Rajeev Raizada

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APPOINTMENTS

Cornell University **July 2011 – present**
Research Scientist, Department of Human Development
Dartmouth College **2008 – 2011**
Research Scientist, Neukom Institute for Computational Science

EDUCATION AND TRAINING

Univ. of Washington, Seattle **2003 – 2008**
Postdoctoral research. Advisor: Prof. Patricia Kuhl
MGH-NMR Center, Charlestown **2000 – 2003**
Postdoctoral research. Advisor: Prof. Russell Poldrack
Boston University **1996 – 2000**
Ph.D. in Cognitive & Neural Systems. Advisor: Prof. Stephen Grossberg
Univ. of Birmingham, England **1994 – 1995**
M.Sc. in Cognitive Science
Univ. of Oxford, England **1991 – 1994**
B.A. in Mathematics & Philosophy

RESEARCH INTERESTS

- How are neural representations structured, and how do they underlie behaviour?
- Developed a novel method of neural decoding, which operates not on neural activation patterns themselves, but instead on the similarity relations between those patterns.
- Applying this new similarity-based decoding approach to show what makes different people's neural representations alike, semantic processing, and across-species neural decoding.
- Brain-computer interface research, using EEG.
- The role of environmental factors in learning, in particular socioeconomic status.

PUBLICATIONS

Under review

- **Raizada, R.D.S.** (2012) Representing the meanings of words: neural similarity matches semantic similarity. *Under review at Psychological Science.*
- **Raizada, R.D.S.**, Lebedeva, G.C., Bhagat, S.V. and Kuhl, P.K. (2012) Differences in parental language predict the structure of Broca's area in five-year-old children. *Under second round of review at Developmental Science.*

In press

- Mackey, A.P., **Raizada, R.D.S.** and Bunge, S.A. (2011) Environmental influences on prefrontal development. To appear in: Principles of frontal lobe function (2nd Edition), edited by Donald Stuss and Robert Knight. Oxford: Oxford University Press.

Published

These papers can be downloaded from http://raizadalab.org/publications.html

- Lee, Y.S., Turkeltaub, P.E., Granger, R.H. and **Raizada, R.D.S.** (2012) Categorical speech processing in Broca's area: An fMRI study using multivariate pattern-based analysis. *Journal of Neuroscience*, 32(11), 3942-3948. PDF.
- **Raizada, R.D.S.** & Connolly, A.C. (2012) What makes different people's representations alike: neural similarity-space solves the problem of across-subject fMRI decoding. *Journal of Cognitive Neuroscience,* 24(4), 868-77. PDF. Matlab and Python analysis code. Supp.Info.

- **Raizada, R.D.S.**, Tsao, F.M., Liu, H.M., Holloway, I.D., Ansari, D. and Kuhl, P.K. (2010) Linking brain-wide multivoxel activation patterns to behaviour: examples from language and math. *NeuroImage*, 51, 462-471. PDF.
- **Raizada, R.D.S.** and Kriegeskorte, N. (2010) Pattern-information fMRI: new questions which it opens up, and challenges which face it. *International Journal of Imaging Systems and Technology*, 20(1), 31-41. Special issue on recent developments in neuroimaging, guest edited by Dae-Shik Kim. PDF.
- **Raizada, R.D.S.** and Kishiyama, M. (2010) Effects of socioeconomic status on brain development, and how Cognitive Neuroscience may contribute to leveling the playing field. *Frontiers in Human Neuroscience.* DOI: http://dx.doi.org/10.3389/neuro.09.003.2010. PDF.
- **Raizada, R.D.S.**, Tsao, F.M., Liu, H.M. and Kuhl, P.K. (2010) Quantifying the adequacy of neural representations for a cross-language phonetic discrimination task: prediction of individual differences. *Cerebral Cortex*, 20(1), 1-12. Advance Online Publication: April 22, 2009. PDF.
- **Raizada, R.D.S.**, Richards, T.L., Meltzoff, A. and Kuhl, P.K. (2008) Socioeconomic status predicts hemispheric specialisation of the left inferior frontal gyrus in young children. *Neuroimage*, 40(3), 1392-401. PDF.
- **Raizada, R.D.S.** and Poldrack, R.A. (2007) Challenge-driven attention: interacting frontal and brainstem systems. *Frontiers in Human Neuroscience*, 1, 3. PDF.
- **Raizada, R.D.S.** and Poldrack, R.A. (2007) Selective amplification of stimulus differences during categorical processing of speech. *Neuron*, 56(4), 726-40. PDF.
- **Raizada, R.D.S.** and Grossberg, S. (2003). Towards a theory of the laminar architecture of cerebral cortex: computational clues from the visual system. *Cerebral Cortex*, 13(1), 100-13. PDF.
- **Raizada, R.D.S.** and Grossberg, S. (2001). Context-sensitive binding by the laminar circuits of V1 and V2: A unified model of perceptual grouping, attention, and orientation contrast. *Visual Cognition*, 8 (3-5), 431-466. PDF.
- Grossberg, S. and **Raizada, R.D.S.** (2000). Contrast-sensitive perceptual grouping and object-based attention in the laminar circuits of primary visual cortex. *Vision Research*, 40, 1413-1432. PDF.

