BIOGRAPHICAL SKETCH

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NAME: Kass, Robert E.

eRA COMMONS USER NAME (credential, e.g., agency login): rekass

POSITION TITLE: Professor, Department of Statistics, Machine Learning Department, and Center for the Neural Basis of Cognition

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Antioch College, Yellow Springs, OH	BA	1975	Mathematics
University of Wisconsin-Madison, Madison, WI		1975-76	Statistics, Mathematics
University of Chicago, Chicago, IL	Ph.D	1980	Statistics

A. Personal Statement

After several years of research on geometrical methods in statistics, in the mid-1980s I focused on Bayesian inference. In 1997 I joined the Center for the Neural Basis of Cognition (CNBC) here at Carnegie Mellon and the University of Pittsburgh. Following my 9-year term as Head of the Department of Statistics, for the 2004-2005 academic year I took an NSF-sponsored sabbatical leave to concentrate on neuroscience. Since then all of my research has been devoted to statistical methods in neuroscience, with a heavy emphasis on spike train analysis. I have organized a series of 8 international symposia at the interface between statistics and neuroscience, and I have given tutorial lectures on recent developments in statistical methods for neurophysiology at 13 workshops on computational neuroscience. My book *Analysis of Neural Data* with Emery Brown and Uri Eden was published in 2014. In 2008 I also became a core voting faculty member of the Machine Learning Department (MLD) in the School of Computer Science. I am currently PI on a pair of NIDA R90/T90 training grants that support our CNBC programs in computational neuroscience, and am also PI on an NSF training grant in statistics and machine learning. I am currently supervising or co-supervising 2 PhD students in Statistics, 1 in Machine Learning, 2 in our joint CNBC-MLD PhD program, 1 in our joint Statistics-CNBC PhD program, and 1 in our joint Statistics-MLD PhD program.

B. Positions and Honors

<u>Positions and Employment</u>

1980-81 NSF Postdoctoral Research Fellow, Department of Statistics, Princeton University
1981- Assistant Professor, 1981-1986; Associate Professor, 1986-1992; Professor, 1992-present; Department Head, 1995-2004; Department of Statistics, Carnegie Mellon University
1997- Professor, Center for the Neural Basis of Cognition, Carnegie Mellon University
2005- Adjunct Professor, Center for Neuroscience, University of Pittsburgh
2008- Professor, Machine Learning Department, Carnegie Mellon University

<u>Other Experience and Professional Memberships</u>

1985-2003 Associate Editor, *The Annals of Statistics,* 1985; Associate Editor, *Journal of the American Statistical Association, Theory and Methods*, 1986-1992; Editorial Board member, *Statistics in Medicine*, 1991-1992; Associate Editor, *Biometrika*, 1996-2003

1992-1994 Executive Editor, *Statistical Science*
1996-1998 American Statistical Association, Chair-elect, Chair, Past Chair, Section on Bayesian Statistical Science
1991-2001 Local organizer and program co-organizer, ``Case Studies in Bayesian Statistics,'' international symposia at Carnegie Mellon, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005
2003-2005 National Academy of Sciences, Board of Mathematical Sciences and its Applications
2003-2006 American Association for the Advancement of Science, Chair-Elect, Chair, Past Chair of the Section on Statistics (U)
2004-2006 Founding Editor-in-Chief, *Bayesian Analysis*
2009-2014 Action Editor, *Neural Computation*
2009- Action Editor, *Journal of Computational Neuroscience*
2012- National Academy of Sciences, Committee on Applied and Theoretical Statistics
2002- Local organizer and program co-organizer, ``Statistical Analysis of Neural Data'' international symposia in Pittsburgh, 2002, 2004, 2006, 2008, 2010, 2012, 2015

Honors

1981 Leonard J. Savage Award for Outstanding Thesis in Bayesian Statistics and Econometrics
1990 Elected Fellow, American Statistical Association
1991 Elected Fellow, Institute of Mathematical Statistics
1992 Special Invited Lecturer, Institute of Mathematical Statistics
2002 Institute Medallion Lecturer, Institute of Mathematical Sciences
2002 Elected Fellow, American Association for the Advancement of Science
2005 Identified as one of 10 Most-Cited Researchers in the field of Mathematics 1995-2005 (ranked #4), by the Institute for Scientific Information
2005 Miller Visiting Research Professor, University of California, Berkeley
2010 Presidential Lecturer, Biometric Society, Eastern North American Region, Annual Meeting
2013 Outstanding Statistical Application Award, American Statistical Association

C. Contribution to Science

1. Geometrical methods in statistics

My earliest work was on the geometrical foundations of statistics. Its main purpose was to deepen understanding of fundamental statistical procedures.

a. Kass, R.E. (1984) Canonical parameterizations and zero parameter-effects curvature, *Journal of the Royal Statistical Society*, B, 46: 86-92.
b. Amari, S.-I., Barndorff Nielsen, O.E., Kass, R.E., Lauritzen, S. and Rao, C.R. (1987) *Differential Geometry in Statistical Inference*, Institute of Mathematical Statistics Monograph Series, Hayward, CA.
c. Kass, R.E. (1989) The geometry of asymptotic inference (with discussion) *Statistical Science*, 4: 188-234.
d. Kass, R.E. and Vos, P. (1997) *Geometrical Foundations of Asymptotic Inference*, New York: Wiley.

