

# University of Alberta Department of Visual Arts

## EXGEN 3849 - Science Concepts in Visual Design [2013]

Classroom: TBA - Day: Mondays - Time 18:30-20:30

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### COURSE DESCRIPTION & OBJECTIVES

This is a multidisciplinary course that explores the biological and physical basis of why certain forms in visual design and specifically, composition in photography, are effective. Engaging a 'bottom-up' approach to perception and utilizing the photographic medium, we explore preferences in composition and proceed to investigate how the cells in the eye's retina (photoreceptor, bipolar, and ganglion cells) are predisposed to detect specific compositional forms such as edges, lines and contrast. The course continues to build on our inherent predilection for visual form by investigating the field of entropy and information theory, particularly as it applies to the visual environment; concepts such as dis/order, un/certainty, un/predictability, complexity, noise and coding are reviewed. These physical descriptors are linked back to eye circuitry and ultimately back to our compositional objective of *why* we visually compose as we do. The course investigates some applications of these basic drivers of 'seeing' by looking at current research in eye movement and fixation, the development of saliency maps and technological applications such as heat maps. Basic visual design concepts are reviewed, discussed and related to the main course material associated with eye and informational organization; these concepts are further related to image cropping and retargeting.

### COURSE READINGS:

1. The Photographer's Guide to the Eye, N. Matthews, Popular Photography, Aug 2008. <http://ilab.usc.edu/publications/doc/Matthews08pp.pdf>
2. How the Retina Works, H. Kolb, American Scientist, V. 91, pp. 28-35 January-February 2003. [http://www.americanscientist.org/libraries/documents/20058313632\\_306.pdf](http://www.americanscientist.org/libraries/documents/20058313632_306.pdf)
3. Entropy and Art: an Essay on Disorder and Order, R. Arnheim, University Of California Press, 1974. [http://books.google.ca/books?hl=en&lr=&id=kL75af7hbXsC&oi=fnd&pg=PA2&dq=%22entropy+and+art:+an+essay+on+disorder+and+order%22&ots=f\\_zU2Saah8&sig=347b07MIN8T6PmbOHJeSgur1zXY](http://books.google.ca/books?hl=en&lr=&id=kL75af7hbXsC&oi=fnd&pg=PA2&dq=%22entropy+and+art:+an+essay+on+disorder+and+order%22&ots=f_zU2Saah8&sig=347b07MIN8T6PmbOHJeSgur1zXY)
4. Information content associated to edges and textures, A. Turiel, J.Grazzini, H. Yahia and N. Parga, <http://www.ft.uam.es/Neurociencia/ARTICLES/CONFERENCES/ICIP03.pdf>
5. Understanding and predicting where people look in images, Chapter 1, Tilke Judd, Ph.D Thesis, Computer Science and Engineering, Massachusetts Institute of Technology, June 2011 *Note: you may need*

*your library CCID access to get this article.*

<http://dspace.mit.edu/handle/1721.1/66008>

6. Models of Bottom-Up Attention and Saliency , L. Itti, G. Rees, and J. Tsotsos, *Neurobiology of attention* 582 (2005). *Reference available on Google Scholar*
7. Investigation of the Role of Aesthetics in Differentiating between Photographs Taken by Amateur and Professional Photographers, Shao-Fu Xue, Qian Lin, Daniel R. Treutter, Seungyon Lee, Zygmunt Pizlo, and Jan Allebach, *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*. Vol. 8302. 2012.  
<http://proceedings.spiedigitallibrary.org/article.aspx?articleid=1284437>  
*Note: you will need your library CCID access to get this article.*
8. Optimizing Photo Composition, L. Renjie, C. L. Wolf, D. Cohen-Or, Technical report, Tel-Aviv University, 2010. 146, 150, 2010.  
<http://www.math.zju.edu.cn/ligangliu/CAGD/Projects/Composition/paper/Composition-TR-low.pdf>

### **GRADING:**

- Three field assignments will be issued at specific intervals in the semester. They are required to be completed by the next class at which they will be presented and discussed to the whole group. The total value of these assignments will be **60%**. (25% - 15% - 20% each).
- The final 'exam' encompasses a field assignment, final presentation, and a 1000 word paper (~ 3-4 pages) submission accompanying the presentation. It will be valued at **40%** of the total mark.
- The 'More advanced' assignment categories are not required for completion and will not be graded, however, I do encourage you to give them a try since they do represent the more quantitative aspects of the subject matter.

