

## Harvard Medical School Curriculum Vitae

**Date Prepared:** July 17, 2012  
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### Education

1995	B.S.	Mechanical Engineering	Cornell University
1998	M.S.	Mechanical Engineering	Massachusetts Institute of Technology
2001	Ph.D.	Medical Engineering (Richard J Gilbert)	Massachusetts Institute of Technology
2002	M.Acup.	Acupuncture	New England School of Acupuncture

### Postdoctoral Training

2001 - 2003	Post-Doctoral Research Fellow	Radiology (Kathleen K.S. Hui)	Martinos Center for Biomedical Imaging, MGH
2002	Visiting Acupuncturist	Acupuncture	Beijing Hospital of Traditional Chinese Medicine, P.R.C.

### Faculty Academic Appointments

2004 - 2007	Instructor	Radiology	Harvard Medical School
2007 -	Assistant Professor	Radiology	Harvard Medical School

### Appointments at Hospitals/Affiliated Institutions

2001 - 2003	Research Fellow	Radiology	Massachusetts General Hospital
2004 -	Assistant in	Radiology	Massachusetts General

2006 -	Neuroscience Acupuncturist	Pain Management Center, Anesthesiology	Hospital Brigham and Women's Hospital
2011 -	Assistant Professor	Anesthesiology	Brigham and Women's Hospital

### Other Professional Positions

### Major Administrative Leadership Positions

#### Local

2005 -	Scientific Coordinator	NCCAM CERC program project grant "Neuroimaging Acupuncture Effects on Human Brain Activity," PI: Bruce Rosen
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#### Regional

#### National and International

2005	Co-chair	Neural Correlates of Acupuncture Action Conference, National Center for Complementary and Alternative Medicine, NIH, Bethesda, MD.
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### Committee Service

#### Local

2000 - 2001	Admissions Committee	Harvard-MIT Division of Health Sciences and Technology Interviewing Member
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#### Regional

#### National and International

### Professional Societies

1998 - 2002	International Society of Magnetic Resonance in Medicine	member
2002 -	Organization for Human Brain Mapping	member
2003 - 2006	American Association of Oriental Medicine	member
2004 -	Society for Neuroscience	member
2004 -	Society for Acupuncture Research	Board of Directors
2008 - 2011	Society for Acupuncture Research	Treasurer
2009 - 2012	Society for Acupuncture Research	Chair of Scientific Review Committee
2011 -	Society for Acupuncture Research	Co-President

2008 -	International Association for the Study of Pain	member
2010 -	Consortium of Academic Health Centers for Integrative Medicine	Program Committee, International Research Congress on Integrative Medicine and Health

### Grant Review Activities

2006, 2009	Grant Review Committee	Physicians' Services Incorporated Foundation, Toronto, Ontario, Canada Ad hoc Reviewer
2007	Grant Review Committee	National Health and Medical Research Council of Australia Ad hoc Reviewer
2011	MOSS-K SBIR/STTR Study Section	NIH Ad hoc Member

### Editorial Activities

Arthritis & Rheumatism  
 BioMed Central: Complementary and Alternative Medicine  
 Brain  
 Bulletin of the Museum of Comparative Zoology, Harvard University  
 Clinical Journal of Pain  
 Clinical Science  
 Complementary Therapies in Medicine  
 European Journal of Neurology  
 Journal of Alternative and Complementary Medicine  
 Journal of Pain  
 Journal of Theoretical Biology  
*MAGMA*, Magnetic Resonance Materials in Physics, Biology and Medicine  
 NeuroImage  
 Neuroscience Letters  
 Pain

### **Other Editorial Roles**

2009 -	Editorial Board	Journal of Alternative and Complementary Medicine
2010 -	Editorial Board	Evidence-based Complementary and Alternative Medicine
2011 -	Editorial Board	BMC Complementary and Alternative Medicine
2011 -	Section Co-Editor	Pain Medicine


## Honors and Prizes

1996-2001	Graduate Fellowship	Whitaker Foundation for Biomedical Engineering
2000	Finalist	Schnitzer Prize for the Visual Arts

