

# RISHI RAJALINGHAM

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## RESEARCH INTERESTS

Systems Neuroscience, Brain-Machine Interfaces, Computer Vision

## EDUCATION

**Massachusetts Institute of Technology** (Sept 2012 - Sept 2018)

Doctorate, Brain and Cognitive Sciences

Supervised by Dr. James J. DiCarlo. GPA: 5.0/5.0

**McGill University** (Sept 2010 - May 2012)

Masters of Engineering, Electrical Engineering

Systems Neuroscience Focus, Thesis Option

Supervised by Dr. Sam Musallam. GPA: 3.83/4.0

**McGill University** (Sept 2006 - May 2010)

Bachelor of Engineering, Electrical Engineering (Honours)

Minor in Mathematics. GPA: 3.87/4.0

## RESEARCH EXPERIENCE

**Post-doctoral Research** (March 2019 - current)

*Jazayeri Laboratory, Massachusetts Institute of Technology, Cambridge, MA*

- Research in systems neuroscience (cognition) under the supervision of Dr. Mehrdad Jazayeri.
  - Investigating the neural basis of internal models underlying flexible spatio-temporal inference in primates.

**Post-doctoral Research** (Sept 2018 - March 2019)

*DiCarlo Laboratory, Massachusetts Institute of Technology, Cambridge, MA*

- Research in systems neuroscience (vision) under the supervision of Dr. James DiCarlo.
  - Tested the potential role of primate inferior temporal cortex in the domain of orthographic processing and visual word-form recognition.

**Doctoral Research** (Sept 2012 - Sept 2018)

*DiCarlo Laboratory, Massachusetts Institute of Technology, Cambridge, MA*

- Research in systems neuroscience (vision) under the supervision of Dr. James DiCarlo.
  - Conducted neurophysiology experiments with pharmacological and optogenetic manipulation of inferior temporal cortex in primates.
  - Constructed and tested deep neural network models of primate object recognition behavior.

**Masters Research** (September 2010 - September 2012)

*Neural Prosthetics Laboratory, McGill University, Montreal, QC*

- Research in systems neuroscience (motor control) under the supervision of Dr. Sam Musallam.
  - Recorded and analyzed neural activity and local cortical oxygen concentration in the posterior parietal cortex of primates for neural prosthetic applications.

**Undergraduate Research** - (May 2007 - August 2010)

*Center of Intelligent Machines, Montreal, QC*

- Analyzed human cortical folding pattern variability with computer vision techniques under the supervision of Dr. Tal Arbel, Dr. Louis Collins (May 2010 - August 2010).
- Conducted research in computer vision (face recognition, pose estimation) under the supervision of Dr. Martin Levine (May 2007 - August 2007), Dr. Tal Arbel (May 2008 - August 2008), and Dr. Jeremy Cooperstock (May 2009 - August 2009).

## PUBLICATIONS AND PRESENTATIONS

### *Journal Publications*

- **Rajalingham R.**, Kar K., Sanghavi S., Dehaene S., DiCarlo J.J. (accepted at Nature Communications). A potential cortical precursor of visual word form recognition in untrained monkeys.
- **Rajalingham, R.**, DiCarlo, J. J. (2019). Reversible inactivation of different millimeter-scale regions of primate IT results in different patterns of core object recognition deficits. *Neuron* 102(2), 493-505.
- **Rajalingham, R.\***, Issa, E. B.\*, Bashivan, P., Kar, K., Schmidt, K., DiCarlo, J. J. (2018). Large-scale, high-resolution comparison of the core visual object recognition behavior of humans, monkeys, and state-of-the-art deep artificial neural networks. *The Journal of Neuroscience*, 0388-18.
- **Rajalingham, R.**, Musallam, S. (2017). Characterization of neurons in the primate medial intraparietal area reveals a joint representation of intended reach direction and amplitude. *PLoS One*, 12(8), e0182519.
- **Rajalingham, R.**, Schmidt, K., and DiCarlo, J. J. (2015). Comparison of Object Recognition Behavior in Human and Monkey. *The Journal of Neuroscience*, 35(35), 12127-12136.
- Bylinskii, Z.\*, DeGennaro, E. M.\*, **Rajalingham, R.\***, Ruda, H.\*, Zhang, J.\*, and Tsotsos, J. K. (2015). Towards the quantitative evaluation of visual attention models. *Vision research*, 116, 258-268.
- **Rajalingham, R.**, Stacey, R. G., Tsoulfas, G., and Musallam, S. (2014). Modulation of neural activity by reward in medial intraparietal cortex is sensitive to temporal sequence of reward. *Journal of neurophysiology*, 112(7), 1775-1789.