### **REQUIRED MATERIALS:**

- Students are expected to have access to a photographic camera for the course. Image presentations and submissions for the assignments and final project must be in digital .jpg format (you can submit on a USB or on a disk). Film can be used but it must be scanned for in-class submission/presentation. Note that images are only for in-class use, they will not be retained.
- The final paper must be submitted in hardcopy.
- The image submissions must conform to the following file naming format:
  - ASSIGN#\_YOURLASTNAME\_PHOTO#.jpg , for example, the three images comprising of assignment #2 would be:  
ASSIGN2\_FENT\_PHOTO1.jpg, ASSIGN2\_FENT\_PHOTO2.jpg,  
ASSIGN2\_FENT\_PHOTO3.jpg
- Data submissions should show individual values and summary values. You can use any presentation mode you prefer (eg. Excel, Calc..)

**ACADEMIC INTEGRITY:**

"Policy about course outlines can be found in ' 23.4(2) of the University Calendar." (GFC 29 SEP 2003)

"The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Code of Student Behaviour (online at [www.ualberta.ca/secretariat/appeals.htm](http://www.ualberta.ca/secretariat/appeals.htm)) and avoid any behaviour which could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University." (GFC 29 SEP 2003)

"Recording is permitted only with the prior written consent of the professor or if recording is part of an approved accommodation plan."

<b>Program</b>				
<b>Topic</b>	<b>Slides</b>	<b>Activity</b>	<b>Time Allocation</b>	<b>Date</b>
Introduction and Background	1-10	Lecture	25 min	Session 1
Constructivist (top-down) and Ecological (bottom-up) Approaches  An Assessment of Preference	11-27	Lecture  Photography assessment  Discussion  Assignment #1  Reading: <i>The Photographer's Guide to the Eye, N. Matthews</i>	65 min	Session 1
Assignment #1 Review	None	Review and Discussion	90 min	Session 2
'How we see' introduction	28-33	Discussion	30 min	Session 3
Eye cells involved in seeing	34-39	Lecture	60 min	Session 3

cones and rods				
Photo-bleaching, hyperpolarization	40-42	Lecture	25 min	Session 4
Bipolar and horizontal cells Centre-surround introduction	43-53	Lecture	65 min	Session 4
Ganglion and amacrine cells Color centre-surround Vision beyond the retina Visual effects	54-73	Lecture, Discussion Assignment# 2 Reading: <i>How the Retina Works, H. Kolb</i>	90 min	Session 5
Assignment #2 review	None	Review and discussion	90 min	Session 6
Entropy Order and Information in Images Image noise and coding Image applications	74-94	Lecture Readings: <i>Entropy and Art: an Essay on Disorder and Order, R. Arnheim</i>  <i>Information content associated to edges and textures, A. Turiel, J. Grazzini, H. Yahia and N. Parga</i>  <i>Optional Reading: Attention: Bits versus Wows, P. F. Baldi, L. Itti</i>	90 min	Session 7
Structural Information Theory Eye movement and fixation Saliency and Heat maps	95-114	Lecture, Discussion Assignment #3 Readings: <i>Models of Bottom-Up Attention and Saliency, L. Itti, G.</i>	90 min	Session 8

		<p><i>Rees, and J. Tsotsos</i></p> <p><i>Optional Reading:</i></p> <p><i>Understanding and predicting where people look in images, Chapter 1 , Tilke Judd</i></p>		
Assignment #3 review	None	Review and Discussion	90 min	Session 9
<p>Framing the visual message</p> <p>Eye movement and composition</p> <p>Basic design principles</p>	115-143	<p>Lecture, Discussion</p> <p>Readings: <i>Optimizing Photo Composition, L. Renjie, C. L. Wolf, D. Cohen-Or</i></p> <p><i>Investigation of the Role of Aesthetics in Differentiating between Photographs Taken by Amateur and Professional Photographers, Shao-Fu Xue, Qian Lin, Daniel R. Tretter, Seungyon Lee, Zygmunt Pizlo, and Jan Allebach</i></p>	90 min	Session 10
<p>Theory and Practice</p> <p>Cropping and Retargeting</p> <p>Wrap-up</p>	144-159	<p>Lecture and Discussion</p> <p>Final project assignment</p>	90 min	Session 11
Final project presentations	None	Final presentations and discussion	120 min	Session 12

