

JONATHAN D. COHEN

CURRICULUM VITAE

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BIOGRAPHICAL

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EDUCATION and TRAINING

UNDERGRADUATE:

1973-77 Yale University B.A., 1977 Biology and Philosophy

GRADUATE:

1979-83 University of Pennsylvania M.D., 1983 Medicine

1987-90 Carnegie Mellon University Ph.D., 1990 Cognitive Psychology

POST-GRADUATE:

1983-89 Internship in General Medicine, Neurology and Psychiatry
Residency in Psychiatry
Stanford University School of Medicine

1985-87 NIMH Research Training Fellowship,
Department of Psychiatry and Behavioral Sciences
Stanford University School of Medicine

APPOINTMENTS and POSITIONS

ACADEMIC:

- 1989- present Assistant to Full Professor of Psychiatry
Western Psychiatric Institute and Clinic
University of Pittsburgh
- 1990-98 Assistant to Associate Professor of Psychology
Carnegie Mellon University
- 1992- present Director, Clinical Cognitive Neuroscience Laboratory
University of Pittsburgh
- 1998- 2005 Professor of Psychology, Princeton University
- 1999- 2007 Founding Director, Center for the Study of Brain, Mind and Behavior
Princeton University
- 2000- 2008 Director, Program in Neuroscience
Princeton University
- 2005- 2012 Eugene Higgins Professor of Psychology, Princeton University
- 2005- present Founding Co-Director, Princeton Neuroscience Institute
- 2012- present Robert Bendheim and Lynn Bendheim Thoman Professor in Neuroscience
Princeton University

MEDICAL LICENSURE

- 1983-2012 California (retired)
- 1986-present Pennsylvania

HONORS and AWARDS

- B.A. Cum Laude 1977
Distinction in the Biology Major

Distinction in the Philosophy Major Yale University	
Miller Foundation Prize for Research in Psychiatry Department of Psychiatry and Behavioral Sciences Stanford University School of Medicine	1986
Annual Resident Research Award Northern California Psychiatric Society	1986
Joseph Zubin Memorial Fund Award for Research in Psychopathology	1993
Kempf Fund Award for Research Development in Psychobiological Psychiatry, American Psychiatric Association	2000
James McKeen Cattell Fund Sabbatical Fellowship Award	2003
Eugene Higgins Chaired Professorship, Princeton University	2005
Salmon Award Lecturer, New York Academy of Medicine	2006
Fellow, Association for Psychological Science	2007
Edward J. Sachar Award, Columbia University School of Medicine	2007
American Psychological Association Distinguished Scientific Contribution Award	2010
Fellow, American Association for the Advancement of Science	2012

PUBLICATIONS

1. Peer-Reviewed Articles

- Cohen JD, Van Putten T, Marder S, Berger PA & Stahl SM (1987). Treatment of the symptoms of schizophrenia with piquindone, a new atypical neuroleptic. Psychopharmacology Bulletin, 23(3), 514-518.
- Cohen JD, Van Putten T, Marder S, Berger PA & Stahl SM. (1987). The efficacy of piquindone, a new atypical neuroleptic, in the treatment of the positive and the negative symptoms of schizophrenia. Journal of Clinical Psychopharmacology, 7(5), 324-329.
- Cohen JD, Dunbar K & McClelland JL (1990). On the control of automatic processes: A parallel distributed processing model of the Stroop effect. Psychological Review, 97(3), 332-361.
- Servan-Schreiber D, Printz H & Cohen JD (1990). A network model of catecholamine effects: Gain, signal-to-noise ratio, and behavior. Science, 249, 892-895.
- Servan-Schreiber D & Cohen JD (1991). Models of neuromodulation and information processing deficits in schizophrenia. Revue Internationale de Psychopathologie, 1, 113-134

- Cohen JD & Servan-Schreiber D (1992). Context, cortex and dopamine: A connectionist approach to behavior and biology in schizophrenia. Psychological Review, 99, 45-77.
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- Cohen JD, Noll DC & Schneider W (1993). Functional Magnetic Resonance Imaging: Overview and methods for psychological research. Behavioral Research Methods, Instruments & Computers, 25(2), 101-113.
- Cohen JD & Servan-Schreiber D (1993). A theory of dopamine function and cognitive deficits in schizophrenia. Schizophrenia Bulletin, 19(1), 85-104.
- Forman SD, Cohen JD & Johnson MH (1993). Frontal eye fields: Inhibition through competition. Behavioral and Brain Sciences, 6, 578.
- Schneider W, Noll DC & Cohen JD (1993). Functional topographic mapping of the cortical ribbon in human vision with conventional MRI scanners. Nature, 365, 150-153.
- Cohen JD, Forman SD, Braver TS, Casey BJ, Servan-Schreiber D & Noll DC (1994). Activation of prefrontal cortex in a non-spatial working memory task with functional MRI. Human Brain Mapping, 1, 293-304.
- Cohen JD & Huston TA (1994). Progress in the use of parallel distributed processing models for understanding attention and performance. In Umiltà C. and Moscovitch M. (Eds.), Attention and Performance XV: Conscious and Nonconscious Information Processing. Cambridge, MA: MIT Press, pp. 453-476.
- Cohen JD, Romero RD, Servan-Schreiber, D & Farah MJ (1994). Mechanisms of spatial attention: The relation of macrostructure to microstructure in parietal neglect. Journal of Cognitive Neuroscience, 6(4), 377-387.
- Armony JL, Servan-Schreiber D, Cohen JD & LeDoux JE (1995). An anatomically-constrained neural network model of fear conditioning. Behavioral Neuroscience, 109(2), 246-256.
- Carter CS, Mintun M & Cohen JD (1995). Interference and facilitation effects during selective attention: An [¹⁵O]-H₂O PET study of Stroop task performance. NeuroImage, 2, 264-272.
- Casey BJ, Cohen JD, Jezzard P, Turner R, Noll DC, Trainor R, Giedd J, Pannier L, Kaysen D & Rapoport JL (1995). Activation of prefrontal cortex in children during a non-spatial working memory task with functional MRI. NeuroImage, 2, 221-229.
- Forman SD, Cohen JD, Fitzgerald M, Eddy WF, Mintun MA & Noll DC (1995). Improved assessment of significant activation in functional magnetic resonance imaging (fMRI): Use of a cluster-size threshold. Magnetic Resonance in Medicine, 33, 636-647.