### *Preprints*

- Schrimpf, M., Kubilius, J., Hong, H., Majaj, N.J., **Rajalingham, R.**, Issa, E.B., Kar, K., Bashivan, P., Prescott-Roy, J., Schmidt, K. and Yamins, D.L., 2018. Brain-Score: which artificial neural network for object recognition is most brain-like?. *BioRxiv*, p.407007.

### *Refereed Conference Talks*

- **Rajalingham R.**, Kar K., Sanghavi S., Dehaene S., DiCarlo J.J. (2019). A precursor of reading: Neural responses to letters strings in the untrained primate inferior temporal cortex predict word recognition behavior. *Vision Sciences Society, St-Pete's, FL*.

### *Refereed Conference Proceedings Publications*

- Kubilius, J., Schrimpf, M., Hong, H., Majaj, N., **Rajalingham, R.**, Issa, E., Kar, K., Bashivan, P., Prescott-Roy, J., Schmidt, K. and Nayebi, A., 2019. Brain-like object recognition with high-performing shallow recurrent ANNs. In *Advances in Neural Information Processing Systems* (pp. 12785-12796).
- **Rajalingham R.**, Lee H., DiCarlo J.J. (2018). Selective behavioral deficits from focal inactivation of primate inferior temporal (IT) cortex: a new quantitative constraint for models of core object recognition. *Cognitive Computational Neuroscience (CCN) Philadelphia, PA*.
- **\*Rajalingham R.**, \*Issa EB, Kar K, Schmidt K, DiCarlo J.J. (2017). Feedforward deep neural networks diverge from humans and monkeys on core visual object recognition behavior. *Cognitive Computational Neuroscience (CCN) New York, NY*.
- **Rajalingham, R.**, Toews, M., Collins, D. L., and Arbel, T. (2011). Exploring cortical folding pattern variability using local image features. In *Medical Computer Vision. Recognition Techniques and Applications in Medical Imaging* (pp. 43-53). Springer Berlin Heidelberg.
- **Rajalingham, R.**, Visell, Y., and Cooperstock, J. R. (2010). Probabilistic tracking of pedestrian movements via in-floor force sensing. In *Computer and Robot Vision (CRV), 2010 Canadian Conference on* (pp. 143-150). IEEE.
- **Rajalingham R.**, Visell Y., Cooperstock J. (2010) Probabilistic Tracking of Pedestrian Move-

ments from In-floor Force Measurements. 7th Canadian Conference on Computer and Robot Vision (CRV), Ottawa, Canada.

- Visell, Y., Smith, S., Law, A., **Rajalingham, R.**, and Cooperstock, J. R. (2010). Contact sensing and interaction techniques for a distributed, multimodal floor display. In 3D User Interfaces (3DUI), 2010 IEEE Symposium on (pp. 75-78). IEEE.

