee on Visual Studies Major.  
2002-05, Executive Committee, Penn's NIH Vision Training Grant.  
2002-03, Chair, Faculty Search Committee.  
2002-03, Chair, Departmental Ad-Hoc Faculty Reappointment Committee.  
2002-03, Departmental Ad-Hoc Tenure Review Committee.  
2002-05, Neuroscience Graduate Admissions Committee.  
2003-04, Departmental Ad-Hoc Target of Opportunity Hiring Committee.  
2003-05, Chair, Departmental Web Site Committee  
2003-04, SAS Personnel Committee.  
2004-05, Chair, SAS Personnel Committee (aka Tenure and Promotions Committee).  
2004-05, Chair, Departmental Ad-Hoc Faculty Reappointment Committee.  
2005-06, Center for Cognitive Neuroscience Steering Committee.  
2005-10, Chair, Department of Psychology  
2006, SAS Task Force on Structure of Personnel Committee.  
2006-2007, Provost's Neuroscience Cluster Working Group.  
2006-2011, Institute for Research in Cognitive Science Executive Committee.  
2007, SAS Committee on Metrics.  
2009-Present, Director, Penn Vision Research Center (Co-Director, 2005-2008).  
2010-11, Department Ad-Hoc Tenure Review Committee.  
2011-12, Chair, Department Ad-Hoc Faculty Reappointment Committee.  
2011-12, Chair, Faculty Search Committee.  
2011-12, Provost's Committee on Sabbaticals.  
2011-12, Chair, SAS Chair Committee.  
2011-2016, Director, Institute for Research in Cognitive Science.  
2012-Present, Co-Director, Penn's NSF IGERT Program in Complex Scene Perception.  
2013-14, Departmental Ad-hoc Faculty Promotion Committee.  
2013-14, Chair, SAS Strategic Planning Working Group on Mapping the Mind.  
2014-15, Chair, Departmental Ad-hoc Faculty Promotion Committee.  
2014-15, Center for Cognitive Neuroscience Review Committee.  
2014-Present, Co-Director, Penn Computational Neuroscience Initiative.  
2015-16, SAS Task Force on Tenure and Promotion Procedures.  
2015-Present, SAS Working Group on Strategic Plan Implementation, Mapping the Mind.  
2017-Present, MINS Neuroscience Advisory Group.

## **Consulting**

1994-1997, Hewlett-Packard Laboratories.

1998-99, Enroute, Inc.

## **Film Appearances**

Played part of Samuel Allison. *Fat Man and Little Boy* (1989. Paramount Pictures. Directed by R. Joffe. Starring P. Newman, J. Cusak).

## **Numbers**

Erdos: 4

Bacon: 2

Erdos-Bacon: 6