- Noll DC, Cohen JD, Meyer CH & Schneider W (1995). Spiral k-space MR imaging of cortical activation. Journal of Magnetic Resonance Imaging, 45, 49-56.
- Barch D, Cohen JD, Servan-Schreiber D, Steingard S, Steinhauer S & van Kammen D (1996). Semantic priming in schizophrenia: An examination of spreading activation using word pronunciation and multiple SOAs. Journal of Abnormal Psychology, 105, 592-601.
- Cohen JD, Braver TS & O'Reilly RC (1996). A computational approach to prefrontal cortex, cognitive control, and schizophrenia: Recent developments and current challenges. Philosophical Transactions of the Royal Society of London Series B (Biological Sciences), 351(1346), 1515-1527.
- Servan-Schreiber D, Cohen JD & Steingard S (1996). Schizophrenic deficits in the processing of context: A test of a theoretical model. Archives of General Psychiatry, 53, 1105-1112.
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- Simen PA & Cohen JD (2007). A diffusion-based neural network model of interval timing and temporal discounting. Society for Neuroscience Abstracts, Program No. 637.13.
- Todd MT, Wong K-F, & Cohen JD (2007). Competition, gating, and learning: A new computational model of task switching. Society for Neuroscience Abstracts, Program No. 634.10.
- van den Bos W, Li J, Lau T, McClure SM, Cohen JD & Montague PR (2007). Social influences on bidding in common value auctions and the Winner's Curse. Abstract at meeting of the Society for Neuroeconomics, Nantucket Beach, MA.
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- Simen PA, Nystrom LE, van Vugt M, Krueger P & Cohen JD (2009). Event-related fMRI during slow decision making can reveal temporal structure in neural activity. [Society for Neuroscience Abstracts](#), 576.9/FF111.
- Tomlin D, Nedic A, Holmes P & Cohen JD (2009). Neural and behavioral responses to social feedback during group decision-making. [Society for Neuroscience Abstracts](#), 475.4/FF27.
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- Getz SJ, Tomlin D, Nystrom LE, Cohen JD & Conway ARA (2010). Executive control of intertemporal choice: Effects of cognitive load on impulsive decision-making. [Abstracts of the Psychonomic Society](#), 3067.
- Todd MT, Niv Y & Cohen JD (2010). Mental set representations in fMRI. [Society for Neuroscience Abstracts](#), 603.8/KKK52
- Tomlin D, Nedic A, Prentice DA, Holmes P & Cohen JD (2010). Group foraging task reveals neural substrates of social influence. [Society for Neuroscience Abstracts](#), 403.9/LLL65.
- Wilson RC, Cohen JD & Niv Y (2010). Inferring relevance in a changing world. [Society for Neuroscience Abstracts](#), 907.12/KKK45.
- Feng S, Schwemmer M & Cohen JD (2011). Computational Constraints on Cognitive Control. [Society for Neuroscience Abstracts](#).
- Geana A, Wilson RC, White JM, Ludvig E & Cohen JD. (2011). The Separate Roles of Reward Magnitude and Uncertainty in the Explore/Exploit Dilemma. [Society for Neuroscience Abstracts](#), 830.10/XX40.
- Lewis-Peacock JA, Salesi MR, Cohen JD & Norman KA (2011). Decoding the use of working memory and episodic memory in prospective remembering. [Society for Neuroscience Abstracts](#), 829.04.
- Todd MT, Botvinick MM, Schwemmer MA, Cohen JD & Dayan P (2011). Normative analysis of task switching. [Society for Neuroscience Abstracts](#).
- Tomlin D, Nedic A, Todd MT, Wilson RC, Prentice DA, Holmes P & Cohen JD (2011). Group foraging task reveals separable influences of individual experience and social information. [Society for Neuroscience Abstracts](#).

- Wilson RC, Geana A, Myles-White J, Ludwig E & Cohen JD (2011). Why the grass is greener on the other side: Behavioral evidence for an ambiguity bonus in human exploratory decision making. Society for Neuroscience Abstracts, 830.13.
- Goldfarb S, Simen P, Caiceido C, Holmes P, Leonard NE & Cohen JD (2011). Optimal performance and the LBA model. Abstracts of the Psychonomic Society.
- Cohen JD, Lewis-Peacock JA & Norman KA (2012). Neural evidence for the flexible use of working memory and episodic memory in prospective remembering. Society for Neuroscience Abstracts.
- deBettencourt MT, Lee RF, Cohen JD, Norman KA & Turk-Browne NB (2012). Real-time decoding and training of sustained attention. Society for Neuroscience Abstracts.
- Eldar E, Radulescu A, Niv Y & Cohen JD (2012). Norepinephrine, neural gain, and "first one wins" network dynamics. *Cosyne 2012*.
- Tomlin D, Nedic A, Wilson RC, Holmes P & Cohen JD (2012). Group foraging task reveals separable influences of individual experience and social information. Society for Neuroscience Abstracts.
- deBettencourt MT, Lee RF, Cohen JD, Norman KA & Turk-Browne NB (2013). Externalizing internal states with real-time neurofeedback to train visual attention. *Journal of Vision Sciences*.
- Wang Y, Li K, Charikar M, Cohen JD & Turk-Browne NB (2013). What you find depends on how you look: Category selectivity in frontal cortex revealed by whole-brain correlation analysis. Journal of Vision Sciences.
- Shenhav A, Botvinick MM & Cohen JD (2013). Decision costs may explain dACC activity in a "foraging" context. Society for Neuroscience Abstracts.
- Wilson RC, White JM & Cohen JD (2013). The role of adaptive decision noise in exploration. Society for Neuroscience Abstracts.

5. Manuscripts Under Review / In Preparation

- deBettencourt MT, Cohen JD, Lee RF, Norman KA & Turk-Browne NB (under review). Closed-loop training of attention with real-time brain imaging.
- Field BA, Buck CL, McClure SM, Nystrom LE, Kahneman D & Cohen JD (under review). Influence of distraction on brain responses to appetitive and aversive stimuli.
- Kim B, Liatsis A, Ballard IC, Cohen JD & McClure SM (under review). The magnitude effect in intertemporal choice results from increased self-control.
- Kriete T, Noelle DC, Cohen JD & O'Reilly RC (under review). Indirection and symbol-like processing in the prefrontal cortex and basal ganglia
- O'Reilly RC, Petrov AA, Cohen JD, Lebiere CJ, Herd SA & Kriete T (under review). How limited systematicity emerges: A computational cognitive neuroscience approach.

