

# Dr. Supratim Ray

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Associate Professor, Centre for Neuroscience  
Associate Faculty, Electrical Engineering  
Old TIFR Building, Centre for Neuroscience  
Indian Institute of Science, Bangalore, India, 560012  
Email: sray@iisc.ac.in, Phone: +918022933437

## Research Interests

- Neural mechanisms of gamma oscillations
- Origins of various brain signals such as local field potential (LFP), electrocorticogram (ECoG) and EEG in both humans and non-human primates
- Neural mechanisms of selective attention
- Brain computer interfacing
- Clinical applications of gamma rhythms in early diagnosis of mental disorders

## Research Experience

Associate Professor	June 2017 – Present
Assistant Professor	June 2011 – May 2017
Indian Institute of Science, Bangalore, India	
Postdoctoral Research Associate	Jan 2008 – May 2011
Harvard Medical School & HHMI, Boston, MA	
Postdoctoral Fellow	October 2007 – Dec 2007
Johns Hopkins University, Baltimore, MD	

## Education

Ph.D. in Biomedical Engineering	October 2007
Johns Hopkins University, Baltimore, MD	
Dissertation: “Effects of attention on ECoG high-gamma activity in humans and relationship of high-gamma to single-unit activity in non-human primates”	
Bachelor of Technology, Electrical Engineering	May 2001
Indian Institute of Technology, Kanpur, India.	

## Full List of Publications

### Peer Reviewed Journals and Reviews/Techsights (indicated by \*)

[19] Dinavahi MVPS\*, Shirhatti V\*, Ravishankar P\* and **Ray S<sup>†</sup>**, *Large visual stimuli induce two distinct gamma oscillations in primate visual cortex.* **Journal of Neuroscience.** *In Press.* (\* indicates joint first author).

[18] Subhash Chandran KS, Seelamantula CS, and **Ray S<sup>†</sup>**. *Duration Analysis Using Matching Pursuit Algorithm Reveals Longer Bouts of Gamma Rhythm.* **Journal of Neurophysiology.** Doi: jn.00154.2017. *In press.*

[17\*] Biswas A and **Ray S<sup>†</sup>** (2017). *Control of alpha rhythm (8-13 Hz) using neurofeedback.* **Journal of the Indian Institute of Science.** Vol 97:4: 527-531.

[16] Dubey A and **Ray S<sup>†</sup>** (2016). *Spatial spread of local field potential is band-pass in the primary visual cortex.* **Journal of Neurophysiology.** Oct 1; 116(4): 1986-99.

[15] Shirhatti V, Borthakur A, and **Ray S<sup>†</sup>** (2016). *Effect of Reference Scheme on Power and Phase of the Local Field Potential.* **Neural Computation.** Vol 28, No. 5: 882-913.

[14\*] Subhash Chandran K S, Mishra A\*, Shirhatti V\* and **Ray S<sup>†</sup>** (2016). *Comparison of Matching Pursuit algorithm with other signal processing techniques for computation of the time-frequency power spectrum of brain signals.* **Journal of Neuroscience.** March 23; 36(12): 3399-3408.

[13\*] **Ray S<sup>†</sup>** (2015) *Challenges in the quantification and interpretation of spike-LFP relationships.* **Current Opinion in Neurobiology.** April 30; 31: 111-118.

[12\*] **Ray S** and Maunsell, JHR<sup>†</sup> (2015). *Do gamma oscillations play a role in cerebral cortex?* **Trends in Cognitive Sciences.** Vol. 19(2): 78-85.

[11] Srinath R and **Ray S<sup>†</sup>** (2014) *Effect of Amplitude Correlations on Coherence in the Local Field Potential.* **Journal of Neurophysiol.** Aug 15; 112(4):741-51.

[10] **Ray S<sup>†</sup>**, Ni AM and Maunsell JHR (2013). *Strength of Gamma Rhythm depends on Normalization.* **PLoS Biology.** 11(2):e1001477.

[9] Ni AM, **Ray S** and Maunsell JHR<sup>†</sup> (2012) *Tuned Normalization Explains the Size of Attention Modulations.* **Neuron.** Feb 23; 73(4): 803-813

[8] **Ray S<sup>†</sup>** and Maunsell JHR (2011) *Network rhythms influence the relationship between spike-triggered local field potential and functional connectivity.* **Journal of Neuroscience.** Aug 31; 31(35):12674-82

[7] **Ray S<sup>†</sup>** and Maunsell JHR (2011) *Different origins of gamma rhythm and high-gamma activity in macaque visual cortex.* **PLoS Biology.** Apr; 9(4):e1000610.