# **Selected references, books, and websites for 'Science Concepts in Visual Design'**

## **JOURNALS**

Journal of Vision <http://www.journalofvision.org/>

Entropy <http://www.mdpi.com/journal/entropy>

## **WEBSITES**

Human Thermodynamics <http://www.eoht.info/>

Eye-Movement and saliency research by L. Itti (USC)  
<http://ilab.usc.edu/publications/bu.html>

## **BOOKS**

Photography: The art of composition, Bert Krages II, Allworth Press 2005.

The Photographer's Eye, Michael Freeman, Focal Press, 2007

Vision and Art: the biology of seeing, Margaret Livingstone, Abrams NY 2002

Information Theory and Esthetic Perception, Abraham Moles, Illini Books 1968

## **ARTICLES**

### Composition Theme

A model of aesthetic appreciation and aesthetic judgments, Helmut Lede, Benno Belke, Andries Oeberst and Dorothee Augustin, British Journal of Psychology (2004), 95, 489-508.

Investigation of the Role of Aesthetics in Differentiating between Photographs Taken by Amateur and Professional Photographers, Shao-Fu Xue, Qian Lin, Daniel R. Tretter, Seungyon Lee, Zygmunt Pizlo, and Jan Allebach, Imaging and Printing in a Web 2.0 World III, edited by Qian Lin, Jan P. Allebach, Zhigang Fan, Proc. of SPIE-IS&T Electronic Imaging, SPIE Vol. 8302, 83020D .<http://proceedings.spiedigitallibrary.org/>

Quantifying center bias of observers in free viewing of dynamic natural scenes, Po-He Tseng, Ran Carmi, Ian G. M. Cameron, Douglas P. Munoz, Laurent Itti, *Journal of Vision* (2009) 9(7):4, 1-16 <http://journalofvision.org/9/7/4/>

Arnheim's Gestalt theory of visual balance: Examining the compositional structure of art photographs and abstract images, I. C. McManus, Katharina Stöver, Do Kim, *i-Perception* (2011) volume 2, pages 615 - 647.

Learning to Photograph, Bin Cheng, Bingbing Ni, Shuicheng Yan, Qi Tian, MM'10, October 25-29, 2010, Firenze, Italy.

Estimating perception of scene layout properties from global image features, Michael G. Ross, Aude Oliva, *Journal of Vision* (2010) 10(1):2, 1-25.  
<http://journalofvision.org/10/1/2/>

The perception of art and the science of perception, Robert Pepperell, *Human Vision and Electronic Imaging XVII*, edited by Bernice E. Rogowitz, Thrasyvoulos N. Pappas, Huib de Ridder, *Proc. of SPIE-IS&T Electronic Imaging*, SPIE Vol. 8291, 829113.  
<http://proceedings.spiedigitallibrary.org/>

The perceptual basis of common photographic practice, Emily A. Cooper, Helen Wills, Elise A. Piazza, Martin S. Banks, *Journal of Vision* (2012) 12(5):8, 1-14.  
<http://www.journalofvision.org/content/12/5/8>

Two visual systems and two theories of perception: An attempt to reconcile the constructivist and ecological approaches, Joel Norman, *Behavioral and Brain Sciences* (2002) 25, 73-144.

Modeling photo composition and its application to photo re-arrangement, Jaesik Park, Joon-Young Lee, Yu-Wing Tai and In So Kweon, *Korea Advanced Institute of Science and Technology*.

Photographs as Evidence, Aaron Meskin and Jonathan Cohen, pp. 1-17. *No reference, see me for this.*

Paintings, photographs, and computer graphics are calculated appearances, John McCann, McCann Imaging, 161 Claflin St., Belmont, MA 02474, USA.

Picture perception: toward a theoretical model, Margaret A. Hagen, Psychological Bulletin 1974, Vol. 81, No. 8, 471-497.

The psychometrics of photographic cropping: The influence of colour, meaning, and expertise, I Christopher McManus, Fanzhi Anita Zhou, Sophie l'Anson, Lucy Waterfield, Katharina Stover, Richard Cook, Perception, 2011, volume 40, pages 332 - 357.