## **Report of Funded and Unfunded Projects**

### Funding Information

#### Past

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- 2003-2011 Neuroimaging Acupuncture Effects on Human Brain Activity  
NCCAM: P01-AT002048  
Project PI on a program project (PI: Rosen) (\$2,395,610)  
The central goal of this application is to investigate the neurobiology of acupuncture. All three projects will investigate the possible brain pathways and circuitries involved in acupuncture.
- 2004-2009 Exploring Neurocircuitry of Acupuncture Action with fMRI  
NCCAM: K01-AT002166  
PI (\$608,750)  
The goals of this study are to understand the neurobiology involved with the full duration acupuncture treatment, thereby promoting the development of this ancient healing technique into evidence-based medicine.
- 2006-2009 fMRI of Autonomic Regulation with Acupuncture  
NCCAM: F05-AT003770  
Co-investigator (PI: Rosen) (\$193,908)  
The goals of this study are to decipher the brain correlates for acupuncture modulation of the autonomic nervous system using multi-modal techniques combining functional MRI with physiological monitoring.
- 2009-2011 Brain Plasticity in Carpal Tunnel Syndrome and its Response to Acupuncture  
NCCAM: R01-AT004714 (Competitive Revision under ARRA)  
PI (\$604,160)  
We propose that a bibehavioral assessment of cortical disinhibition quantified by maladaptive change in adaptation metrics will be sensitive to brain abnormalities in CTS. In this study, we will combine bibehavioral testing with fMRI neuroimaging to better delineate the central mechanisms by which acupuncture ameliorates CTS pathology.

#### Current

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- 2007-2012 Neuroenteric Research Program  
International Foundation of Functional GI Disorders

Consultant (PI: Kuo) (\$450,000)

This project is aimed at providing resources towards the clinical care and clinical and translational research of neuroenteric disorders such as nausea, cyclic vomiting syndrome and GI motility, as well as chronic pain disorders.

2008-2013

Brain Plasticity in Carpal Tunnel Syndrome and its Response to Acupuncture

NCCAM: R01-AT004714

PI (\$4,014,928)

This study will characterize brain plasticity in Carpal Tunnel Syndrome and will determine how this central fMRI biomarker is modulated by acupuncture. This study will also investigate the behavioral consequences of maladaptive cortical plasticity in this disease population.

2010-2015

An fMRI study of expectancy on acupuncture treatment outcomes in knee OA

NCCAM R01-AT005280

Co-Investigator (PI: Gollub/Kaptchuk) (\$2,152,080)

The goal of this study is to elucidate the functional neurocircuitry associated with endogenous inhibition of pain perception in patients with chronic knee pain.

2011-2016

Neuroimaging Acupuncture Effects Brain Activity in Chronic Low Back Pain

NCCAM: P01-AT006663

Project PI on a program project (PI: Rosen) (\$6,333,600)

This program project grant will investigate the different neurophysiological mechanisms underlying the clinical response for different acupuncture interventions in chronic low back pain patients.

### Current Unfunded Projects

2007 -

PI / Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS) for chronic pelvic pain

This project has developed a novel form of non-invasive vagal nerve stimulation, which will be tested for analgesia and other applications. Industry support is being sought.

2009 -

Co-PI / Brain mechanisms underlying acupuncture reduction of itch in atopic dermatitis

This project, in collaboration with Florian Pfab MD from Munich, Germany, applies fMRI to study how brain processing of itch is influenced by acupuncture. A pilot study is completed and manuscripts are in preparation. R01 support is being sought from the NIH.

2010 -

Co-PI / Neuroimaging distractibility from pain in fibromyalgia treated by cognitive behavioral therapy.

This project, in collaboration with Robert Edwards PhD from BWH, evaluates brain response to pain during different cognitive modulation conditions, and how this processing is influenced by a longitudinal course of cognitive behavioral therapy. Manuscripts are in preparation, and future R01 support will be sought.

## **Report of Local Teaching and Training**

### Teaching of Students in Courses

2006, 2008

HST-583: Functional Magnetic Resonance Imaging: Data Acquisition and Analysis  
Graduate and undergraduate students

Massachusetts Institute of Technology

1 1-hour lecture and discussion

2006	22.013 MIT: Freshman Seminar: Careers in Biomedical Engineering undergraduate students	Massachusetts Institute of Technology 1 2-hour lecture and discussion
2008 - 2010	Evidence-based Complementary and Alternative Medicine Medical school students	Tufts Medical School 1 1-hour lecture and discussion

### Laboratory and Other Research Supervisory and Training Responsibilities

2005-present	Supervision of post-doctorate research fellow(s)	Daily mentorship
2006-present	Supervision of research assistant(s)	Daily mentorship
2008-present	MIT Traditional Medicine Society advisory board	Undergraduate student mentorship