[6] **Ray S<sup>†</sup>** and Maunsell JHR (2010) *Differences in gamma frequencies across visual cortex restrict their possible use in computation.* **Neuron.** Sep 9; 67:885-896

[5] **Ray S<sup>†</sup>**, Crone NE, Niebur E, Franaszczuk PJ and Hsiao SS (2008) *Neural correlates of high-gamma oscillations (60-200 Hz) in macaque local field potentials and their potential implications in electrocorticography.* **Journal of Neuroscience.** Nov 5; 28(45): 11526-36.

[4] **Ray S<sup>†</sup>**, Hsiao SS, Crone NE, Franaszczuk PJ and Niebur E (2008) *Effect of stimulus intensity on the spike-local field potential relationship in the secondary somatosensory cortex.* **Journal of Neuroscience.** Jul 16; 28(29): 7334-43

[3] **Ray S**, Niebur E, Hsiao SS, Sinai A and Crone NE<sup>†</sup> (2008) *High-frequency gamma activity (80-150 Hz) is increased in human cortex during selective attention.* **Clinical Neurophysiology.** Jan; 119(1):116-33.

[2] Muniak MA, **Ray S**, Hsiao SS, Dammann JF, Bensmaia SJ<sup>†</sup> (2007) *The neural coding of stimulus intensity: linking the population response of mechanoreceptive afferents with psychophysical behavior.* **Journal of Neuroscience.** Oct 24; 27(43):11687-99.

[1] **Ray S<sup>†</sup>**, Jouny CC, Crone NE, Boatman D, Thakor NV, Franaszczuk PJ (2003) *Human ECoG analysis during speech perception using matching pursuit: a comparison between stochastic and dyadic dictionaries.* **IEEE Transactions in Biomedical Engineering.** 50:1371-1373.

(Corresponding Author indicated by <sup>†</sup>)

#### Submitted/Under Review

- Siddhesh Salelkar, Gowri Manohari Somasekhar, and Supratim Ray. *Distinct frequency bands in the local field potential reflect input, processing and output.* Under Revision.
- Vinay Shirhatti and Supratim Ray. *Red hues induce unusually large gamma oscillations in the primate primary visual cortex.* Under Revision.

### **Peer reviewed conference proceedings**

- Saxena A, **Ray S** and Varma R.K. (2002) *A Novel Electric Shock Protection System Based on Contact Currents on Skin Surface*, Proc. of 12th National Power Systems Conference, IIT Kharagpur, India, December 27-29

### **Books**

- **Ray S** (2008) *Linking Spikes with Neuronal Oscillations*. ISBN-13: 978-3639097986. Publisher: VDM Verlag Dr. Mueller e.K.

### **Book chapters**

- Crone NE, Korzeniewska A, **Ray S**, Franaszczuk PJ. *Cortical Function Mapping with Intracranial EEG*. In: Tong, S, Thakor, NV. (2009) *Quantitative EEG Analysis Methods and Clinical Applications (Engineering in Medicine & Biology)*. ISBN-13: 978-1-59693-204-3. Publisher: Artech House, Inc.

### **Book Reviews**

- **Ray S** (2014) Review of “Discovering the Human Connectome” by Olaf Sporns. *Current Science*, vol. 106, 2, Jan 25, page 311-312.

### **Conference Presentations**

- Dubey A and Ray S (2017). *Local origins of electrocorticogram (ECoG) in visual cortex*. Society for Neuroscience. Abstract 490.22.
- Dinavahi MVPS, Shirhatti V, Ravishankar R and Ray S (2016). *Stimulus dependence of gamma oscillations (20 – 70 Hz) in human EEG*. Society for Neuroscience. Abstract 54.15.
- Ravishankar P, Dinavahi MVPS, Shirhatti V and Ray S (2016). *Large visual stimuli induce two distinct gamma oscillations with different tuning properties in the primary visual cortex of macaque monkeys*. Society for Neuroscience, San Diego, CA. Abstract 54.03.
- Shirhatti V and Ray S (2016). *Effect of stimulus discontinuities and chromatic input on gamma rhythm in primate primary visual cortex*. Society for Neuroscience. Abstract 54.07.