#### *Refereed Conference Poster Presentations*

- **Rajalingham R.**, Piccato A., Jazayeri M. (2020). Comparing physical inferences in humans, monkeys and task-optimized recurrent neural network models. COSYNE, Denver, CO.
- **Rajalingham R.**, Jazayeri M. (2019). Imposing inductive biases to solve general inference tasks in recurrent neural networks. Neuroscience (SFN), Chicago, IL.
- Schrimpf, M., Kubilius, J., Hong, H., Majaj, N.J., **Rajalingham, R.**, Ziemba, C., Issa, E.B., Kar, K., Bashivan, P., Prescott-Roy, J. and Schmidt, K., (2019). Using Brain-Score to Evaluate and Build Neural Networks for Brain-Like Object Recognition. COSYNE, Lisbon, Portugal.
- **Rajalingham R.**, DiCarlo J.J. (2018). Focal reversible inactivation of macaque inferior temporal (IT) cortex reveals a topographically selective causal role in primate core object recognition behavior. Neuroscience (SFN) San Diego, CA.
- **Rajalingham R.**, Lee H., DiCarlo J.J. (2018). Selective behavioral deficits from focal inactivation of primate inferior temporal (IT) cortex: a new quantitative constraint for models of core object recognition. Cognitive Computational Neuroscience (CCN) Philadelphia, PA.
- **Rajalingham R.**, DiCarlo J.J. (2018). Focal reversible inactivation of macaque inferior temporal (IT) cortex reveals a topographically selective causal role in primate core object recognition behavior. Gordon Research Conference, Neurobiology of Cognition, Newry, ME.
- **\*Rajalingham R.**, \*Issa EB, Kar K, Schmidt K, DiCarlo J.J. (2017). Feedforward deep neural networks diverge from humans and monkeys on core visual object recognition behavior. Cognitive Computational Neuroscience (CCN) New York, NY.
- **\*Rajalingham R.**, \*Issa EB, Kar K, Schmidt K, DiCarlo JJ (2016). Image-grain comparison of core object recognition behavior in humans, monkeys and machines. Neuroscience (SFN), San Diego, CA
- **Rajalingham R.**, Schmidt K., DiCarlo J.J. (2014) Comparison of Object Recognition Behavior in Human and Monkey. Vision Sciences Society, St-Pete's, FL.
- Stacey R.G., **Rajalingham R.**, Musallam S. (2013) Dynamic reach plan updating in the medial intraparietal sulcus and dorsal premotor cortex. Neuroscience, San Diego, California.
- **Rajalingham R.**, Musallam S. (2012) Contextual Reward Encoding in the Medial Intraparietal Cortex Leads to Filtering of Risk. Centre for Applied Mathematics in Bioscience and Medicine Poster Session (CAMBAM), Montreal, Canada.
- Zhao E., **Rajalingham R.**, Musallam S. (2011) The Role of Local Field Potentials in the Back-Propagation of Errors. Centre for Applied Mathematics in Bioscience and Medicine Poster Session (CAMBAM), Montreal, Canada.
- **Rajalingham R.**, Musallam S. (2011) Local Tissue Oxygenation in the Posterior Parietal Cortex. Centre for Applied Mathematics in Bioscience and Medicine Poster Session (CAMBAM), Montreal, Canada.
- **Rajalingham R.**, Musallam S. (2011). Local Tissue Oxygenation in the Posterior Parietal Cortex. Canadian Physiological Society: Physiological Mechanisms of Perception, Cognition and Action 2011 (CPS/CapNET) St-Adele, Canada.
- **Rajalingham R.**, Toews M., Collins D.L., Arbel T. (2010) Exploring Cortical Folding Pattern Variability Using Local Image Features. Workshop on Medical Computer Vision (MCV), Medical Image Computing and Computer Assisted Intervention 2010 (MICCAI), Beijing, China.

#### *Invited Talks*

- How does the primate ventral visual stream causally support core object recognition?