The Photographer's Guide to the Eye, N. Matthews, Popular Photography, Aug 2008.  
<http://ilab.usc.edu/publications/doc/Matthews08pp.pdf>

### Eye Movement and Saliency Theme

What and Where: A Bayesian Inference Theory of Visual Attention , Sharat Chikkerur , Ph.D Thesis Oct. 2010 , Computer Science and Engineering , Massachusetts Institute of Technology.

Evidence of Clutter Avoidance in Complex Scenes , Maura C. Lohrenz and Melissa R. Beck , Proceedings of the Human Factors and Ergonomics Society Annual Meeting 2010 54: 1355 .<http://pro.sagepub.com/content/54/18/1355>

The influence of clutter on real-world scene search: Evidence from search efficiency and eye movements , John M. Henderson, Myriam Chanceaux, Tim J. Smith , Journal of Vision (2009) 9(1):32, 1-8 . <http://journalofvision.org/9/1/32/>

How We Look at Photographs—As Indicated by Contrast , Detection, Preference and Eye-Movement Patterns , S. Gershoni and H. Kobayashi, 21st International Conference on Digital Printing Technologies Final Program and Proceedings , pp. 124-125.



Analysis of the Eye Movements and its Applications to Image Evaluation , Chizuko Endo, Takuya Asada, Hideaki Haneishi and Yoichi Miyake, IS&T and SID's 2nd Color Imaging Conference: Color Science, Systems and Applications (1994) , pp.153-155.

Measuring visual clutter , Ruth Rosenholtz, Yuanzhen Li, Lisa Nakano, Journal of Vision (2007) 7(2):17, 1-22 . <http://journalofvision.org/7/2/17/>

Eye guidance in natural vision: Reinterpreting salience , Benjamin W. Tatler , Mary M. Hayhoe , Michael F. Land, Dana H. Ballard, Journal of Vision (2011) 11(5):5, 1-23  
<http://www.journalofvision.org/content/11/5/5>

Retargeting Images and Video for Preserving Information Saliency , Vidya Setlur , Tom Lechner , Marc Nienhaus , Bruce Gooch , IEEE Computer Society , September/October 2007 , pp.80-88.

A survey of image retargeting techniques , Daniel Vaquero , Matthew Turk , Kari Pulli , Marius Tico , Natasha Gelfand, Applications of Digital Image Processing XXXIII, Andrew G. Tescher, Editor, Proc. SPIE 7798, 779814 (2010) .

Rule of Thirds Detection from Photograph , Long Mai, Hoang Le, Yuzhen Niu, and Feng Liu , Multimedia (ISM), 2011 IEEE International Symposium on. IEEE, 2011.

A model of saliency-based visual attention for rapid scene analysis , Laurent Itti, Christof Koch, and Ernst Niebur , IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 20, no. 11, November 1998

Saliency, attention, and visual search: An information theoretic approach , Neil D. B. Bruce, John K. Tsotsos, Journal of Vision (2009) 9(3):5, 1-24 .  
<http://journalofvision.org/9/3/5/>

Saliency for image manipulation , Ran Margolin, Lihi Zelnik-Manor, Ayellet Tal , Vis Comput , 2012. The Visual Computer (2012): 1-12.

Saliency Retargeting: An Approach to Enhance Image Aesthetics , Lai-Kuan Wong , Kok-Lim Low , Applications of Computer Vision (WACV), 2011 IEEE Workshop on. IEEE, 2011.

Salient Object Detection by Composition , Jie Feng, Yichen Wei , Litian Tao , Chao Zhang , Jian Sun, Computer Vision (ICCV), 2011 IEEE International Conference on. IEEE, 2011.

Small object detection in cluttered image using a correlation based active contour model , Alireza Vard, Kamal Jamshidi, Naser Movahhedinia , Pattern Recognition Letters 33 (2012) 543-553 . <http://www.elsevier.com/locate/patrec>

Using a Saliency Map for Active Spatial Selective Attention: Implementation & Initial Results , Shumeet Baluja , Dean A. Pomerleau , Advances in Neural Information Processing , Systems, Vol 6, San Mateo, CA 1994. *Reference available from Google Scholar.*

Medium Spatial Frequencies, a Strong Predictor of Saliency , Fabrice Urban, Brice Follet, Christel Chamaret , Olivier Le Meur, Thierry Baccino , Cogn Comput 3 (2011) 37-47 .