- Subhash Chandran KS, Seelamantula CS and Ray S (2016). *Duration Analysis of the Gamma Rhythm - Too Short to be a Reference!*," Bernstein Conference, Berlin. Sep 21-23
- Kanth ST and Ray S (2014) *Comparison of spikes versus local field potential (LFP) and its implication on brain computer interfacing applications*. Society for Neuroscience, Washington DC, Abstract 61.08.
- Borthakur A, Shirhatti V and Ray S (2014) *Effect of Reference Scheme on Power and Phase of the Local Field Potential*. Society for Neuroscience, Washington DC, Abstract 61.14.
- Ray S and Maunsell JHR (2010) *Contrast dependent changes in Monkey V1 gamma frequency undermine its reliability in binding/control*. Front. Neurosci. Conference Abstract: Computational and Systems Neuroscience 2010. doi: 10.3389/conf.fnins.2010.03.00323
- Ray S and Maunsell JHR (2009) *Gamma oscillations in macaque V1 depend on stimulus characteristics*. Society for Neuroscience, Abstract 166.6.
- Ray S, Crone NE, Niebur E and Hsiao SS (2007) *Neural correlates of high-gamma activity in local field potential and electrocorticogram: Relationship between LFP and ECoG High-gamma with firing properties of the neural population*. Workshop on Large Scale Brain Dynamics. Neural Information Processing Systems.
- Ray S, Crone NE, Hsiao SS, Franaszczuk P and Niebur N (2007) *Neural correlates of high-gamma activity in local field potential and electrocorticogram: Relationship between high-gamma and spikes*. Workshop on Large Scale Brain Dynamics. Neural Information Processing Systems.
- Ray S, Sripathi SP, Yoshioka T, Hsiao SS and Johnson, KO (2003) *Classification of Neurons in the Somatosensory Cortex using Time-Warping Method*. Society for Neuroscience, Abstract 173.14.

## **Workshops/Symposia/Conferences**

### **2018**

- *Gamma rhythm as a tool to investigate neural processing*. Workshop on Brain, Computation and Learning, IISc Bangalore, Jan 8-13

### **2017**

- *Gamma rhythm as a tool to investigate neural processing*. BrainModes, National Brain Research Centre (NBRC), Dec 11-14
- *Relationship between Spikes and Local Field Potential*. BrainModes, National Brain

Research Centre (NBRC), Dec 11-14

- *Role of Gamma Oscillations in processing of Natural Stimuli*. 1<sup>st</sup> IBRO-APRC Bangladesh Associate School of Neuroscience: Translational Neuroscience and Research. United International University, 23-27 September, Bangladesh
- *Local field potential*. 1<sup>st</sup> IBRO-APRC Bangladesh Associate School of Neuroscience: Translational Neuroscience and Research. United International University, 23-27 September, Bangladesh
- *Overview of signal processing techniques to study brain signals*. 1<sup>st</sup> IBRO-APRC Bangladesh Associate School of Neuroscience: Translational Neuroscience and Research. United International University, 23-27 September, Bangladesh
- *Role of Gamma Oscillations in processing of Natural Stimuli*. Faculty Development Programme on Machine Learning techniques and Advances for Cognitive Computing, Aug 1-3, MSRIT, Bangalore
- *Role of Gamma Oscillations in processing of Natural Stimuli*. Computational Approaches to Memory and Plasticity, July 19-Aug 3, NCBS, Bangalore
- *Role of Gamma Oscillations in processing of Natural Stimuli*. Meeting on Neuroscience across Scales, July 17-19, NCBS, Bangalore
- *Role of Gamma Oscillations in processing of Natural Stimuli*. Workshop on Physical and Systems Biology, Jun 12-25, ICTS, Bangalore
- *Understanding the role of brain oscillations in cortical processing*. Indo-UK Workshop, Feb 20-22, IISc Bangalore
- *Brain signals – biophysics and signal processing*. B4 Neuroscience Workshop, NCBS, Bangalore.