In preparation

- **Raizada, R.D.S.**, Kiani, R. and Kriegeskorte, N. (2011) Across-species neural decoding reveals the similarities and differences in how humans and monkeys represent the visual world.

Peer-reviewed conference publications

- Casey, M.A., Thompson, J., Kang,O., **Raizada, R.D.S.**, and Wheatley.T (2011) Population codes representing musical timbre for high-level fMRI categorization of music genres. *Proceedings of the NIPS 2011 workshop on machine learning and interpretation in neuroimaging.* PDF.
- Campbell, A.T., Choudhury, T., Hu, S., Lu, H., Mukerjee, M.K., Rabbi, M. and **Raizada, R.D.S.** (2010) NeuroPhone: Brain-mobile phone interface using a wireless EEG headset. *2010 ACM SIGCOMM Workshop on Networking, Systems, and Applications on Mobile Handhelds - MobiHeld '10.* PDF.

GRANTS

Under review

- NSF Cognitive Neuroscience proposal: "Measuring and modeling object similarity in the brain: combining conceptual and perceptual representations." ($600K over three years. PI: Rajeev Raizada. Co-PI: Shimon Edelman)

Currently funded

- NSF Award #1058753. Co-PI with Andrew Campbell and Tanzeem Choudhury. "EAGER: Brain-Mobile Interfaces: Exploratory Research into the Development of Networked Neuro-Phones." $250K over two years: Sept.2010-2012.

Previously funded

- NSF 0121950 Cognitive Neuroscience Pilot Grant (2001-2002, $50K indirect, co-P.I. with Russ Poldrack): "Enhancing human cortical plasticity: Visual psychophysics and fMRI".
- General Grant Award, International Dyslexia Association (2001-2002: $15K direct, co-P.I. with Russ Poldrack): "Magnetic resonance imaging of cross-modal processing in dyslexia"

AWARDS

McDonnell-Pew Postdoctoral Fellowship in Cognitive Neuroscience **2000 – 2003**
One of twenty-five awarded nationwide. $150K over three years

Presidential University Graduate Fellowship, Boston University **1996 – 2000**
One of twenty-five awarded each year across all BU graduate programs

Radcliffe Prize, University of Birmingham, England **1995**
One of two awarded each year in the Faculty of Science