### Formally Supervised Trainees

2005-2007	Rupali Dhond, PhD / Instructor, Harvard Medical School Mentored Polly as post-doc and senior-authored her several first-author manuscripts in top peer-reviewed journals including Pain and JACM, as well as mentored her successful K01 training grant submission to NCCAM, NIH.
2006-2009	Kyungmo Park, PhD / Associate Professor, Dept. Biomedical Engineering, Kyunghee University, Korea Mentored Kyungmo when he was a visiting research fellow at MGH, co-authored several manuscripts with him in leading peer-reviewed journals such as Neuroimage.
2006-2007	Calvin Yeh, MS / Industry Supervised Calvin as a research assistant. Calvin was co-author on a manuscript with our Lab published in Pain.
2007-2010	Lauren LaCount, BS / Research Assistant at MGH Supervised Lauren as a research assistant. Senior authored several manuscripts with Lauren as both first-author and/or co-author.
2010-2011	Ang Li, BS / Research Assistant at MGH Supervised Ang as research assistant, who is a co-author on several manuscripts, in preparation.
2007-	Jieun Kim, PhD / Post-Doctoral Research Fellow at MGH Supervised Jieun as a visiting doctoral student, served on her PhD thesis committee, and am now supervising Jieun as a post-doc in my lab, where she has co-authored several important publications.

- 2007- Steve Cina, LicAc / Research Assistant at MGH  
As a research assistant in my lab, Steve has first-authored an abstract and is working on a manuscript detailing his research.
- 2008- Jeungchan Lee, MS / Doctoral Student at Kyunghee University, Korea  
As doctoral student advisee, Jeungchan co-authored several abstracts and manuscripts.
- 2008- Yumi Maeda, MD PhD / Post-Doctoral Research Fellow at MGH  
Supervised Yumi as a post-doc in my lab. Yumi has been lead author on several abstracts at conferences including Human Brain Mapping and International Association for the Study of Pain. Manuscripts in preparation.
- 2009- Marco Loggia, PhD / Post-Doctoral Research Fellow at MGH  
Supervised Marco on projects related to deep receptor pain processing in healthy adults and patients suffering from fibromyalgia. Marco is lead authoring a publication stemming from this research on which I will appear as senior author.
- 2009- Gaelle Desbordes, Ph. D. / Post-Doctoral Research Fellow at Boston University  
Supervised Gaelle in the combined collection of autonomic and fMRI data in a study evaluating the neural mechanisms of meditation. Several manuscripts are in preparation.
- 2010-2012 Florian Pfab MD PhD / visiting associate professor  
Supervised Florian on a DFG-funded research project aimed at evaluating brain mechanisms underlying acupuncture relief if itch in atopic dermatitis patients. Several manuscripts have been published with several more in preparation.
- 2011-2012 Jaehyun Im, BS / Research Assistant at MGH  
Supervised Jay as an RA. Jay will be a co-author on several manuscripts in preparation.
- 2011-2012 Wei-Ta Chen, MD / visiting fellow  
Co-Supervised Wei-Ta on a project evaluating MEG response to somatosensory stimulation in migraine patients treated by acupuncture and resting brain connectivity using fMRI data. Currently co-authoring several manuscripts.
- 2012 Sabina Lim, PhD / visiting professor  
Mentored Sabina, providing training and expertise in fMRI project design and fostering inter-institutional communication between Kyunghee University in Korea and HMS.

**Formal Teaching of Peers (e.g., CME and other continuing education courses)**

2005-2012	Neuroimaging applications to acupuncture HMS AP101 - Structural Acupuncture for Physicians	Single presentation per year Boston, MA
2008-2010	Resting State Brain Connectivity with fMRI – State or Trait? Advanced Neuroimaging Techniques, Continuing	Single presentation per year Boston, MA

### Local Invited Presentations

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|------------|---|
| 2004       | Employing functional MRI for the study of acupuncture: Experiment design and the neurocorrelates of acupuncture deqi sensation / Invited Lecture<br>Osher Institute, Harvard Medical School                         |
| 2006, 2009 | The Role of Acupuncture in Chronic Pain Management / Invited Lecture<br>Pain Management Center, Brigham and Women's Hospital, Harvard Medical School  |
| 2006       | Sham and Placebo Acupuncture in Clinical Trials: The Neuroimaging Evidence / Invited Lecture<br>Harvard Medical School  |
| 2006       | Evidence of Somatosensory Cortical Plasticity in Carpal Tunnel Syndrome Treated with Acupuncture - an fMRI Assessment / Invited Lecture<br>Martinos Center for Biomedical Imaging, Dept. Radiology, MGH             |
| 2007       | Acupuncture Modulation of Resting State Networks / Invited Lecture<br>Martinos Center for Biomedical Imaging, Dept. Radiology, MGH  |
| 2011       | How does Acupuncture work? Brain activity underlying acupuncture efficacy / Invited Lecture<br>Massachusetts General Hospital CSSA  |
| 2012       | Neuroimaging markers for chronic pain disorders - objective outcomes for evaluating acupuncture therapy / Invited Lecture<br>Brainmap Lecture, Martinos Center for Biomedical Imaging, MGH                          |
| 2012       | Acupuncture for the Treatment of Chronic Pain: Integrating Clinical and Neuroimaging Research / Invited Lecture<br>Osher Center for Integrative Medicine at Harvard Medical School and Brigham and Women's Hospital |