Interesting objects are visually salient , Lior Elazary , Laurent Itti , Journal of Vision (2008) 8(3):3, 1-15 . <http://journalofvision.org/8/3/3/>

Human gaze control during real-world scene perception , John M. Henderson , TRENDS in Cognitive Sciences , Vol.7 No.11 November 2003 .

Where to look next? Eye movements reduce local uncertainty , Laura Walker Renninger, Preeti Verghese, James Coughlan, Journal of Vision (2007) 7(3):6, 1-17 . <http://journalofvision.org/7/3/6/>

Yarbus, eye movements, and vision , Benjamin W Tatler , Nicholas J Wade , Hoi Kwan , John M Findlay, Boris M Velichkovsky , i-Perception (2010) volume 1, pages 7 - 27 .

Eye-Tracking: Characteristics and Methods Eye-Tracking: Research Areas and Applications Daniel C. Richardson , Michael J. Spivey , Encyclopedia of Biomaterials and Biomedical Engineering, Wnek. G. & Bowlin, G. (Eds.) , Feb. 2004.

Feature Congestion: A Measure of Display Clutter , Ruth Rosenholtz, Yuanzhen Li, Jonathan Mansfield, and Zhenlan Jin , CHI 2005, April 2-7, 2005, Portland, Oregon, USA

Objects predict fixations better than early saliency , Wolfgang Einhäuser , Merrielle Spain, Pietro Perona, Journal of Vision (2008) 8(14):18, 1-26 .  
<http://journalofvision.org/8/14/18/>

Fixations on low-resolution images , Tilke Judd, Fredo Durand, Antonio Torralba, Journal of Vision (2011) 11(4):14, 1-20 <http://www.journalofvision.org/content/11/4/14>

An Image Statistics-Based Model for Fixation Prediction , Victoria Yanulevskaya, Jan Bernard Marsman , Frans Cornelissen, Jan-Mark Geusebroek , Cogn Comput (2011) 3:94-104 .

Classification images with uncertainty , Bosco S. Tjan , Anirvan S. Nandy , Journal of Vision (2006) 6, 387-413 . <http://journalofvision.org/6/4/8/>

Pioneers of eye movement research , Nicholas J Wade , i-Perception (2010) volume 1, pages 33 - 68 .

Methods for comparing scanpaths and saliency maps: strengths and weaknesses , Olivier Le Meur, Thierry Baccino , Behavior Research Methods(2011): 1-16.

A Statistical Study of the Correlation Between Interest Points and Gaze Points , Michael Nauge, Mohamed-Chaker Larabi and Christine Fernandez-Maloigne , Human Vision and Electronic Imaging XVII, edited by Bernice E. Rogowitz, Thrasyvoulos N. Pappas, Huib de Ridder, Proc. of SPIE-IS&T Electronic Imaging, SPIE Vol. 8291, 829111 .

Qualitative Evaluation of Detection and Tracking Performance , Swaminathan Sankaranarayanan , Francois Bremond , David Tax. *No Reference, available via Google Scholar.*

State-of-the-art in Visual Attention Modeling, Borji, Ali, and Laurent Itti.(2012): 1-1.  
[http://ilab.usc.edu/publications/doc/Borji\\_Itti12pami.pdf](http://ilab.usc.edu/publications/doc/Borji_Itti12pami.pdf)

### Entropy - Information Theme

Aesthetics and entropy: optimization of the brightness distribution , M. R. V. Sahyun , Human Vision and Electronic Imaging XVII, edited by Bernice E. Rogowitz, Thrasyvoulos N. Pappas, Huib de Ridder, Proc. of SPIE-IS&T Electronic Imaging, SPIE Vol. 8291, 82911H.

Abstract Painting with Interactive Control of Perceptual Entropy, Mingtian Zhao and Song-Chun Zhu, ACM Trans. Appl. Percept. 0, 0, Article 0 (July 2012), 20 pages.

How do image complexity, task demands and looking biases influence human gaze behavior? B. Bonev, L.L. Chuang , F. Escolano, Pattern Recognition Letters (2012, in press).

Information Theory , information, entropy, communication, coding, bit, learning , Ghahramani, Zoubin , Zoubin Ghahramani , ENCYCLOPEDIA OF COGNITIVE SCIENCE 2000 .

