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Faculty Search Committee
Department of Neuroscience
Brown University

April 2, 2012

Dear members of the search committee:

Please consider my application for the opening for an Assistant Professor in your department. I am a postdoctoral fellow in the lab of Jack Gallant at the University of California, Berkeley. I am a systems neuroscientist with formal training in biophysical engineering, and extensive research experience in both animal neurophysiology (feline and macaque) and human fMRI. Because my academic training was originally in engineering, my approach to neuroscience is thoroughly quantitative and computational, and I am very interested in using quantitative modeling to address questions about perception and cognition. I am also interested in applying the quantitative modeling framework to perform decoding of brain activity. I enjoy teaching and I take an active role in advising the graduate students in Prof. Gallant's lab.

My curriculum vitae, research and teaching statements, and three representative publications are attached. If you would like any further information, please call (510-435-1724) or email (shinji@berkeley.edu). Thanks very much for your consideration.

Sincerely,

Shinji Nishimoto, Ph.D.
University of California, Berkeley

Shinji Nishimoto, Ph.D.

Curriculum Vitae (April 2012)

Contact Info:

Psychology Department (Gallant lab)
University of California, Berkeley
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Education:

2005 **Ph.D., Neuroscience**
Graduate School of Engineering Science, Osaka University, Osaka, Japan

2002 **M.Eng., Neuroscience**
Graduate School of Engineering Science, Osaka University, Osaka, Japan

2000 **B.S.** (*equivalent)**, Biophysical engineering**
School of Engineering Science, Osaka University, Osaka, Japan
(*Honored to enter the graduate school at the end of junior grade)

Academic experience:

2005-present, **Postdoctoral fellow**

- Institution: University of California, Berkeley
- Principal Investigator: Prof. Jack L. Gallant
- Research topics: visual representations in early and mid-level visual areas
- Notable achievements: I introduced a new framework that allows quantitative modeling of brain activity evoked by dynamic natural stimuli. I designed and conducted experiments using this framework in both animal physiology and human fMRI. These studies revealed the neural representations of dynamic visual signals in natural movies. I also demonstrated that this framework can be used for decoding visual experiences.

2000-2005, **Graduate student**

- Institution: Osaka University, Osaka, Japan
- Principal Investigator: Prof. Izumi Ohzawa
- Research topics: visual representations in early visual areas
- Notable achievements: I developed a novel method that can reveal spatiotemporally inhomogeneous representations of nonlinear neurons in early visual areas. As the first student in the lab I built an advanced recording suite (experimental control, recording and stimulation software in C++) that is now used in multiple labs.

Publications:

Nishimoto S. (2012) Quantitative modeling of the visual system (in Japanese). *The Brain and Neural Networks*, 19(1):39-49.

Tao X, Zhang B, Smith EL 3rd, Nishimoto S, Ohzawa I, Chino YM. (2012) Local sensitivity to stimulus orientation and spatial frequency within the receptive fields of neurons in visual area 2 (v2) of macaque monkeys. *Journal of Neurophysiology*, 107(4):1094-1110.

Nishimoto S, Gallant JL. (2011) A three-dimensional spatiotemporal receptive field model explains responses of area MT neurons to naturalistic movies. *The Journal of Neuroscience*, 31(41):14551-14564.

Nishimoto S, Vu AT, Naselaris T, Benjamini Y, Yu B, Gallant JL. (2011) Reconstructing visual experiences from brain activity evoked by natural movies. *Current Biology*, 21(19):1641-1646.

Naselaris T, Kay KN, Nishimoto S, Gallant JL. (2011) Encoding and decoding in fMRI. *Neuroimage* 56(2):400-410.

Gallant JL, Naselaris T, Prenger RJ, Kay KN, Stansbury D, Oliver M, Vu AT, Nishimoto S. (2009) Bayesian Reconstruction of Perceptual Experiences from Human Brain Activity. *Proceedings in Human Computer Interaction* 5638:390-393.

Nishimoto S, Ishida T, Ohzawa I. (2006) Receptive field properties of neurons in the early visual cortex revealed by local spectral reverse correlation. *The Journal of Neuroscience* 26(12):3269-3280.

Nishimoto S, Arai M, Ohzawa I. (2005) Accuracy of subspace mapping of spatiotemporal frequency domain visual receptive fields. *Journal of Neurophysiology* 93(6):3524-3536.

Book Chapter:

Gallant JL, Nishimoto S, Naselaris T, Wu MCK. (2011) System identification, encoding models and decoding models: a powerful new approach to fMRI research. In Kriegeskorte N and Kreiman G (eds.), *Visual Population Codes* (pp.163-188), Cambridge: MIT press.