### **Report of Regional, National and International Invited Teaching and Presentations**

#### Invited Presentations and Courses

##### **Regional**

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|------|--|
| 2004 | What can functional MRI tell us about acupuncture and the "Sea of Marrow" that we don't already know? / Invited Lecture<br>New England School of Acupuncture, Newton, MA |
| 2004 | The Modulatory Effects of Acupuncture on the Brain as Imaged by fMRI / Invited Lecture   |

Tufts School of Medicine, Boston, MA

- 2005 Pain Relief and Acupuncture Research: from Endorphins to fMRI / Invited Lecture at Biomatrix Evening Colloquium  
Massachusetts Institute of Technology, Cambridge, MA
- 2006 Neuroplasticity in Carpal Tunnel Syndrome Treated by Acupuncture: An fMRI Evaluation / Invited Lecture  
Dept. PM&R, Tufts-New England Med Center, Boston, MA
- 2007 Neuroimaging the Effects of Acupuncture for Carpal Tunnel Syndrome / Grand Rounds  
Massachusetts Institute of Technology Medical Clinic, Cambridge, MA
- 2007 Acupuncture in Pain Management: From Philosophy to Brain Imaging / Pain Management Deep Learning Summit: Future of Pain Prevention and Treatment  
Massachusetts Institute of Technology Faculty Club, Cambridge, MA (Johnson and Johnson)
- 2010 An Overview of Acupuncture Research: from clinical trials to neuroimaging  
Intercollegiate Taiwanese American Students Association (ITASA) Annual Meeting,  
Massachusetts Institute of Technology, Cambridge, MA
- 2010 Neuroimaging for Complex Pain Syndromes / Future of Pain Management Summit  
Massachusetts Institute of Technology Faculty Club, Cambridge, MA (Johnson and Johnson)
- 2011 Paradoxes in Acupuncture Research: A Brain's-eye View Using Neuroimaging / New England Society of Medical Acupuncture, Children's Hospital, Waltham, MA
- 2012 Neuroimaging Potential Brain Mechanisms for Acupuncture – from Carpal Tunnel Syndrome to Fibromyalgia / Neuroscience Grand Rounds, University of Vermont, Burlington, VT

**National**

- 2003 The Modulatory Effects of Acupuncture on the Brain as Imaged by fMRI / Grand Rounds  
Physical Rehabilitation Branch, National Institutes of Health, Bethesda, MD
- 2003 A Biomechanical Investigation of the Structure-Function Relationships in the Tongue / Grand Rounds  
Physical Rehabilitation Branch, National Institutes of Health, Bethesda, MD
- 2003 A Biomechanical Investigation of the Structure-Function Relationships in the Tongue / Grand Rounds  
Physical Rehabilitation Branch, National Institutes of Health, Bethesda, MD
- 2005 Evidence of Cortical Plasticity in Carpal Tunnel Syndrome Treated with Acupuncture /

Invited Lecture

National Center for Complementary and Alternative Medicine (NCCAM), National Institutes of Health, Bethesda, MD

- 2007 NCCAM Center of Excellence: Neuroimaging Acupuncture Effects on Brain Activity / Invited Lecture  
NCCAM Centers Meeting. Bethesda, MD
- 2007 Acupuncture for Carpal Tunnel Syndrome: Neuroimaging Cortical Plasticity and Acupuncture Processing for Chronic Pain / Keynote Lecture  
American Academy of Medical Acupuncture 19<sup>th</sup> Annual Symposium, Baltimore, MD
- 2008 Acupuncture Modulates Resting Brain Networks / Invited Lecture  
Chronic Pain and Fatigue Research Center, University of Michigan. Ann Arbor, MI
- 2008 Evaluating Acupuncture with fMRI: From Characterization to Translational Research / Grand Rounds  
Physical Medicine and Rehabilitation Branch, National Institutes of Health, Bethesda, MD
- 2009 Neuroimaging in basic and translational acupuncture research / Invited Lecture in the Integrative Medicine Lecture Series  
College of Pharmacy, University of Texas at Austin.
- 2009 Neuroimaging of CAM techniques / Invited Lecture in the 3<sup>rd</sup> National Symposium on Complementary & Alternative Geriatric Health Care  
Logan College of Chiropractic, Chesterfield, MO

