KENDRICK KAY

CURRICULUM VITAE

phone: (510) 206-1059

e-mail: kendrick@post.harvard.edu

web: http://kendrickkay.net

Education and Professional History

Postdoctoral: 2009–present, Stanford University, postdoctoral researcher. Advisor: Brian Wandell

Graduate: 2003–2009, University of California, Berkeley, Ph.D. in Psychology. Advisor: Jack Gallant

Undergraduate: 1998–2002, Harvard University, A.B. in Philosophy, magna cum laude

Awards

2003, National Defense Science and Engineering Graduate Fellowship

Publications (articles)

Vu, V.Q., Ravikumar, P., Naselaris, T., **Kay, K.N.**, Gallant, J.L. & Yu, B. Encoding and decoding V1 fMRI responses to natural images with sparse nonparametric models. *Annals of Applied Statistics* 5, 1159–1182 (2011).

Naselaris, T., Prenger, R.J., **Kay, K.N.**, Oliver, M. & Gallant, J.L. Bayesian reconstruction of natural images from human brain activity. *Neuron* 63, 902–915 (2009). PMID: 19778517.

Gallant, J., Naselaris, T., Prenger, R., **Kay, K.**, Stansbury, D., Oliver, M., Vu, A., & Nishimoto, S. Bayesian Reconstruction of Perceptual Experiences from Brain Activity Measurements. In: *Augmented Cognition*, HCII 2009, LNAI 5638, edited by D.D. Schmorrow et al. (2009).

Ravikumar, P., Vu, V.Q., Yu, B., Naselaris, T., **Kay, K.N.** & Gallant, J.L. Nonparametric sparse hierarchical models describe V1 fMRI responses to natural images. In: *Advances in Neural Information Processing Systems* 21, edited by D. Koller, D. Schuurmans, Y. Bengio, & L. Bottou (2009).

Kay, K.N., Naselaris, T., Prenger, R.J. & Gallant, J.L. Identifying natural images from human brain activity. *Nature* 452, 352–355 (2008). PMID: 18322462.

Kay, K.N., David, S.V., Prenger, R.J., Hansen, K.A. & Gallant, J.L. Modeling low-frequency fluctuation and hemodynamic response timecourse in event-related fMRI. *Hum. Brain Mapp.* 29, 142–156 (2008). PMID: 17394212.

Hansen, K.A., **Kay, K.N.** & Gallant, J.L. Topographic organization in and near human visual area V4. *J. Neurosci.* 27, 11896–11911 (2007). PMID: 17978030.

Publications (book chapters, reviews, commentary)

Kay, K.N. Understanding visual representation by developing receptive-field models. In: *Visual Population Codes: Towards a Common Multivariate Framework for Cell Recording and Functional Imaging*, edited by N. Kriegeskorte & G. Kreiman (2011).

Naselaris, T., **Kay, K.N.**, Nishimoto, S. & Gallant, J.L. Encoding and decoding in fMRI. *NeuroImage* 56, 400–410 (2011). PMID: 20691790.

Kay, K.N. & Gallant, J.L. I can see what you see. *Nature Neuroscience* 12, 245–246 (2009). PMID: 19238184.

Manuscripts under revision

Kay, K.N., Winawer, J., Mezer, A., & Wandell, B.A. Compressive spatial summation in human visual cortex.

Invited talks

2008-11, Dartmouth, Psychology and Brain Sciences
Using computational models of voxels to identify images seen by an observer

2008-11, Guest Lecture for Math 126 at Dartmouth
Building computational models of V1 voxels &
Mathematical details of estimating receptive-field models

2008-03, Cosyne (Computational and Systems Neuroscience) Workshops
Using voxel receptive field models to identify natural images seen by an observer

2007-12, UC-Berkeley Brain Imaging Center Research Day
Building a general decoder for human visual cortex

Abstracts

2012-02, Cosyne (Computational and Systems Neuroscience)
Compressive spatial summation: a characteristic of extrastriate computation

2011-11, SFN (Society for Neuroscience)
Compressive spatial summation improves models of extrastriate responses

2011-05, VSS (Vision Sciences Society)
Spatial saturation in human visual cortex

2007-11, SFN (Society for Neuroscience)
Decoding human visual cortical activity evoked by novel natural images

2007-09, UC-Berkeley Neuroscience Research Conference and Retreat
Estimation of voxel receptive fields in human visual cortex using natural images

2007-08, BAVRD (Bay Area Vision Research Day)
Building a general decoder for human visual cortex

2007-05, VSS (Vision Sciences Society)
Estimation of voxel receptive fields in human visual cortex using natural images

2006-11, UC-Berkeley Neuroscience Research Conference and Retreat
Investigating shape representation in human visual cortex using fMRI

2005-11, SFN (Society for Neuroscience)
Artifacts in phase-encoded fMRI retinotopic mapping

2004-12, UC-Berkeley Brain Imaging Center Research Day
Artifacts in standard fMRI retinotopic mapping

Teaching experience

2012, Instructor, Stanford University
Psychology 216A: Statistics and Data Analysis in MATLAB

2011, Teaching Assistant, Stanford University
Psychology 30: Sensation and Perception

2004, Graduate Student Instructor, UC-Berkeley
Psychology 110: Biological Psychology
Psychology 101: Research Design and Data Analysis

2002–2003, Teaching Assistant, Harvard University
Computer Science Extension 220: Artificial Intelligence

2000–2002, Teaching Fellow, Harvard University
Computer Science 121: Introduction to Formal Systems and Computation

Peer reviewer for

Cerebral Cortex
Human Brain Mapping
Journal of Neurophysiology
Journal of Neuroscience
National Science Foundation (Cognitive Neuroscience)
NeuroImage
Statistica Sinica