Schurger A, Kim M & Cohen JD (under review). Paradoxical effects of fixational eye movements at the threshold of visual awareness.

van Vugt MK, Simen P, Nystrom LE, Holmes PJ & Cohen JD (under review). Lateralized readiness potentials reveal properties of a neural mechanism for crossing a decision threshold.

Wang Y, Li K, Cohen JD & Turk-Browne N (under review). What you see depends upon how you look: Category-selective interactions with frontal cortex during object perception.

White JM, Ericson KMM, Laibson D & Cohen JD (under review). Measuring Impatience: What Can Intertemporal Choice Experiments Tell Us?

Wilson RC, Geana A, White JM, Ludvig EA & Cohen JD (under review). To boldly go: Ambiguity-seeking in human exploratory decision making.

D'Ardenne K, McClure SM, Field BA, Nystrom LE & Cohen JD (in preparation). Universal compassion meditation modulates subjective experience of reward and BOLD responses in the ventromedial prefrontal cortex.

Greene JD, Lowenberg K, Paxton JM, Nystrom LE, Darley JM & Cohen JD (in preparation). Duty vs. the greater good: dissociable neural bases of deontological and utilitarian moral judgment in the context of keeping and breaking promises.

Todd MT & Cohen JD (in preparation). Including explicit losses with gains: A new test of the reward prediction error model of human ventral striatum and midbrain BOLD signals.

Todd MT, Schwemmer M, Botvinick MM, Cohen JD & Dayan P (in preparation). Task switching and cost minimization.

Usher M & Cohen JD (in preparation). A connectionist model of the Stroop task revisited: Reaction time distributions and differential effects on facilitation and interference captured by a single set of mechanisms.

PROFESSIONAL ACTIVITIES

TEACHING:

1. Courses

- 1989-96 Introduction to Cognitive Psychology (undergraduate survey course)
Department of Psychology, Carnegie Mellon University
- 1989-96 Cognitive Neuroscience section of Cognitive Core (graduate survey course).
Department of Psychology, Carnegie Mellon University
- 1990-93 Co-coordinator, Fellowship Training Program in Schizophrenia Research. Western Psychiatric Institute and Clinic, University of Pittsburgh

- 1992-93 Research Methods in Cognitive Neuroscience (advanced undergraduate seminar).
Department of Psychology, Carnegie Mellon University
- 1992-93 Functional Neural Circuits (graduate and advanced undergraduate seminar).
Department of Psychology, Carnegie Mellon University
- 1994-95 Neural and Psychological Mechanisms of Working Memory (graduate and advanced
undergraduate seminar). Department of Psychology, Carnegie Mellon University
- 1996-97 Advanced Topics in Cognitive Neuroscience (graduate and advanced undergraduate
seminar). Department of Psychology, Carnegie Mellon University.
- 1996-97 Biological and Psychological Mechanisms of Attention (graduate and advanced
undergraduate seminar). Department of Psychology, Carnegie Mellon University;
co-taught with Gary Aston-Jones.
- 1999-00 Neural Bases of Cognitive Control (undergraduate course). Department of
Psychology, Princeton University.
- 1999-01 Topics in Molecular and Cognitive Neuroscience (graduate seminar). Departments of
Psychology and Molecular Biology, Princeton University.
- 1999-01 Introduction to Neural Networks (undergraduate course). Department of Psychology,
Princeton University.
- 2001-02 Advanced Topics in Neural Network Models of Psychological Function (advanced
undergraduate / graduate seminar). Department of Psychology, Princeton University.
- 2002-03 Statistical Methods in Psychological Research (advanced undergraduate / graduate
course). Department of Psychology, Princeton University.
- 2004-07 Graduate Proseminar in Cognitive Psychology. Department of Psychology, Princeton
University.
- 2009-12 Core Course for Ph.D. Program in Neuroscience, Princeton Neuroscience Institute,
Princeton University

2. Tutorials and Workshops

May, 1990-93 — Cohen JD, Servan-Schreiber D. Course co-directors, A primer on neural modeling in psychiatry. 144-7th Annual Meetings of the American Psychiatric Society, New York.

July, 1991 — Invited faculty member. James S. McDonnell Summer Institute in Cognitive Neuroscience, Dartmouth College, Hanover.

October, 1993 — Applications of Functional MRI to Studies of Human Memory. Invited tutorial, Memory Disorders Research Society, Boston.

November, 1993 — Functional neuroimaging. Invited tutorial, Neural Information Processing Society, Boulder.

August, 1996 — Neuroimaging and Behavior. Invited workshop, XXVI International Congress of Psychology, Montreal.

January, 1997 — The Role of Neuromodulation in Cognition: Physiological and Computational Approaches. Panel organizer, 30th Winter Conference on Brain Research, Breckenridge, Colorado.

July, 1997 — Invited faculty member. James S. McDonnell Summer Institute in Cognitive Neuroscience, Dartmouth College, Hanover.

September, 2000 — International Workshop on Neural Bases of Executive Functions and Performance Monitoring, Jena, Germany.

July, 2001 — Invited faculty member. James S. McDonnell Summer Institute in Cognitive Neuroscience, Dartmouth College, Hanover.