2**.** Bayesian statistical methods

The use of Bayes' Theorem to make scientific inferences from data in a variety of contexts was developed initially by Harold Jeffreys in the first half of the 20th century. The main thrust of my work involved modernizing Jeffreys' approach by considering it as a way to attack complicated statistical problems using newly available computational tools. From the mid-1980s through the 1990s I developed Bayesian statistical methods and I evaluated Bayesian reasoning from a pragmatic data analytic perspective; this led to highly-cited publications (e.g., according to the Institute for Scientific Information, I was ranked #4 in citations in the mathematical sciences across a 10 year period, and one of my papers was ranked #1 in citations).

a. Kass, R.E. and Steffey, D. (1989) Approximate Bayesian inference in conditionally independent hierarchical models (parametric empirical Bayes models), *Journal of the American Statistical Association*, 84: 717-726.

b. Kass, R.E. and Raftery, A. (1995) Bayes factors, *Journal of the American Statistical Association*, 90: 773-795.
c. Kass, R.E. and Wasserman, L.A. (1995) A reference Bayesian test for nested hypotheses and its relationship to the Schwarz criterion, *Journal of the American Statistical Association*, 90: 928-934.
d. Kass, R.E. and Wasserman, L.A. (1996) The selection of prior distributions by formal rules, Journal of the *American Statistical Association*, 91: 1343–1370.

3. Statistical methods in neuroscience

Over the past 15 years I have devoted my research to development and use of statistical methods in neuroscience. While a handful of my publications have involved neuroimaging, the large majority have had to do with neural signals recorded from single and multiple electrodes. Spike trains are sequences of events, the timing of which varies from trial to trial, and in statistics such event-time data are usually represented as *point processes*. Thus, much of my attention has been devoted to development of point process methods for spike trains, including one of the first papers to describe the way in which a simple framework, known as *generalized linear models*, can be applied effectively.

a. Kass, R.E. and Ventura, V. (2001) A spike train probability model, *Neural Computation*, 13: 1713-1720.
b. Kass, R.E., Ventura, V., and Brown, E.N. (2005) Statistical issues in the analysis of neuronal data, *Journal of Neurophysiology*, 94: 8-25.
c. Behseta, S., Berdyyeva, T., Olson, C.R., and Kass, R.E. (2009) Bayesian correction for attenuation of correlation in multi-trial spike count data, *Journal of Neurophysiology*, 101: 2186-2193.
d. Kass, R.E., Eden, U.T., and Brown, E.N. (2014) *Analysis of Neural Data*, New York: Springer.

4. Decoding and brain-machine interface (BCI)

For several years I worked on developing and studying statistical methods for neural prosthetics. My collaborators and I showed how Bayesian approaches could, in principle, produce far better results than suboptimal alternatives, yet, in practice, using closed-loop experiments, subjects often used visual feedback to compensate for defects in decoding methods. We also showed how BCI could be used to probe the neural basis of learning by perturbing the mapping between neural activity and the output of the interfaced device, such as a cursor on a screen in front of the subject. In a series of experiments we discovered the remarkable fact that brain networks can adapt differentially in populations of perturbed and unperturbed neurons.

a. Brockwell, A.E., Rojas, A. and Kass, R.E. (2004) Recursive Bayesian decoding of motor cortical signals by particle filtering, *Journal of Neurophysiology*, 91: 1899-1907.
b. Jarosiewicz, B., Chase, S.M., Fraser, G.W., Velliste, M. Kass, R.E., and Schwartz, A.B. (2008) Functional network reorganization during learning in a brain-machine interface paradigm. *Proceedings of the National Academy of Sciences*,105:19486-19491.
c. Koyama, S., Chase, S.M., Whitford, A.S., Velliste, M., Schwartz, A.B., and Kass, R.E. (2009) Comparison of brain-computer interface decoding algorithms in open-loop and closed-loop control, *Journal of Computational Neuroscience*, 29: 73-87.
d. Chase, S., Kass, R.E., and Schwartz, A.B. (2012) Behavioral and neural correlates of visuomotor adaptation observed through a brain-computer interface in primary motor cortex, *Journal of Neurophysiology*,108:624-644.

5. Analysis of multiple spike train data

When multiple spike trains are recorded simultaneously there are great opportunities to identify functional relationships among neurons, but there are also statistical subtleties. My work has discussed the issues, and has focused especially on statistical assessment of neural synchrony, where two or more neurons fire at nearly the same time. An initially perplexing problem was that the standard point process framework does not allow for simultaneous events, and this made it unclear how synchronous spiking could be described using point process theory. We solved this problem, and developed rigorous statistical methodology, in a 2011 paper, which was awarded the 2013 Outstanding Application Award from the American Statistical Association.

a. Brown, E.N., Kass, R.E., and Mitra, P.P. (2004) Multiple neural spike train analysis: state-of-the-art and future challenges, *Nature Neuroscience*, 7: 456-461.

b. Kelly, R.C, Smith, M.A., Kass, R.E., and Lee, T.-S. (2010) Accounting for network effects in neuronal responses using L1 penalized point process models, *Advances in Neural Information Processing Systems*, 23.

c. Kass, R.E., Kelly, R.C., and Loh, W.-L. (2011) Assessment of synchrony in multiple neural spike trains using loglinear point process models, *Annals of Applied Statistics*, 5: 1262--1292.

d. Harrison, M.T., Amarasingham, A., and Kass, R.E. (2013) Statistical identification of synchronous spiking. In, *Spike Timing: Mechanisms and Function*, Eds: Patricia Di Lorenzo and Jonathan Victor. Taylor & Francis, pp. 77-120.