KENDRICK KAY

Research statement

My primary research interest is to understand the computations that the human visual system performs on visual input. I am specifically interested in form representation and how the visual system processes naturalistic stimuli such as objects and scenes. My research approach combines experimental data from functional magnetic resonance imaging (fMRI) with computational modeling, with the goal of developing quantitative models that accurately characterize responses of the visual system to arbitrary images. Such models would be instrumental to understanding how the visual system performs the core task of object recognition. Building stimulus-response models has a rich history in electrophysiology (Enroth-Cugell, Movshon, Shapley, Carandini, Dan, Chichilnisky, Gallant) but has been relatively unexplored in population measurement techniques such as fMRI. Functional MRI serves as a useful complement to electrophysiology given its ability to measure activity in many visual areas simultaneously and its rapid experimental execution time.

Although models based on simple filtering operations describe responses at the first stage of cortical visual processing (V1) fairly well, the performance of these models is degraded in extrastriate areas (with the exception of V5/MT). In principle, to improve model performance we simply need to identify the ways in which current models fail and modify the models so as to fix those failures. This is, however, easier said than done. One challenge is selecting a suitable class of models to explore. I think a reasonable starting point is to explore hierarchical feedforward models, i.e. models in which V1-like oriented filters are applied to the stimulus and then nonlinear combinations of these filters are constructed to produce putative higher-order responses. This type of model originates in classic studies by Hubel and Wiesel and is commonly discussed in the theoretical literature (Poggio, DiCarlo). However, properly fitting and testing such models on experimental data is not trivial (mainly due to the large number of parameters that must be specified). It remains an important open question how well hierarchical feedforward models characterize extrastriate cortex.

Another challenge is stimulus selection. In any given experiment, one can measure responses to only a small number of stimuli relative to the number of potential stimuli that could be shown. The question is, exactly what stimuli should be used? At one extreme is the strategy of performing minimal stimulus selection and randomly sampling from a general stimulus class such as natural images. The main disadvantage of this approach is difficulty of interpretation: images are high-dimensional and many different aspects of a complex image could be driving responses. At the other extreme is the strategy of choosing a very specific type of stimulus (e.g. angles, contours, texture boundaries, pre-segmented objects) and then parametically varying some aspect of the stimuli. This approach facilitates interpretation but the models that are developed may generalize poorly to other stimuli. In recent work, I have developed a hybrid strategy that uses a wide range of carefully designed artificial stimuli in combination with randomly sampled natural stimuli. This approach inherits the benefits of both worlds, as the data are both interpretable and diverse enough to ensure model generality. The artificial stimuli I use is guided by basic principles (e.g. using sinusoidal gratings to measure orientation tuning), by the types of stimuli used in previous studies, and by theories of visual coding that I have developed through explorations of natural image statistics.

Computational models are powerful in that they can be applied and generalized across experimental paradigms. Through collaboration with other researchers, I plan to take the extrastriate models that I develop through fMRI and apply them to other modalities such as single-unit recordings, EEG, and psychophysics. In addition, I intend to investigate whether and in what way higher-order extrastriate representations subserve broad computer vision goals such as improved object classification. Finally, a long-term goal of mine is to apply the computational principles and modeling tools that I develop to other sensory systems such as the auditory system.

Although the end goal of my research is to better understand the visual system, a sizable chunk of my time is directed towards fMRI methods. This is because access to high-quality data is of crucial importance to the model building process (e.g. parameter estimation, model evaluation). In order to obtain accurate and reliable fMRI measurements, I develop and evaluate fMRI methods pertaining to optimization of MR parameters, experimental design, undistortion and coregistration of brain volumes, and GLM analysis of fMRI time-series data. In this regard I often find myself honing my understanding of MR imaging (e.g. pulse sequences, effects of field inhomogeneities) and engaging in discussions with MR physicists.

KENDRICK KAY

Teaching statement

I am committed to teaching and mentoring. I find the process of learning about statistical analysis and quantitative methods inspiring, and I enjoy sharing these ideas with others. I have worked with many people in the Gallant and Wandell labs to better understand methods, and I think methodological improvement is critical to scientific progress.

In one example, this quarter I am leading a new graduate-level class on statistics and data analysis. This course is taught as part of the Psychology curriculum, but it has drawn many students from departments across campus. The class emphasizes nonparametric and computational approaches to statistical problems, and is geared towards members of the psychology and neuroscience communities who are interested in understanding and applying advanced statistical analyses to their datasets. The class has a dual focus: on the one hand, the class pays special attention to the theory and principles that underlie statistical procedures; on the other hand, the class ensures that theory and principles are translated into practice by illustrating how to implement them efficiently and effectively in the MATLAB programming environment. My hope is that the class will help researchers tackle the kind of complex, large-scale datasets that are increasingly being collected in psychology and neuroscience.

Two other members of the Wandell lab are helping me, and we have made special efforts to ensure that the class has both a high level of sophistication and accessibility to students lacking extensive statistical background. The class web site is at http://white.stanford.edu/~knk/Psych216A/ and includes lecture notes and slides, video recordings of lectures, and MATLAB tutorials. I am enjoying developing and teaching the class, and in the future I envision developing a similar-style class on fMRI methods.

In addition to statistics and fMRI, other topics that I enjoy teaching include visual neuroscience and perception. For example, last fall quarter at Stanford, I collaborated with Professor Kalanit Grill-Spector to help her teach a class on visual perception. I find that teaching and mentoring are rewarding and provide an opportunity to polish my understanding of topics that are useful to my own research.