3. Trainees

Graduate advisees:

Therese Huston, Ph.D. (1990-1995)
CMU Department of Psychology
Behavioral and computational modeling studies of selective attention
Director, Center for Excellence in Teaching & Learning, University of Seattle

Todd Braver, Ph.D. (1992- 97)
CMU Department of Psychology
Computational and neuroimaging studies of prefrontal cortex and cognitive control
Associate Professor of Psychology, Washington University, St. Louis

Matthew Botvinick, M.D., Ph.D. (1995-2001)
CMU Department of Psychology
Computational modeling and fMRI studies of the role of anterior cingulate cortex in conflict monitoring and control
Assistant Professor of Psychology and Neuroscience, Princeton University

Mark Gilzenrat, Ph.D. (1996-2006)
CMU Department of Psychology (1996-1998)

Princeton Department of Psychology (1998-2006)
Computational models and pupillometric studies of neuromodulatory influences on selective attention

Software architect, Navaraga Corporation

Raymond Cho, M.D. (1999-2003)

Department of Psychology, Princeton University

Assistant Professor of Psychiatry, University of Pittsburgh

Eric Brown, Ph.D. (1999-2004)

Program in Applied and Computational Mathematics, Princeton University

Co-advisor with Philip Holmes

Neural oscillators and integrators in the dynamics of decision tasks

Assistant Professor of Applied Mathematics, University of Washington, Seattle

Sean Polyn (2000-2005)

Department of Psychology, Princeton University

Computational modeling of context updating, reinforcement learning and dopamine function

Postdoctoral Fellow, Kahana Lab, University of Pennsylvania

Aaron Schurger (2001-2008)

Department of Psychology, Princeton University

Electrophysiological and fMRI studies of perceptual awareness

Postdoctoral Fellow, Dehaene Lab, Inserm-CEA

Agatha Lenartowicz (2002-2008)

Department of Psychology, Princeton University

Behavioral, electrophysiological and fMRI studies of task switching

Postdoctoral Fellow, UCLA

Kimberly D'Ardenne McClure (2005-2008)

Department of Chemistry, Princeton University

fMRI studies of brainstem neuromodulatory nuclei

Postdoctoral Fellow, Montague Lab, Virginia Tech

Susan Robison (2005-2009; co-advised with Ken Norman)

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Behavioral and fMRI studies of cognitive control and episodic memory

Emily Chakwin (2006-2008)

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Behavioral and fMRI studies of moral reasoning

Michael Todd (2006-2012)

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Computational modeling studies of cognitive control

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Behavioral and fMRI studies of moral reasoning

John White (2008-present)
Department of Psychology, Princeton University
Behavioral and fMRI studies of economic decision making

Sarah Getz (2008-present; co-advised with Andy Conway)
Department of Psychology, Princeton University
Behavioral and fMRI studies of economic decision making

Andra Geana (2010-present)
Department of Psychology, Princeton University
Behavioral and fMRI studies of exploration and exploitation in decision making

Jane Keung (2011-present)
Princeton Neuroscience Institute, Princeton University
Behavioral and fMRI studies of prefrontal cortex and cognitive control

Pavlos Kollias (2012-present; co-advised with Matt Botvinick)
Department of Psychology, Princeton University
Behavioral and fMRI studies of abstract reasoning and creativity

Ph.D. Committees (outside of Neuroscience and Psychology):

Cliona Golden (2004, Ingrid Daubechies), PACM, Princeton University

Adi Livnat (2005, Simon Levin), Ecology and Evolutionary Biology, Princeton University

Ilya Fischhoff (2006, Daniel Rubenstein), Ecology and Evolutionary Biology, Princeton
University

Juan Gao (2007, Phil Holmes), Program in Applied and Computational Mathematics, Princeton
University

Yuan (Sophie) Liu (2007, Phil Holmes), Physics, Princeton University

Caitlin Newberry (2007, Wolf Richter), Chemistry, Princeton University

Phil Eckoff (2008, Phil Holmes), Program in Applied and Computational Mathematics, Princeton
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Andrea Nedic (2011, Phil Holmes), Electrical Engineering, Princeton University

Samuel Feng (Phil Holmes), Program in Applied and Computational Mathematic, Princeton
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Stephanie Goldfarb (Naomi Lenoard), Program in Applied and Computational Mathematic,
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fMRI studies of prefrontal function

Associate Professor of Psychiatry, University of Pittsburgh

Medical Director of the Center for Treatment of Addictive Disorders, Pittsburgh VA

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Computational models of catecholaminergic neuromodulation and selective attention

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Electrophysiological and fMRI studies of working memory in schizophrenia

Associate Professor of Clinical and Health Psychology and Psychiatry, University of Florida,
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Functional neuroimaging studies of novelty detection

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Computational modeling studies of basal ganglia function in control of sequential action

Computer Scientist, Artificial Intelligence Center, SRI International

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fMRI studies of prefrontal cortex organization

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Modeling, ERP and fMRI studies of conflict monitoring and cognitive control

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ERP studies and neural network modeling of performance monitoring, task switching and the attentional blink.
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Neural bases of moral reasoning
Assistant Professor of Psychology, Harvard University

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Neural network modeling and neuroimaging studies of reinforcement learning and decision making
Assistant Professor of Psychology, Stanford University

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Neuroimaging studies of decision making, conflict monitoring and cognitive control

Postdoctoral Fellow, L'Hôpital de la Salpêtrière in Paris

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Computational modeling, mathematical analysis, behavioral and neuroimaging studies of decision making and cognitive control

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Neuroimaging studies of prefrontal cortex organization and function

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Behavioral and neuroimaging studies of attention and emotional regulation among meditation practitioners

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Computational modeling and mathematical analysis studies of decision making and cognitive control

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Princeton University Department of Psychology and Center for Health and Well Being of the Woodrow Wilson School for Public Policy

Neuroimaging studies of age-related differences in economic decision making and cognitive control

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Marieke van Vugt, Ph.D. (2008-2010)
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Neuroimaging and computational modeling studies of decision making and cognitive control
Assistant Professor, University of Groningen

Fuat Balci, Ph.D. (2008-2010)
Princeton University Department of Psychology
Theoretical and behavioral studies of interval timing and decision making

Robert Wilson, Ph.D. (2009-present)
Princeton University Department of Psychology and Princeton Neuroscience Institute
Theoretical, behavioral and neuroimaging studies of cognitive control & locus coeruleus function

Michael Schwemmer, Ph.D. (2010-2012)
Princeton Neuroscience Institute
Theoretical analyses of capacity constraints on cognitive control

Jarrod Lewis-Peacock, Ph.D. (2011-present; co-advised with Ken Norman)
Princeton Neuroscience Institute
Neuroimaging studies of cognitive control and prospective memory

Amitai Shenhav, Ph.D. (2012-present; co-advised with Matt Botvinick)
CV Starr Fellow, Princeton Neuroscience Institute
Theoretical and neuroimaging studies of the costs of cognitive control

RESEARCH and PROFESSIONAL ACTIVITIES:

1. Scientific Interests

Research in my laboratory focuses on the neurobiological mechanisms underlying cognitive control, and their disturbance in psychiatric disorders such as schizophrenia and depression. Cognitive control is the ability to guide attention, thought and action in accord with internally represented goals or intentions. One of the fundamental mysteries of neuroscience is how this capacity for coordinated, purposeful behavior arises from the distributed activity of many billions of neurons in the brain. Several decades of cognitive and neuroscientific research have focused on the mechanisms by which control influences processing (e.g., attentional effects in sensory processing, goal directed sequencing of motor output, etc.), and the brain structures upon which these functions depend, such as the prefrontal cortex, anterior cingulate cortex, basal ganglia and brainstem neuromodulatory systems. However, we still have a poor understanding of *how* these systems give rise to cognitive control. Our work seeks to develop mechanistically explicit hypotheses about the functioning of these systems, and to test these hypotheses in empirical studies. An important motivation for this work is the development of a theoretically sound foundation for research on the relationship between disturbances of brain function and their manifestation as disorders of thought and behavior in psychiatric illness.

Theoretical work. Neural network models are developed as a way of articulating precise hypotheses about the function of particular brain systems, and their role in cognitive control. This work seeks to bridge between the traditionally disparate levels of analysis of neurophysiology, systems neuroscience, and cognitive psychology. Projects focus on the function of systems considered to be critical for cognitive control, including: a) the role of prefrontal cortex in biasing attention and response selection in posterior structures; b) the role of brainstem dopamine systems in regulating learning and updating of representations in prefrontal cortex; c) the role of the anterior cingulate cortex in monitoring performance, and its influence on adaptations in control; and d) the influence of locus coeruleus and norepinephrine on attentional state and the balance between exploration and exploitation. In many cases, modeling work has led to novel predictions about neurophysiological mechanisms underlying systems-level function, such as: a) gain control as a mechanism for dopaminergic and noradrenergic neuromodulation; b) the role of dopamine in coordinating reinforcement learning and the gating of information into prefrontal cortex; c) the influence of electrotonic coupling on population dynamics within the locus coeruleus; and d) the effects of changes in locus coeruleus physiological state on attentional mode. In other cases, this work has led to novel hypotheses about system level function, such as the response of anterior cingulate cortex to conflict in processing and its influence on adaptive changes in cognitive control, and the role of locus coeruleus in regulating the balance between exploration and exploitation. This work has also predicted, and led to the discovery of new anatomic relationships, such as projections from the anterior cingulate cortex to locus coeruleus. More recent work has examined the relationship between neural network models and simpler, but analytically tractable mathematical models (such as the drift diffusion model) that have been developed for understanding simple forms of decision making at both the neural and behavioral levels.

Empirical work. Experimental studies within the laboratory make use of behavioral testing and neuroimaging (using functional magnetic resonance imaging and scalp electrical recordings) in humans. Collaborations with neurophysiologists also involve direct neuronal recordings in non-human species performing cognitive tasks, and detailed anatomic studies. Experiments are designed to test predictions made by neural network models, and to provide data needed to guide their further development. An important motivation for this work is the generation and testing of hypotheses about the neurobiological mechanisms underlying disturbances of behavior in psychiatric disorders. By manipulating variables of biological interest in our models, we are able to explore the effects that disturbances in these variables have on behavior, and then test these in empirical studies. Empirical findings emerging from this work include: a) the first demonstration in humans of sustained activity in prefrontal cortex associated with working memory performance; b) the correlation of prefrontal cortex activity with parametric manipulations of working memory load; c) the dissociation of frontal responses to working memory load from task difficulty; d) the effects of dopamine manipulation on performance in selective attention and working memory tasks; e) selective deficits both in behavior and prefrontal activity among patients with schizophrenia in these tasks; f) the response of the anterior cingulate cortex to processing conflict in the absence of performance errors; g) the co-localization of event-related potentials associated with errors (ERN) and processing conflict

(N₂C); and g) the first demonstration of responses in the human ventral tegmental area to reward prediction errors.

New directions. A focus of increasing interest within the laboratory is the interaction between cognitive control and emotional processing in decision making. This stems from an appreciation of the close interactions between executive (e.g. prefrontal) and evaluative (e.g., anterior cingulate) functions evident in our work on cognitive control, and an equal appreciation of the fact that few, if any, aspects of real world behavior are devoid of such interactions. Studies in the laboratory have explored interactions between cognitive and emotional processes in a variety of behavioral domains, including economic choice (e.g., gambling tasks and intertemporal choice), social interaction (e.g., ultimatum and bargaining games), and moral decision making. Initial findings, using both behavioral and neuroimaging methods, have provided clear evidence for the prevalent engagement of emotional systems in tasks traditionally considered to be predominantly cognitive. This work has set the stage for more detailed studies that examine the interaction between the systems involved in such decision making tasks, with the goal of developing a more accurate understanding of real world behavior. It is also likely to have direct relevance to our understanding of psychiatric disorders, which invariably involve complex interactions between disturbances of thought and feeling.

2. Grants

Scottish Rite Foundation	Context Disturbance in Schizophrenia	PI	1986-88	
NIMH Physician Scientist Award	Context Disturbance in Schizophrenia: Models and Measures	PI	1987-92	MH00673
NIMH P50	Cortical Circuitry and Cognition in Schizophrenia (Edward Stricker, PI) Project 4 (1990-96), Project 7 (1997-02): The Role of Prefrontal Cortex in the Cognitive Dysfunctions of Schizophrenia; Project ?? (2003-07): Neuroendophenotypes and the expression of illness liability in schizophrenia	PI, Project 4,7	1990-07	MH45156
NIMH FIRST Award; RO1	Mechanisms of Context Processing in Schizophrenia	PI	1991-2012	MH47073
NIMH Program Project	Toward Models of Normal and Disordered Cognition (James L. McClelland, PI) Project 2 (1991-96): Neuromodulation and the Processing of Context in Schizophrenia; Project 4 (1997-02): Mechanisms of Cognitive Control	PI, Project 2,4	1991-2002	MH47566