Invited talks:

Nishimoto S (2012) Modeling and decoding brain activity evoked by time-varying movies. Invited talk at Massachusetts Institute of Technology, McGovern Institute

Nishimoto S (2011) Modeling and decoding brain activity evoked by natural movies. Invited talk at Advanced Telecommunications Research Institute, Kyoto, Japan

Nishimoto S (2011) Reconstructing visual experiences from brain activity evoked by natural movies. Invited talk at Redwood Seminar, University of California, Berkeley, Redwood Center for Theoretical Neuroscience

Nishimoto S (2010) A three-dimensional space-time model of MT neurons that predicts responses to natural movies / Decoding visual experiences from brain activity evoked by color natural movies. Invited talk at National Institute for Physiological Sciences, Aichi, Japan

Nishimoto S (2010) A three-dimensional space-time model of MT neurons that predicts responses to natural movies / Decoding visual experiences from brain activity evoked by color natural movies. Invited talk at Osaka University, Graduate School of Frontier Biosciences, Osaka, Japan

Nishimoto S (2008) A three-dimensional space-time model of MT neurons that predicts responses to natural movies. Invited talk at Oxyopia, University of California, Berkeley, School of Optometry

Honors and Awards:

2012 honored to be selected in The 10 hopes in science 2012, *Science & vie*
2012 honored to be selected in The Netexplo 2012 100 outstanding innovations
2011 honored to be selected in The 50 Best Inventions 2011, *Time Magazine*
2011 honored to be selected in Biggest Scientific Breakthroughs of 2011, *io9*
2011 honored to be selected in The top seven news in biology 2011, *Wired Vision*
2004-2005 Japan student services organization scholarship
2001-2004 The Japan scholarship foundation scholarship

Recent conference presentations:

Huth A, Lee T, Nishimoto S, Vu AT, Gallant JL (2012) Decoding semantic content from fMRI responses to natural movies. Computational and Systems Neuroscience (Cosyne) 2012 II-60

Sasaki KS, Kimura R, Ninomiya T, Tabuchi Y, Tanaka H, Fukui M, Asada YC, Arai T, Nishimoto S, Sanada TM, Tani T, Imamura K, Tanaka S, Ohzawa I (2011) Sparse orientation representation in experience-restricted animals. Society for Neuroscience 2011 annual meeting 798.19

Cukur A, Nishimoto S, Huth A, Gallant JL (2011) Object-based attention shifts semantic selectivity toward an attended object category during natural vision. Society for Neuroscience 2011 annual meeting 324.10

Nishimoto S, Huth A, Oliver MD, Vu AT, Naselaris T, Gallant JL (2011) Motion-energy model explains human visual area responses evoked by natural movies. Neural Computation: Population Coding of High-Level Representations, Dartmouth College

Asada Y, Nishimoto S, Sanada T, Ohzawa I (2011) Does functional columnar organization extend across hemispheric boundaries? Japan Neuroscience Society 2011 annual meeting O3-I-3-3

Nishimoto S, Benjamini Y, Oliver MD, Vu AT, Naselaris T, Yu B, Gallant JL (2010) Single- and multiple-entity receptive field estimation using multivariate probabilistic modeling. Society for Neuroscience 2010 annual meeting 73.8

Zhang B, Tao X, Smith E, Ohzawa I, Nishimoto S, Chino Y (2010) Local sensitivity to stimulus orientation and spatial frequency within the receptive fields of neurons in visual area 2 of macaque monkeys. Society for Neuroscience 2010 annual meeting 372.2

Asada Y, Nishimoto S, Sanada TM, Ohzawa I (2010) Does functional columnar organization extend across hemispheric boundaries? Society for Neuroscience 2010 annual meeting 483.4

Huth AG, Nishimoto S, Gao JS, Griffiths TL, Gallant JL (2010) Using linguistic models to predict and decode fMRI responses to natural movies. Society for Neuroscience 2010 annual meeting 675.17

Sasaki KS, Aoyama M, Nishimoto S, Ohzawa I (2010) Neurons in the early visual cortex show the peak response faster when two eyes are used than one. Society for Neuroscience 2010 annual meeting 776.2

Nishimoto S (2009) Decoding visual experiences from brain activity evoked by color natural movies. Brain Imaging Day, University of California, Berkeley

Nishimoto S, Vu AT, Naselaris T, Gallant JL (2009) Decoding visual experiences from brain activity evoked by color natural movies. Society for Neuroscience 2009 annual meeting 166.15

Naselaris T, Vu AT, Stansbury DE, Nishimoto S, Gallant JL (2009) Cortical representation of multiple objects and their locations in complex natural scenes. Society for Neuroscience 2009 annual meeting 262.10

Aoyama M, Sasaki K, Ishiko E, Nishimoto S, Ohzawa I (2009) Response of V1 neurons are faster when two eye are used than one. Japan Neuroscience Society 2009 annual meeting P1-g28