## 2016

- *Understanding the role of brain oscillations in cortical processing*. 4<sup>th</sup> Bangalore Cognition Workshop, IISc Bangalore
- *Spike train analysis*, National Network for Mathematical and Computational Biology, IISc Bangalore

## 2014

- *Attention and Gamma Rhythms*. Indo-Swiss workshop “Frontiers of Biology and Medicine”, IISc Bangalore
- *Attention and Brain Rhythms*. “From neurons to consciousness”, Mini-workshop, IIT Kanpur

## 2013

- *Do gamma rhythms play a functional role in cortical processing?* 3<sup>rd</sup> Bangalore Cognition Workshop, IISc Bangalore

## 2012

- *Attention and Gamma Rhythms*. VI-MSS Winter conference on Computational Aspects of Neural Engineering. IISc, Bangalore
- *Local Field Potential*. IBRO-UNESCO Inter-Regional School on Computational and

Theoretical Neuroscience, Hyderabad

- *Attention, normalization and Gamma rhythm*. IBRO-UNESCO Inter-Regional School on Computational and Theoretical Neuroscience, Hyderabad
- *Recording/Stimulation Techniques: Microelectrodes, ECoG and EEG*. VI-MSS Winter school on Computational Aspects of Neural Engineering. IISc, Bangalore
- *Attention, Gamma Rhythm and High-gamma activity*. Medical Imaging and Signal Processing (MISP 2012), IIT Guwahati
- *Attention and Gamma Rhythm*. Symposium on Neurobiology of Cognition, NIMHANS, Bangalore

**2011**

- *Gamma Rhythm and Normalization in monkey visual cortex*. Third International Workshop in Visual Attention, Allahabad.

### **Invited Talks**

2017

- Bodian Seminar, Mind/Brain Institute, Johns Hopkins University
- Johns Hopkins School of Medicine, invited by Dr. Nathan Crone
- Bangladesh University of Engineering and Technology (BUET), invited by Dr. Shaikh Fattah, organized by IEEE EMBS Bangladesh Chapter, IEEE Bangladesh Section and IEEE BUET Student Branch
- BEST Lecture series, BioSystems Science and Engineering, IISc Bangalore
- Electrical Engineering, IISc Bangalore

2014

- IIT Kanpur, invited by Dr. Amitabha Mukerjee

2012

- Jain University, Bangalore, invited by Dr. Vijayalakshmi Pradeep
- Fortis Hospital, Bangalore, invited by Dr. Rajakumar Deshpande

2011

- Indian Statistical Institute, Bangalore, invited by Dr. Kaushik Majumdar
- Sri Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, invited by Dr. K. Radhakrishnan
- Massachusetts Institute of Technology, invited by Dr. James Dicarolo

2010

- Young Investigator Meeting, Boston
- New York University, invited by Dr. Robert M. Shapley

2008

- Salk Institute, invited by Dr. John Reynolds
- Harvard Medical School, invited by Dr. John Maunsell

## **Awards and Honours**

- Prof. Priti Shankar Teaching Award for Assistant Professors for Science, 2015.
- Associate of the Indian Academy of Sciences (IAS), 2012.
- Honorary member of the Phi Beta Kappa society for academic excellence in graduate school, 2008.
- Director's silver medal for standing first in the Electrical Engineering department at IIT Kanpur, 2001.
- Ratan Swarup Gold medal for excellence in academics and outstanding all round achievements in Electrical Engineering and Computer Science departments at IIT Kanpur, 2001.
- Lalit Narayan Das Memorial scholarship for standing first in the Electrical Engineering Department at the end of third year at IIT Kanpur, 2000.
- Academic Excellence Award given by the director, IIT Kanpur in 1st and 2nd year for being within the top 20 students in Academics.
- National Talent Search (NTS) Scholarship awarded by the Government of India, 1995-2001.

## **Reviewer**

Cerebral Cortex

Frontiers in Psychology

Journal of Neurophysiology

Journal of Neuroscience

Journal of Neuroscience Methods

Nature

Nature Neuroscience

Nature Communications

Neuron

Open Biology

Proceedings of the National Academy of Sciences (PNAS)

PLoS One

## **Editorial Board Member**

Journal of Neuroscience Methods

## **Grants**

Title: "Study of basic cortical circuitry at multiple scales of neural integration to understand the neural mechanisms underlying selective attention"

Granting Body: Wellcome-DBT India Alliance (Intermediate Fellowship)

Duration: 2011-2016

Title: "Alzheimer's Disease: Understanding mechanisms for early diagnosis and treatment".

Granting Body: Tata Trust

Duration: 2014-2019