NIMH P50	Center for Functional Brain Imaging (Robert Moore & Mark Mintun, Co-PIs) Cognitive Studies Core	Co-Direct., Cognitive Core	1992-97	MH49815
McDonnell Foundation	Neural Bases of Rehearsal and Maintenance in Working Memory	PI	1994-96	JSMF 94-32
NSF CRI	Computational and Statistical Methods for the Analysis of Neuroimaging Datasets	PI	1995-96	IBN9418982
NIMH RO1	fMRI Studies of Prefrontal Cortex	PI	1996-2009	MH52864
NIMH Program Project	Toward Models of Normal and Disordered Cognition (James L. McClelland, PI)	PI, Project 4	1997-02	MH47566
NIDA/HBP RO1	Advanced Methods for Neuroimaging Data Analysis	PI	1997-99	DA11469
NSF ESI	Tracking the Human Brain: An Interactive Planetarium Exposition (Bryan Rogers, PI)	Co-Invest.	1997-99	ESI9705491
NARSAD Independent Investigator Award	An fMRI Study of the Role of Anterior Cingulate in Working Memory Dysfunction in Schizophrenia	PI	1997-99	
NIMH RO1	Neurophysiological and Modeling Studies of Locus Coeruleus (Gary Aston-Jones, Co-PI)	Co-PI	1998-2001	MH33194
NSF MRI	Acquisition of Core Equipment for Princeton Cognitive and Behavioral Neuroscience Initiative (Marcia Johnson and Charles Gross, Co-PIs)	Co-PI	1998-2001	MRI/OST19871186
NJCST	New Jersey Brain Imaging Consortium: Acquisition of high field MRI scanner	PI	1999	
NIMH/HBP RO1	Usability and Interoperability of Neuroimaging Software	PI	2000-03	MH62006
NIMH RO1	Pathophysiology of Cognitive Disability in Schizophrenia (Cameron Carter, PI)	Co-Invest.	2000-04	MH59883
NIMH P50	Conte Center for Neuroscience Research: Cognitive and Neural Mechanisms of Conflict and Control	PI	2000-10	MH62196
Seaver Institute	Neural Economics: Understanding the brain mechanisms underlying cognitive-emotional interactions in decision making	PI	2001-02	
NIDA R21	Hyperscan: Simultaneous fMRI Across the Internet (Emory University; Greg Berns, PI)	Co-Invest.	2001-03	DA014883
MacArthur Foundation	Neural Bases of Placebo Effect and the Expectation of Pain	PI	2001-03	

NIMH P50	IBSC: Toward a Neurobiologically Constrained Framework for Modeling Human Cognition (James L. McClelland, PI). Project 4: Mechanisms of Cognitive Control	PI Project 4	2002-07	MH64445
NIMH RO1	New Wavelet-Based and Source Separation Methods for fMRI (Ingrid Daubechies, PI)	Co-Invest.	2002-07	MH067204
NIMH T32	Training Program in Quantitative Neuroscience	PI	2002-13	MH65214
NJCST	Center for Molecular and Biomolecular Imaging (Warren Warren, PI)	Co-Invest.	2002-09	
DURIP-ONR	Computing Environment for Computational Modeling of Brain Functions	PI	2003	
NSF BCS	Social Cognitive Neuroscience of Category-based Responses (Susan Fiske, PI)	Co-Invest.	2004-05	
NIDA RO1	Neural Mechanisms and Social Influence in Delay Discounting and Impulsive Behavior	PI	2006-11	DA022564
NIDA T90	Training Program in Quantitative and Computational Neuroscience (David Tank, Co-PI)	Co-PI	2006-11	DA022770
MURI	Dynamic Decision Making in Complex Task Environments: Principles and Neural Mechanisms (James L. McClelland, PI)	Co-Invest.	2006-11	AFOSR
MURI	Behavioral Dynamics in the Cooperative Control of Mixed Human/Robotic Teams (John Baillieul, PI)	Co-Invest.	2006-11	AFOSR
DURIP	A Second Generation Flexible Computing Environment for Computational Modeling of Brain Function and Neuroimaging Data Analysis	PI	2008	AFOSR
NCRR	Expansion of a Computing Facility for fMRI and Neuroimaging Analysis	PI	2008	RR023532
NSF MRI	Acquisition of High Performance Compute Cluster for Multivariate Realtime.	PI	2012	
John Templeton Foundation	Toward a Scientific Understanding of the Human Capacity for Cognitive Control	PI	2012-2015	

3. Invited Lectureships

American Association for the Advancement of Science (2002)

American Association of Directors of Psychiatry Residency Training (AADPRT), Annual Meeting, Schein Lecture (2012)

American College of Neuropsychopharmacology, Panels (1994, 1995, 1997, 1998, 1999, 2005)

American Economic Association, Symposia (2003, 2005, 2006)

American Psychological Association, Distinguished Scientific Contribution Award Lecture (2010)

American Psychological Society (1994, 1998)

ARVO (2000)

Association for Research in Nervous and Mental Disease, Annual Conference Special Lecture (2006)

Attention and Performance XV, XVIII (1992, 1998)

Baylor College of Medicine, Neuroscience Colloquium (1999); Keynote speaker, Annual Neuroscience Retreat and Rush and Helen Record Forum (2008)

Beckman Institute for Advanced Science and Technology, University of Illinois, Smith, Hinchman & Grills Distinguished Lecture (2003)

Behavioral Neurology Society, Keynote Address (1998)

Biological Psychiatry Society, Presidential Symposium (2002, 2008)

Boston University, Department of Cognitive and Neural Systems Colloquium (2001)

Brandeis University, Department of Biology, Colloquium (1997, 2003)

Cambridge University and the Royal Society, Symposium on Executive and Cognitive Functions of Prefrontal Cortex (1996)

Cardiff University, Cardiff Cognitive Neuroscience Seminar Series (2005)

Carmel Conference XV (1997)

Carnegie Mellon University, Psychology Department Colloquium (1994, 2009)

Cognitive Neuroscience Society (1995, 1996, 2000, 2002, 2006)

Cognitive Neuroscience Treatment Research to Improve Cognition in Schizophrenia Meeting, Invited Talk (2007)

Cold Spring Harbor Laboratory, Computational and Systems Neuroscience Workshop (2004)

College de France, Colloque de Rentrée, Invited Talk (2007)

Columbia Presbyterian Hospital, Joseph Zubin Memorial Fund Award Lecture (1994)

Columbia University, College of Physicians and Surgeons, Department of Psychiatry, Grand Rounds (1990)

Cornell Medical School, Sackler Institute Colloquium (2002)

CUNY, Department of Psychology Colloquium (2000)