Nishimoto S, Vu AT, Gallant JL (2009) Decoding human visual cortical activity evoked by continuous time-varying movies. Vision Science Society 2009 annual meeting 56.531

Ohzawa I, Sasaki K, Nishimoto S, Ninomiya T, Tanaka H, Sanada T, Kimura R, Tabuchi Y, Asada Y, Arai T, Fukui M, Tani T, Imamura K, Tanaka S (2008) Receptive field structure of visual cortical neurons in cats reared with restricted orientations. Japanese Neuroscience Society 2008 annual meeting P2-k14

Ohzawa I, Sasaki KS, Nishimoto S, Ninomiya Y, Tabuchi Y, Tanaka H, Sanada TM, Kimura R, Asada Y, Arai T, Fukui M, Tani T, Imamura K, Tanaka S (2007) Elongation of receptive fields of visual cortical neurons in cats reared with restricted orientations. Society for Neuroscience 2007 annual meeting 663.2

Nishimoto S, Gallant JL (2007) Spatio-temporal receptive field profiles of area MT neurons revealed by time-varying natural scenes. Society for Neuroscience 2007 annual meeting 715.14

Ohzawa I, Ishida T, Nishimoto S (2006) New approaches for studying receptive fields of neurons in high-order visual areas. The 2nd Shanghai International Conference on Physiological Biophysics, Shanghai, China

Ohzawa I, Nishimoto S, Ishida T (2006) Local spectral reverse correlation: a new approach suitable for multi-electrode recordings in mid- and high-level visual areas. Japanese Neuroscience Society 2006 annual meeting OS3P-4-05

Nishimoto S, Ishida T, Ohzawa I (2005) Spatial inhomogeneity of receptive field profiles in the early visual cortex revealed by a local spectral reverse correlation. Society for Neuroscience 2005 annual meeting 618.2

Nishimoto S, Sanada T, Ohzawa I (2005) Neural representations of spatiotemporal depth gradients in early visual areas. Vision Science Forum 2005, Aomori, Japan

Nishimoto S, Ishida T, Ohzawa I (2005) Receptive field analysis of early visual area neurons by local spectral reverse correlation. Japanese Neuroscience Society 2005 annual meeting P1-202

Nishimoto S, Ohzawa I (2004) Linear and non-linear temporal interactions of spatial frequency tunings in the cat areas 17 and 18. Society for Neuroscience 2004 annual meeting 368.1

Nishimoto S, Ohzawa I (2004) Motion-in-depth selectivity of neurons in early visual areas. Japanese Neuroscience Society 2004 annual meeting P1-266

Nishimoto S, Arai M, Ohzawa I (2003) A comparison of tuning characteristics of visual neurons between subspace mapping and drifting sinusoidal gratings. Society for Neuroscience 2003 annual meeting 338.1

Research statement

General interests and previous achievements

My general scientific goal is to understand how the brain works at a quantitative (computational) level. More specifically, I am to model the brain accurately enough so that I can predict brain activity in dynamic naturalistic environments. Building such a model provides critical insights about neural representations and the underlying computations. Predictability is the gold standard for validating any scientific knowledge, and a predictive model at a level can be a basis for studying higher-level processing. Finally, because the raison d'être of the brain is to facilitate behavior in a dynamic, changing world, I have been particularly interested in modeling brain activity under naturalistic conditions.

Toward this goal, I have studied visual processing in early and mid-level visual areas. The visual system has been the most intensively studied part of the brain. However, much of our knowledge about visual processing has been obtained using relatively simple, limited stimuli (e.g., gratings, isolated visual objects, etc.). It has therefore been unclear how the scientific knowledge thus obtained would generalize to more complex stimuli such as dynamic natural movies. Throughout my graduate and post-doc career I have studied the visual system in order to obtain a more comprehensive understanding of visual processing. My research has revealed new aspects of visual processing and visual representation that are directly relevant to natural vision (Nishimoto et al., 2006, 2011; Nishimoto and Gallant 2011).

Although most of my work has focused on modeling stimulus-response relationships, these models have interesting applications in brain decoding, in order to infer objective or subjective mental experiences from brain activity. Brain decoding has recently received much attention because of its potential for applications including medical diagnosis, neural prostheses and brain computer interfaces. In my most recent publication I showed that the modeling framework that I had developed to describe visual processing of dynamic scenes could be used to reconstruct visual experiences from brain activity evoked by natural movies (Nishimoto et al., 2011). My approach provides a critical platform for building a general brain decoder that can be used under dynamic natural conditions.