Entropy and Art : an Essay on Disorder and Order , Rudolf Arnheim , University Of California Press, Berkeley - Los Angeles - London, 1971 .

Entropy: a guide for the perplexed , Roman Frigg and Charlotte Werndl , C. Beisbart & S. Hartmann (eds), Probabilities in Physics, Oxford University Press 2011, 115-42 .

Image Region Entropy: A Measure of "Visualness" of Web Images Associated with One Concept , Keiji Yanai, Kobus Barnard, MM'05, November 6-11, 2005, Singapore .

Information content associated to edges and textures , A. Turiel, J. Grazzini, H. Yahia and N. Parga , *No Reference, available on Google Scholar*

Information processing in the retina , Chapter 13, pp.85-92, *No Reference, see me for this*

Could information theory provide an ecological theory of sensory processing? Joseph J Atick , *Network 3 (1992) 213-251.*

Information Theory Applied to Perceptual Research Involving Art Stimuli , Kerry Freedman , Marilyn Zurmuehlen *Working Papers in Art Education , Volume 2, Issue 1 , Article 35 .*

Basic concepts in information theory , Marc Uro. *No Reference, see me for this.*

The essence of information: paradoxes, contradictions, and solutions , M. Burgin, *Electronic Conf on the Foundations of Information Science. 2002.*

Information Theory , Peter Dayan and L.F. Abbott , Chapter 4, *Theoretical Neuroscience, 2000*

A Mathematical Theory of Communication , C. E. Shannon , *The Bell System Technical Journal, Vol. 27, pp. 379-423, 623-656, July, October, 1948.*

Measuring Visual Saliency by Site Entropy Rate , Wei Wang, Yizhou Wang, Qingming Huang, Wen Gao , *IEEE 2010 pp.2368-2375.*

Contrast statistics for foveated visual systems: fixation selection by minimizing contrast entropy , Raghu Raj , Wilson S. Geisler and Robert A. Frazor , Alan C. Bovik , J. Opt. Soc. Am. A , Vol. 22, No. 10 / October 2005.

Attention: Bits versus Wows, P. F. Baldi, L. Itti, Proc. IEEE International Conference on Neural Networks and Brain, Beijing, China, M. Zhao, Z. Shi Ed., Vol. 1, pp. PL56-PL61, Oct 2005. [http://ilab.usc.edu/publications/doc/Baldi\\_Itti05icnnb.pdf](http://ilab.usc.edu/publications/doc/Baldi_Itti05icnnb.pdf)

### Eye Physiology

How the Retina Works , Helga Kolb , American Scientist, Volume 91 , 2004.

Brightness contrast inhibits color induction: evidence for a new kind of color theory , James Gordon , and Robert Shapley, Spatial Vision, Vol. 19, No. 2-4, pp. 133- 146 (2006) .

The "Independent Components" of Natural Scenes are Edge Filters , A. J. Bell, T.J. Sejnowski, Vision Res., Vol. 37, No. 23, pp. 3327-3338, 1997 .

Different Circuits for ON and OFF Retinal Ganglion Cells Cause Different Contrast Sensitivities , Kareem A. Zaghloul, Kwabena Boahen, and Jonathan B. Demb , the Journal of Neuroscience, April 1, 2003 • 23(7):2645–2654 .

Statistical characterization of real-world illumination , Ron O. Dror, Alan S. Willsky, Edward H. Adelson, Journal of Vision (2004) 4, 821-837 .  
<http://journalofvision.org/4/9/11/>

Why We See What We Do , Dale Purves, R. Beau Lotto, Surajit Nundy , American Scientist, Volume: 90 Number: 3 .

Psychophysical and Psychophysiological Measurement of Image Emotion, Joohee Jun, Li-Chen Ou, Boris Oicherman, Shuo-Ting Wei, M. Ronnier Luo, Hila Nachilieli, Carl Staelin, 18th Color Imaging Conference Final Program and Proceedings , pp.121-127, 2010 Society for Imaging Science and Technology .

What does the retina know about natural scenes? J.J Atlick, A.N. Redlich, Neural Computation 4, 196-210, 1992.

Vision and the statistics of the visual environment , Eero P Simoncelli , Current Opinion in Neurobiology 2003, 13:144-149 .