INVITED TALKS

Dept. of Linguistics, University of Texas at Austin	**Jan. 2012**
Dept. of Brain & Cognitive Sciences, University of Rochester	**Jan. 2012**
Dept. of Cognitive Science, UCSD	**June 2011**
Integrated Brain Imaging Center, University of Washington	**Oct. 2010**
Dept. of Human Development & Dept. of Information Science, Cornell	**June 2010**
Symposium speaker at Association for Psychological Science Convention: "Effects of socioeconomic status on brain development"	**May 2010**
Center for Cog.Neuro., Bangor University	**Feb. 2010**
Center for Cog.Neuro., Medical University of South Carolina	**Feb. 2010**
Dept. of Communication Sciences & Disorders, Northwestern University	**Feb. 2010**
Bernstein Centre For Comput. Neuro. / Berlin Inst. of Technology	**Jan. 2010**
Colloquium, Dept. of Cognitive Science, Johns Hopkins University	**Oct. 2009**
Neuroscience colloquium, University of Western Ontario	**May 2009**
Mind, Brain and Education Colloquium, Univ. of Texas at Arlington	**Apr. 2009**
Helen Wills Neuroscience Institute, Univ. of California, Berkeley	**March 2009**
CELEST Colloquium Series, Boston University	**Jan. 2009**
Chaired and presented symposium at Cognitive Neuroscience Society Meeting: "Pattern-based fMRI analyses as a route to revealing neural representations"	**June 2008**
Computational and Systems Neuroscience (CoSyNe) workshop, Snowbird	**March 2008**
Department of Psychology, Temple University	**Jan. 2007**
Department of Cognitive Science, Case Western Reserve University	**Jan. 2007**
Brain & Math workshop, Vanderbilt University	**Nov. 2006**
Institute of Cognitive Neuroscience, UCL	**May 2006**
MRC Cognition and Brain Sciences Unit, Cambridge, UK	**May 2006**
Stanford NSF-LIFE Center Workshop	**2005**
BrainMap Colloquium Series, MGH-NMR Center	**2002**
Brain, Behavior & Cognition Colloq. Series, Dept. of Psychology, Boston University	**2000**
Invited workshop talk: Computation in the Cortical Column, Neural Information Processing Systems Conference, Breckenridge, Colorado	**2000**

Teaching and Mentoring Experience

Co-advised a Ph.D. student: Yune-Sang Lee, Psych. Dept., Dartmouth	**2008 – 2011**
Guest lecturer, Boston Univ. Course CN 730: Models of Visual Perception	**Jan. 2009**
Guest lecturer, Dartmouth Course Math 126: Topics in Visual Neuroscience	**Oct. 2008**
Guest lecturer, Univ. of Washington Course SPHSC 425: "Language and fMRI"	**2004 – 2006**
Guest lecturer, MIT Course HST583: "Matlab for fMRI: convolution, design matrices and image display"	**2002**
Guest lecturer, Boston University Course CNS510: "Neurobiological evidence for Adaptive Resonance Theory mechanisms"	**2000**

Tutorial Webpages

- **Interactive statistics tutorials, in Python and Matlab**
  A YouTube video illustrating the interactive programs in action can be found here. These tutorials have been used for teaching at U.Mass Boston.
- **Matlab for fMRI, pattern-based analysis and SPM**
  This webpage comes top in a Google search for "fMRI matlab", out of more than 200,000 results. Used for teaching at the Univ. of Arizona.
- **Matlab for neural networks**
  Used for teaching at the the University of Regensburg.

Media Coverage

- New York Times magazine article describing my Brain-Computer Interface work.
- News article in Science magazine describing my research work, and also the symposium that I chaired at the Cognitive Neuroscience Society Meeting (see p.3 of the article). Details of the symposium, "Pattern-based fMRI analyses as a route to revealing neural representations," are at http://www.dartmouth.edu/~raj/CNS_symposium.html.
- Press reports about my paper on neural amplification in Neuron, at Science Daily and Medical News Today.
- Report about my paper on SES and Broca's area in NeuroImage in the British Psychological Society Research Digest.

Experience with Children and Patient Populations

- Performed fMRI and psychophysical testing of dyslexic and normal children, aged 5-14.
- Sept. 1995 - July 1996: Carried out voluntary work in a residential school for disabled children, Überlingen, Germany. Responsible for day-to-day care, activities and supervision of a group of three boys, ages 8 to 14. Two were autistic, one epileptic with "frontal-lobe"-esque behavioural difficulties.

Professional Memberships

- Society for Neuroscience
- Cognitive Neuroscience Society
- Association for Psychological Science

Referee Duties

- Review Editor for the journal Frontiers in Developmental Psychology.
- Ad hoc reviewer for: National Science Foundation, Natural Sciences and Engineering Research Council of Canada, Trends in Cognitive Sciences, NeuroImage, Developmental Science, Cerebral Cortex, UK Medical Research Council, Journal of Cognitive Neuroscience, Frontiers in Human Neuroscience, Neural Networks, Neuropsychologia, American Educational Research Association (AERA), IEEE Transactions on Robotics, IEEE Transactions on Autonomous Mental Development, Wiley Interdisciplinary Reviews in Cognitive Science, American Journal of Public Health.