**International**

- 2006 Sham / Placebo Controls in Acupuncture: The Evidence from Neuroimaging / Invited seminar lecture  
North American Research Conference on Complementary and Integrative Medicine.  
Edmonton, Alberta, Canada
- 2007 Evaluating Acupuncture with Functional MRI: From Characterization to Translational Research / Invited lecture  
Society for Acupuncture Research Annual Conference: The Status and Future of Acupuncture Research: 10 Years Post-NIH Consensus Conference, Baltimore, MD
- 2008 Evaluating Acupuncture with fMRI: From Characterization to Translational Research / Keynote lecture  
Acupuncture Research Resource Council Annual Conference, London, UK
- 2009 Elucidating Acupuncture Mechanisms of Action with fMRI / Invited lecture  
1st Sino-German Conference in Acupuncture and Moxibustion, Chengdu, Sichuan Province, People's Republic of China (Chinesisch-Deutsches Zentrum fur Wissenschaftsforderung)

- 2010 Neuroimaging in Basic and Translational Acupuncture Research / Invited lecture  
York Neuroimaging Centre, University of York, York, United Kingdom
- 2010 Acupuncture Neuroimaging Research / Invited lecture  
Kyunghye University, Seoul, Republic of Korea
- 2010 Neuroimaging in Basic and Translational Acupuncture Research / Invited plenary lecture  
Symposium on Acupuncture and Meridian Studies, Pusan, Republic of Korea
- 2011 The Research Matrix: Mapping Acupuncture Effects on the Human Brain / Invited  
Keynote Lecture  
AACP (Acupuncture Association of Chartered Physiotherapists) Annual Conference,  
Wyboston, United Kingdom
- 2011 Neuroimaging Acupuncture: acupoint specificity and potential mechanisms of action /  
Invited Keynote Lecture  
DAGfA (Deutsche Arztegesellschaft fur Akupunktur, German Medical Acupuncture  
Association), Bad Nauheim, Germany

## **Report of Clinical Activities and Innovations**

### **Current Licensure and Certification**

2002- Acupuncture

### **Practice Activities**

2006- Acupuncturist Pain Management Center, 1 afternoon clinic per week  
BWH

## **Report of Technological and Other Scientific Innovations**

Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS) US and International Provisional Patent disclosure filed: PCT/US2010/029221  
Envisioned and built a prototype of a novel device which can be used to provide a form of non-invasive vagal nerve stimulation to treat chronic pain and other disorders. This device is currently being evaluated for clinical efficacy.

## **Report of Education of Patients and Service to the Community**

## Activities

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|------|---|
| 2005 | Acupuncture and Oriental Medicine Society of Massachusetts Annual Meeting<br>Presented research talk to acupuncturists and lay public entitled “Cortical Plasticity in Carpal Tunnel Syndrome Treated with Acupuncture” |
| 2006 | American Organization for Bodywork Therapies of Asia<br>Presented research talk to bodyworkers and lay public entitled “Neuroimaging of Acupuncture for Carpal Tunnel Syndrome.”  |
| 2009 | American Acupuncturist Journal<br>Authored a review for acupuncture professionals entitled “Promise of Neuroimaging of Acupuncture Research.”   |