- Massachusetts Institute of Technology, Cambridge, MA. Nancy Kanwisher, March 2019.
- Montreal Neurological Institute, Montreal, Canada. Tal Arbel, December 2018.
- National Institute of Health, Bethesda MD. Bevil Conway, December 2018.
- Harvard Medical School, Cambridge, MA. Gabriel Kreiman, November 2018.
- Columbia University, New York, NY. Elias Issa, October 2018.
- Neurospin, Paris, France. Stanislas Dhaene, September 2018.
- Janelia Farm, Ashburn, VA. Karel Svoboda, September 2018.
- Yale University, New Haven, CT. Daeyeol Lee, August 2018.
- University of Minnesota, Minneapolis, MN. Benjamin Hayden, August 2018.
- Massachusetts Institute of Technology, Cambridge, MA. Michael Halassa, July 2018.
- Baylor College of Medicine, Houston, TX. Nuo Li, July 2018.

#### *Book Chapters*

- Visell Y., **Rajalingham R.**, Cooperstock J. (2011). A review of nonvisual signatures of human walking with applications to person tracking in augmented environments. In: Y. Visell, F. Fontana Walking with the senses: Perceptual techniques for walking in simulated environments. Berlin: Logos Verlag.

#### *Theses*

- **Rajalingham R.** How does the primate ventral visual stream causally support core object recognition? (Doctoral Thesis, Massachusetts Institute of Technology, 2018).
- **Rajalingham R.** Characterization, Modeling and Analysis of Neural Signals for Brain-Machine Interface Applications (Masters Thesis, McGill University, 2012).
- **Rajalingham R.** Exploring Cortical Folding Pattern Variability Using Local Features (Undergraduate Honours Thesis, McGill University, 2010).

\*denotes equal contribution.

## TEACHING EXPERIENCE

### **Quantitative Methods Workshop Lecturer**

*Massachusetts Institute of Technology (January 2020)*

- Prepared and presented a lecture to a class of 80+ URM students on "Encoding and decoding models for neural systems."

### **Teaching Assistantship**

*Massachusetts Institute of Technology (Fall 2013, Fall 2014, Winter 2018)*

- Lectured, graded and led seminar discussions for graduate course 9.S914 Neural mechanisms of cognitive computations
- Lectured and graded for undergraduate course 9.16 Cellular Neurophysiology

*McGill University (January 2011 - December 2011)*

- Lectured for graduate engineering course ECSE517 - Neural Prosthetics (Jan 2011).
- Lecture for undergraduate physiology course PHGY314 - Integrative Neuroscience (Sept 2011).
- Lectured for graduate physiology course PHGY556 - Topics in Systems Neuroscience (March 2012).
- Graded weekly assignments in Real Analysis 1 and Honours Real Analysis II (Sept 2009).

*Marianopolis College (September 2005 - May 2008)*

- Tutored college-level mathematics courses to individual students.
- Graded weekly assignments in calculus (I, II, III) and linear algebra.

### **Undergraduate Mentorship** (May 2011 - September 2011)

*Neural Prosthetics Laboratory, McGill University, Montreal, QC*

- Mentored physiology/physics undergraduate student Eric Zhao.

## SERVICE

### Reviewer for

- Public Library of Science (PLOS) Computational Biology
- Zoological Research

## AWARDS AND HONOURS

### *Fellowships*

- Helen Hay Whitney Foundation Postdoctoral Fellowship (2020-2023)
- Shoemaker Fellowship (2016-2017)
- Leventhal Fellowship (2013-2014, 2014-2015, 2015-2016)
- Singleton Fellowship (2012-2013)
- NSERC Postgraduate Scholarship (PGS-D) (2012-2015)
- NSERC Alexander Graham Bell Canada Graduate Scholarship (CGS-M) (2010)
- Provosts Graduate Fellowship, McGill University (2010)
- NSERC Undergraduate Student Research Award (2007, 2008, 2009)
- McGill Duggan G H Entrance Scholarship (2006, 2007, 2008, 2009)

### *Awards*

- Cognitive Computational Neuroscience Travel Award (2018)
- Cognitive Computational Neuroscience Travel Award (2017)

### *Honours*

- Sigma Xi Excellence in Undergraduate Research Award (2010)
- Governor Generals Bronze Medal (2004)

## Languages

### *Programming:*

- Python
- MATLAB
- Bash
- Java, C, C++

### *Natural:*

- English
- French