Conference Presentations (Partial Listing)

- Raizada, R.D.S. (2011) A new approach to neural decoding: acting on the similarities between activation patterns, rather than on the patterns themselves. *NIPS 2011 workshop on machine learning and interpretation in neuroimaging.*
- Raizada, R.D.S., Tsao, F.M., Liu, H.M., Holloway, I.D., Ansari, D. and Kuhl, P.K. (2009) Linking whole brain activation patterns to behaviour: examples from language and math. *Society for Neuroscience*, 673.

- Lee, Y.S., Granger, R.H. and Raizada, R.D.S. (2009) Distributed and Overlapping Neural Representation of The /ba/-/da/ Phonemic Continuum: MVPA (Multi-Variate Pattern based Analysis) vs. GLM. *Human Brain Mapping.*
- Raizada, R.D.S., Tsao, F.M., Liu, H.M. and Kuhl, P.K. (2008) Individual differences in speech perception are predicted by the distinctness of underlying neural representations. *Cognitive Neuroscience Society Annual Meeting*, 15, G118.
- Raizada, R.D.S., Tsao, F.M., Liu, H.M. and Kuhl, P.K. (2007) Perceptual discriminability of stimuli is predicted by separability of evoked neural patterns. *Society for Neuroscience*, 864.1
- Raizada, R.D.S., Schwartz, D., O'Mahony, T.K., Bransford, J. and Kuhl, P.K. (2006) Trial-and-error learning and the neural reward system. *Society for Neuroscience Satellite Symposium, "From Synapse to Schoolroom: The Science of Learning"*
- Raizada, R.D.S. and Kuhl, P.K. (2006) Socioeconomic status predicts hemispheric specialisation of Broca's area. *Society for Neuroscience*, 779.1
- Raizada, R.D.S. and Poldrack, R.A. (2004) Probing the structure of phonetic categories in the human brain. *Cognitive Neuroscience Society Annual Meeting*, 11, B133.
- Raizada, R.D.S. and Poldrack, R.A. (2003). Difficult, unpredictable trials coactivate noradrenergic and frontal attentional systems. *Society for Neuroscience*, 401.4
- Raizada, R.D.S. and Poldrack, R.A. (2002). Adaptation-fMRI of categorical processing of speech. *Society for Neuroscience*, 17.7
- Raizada, R.D.S. and Poldrack, R.A. (2001) Event-related fMRI of audio-visual simultaneity perception. *Society for Neuroscience Abstracts*, 31, 511.14
- Raizada, R.D.S. and Grossberg, S. (2000) Interactions between attention, collinear grouping and orientation contrast in the laminar circuits of V1 and V2. *Society for Neurosci.*, 30, 211.12
- Raizada, R.D.S. and Grossberg, S. (1999) Laminar substrates of attention, grouping and perceptual learning in V1 and V2. *Investigative Ophth. and Visual Science (ARVO)*, 40(4), S645
- Raizada, R.D.S. and Grossberg, S. (1999) Context-sensitive processing in the laminar circuits of V1 and V2: Interacting attention, collinear grouping and orientation-contrast effects. *Society for Neuroscience*, 29, 427.13
- Raizada, R.D.S. and Grossberg, S. (1998) What are the layers of cortex for? A neural model of attention, perceptual grouping and learning in V1 and V2. *Society for Neuroscience*, 28, 105.10

REFEREES

Patricia Kuhl (Former postdoctoral advisor)
Bezos Family Foundation Endowed Chair in Early Childhood Learning
Co-Director, Institute for Learning and Brain Sciences
University of Washington
Box 357988, Seattle WA 98195
E.mail: pkkuhl@u.washington.edu

Russell Poldrack (Former postdoctoral advisor)
Director of the Imaging Research Center
The University of Texas at Austin
Department of Psychology
1 University Station A8000, Austin, Texas 78712-0187
E.mail: poldrack@mail.utexas.edu

Stephen Grossberg (Doctoral advisor)
Wang Professor of Cognitive and Neural Systems
Center for Adaptive Systems
Boston University
677 Beacon St., Boston, MA 02215
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