Quantitative modeling of brain activity under natural conditions is an ambitious goal that requires a multidisciplinary approach based on experimental neuroscience, statistical and mathematical modeling. My unique career path has made me uniquely qualified to pursue this work. My undergraduate major was biophysical engineering, which is itself a multidisciplinary field. I was trained in the laboratories of Prof. Izumi Ohzawa and Prof. Jack Gallant, both neurophysiologists who are well known for their strengths in quantitative analysis and modeling. I have experienced two of the most fundamental technologies for systems neuroscience: single-neuron extracellular recordings in anesthetized and awake animals, and functional MRI in humans. My undergraduate training and my exposure to complementary experimental approaches have given me a unique perspective on neuroscience, and have enabled me to undertake important and challenging projects, such as modeling human brain activity evoked by natural movies (Nishimoto et al. 2011).

Research plan

In my faculty position I plan to generalize my research beyond early and mid-level vision to include higher-order perception and cognition. I plan to begin this effort by extending my previous model (Nishimoto et al., 2011) by incorporating higher-order perceptual and cognitive features and the internal dynamics of brain activity into the model.

My previous work has focused on low- and mid-level visual processing. To model these mechanisms it is usually sufficient to build a *static* model that links static or dynamic visual features and measured brain activity. However, much of our internal mental life is dynamic; our cognition has internal states that evolve over time. These states should reflect or be reflected in brain activity. Therefore, to model these higher-order cognitive phenomenon (e.g., attention, internal thoughts, emotion, language, memory retrieval, learning and concept formation) I plan to extend my work to build *dynamic* models. These models will provide important new insights into fundamental mechanisms of cognition.

I plan to extend my current model gradually, adding perceptual and cognitive features and their dynamical components as necessary. The importance of these additional components will be assessed by examining how well they improve predictions. Although the computational formalism for this modeling effort is well established in my current laboratory, the addition of model elements that reflect brain dynamics will increase the complexity of the model substantially. Therefore, part of my research program will focus on the development of new statistical tools for fitting and regularizing such models.

One interesting application area for dynamic modeling is attention. It is well known that attention enhances local brain activity. Up to now this phenomenon has been understood as a change of the static relationship between stimulus and brain activity. However, a dynamic model could provide a more direct causal explanation of this phenomenon in terms of, for example, changes in functional connectivity or of the states of internal attractor networks. Note that dynamic modeling is a general framework that can be applied to any perceptual and cognitive function. Given that natural brain dynamics involve mixtures of many cognitive variables, as more cognitive features are added to the model it should better reflect the dynamic operation of the human brain.

One of the advantages of my modeling framework is that improvements in the model benefit decoding directly (Naselaris, Kay, Nishimoto and Gallant, 2011). Decoding dynamic brain activity has many potential applications as tools for psychiatric diagnosis and as the foundation of brain machine interface devices, and demonstrations of decoding provide a great platform for science communication to the general public. (For example my recent decoding study (Nishimoto et al. 2011) appeared more than 500 news outlets, and a movie illustrating the technique received more than one million YouTube hits in the first five days after publication.)

The success of modeling critically depends on proper parameterization of perceptual and cognitive processes. Discovering efficient features for such models can be done inductively from the data, but it is often more efficient to leverage academic expertise for this purpose. One exciting aspect of the Brown position is the potential for collaborations with the Brown cognitive neuroscience community on this important effort.

Teaching Statement

I have acquired teaching experience at every stage of my academic career. As a graduate student I served as a teaching assistant in computer programming and signal processing classes for several years. In those classes I taught undergraduates from a wide variety of different fields, including biology, engineering and physics.

As a senior graduate student I hosted an intensive seminar series for junior members of Prof. Izumi Ohzawa's lab, in order to provide a basic grounding in the historical, mathematical and computational knowledge that underpins much of modern systems and computational neuroscience. I quite enjoyed organizing and teaching seminar series. I also regularly mentored undergraduate and Masters students.

As a post-doc in Prof. Jack L. Gallant's lab my teaching experiences have centered on mentoring graduate students. I have advised many rotation students, and have helped several PhD students develop their Thesis projects.

I am well qualified to teach broadly within the domains of systems, cognitive and computational neuroscience. I would especially enjoy teaching courses on vision, quantitative methods for neuroscience and fMRI.

References

Nishimoto S, Gallant JL. (2011) A three-dimensional spatiotemporal receptive field model explains responses of area MT neurons to naturalistic movies. The Journal of Neuroscience, 31(41):14551-64

Nishimoto S, Vu AT, Naselaris T, Benjamini Y, Yu B, Gallant JL. (2011) Reconstructing visual experiences from brain activity evoked by natural movies. Current Biology, 21(19):1641-6

Naselaris T, Kay KN, Nishimoto S, Gallant JL. (2011) Encoding and decoding in fMRI. Neuroimage 56(2):400-10.

Nishimoto S, Ishida T, Ohzawa I. (2006) Receptive field properties of neurons in the early visual cortex revealed by local spectral reverse correlation. The Journal of Neuroscience 26(12):3269-80.