## Report of Scholarship

### Publications

#### Peer reviewed publications in print or other media

##### *Research investigations*

1. **Napadow V**, Chen Q, Wedeen VJ, Gilbert RJ. Intramural mechanics of the human tongue in association with physiological deformation. *Journal of Biomechanics*. 1999; 32 (1):1-12.
2. **Napadow V**, Chen Q, Wedeen VJ, Gilbert RJ. Biomechanical basis for lingual muscular deformation during swallowing. *American Journal of Physiology*. 1999; 40 (3):G695-G701.
3. Wedeen V, Reese TG, **Napadow V**, Gilbert RJ. Demonstration of primary and secondary muscle fiber architecture of the Bovine tongue by diffusion tensor MRI. *Biophysical Journal*. 2001; 80 (2):1024-8.
4. **Napadow V**, Wedeen VJ, Chen Q, Mai V, So PTC, Gilbert RJ. Quantitative analysis of 3D-resolved lingual fiber architecture in intact tissue with diffusion tensor MRI and two-photon microscopy. *Biophysical Journal*. 2001; 80 (6):2968-75.
5. Chen Q, Mai V, Bankier AA, **Napadow V**, Gilbert RJ, Edelman R. An ultra-fast MR grid tagging sequence for assessment of local mechanical properties of the lungs. *Magnetic Resonance in Medicine*. 2001; 45 (1):24-8.
6. **Napadow V**, Mai V, Bankier AA, Gilbert RJ, Edelman R, Chen Q. Determination of regional pulmonary parenchymal strain during normal respiration using spin inversion tagged magnetization MRI. *Journal of Magnetic Resonance Imaging*. 2001; 13 (3):467-74.
7. **Napadow V**, Kamm RD, Gilbert RJ. A biomechanical model of sagittal tongue bending. *Journal of*

Biomechanical Engineering. 2002; 124 (5):547-56.

8. **Napadow V**, Kaptchuk TJ. Patient characteristics for outpatient acupuncture in Beijing, China. *J Altern Complement Med*. 2004 Jun;10(3):565-72.
9. **Napadow V**, Liu J, Kaptchuk TJ. A systematic study of acupuncture practice: acupoint usage in an outpatient setting in Beijing, China. *Complement Ther Med*. 2004 Dec;12(4):209-16.
10. **Napadow V**, Makris N, Liu J, Kettner NW, Kwong KK, Hui KK. Effects of electroacupuncture versus manual acupuncture on the human brain as measured by fMRI. *Hum Brain Mapp*. 2005 Mar;24(3):193-205.
11. Gilbert RJ, **Napadow VJ**. Three-dimensional muscular architecture of the human tongue determined in vivo with diffusion tensor magnetic resonance imaging. *Dysphagia*. 2005 Winter;20(1):1-7.
12. Hui KK, Liu J, Marina O, **Napadow V**, Haselgrove C, Kwong KK, Kennedy DN, Makris N. The integrated response of the human cerebro-cerebellar and limbic systems to acupuncture stimulation at ST 36 as evidenced by fMRI. *Neuroimage*. 2005 Sep;27(3):479-96.
13. **Napadow V**, Kettner N, Ryan A, Kwong KK, Audette J, Hui KKS. Somatosensory Cortical Plasticity in Carpal Tunnel Syndrome - a Cross-sectional fMRI Evaluation. *Neuroimage*. 2006 Jun;31(2):520-30.
14. Gilbert RJ, Magnusson LH, **Napadow V**, Benner T, Wang R, Wedeen V. Mapping complex myoarchitecture in the bovine tongue with diffusion spectrum magnetic resonance imaging. *Biophysical Journal*. 2006 Aug 1;91(3):1014-22.
15. **Napadow V**, Dhond R, Kennedy D, Hui KKS, Makris N. Automated Brainstem Co-registration (ABC) for MRI. *Neuroimage*. 2006, 32(3):1113-9.
16. Gilbert RJ, Wedeen VJ, Magnusson LH, Benner T, Wang R, Dai G, **Napadow VJ**, Roche KK. Three-dimensional myoarchitecture of the bovine tongue demonstrated by diffusion spectrum magnetic resonance imaging with tractography. *Anat Rec A Discov Mol Cell Evol Biol*. 2006, 288A(11):1173-1182.
17. **Napadow V**, Liu J, Li M, Kettner N, Ryan A, Kwong KK, Hui KKS, Audette J. Somatosensory cortical plasticity in carpal tunnel syndrome treated by acupuncture. *Human Brain Mapping*. 2007, 28(3):159-71.
18. **Napadow V**, N Kettner, J Liu, M Li, KK Kwong, M Vangel, N Makris, J Audette and KK Hui. Hypothalamus and Amygdala Response to Acupuncture Stimuli in Carpal Tunnel Syndrome. *Pain*. 2007, 130(3):254-66.
19. Hui KK, Nixon EE, Vangel MG, Liu J, Marina O, **Napadow V**, Hodge SM, Rosen BR, Makris N, Kennedy DN. Characterization of the "Deqi" Response in Acupuncture. *BMC Complement Altern Med*. 2007, 7(1):33.
20. Dhond RP, Yeh C, Park K, Kettner N, **Napadow V**. Acupuncture modulates resting state