Dynamical Systems in Neuroscience, Annual Meeting (1999)

Eden Institute Foundation, Lecture Series Fellow (2001)

Emory School of Medicine, Department of Psychiatry, Grand Rounds (1999)

Ellison Medical Foundation, Workshop of the Biological Assessment of Mental Processes (2006)

Eunice Kennedy Shriver Center for Developmental Cognitive Neuroscience, Colloquium (2000)

Florida State University, Department of Psychology, Colloquium (1998)

Frankfurt Institute for Advanced Studies, Ernst Strüngmann Forum (2007)

Harvard University, Department of Psychology, Colloquium (1996, 2002)

Harvard University, Department of Economics, Labor Economics Seminar (2003)

Human Brain Project, Annual Conference (1998, 1999)

Indiana University, William Lowe Bryan Memorial Lecture on Cognitive Science (1992)

Institute for Advanced Studies, Department of Mathematics, Symposium (2003)

Institute of Psychiatry, King's College, London, Paul Janssen Lecture (2010)

Interface 95 - The 27th Symposium on the Interface: Computing Science and Statistics (1995)
International Conference on Cognitive and Neural Systems, 10th Annual Meeting (2006), Invited Address
International Conference on Cognitive Neuroscience, Keynote Address (1996)
International Congress on Schizophrenia Research (1997), Invited Address
International Meeting on Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine (1997)
International Neuropsychological Society (1992), Invited Address
James S. McDonnell Summer Institute in Cognitive Neuroscience (1995, 1997, 2001)
Japanese Neuropsychological Association, Keynote Address (1997)
Jena International Workshop on Executive Functions and the Brain (2000)
Library of Congress / NIMH Annual Decade of the Brain Public Program (1999)
Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Distinguished Guest Lecture Series (2011)
McGill University, Department of Psychiatry, Grand Rounds (1991)
Memory Disorders Research Society (1994, 1997, 1999)
Mind-Life Institute / M.I.T. (2003)
National Foundation for Functional Brain Imaging 1st Annual Meeting (1999)
New York Academy of Medicine, Annual Salmon Lecture (2006)
New York Academy of Sciences, Imaging Discussion Group Meeting (2005)
NIDA, Invited Seminar (2011)
NINDS, Cognitive Neuroscience Section, Grand Rounds (1993)
NIMH, St. Elizabeth's Hospital, Grand Rounds (1997)
NIMH Extramural program, Colloquia and Workshops (1999, 2000, 2001)
NIMH Intramural program, Neuroscience Colloquium (1999)
Nordic Center of Excellence and the Stockholm Brain Institute, Invited Talk (2007)
Northern California Psychiatric Society, Award Address (1986)
Northwestern University, Department of Psychology, Colloquium (1998)
NYU, Departments of Psychology and Neuroscience, Colloquia (1999, 2000)
Ohio State University, Mathematical Biosciences Institute Workshop on Systems Level Modeling (2002)
President's Council on Bioethics (2004)
Princeton Conference on Cerebral Vascular Disease (1994)
Princeton Plasma Physics Laboratory, Colloquium (2004)
Princeton University, Department of Psychology, Colloquium (1996)
Princeton University, Council on Science and Technology Public Lecture Series (2000)
Psychonomic Society, Invited Symposium Lectures (1996, 2002)
Queens College, CUNY, Annual Neuropsychology Symposium, Keynote Address (2007)
Research Society on Alcoholism, Plenary Address (2002)
Rockefeller University, Neuroscience Colloquium (1999)
Rotman Research Institute, 10th Annual Conference on the Frontal Lobes (2000)
Royal Society, UK, Mental Processes in the Human Brain (2006)

Rutgers University, Department of Psychology & Center for Molecular and Behavioral Neuroscience Colloquium (1999, 2000)
SISA, Trieste Encounters in Cognition (1992)
Smithsonian Institute Public Lecture Series (1999)
Society for Psychophysiological Research, Invited Address (2006)
Society for Research on Psychopathology (1993)
Stanford University, Neurobiology Department, Frontiers in Neuroscience Lecture Series (2009)
TPG Annual Retreat, Featured Speaker (2007)
University of California, Berkeley, Helen Wills Neuroscience Institute Inaugural Lecture (2000)
University of California, Berkeley, Neuroscience Student Seminar Series (2010)
University of California, Davis, Keynote Address, Opening of Brain Imaging Center (2005)
University of California, Davis, Department of Psychiatry Grand Rounds (2005)
University of California, San Francisco, Department of Psychiatry Grand Rounds (2001)
University College London and Wellcome Functional Imaging Laboratory (1997, 2000)
University of Colorado Boulder, Department of Psychology, Symposium (1997, 2002)
University of Colorado Boulder, Determinants of Executive Function & Dysfunction Conference (2013)
University of Illinois, Program in Neuroscience, Colloquium (1998)
University of Michigan, Departments of Psychology and Psychiatry Colloquia (1994, 2000)
University of Michigan, Marshall Weinberg Cognitive Science Symposium (2013)
University of Maryland, Psychiatric Research Center, 25th Anniversary Symposium (2002)
University of Medicine and Dentistry of New Jersey, Graduate Program in Physiology and Neurobiology, Special Lecture (1999)
University of Medicine and Dentistry of New Jersey, Dept. of Neurology Grand Rounds (2002)
University of North Carolina at Greensboro, Kendon Smith Annual Lecture Series (2004)
University of Oregon, Institute of Cognitive and Decision Sciences, Symposia (1990, 1996)
University of Pennsylvania, Department of Psychology, Cognitive Science Program, and Institute for Neural Sciences Colloquia (1996, 2001)
University of Pennsylvania, Institute of Neurological Sciences, James M. Sprague Annual Lecture (2006)
University of Pennsylvania and Philadelphia Psychoanalytic Center, Evening Program (2006)
University of Rochester, Department of Brain and Cognitive Sciences, Colloquium (2006)
University of Texas Southwestern Medical Center, Dept. of Psychiatry, Colloquium (2003)
University of Vermont, Department of Psychiatry, Grand Rounds (1992)
University of Waterloo, Centre for Theoretical Neuroscience, 5th Annual Brain Day (2011)
University of Wisconsin, Department of Psychology, Colloquium (1987, 2002)
University of Wisconsin Medical School, 5th Annual Symposium on Emotion (1999)
Vanderbilt University, Annual Neuroscience Retreat Keynote Address (2001)
Vanderbilt University, Stroopfest (2002)
Washington University, Department of Psychiatry, Grand Rounds (2003)
Winter Conference on Brain Research (1993, 1996, 1997, 1998)
Workshop on Neural Modeling of Brain and Cognitive Disorders (1995, 1998)
Yale University School of Medicine, Department of Neurobiology, Colloquium (2002)