- connectivity in default and sensorimotor brain networks. *Pain*. 2008, 136(3):407-18. PMID: 18337009
21. **Napadow V**, Dhond RP, Conti G, Makris N, Brown EN, Barbieri R. Brain Correlates of Autonomic Modulation: Combining Heart Rate Variability with fMRI. *Neuroimage*. 2008, 42(1):169-77. PMID: 18524629.
  22. Dhond RP, Witzel T, Hämäläinen M, Kettner N, **Napadow V**. Spatiotemporal mapping the neural correlates of acupuncture with MEG. *J Altern Complement Med*. 2008 Jul;14(6):679-88. PMID: 18684075
  23. **Napadow V**, Dhond RP, Park K, Kim J, Makris N, Kwong KK, Harris RE, Purdon P, Kettner N, Hui KKS. Time-Variant fMRI Activity in the Brainstem and Higher Structures in Response to Acupuncture. *Neuroimage*. 2009; 47(1):289-301. PMID: 19345268.
  24. **Napadow V**, Dhond RP, Kim J, LaCount L, Vangel M, Harris RE, Kettner N, Park K. Brain encoding of acupuncture sensation - coupling on-line rating with fMRI. *Neuroimage*. 2009; 47(3):1055-65. PMID: 19500677
  25. Harris RE, Zubieta JK, Scott DJ, **Napadow V**, Gracely RH, Clauw DJ. Traditional Chinese Acupuncture and Placebo (Sham) Acupuncture Are Differentiated by Their Effects on  $\mu$ -Opioid Receptors (MORs). *Neuroimage*. 2009; 47(3): 1077-85. PMID: 19501658
  26. Hui KK, Marina O, Claunch JD, Nixon EE, Fang J, Liu J, Li M, **Napadow V**, Vangel M, Makris N, Chan ST, Kwong KK, Rosen BR. Acupuncture mobilizes the brain's default mode and its anti-correlated network in healthy subjects. *Brain Res*. 2009; 1287:84-103. PMID: 19559684
  27. Harris RE, Sundgren PC, Craig AD, Kirshenbaum E, Sen A, **Napadow V**, Clauw DJ. Elevated Insular Glutamate in Fibromyalgia Is Associated With Experimental Pain. *Arthritis & Rheumatism*. 2009; 60(10): 3146–3152. PMID: 19790053
  28. Lacount L, **Napadow V**, Kuo B, Park K, Kim J, Brown E, Barbieri R. Dynamic Cardiovagal Response to Motion Sickness: A Point-Process Heart Rate Variability Study. *Comput Cardiol*. 2009 Jan 1;36:49-52. PMID: 20445767
  29. Hui KK, **Napadow V**, Liu J, Li M, Marina O, Nixon EE, Claunch JD, LaCount L, Sporko T, Kwong KK. Monitoring acupuncture effects on human brain by FMRI. *J Vis Exp*. 2010 (38): 1190. PMID: 20379133
  30. **Napadow V**, LaCount L, Park K, As-Sanie S, Clauw DJ, Harris RE. Intrinsic brain connectivity in fibromyalgia is associated with chronic pain intensity. *Arthritis & Rheumatism*. 2010. 62(8):2545-55. PMID: 20506181
  31. Pfab F, Winhard M, Nowak-Machen M, **Napadow V**, Irnich D, Pawlik M, Bein T, Hansen E. Acupuncture in Critically Ill Patients Improves Delayed Gastric Emptying: A Randomized Controlled Trial. *Anesth Analg*. 2011 112(1):150-5. PMID: 21081772
  32. LaCount, L.T., R. Barbieri, K. Park, J. Kim, E.N. Brown, B. Kuo, **V. Napadow**. Static and Dynamic

Autonomic Response with Increasing Nausea Perception. *Aviat Space Environ Med.*, 2011. 82(4):424-33. PMID: 21485400