Yale University School of Medicine, Department of Psychiatry, Abraham Ribicoff Annual Lecture (2004)

4. Other research-related activities

Advisory Boards and Councils

Allegheny County Neuropsychiatric Survey, Executive Advisory Board (1996-8)
University of Michigan, Department of Psychology, External Advisory Board (1997)
National Alliance for Research on Schizophrenia and Depression (NARSAD), Scientific Council (1998-present)
NIMH Board of Scientific Counselors, Advisory Panel on Intramural Research Program (1999)
Yale-New Haven VAMC Schizophrenia Research Center, Scientific Advisory Board (1999)
International Organization of Human Brain Mapping, Governing Council (1998-2002), Treasurer (2000-2001), Chair of Neuroinformatics Committee (1998-2001), Chair, Nominations Committee (2001)
National Foundation for Functional Brain Imaging, Advisory Board (1999-2004)
Center for Magnetic Resonance Research, University of Minnesota, Advisory Board (2000)
Harvard Initiative in Systems Neuroscience, Advisory Board (2000)
American Psychiatric Association / NIMH DSM-V Workgroup on Neuroscience (2000-2002)
NIMH Workgroup on Strategic Plan for Mood Disorders (2000-2002).
International Association for the Study of Attention and Performance, Advisory Council (2001-present)
University of Pennsylvania NIMH Silvio O. Conte Center for Neuroscience Research, “The Neurobiology of Stimulus Encoding in Schizophrenia,” External Advisory Board (2003, 2008)
Harvard University, Department of Psychology, External Advisory Board (2003-6)
NIMH Measurement and Treatment Development Activities on Cognition in Schizophrenia (MATRICS), Neurocognition Committee (2002-2006)
Council of Princeton University, Executive Committee (2004-5)
National Advisory Mental Health Council (NAMHC) (2004-8)
The Society for Neuroeconomics, Board of Directors (2004-2005)
Gatsby Computational Neuroscience Unit, UCL, Quinquennial Review Panel (2005)
National Advisory Mental Health Council Workgroup on MRI Safety (2005-2007)
Brookhaven National Laboratory, Science and Technology Steering Committee (2005-present)
Institute for Advanced Studies, Princeton, Decadal Visiting Committee for School of Social Sciences (2007)
National Advisory Mental Health Council Workgroup on Neuroscience Training (2007-2008)
University of Colorado, Boulder NIMH Interdisciplinary Behavioral Science Center, “Executive Function and Dysfunction,” External Advisory Board (2009)
Princeton University Research Computing Advisory Council, Member (2011-present)

Editorial Boards

American Journal of Psychiatry, Consulting Editor (2001-2006)
Biological Psychiatry, Board of Editors (1999-2009)
Brain Research, Senior Editor for Computational Neuroscience (2005-2010)
Cognitive Neuropsychology, Advisory editor (1997-2002)
Journal of Experimental Psychology: General, Consulting Editor (1996-2005)
Journal of Neurophysiology (2003-2004)
Neuroimage, Board of Editors (2002-2003)
Neuroinformatics, Board of Editors (2002-present)
Neuropsychopharmacology, Board of Editors (1999-2008)
Neuroscience, Board of Editors (1999-2003)
NMR in Biomedicine, Board of Editors (2003-2006)
Proceedings of the Royal Society, Biological Sciences, Board of Editors (2003-2008)
Science, Board of Reviewing Editors (1998-present)
Trends in Cognitive Science, Advisory Editorial Board (2004-present)

Grant Review

Member, Integrative Cognitive Functional Neuroscience (IFCN-8), NIH Study Section (1998-2003)

Ad hoc reviews for:

Behavioral Science Division, NSF
Clinical Psychopathology Study Section, NIMH
Human Development and Aging Study Section, NIH
Human Frontier Science Program
National Center for Research Resources, NIH
NIMH Intramural Research Program, NIH
Wellcome Trust

Conference Organization

New Directions in Health Care and Education Annual Colloquium. University of Pennsylvania Medical School, May, 1980. Founder and Co-organizer.

25th Annual Carnegie Symposium on Cognition: Scientific Approaches to the Question of Consciousness. Carnegie Mellon University, May, 1993. Co-organizer.

Center for Neuroscience and Mental Disorders bi-annual workshop: Cognitive Neuroscience Approaches to Schizophrenia. University of Pittsburgh, May, 1994. Organizer.

International Congress on Schizophrenia Research. Colorado Springs, April, 1997. Program Consultant.

Society for Research in Psychopathology. Palm Springs, October, 1997. Program Committee.

Neural Processes and Economics Workshop, Woodrow Wilson School, Princeton University. Co-organizer, 2000.

Organization for Human Brain Mapping, New York City, 2003, Chair, Local Organizing Committee.

Computational Cognitive Neuroscience Conference, Co-Founder (with Randall O'Reilly); 2005-2008, Program Committee.

Membership in Professional Organizations

American Association for the Advancement of Science

American Psychological Society

Organization for Human Brain Mapping

Psychonomic Society

Society for Neuroscience

Software Development

PsyScope, Designer and Co-Producer — this is a graphical, interactive program for the design and implementation of cognitive experimental tasks on MacIntosh computers. It provides the ability to present stimuli in text, graphic, and acoustic form, and can be used to record manual or voice responses with millisecond accuracy. It incorporates a fully general scripting language, as well as a graphic interface, and is extensible through the use of plug-and-play add-on modules. *PsyScope* is available for free via anonymous ftp, and is currently being used for experimental research and as a teaching instrument in over 500 centers internationally. A new program called *E-Prime*, based largely on *PsyScope* and *MEL*, its PC analog, has been developed in collaboration with Psychology Software Tools (PST) Inc, and version 1.0 was recently released. This is a cross-platform program (Windows and Macintosh), and significantly extends the functionality of both *PsyScope* and *MEL*.