33. Wasan AD, Loggia ML, Chen LQ, **Napadow V**, Kong J, Gollub RL. Neural Correlates of Chronic Low Back Pain Measured by Arterial Spin Labeling. *Anesthesiology*, 2011. 115(2): 364-374. PMID: 21720241
34. Witzel T, **Napadow V**, Kettner NW, Vangel MG, Hamalainen MS, Dhond RP. Differences in Cortical Response to Acupressure and Electroacupuncture Stimuli. *BMC Neuroscience*, 2011. 12(1): 73. PMID: 21794103
35. **Napadow V**, Kim J, Clauw DJ, Harris RE. Decreased Intrinsic Brain Connectivity is Associated with Reduced Clinical Pain in Fibromyalgia. *Arthritis & Rheumatism*. 2012. 64(7): 2398-403. PMID: 22294427
36. Pfab F, Kirchner MT, Huss-Marp J, Schuster T, Schalock PC, Fuqin J, Athanasiadis GI, Behrendt H, Ring J, Darsow U, **Napadow V**. Acupuncture compared to oral antihistamine for type I hypersensitivity itch and skin response in adults with atopic dermatitis – a patient and examiner blinded, randomized, placebo-controlled, crossover trial. *Allergy*. 2012. 67(4):566-73. PMID: 22313287
37. **Napadow V**, Robert R Edwards, Christine M Cahalan, George Mensing, Seth Greenbaum, Assia Valovska, Ang Li, Jieun Kim, Yumi Maeda, Kyungmo Park, Ajay D. Wasan. Evoked Pain Analgesia in Chronic Pelvic Pain Patients using Respiratory-gated Auricular Vagal Afferent Nerve Stimulation. *Pain Medicine*. 2012. 13(6): 777-89. PMID: 22568773
38. **Napadow V**, Jeungchan Lee, Jieun Kim; Stephen Cina; Yumi Maeda; Riccardo Barbieri; Richard E Harris, Norman Kettner, Kyungmo Park. Brain Correlates of Phasic Autonomic Response to Acupuncture Stimulation: an event-related fMRI study. *Human Brain Mapping*. 2012. *In press*. PMID: 22504841
39. **Napadow V**, Sheehan J, Kim J, LaCount L, Park K, Kaptchuk T, Rosen BR, Kuo B. The Brain Circuitry Underlying the Temporal Evolution of Nausea in Humans. *Cerebral Cortex*, 2012. *In press*. PMID: 22473843
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## Narrative Report (limit to 500 words)

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My research is aimed at elucidating the neural mechanisms underlying chronic pain and potential therapies such as acupuncture. While my efforts are mainly focused on research, I maintain a part-time clinical acupuncture service at the Pain Management Center at BWH. My laboratory has produced one of the most extensive publication records for acupuncture neuroimaging in the world, and we continue to push technological and experimental design boundaries in order to move this nascent field forward.

Currently, my laboratory is using functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) to probe the changes in brain activation associated with chronic pain, and its

treatment by acupuncture. A recent publication in *Arthritis and Rheumatism* [29] detailed how resting brain functional connectivity is associated with the spontaneous pain in fibromyalgia patients. We have also found that acupuncture modulates such resting connectivity [20], which may help explain mechanisms of action. Our results also suggest that acupuncture modulates the brainstem [23] and limbic system; a network of regions including the amygdala, hippocampus, and cingulate cortex, which are important in emotion processing and influence cognitive and affective components of pain [10, 12].

My lab is also investigating the effects of acupuncture on cortical plasticity in carpal tunnel syndrome (CTS). Cortical plasticity has been reported for other chronic pain conditions, including low back pain. Our studies were the first to apply fMRI in CTS patients. We found that CTS patients respond to tactile stimulation of median nerve innervated fingers with hyperactivation of primary sensory and motor areas of the brain [13]. Furthermore, adjacent fingers have overlapping or blurred representations in the primary sensory homunculus [13]. After a five-week session of acupuncture, we found evidence for clinical improvement, release from hyperactivation, and more separated finger representations for CTS patients [15]. We are currently following up on these promising preliminary results with an NIH R01-funded multi-arm placebo-controlled longitudinal trial incorporating neuroimaging biomarkers.

Other pilot projects investigate the brain circuitry underlying other pathological interoceptive states such as nausea and itch. We are using fMRI in combination with novel, recently developed models for inducing nausea or itch, and will be exploring the potential brain mechanisms by which acupuncture helps ameliorate these aversive interoceptive states.

In addition to lecturing both locally and internationally, I continue to mentor students and research fellows in my laboratory. Currently, I am mentoring three post-doctoral research fellows, several research assistants, and a visiting associate professor on various neuroimaging projects related to either pain or acupuncture.

My administrative obligations include a significant leadership role in the Society for Acupuncture research, an international organization focused on advancing acupuncture research. I serve as co-President on the organizational board of directors, and chair the scientific review committee for our bi-annual international meetings.

In summary, while my academic focus lies squarely within biomedical research, I continue to support both clinical and teaching obligations. My research pursuits are focused on employing neuroimaging to unravel the mysteries of the chronic pain state, as well as how it may be treated by acupuncture therapy.