

**The Faculty of Medicine of Harvard University
Curriculum Vitae**

Date Prepared: December 4, 2023
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Education:

12/1995	B.S	Mechanical Engineering	Cornell University
05/1998	M.S	Mechanical Engineering	Massachusetts Institute of Technology
09/2001	Ph.D	Medical Engineering (Dr. Richard J Gilbert)	Massachusetts Institute of Technology
05/2002	M.Acup	Acupuncture	New England School of Acupuncture

Postdoctoral Training:

07/01-12/03	Post-Doctoral Research Fellow	Radiology (Kathleen K.S. Hui)	Martinos Center for Biomedical Imaging, MGH
08/02-02/03	Visiting Acupuncturist	Acupuncture	Beijing Hospital of Traditional Chinese Medicine, P.R.C

Faculty Academic Appointments:

2004-2007	Instructor	Radiology	Harvard Medical School
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2007-2013	Assistant Professor	Radiology	Harvard Medical School
2010-2013	Assistant Professor	Anaesthesiology	Harvard Medical School
2014-2020	Associate Professor	Radiology	Harvard Medical School
2014-2021	Associate Professor	Anaesthesiology	Harvard Medical School
2021	Professor	Physical Medicine and Rehabilitation	Harvard Medical School
2021-	Professor	Radiology	Harvard Medical School

Appointments at Hospitals/Affiliated Institutions:

2001-2003	Research Fellow	Radiology (Neuroscience)	Massachusetts General Hospital
2004-2015	Assistant	Radiology (Neuroscience)	Massachusetts General Hospital
2005-	Adjunct Faculty	Radiology	Logan University, Chesterfield, MO (non-voting)
2006-	Acupuncturist	Pain Management Center, Anesthesiology	Brigham and Women's Hospital
2016-	Research Staff	Radiology (Neuroscience)	Massachusetts General Hospital
2021-	Research Staff	Physical Medicine and Rehabilitation	Spaulding Rehabilitation Network

Other Professional Positions:

2015-2018	Consultant (study on nausea neurocircuitry)	Glaxo-Smith-Kline, Inc
2018-	Consultant and Scientific Advisory Board (Technology transfer for	Cala Health, Inc

neuromodulation
devices)

2022- Consultant Click Therapeutics, Inc.

Major Administrative Leadership Positions:

Local

2005-2012	Scientific Coordinator, NCCIH CERC program project grant “Neuroimaging Acupuncture Effects on Human Brain Activity,” PI: Bruce Rosen	Massachusetts General Hospital
2015-	Director, Center for Integrative Pain NeuroImaging (CiPNI)	Massachusetts General Hospital
2018-	Director of Cognitive Neuroscience, Program in Placebo Studies & Therapeutic Encounter (PiPS)	Harvard Medical School
2021-	Director, Scott Schoen and Nancy Adams Discovery Center for Recovery from Chronic Pain	Spaulding Research Network

National

2005	Co-Chair, Neural Correlates of Acupuncture Action Conference, Bethesda, MD	NCCIH, NIH
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Committee Service:

Local

2000-2001	Admissions Committee	Harvard-MIT Division of Health Sciences and Technology
2014-	Training Program Faculty	Neuroimaging Training Program (NTP), Harvard-MIT Division of Health Sciences and Technology
2015-2017	Neuroimaging Workgroup, The Football Players Health Study	Harvard University

2021-	PM&R Promotions Committee	Spaulding Rehabilitation Hospital, HMS
2022-	HMS Standing Committee on Promotions, Reappointments, and Appointments	Harvard Medical School
National		
2015	International Society for Complementary Medicine Research	Program Committee, International Congress on Complementary Medicine Research
2016-2018	External Advisory Committee	National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), NIH Multi-Disciplinary Approach to the Study of Chronic Pelvic Pain (MAPP) Research Network
2017-	External Advisory Board	University of Michigan Center of Research Translation (CORT) program project grant for chronic musculoskeletal pain (NIAMS, P60AR070600)
2018-2018	Program Committee, The Role of Nonpharmacological Approaches to Pain Management: A Workshop	National Academies of Sciences, Engineering, and Medicine
2019-2020	Exploratory Committee	United States Association for the Study of Pain (US-ASP)
2020-2022	Ishtiaq Mawla PhD Thesis Committee	University of Michigan
2022-	Noah Waller PhD Thesis Committee	University of Michigan

Professional Societies:

1998-2002	International Society of Magnetic Resonance in Medicine	
	1998-2002	Member
2002-	Organization for Human Brain Mapping	

	2002-	Member
2003-2006	American Association of Oriental Medicine	
	2003-2006	Member
2004-	Society for Acupuncture Research	
	2004-	
	2008-2011	Treasurer
	2009-2012	Chair of Scientific Review Committee
	2011-2018	President
	2015, 2017, 2019	Co-Chair, Program Committee
2004-	Society for Neuroscience	
	2004-	Member
2008-	International Association for the Study of Pain	
	2008-	Member
	2018	Lead organizer for the Pain Neuroimaging Night @ the A.A. Martinos Center for Biomedical Imaging
	2018	Local Organizing Committee, 17th IASP World Congress on Pain, Boston, MA, USA
2012-2019	American Pain Society	
	2012-2019	Member
2020-	United States Association for the Study of Pain (USASP)	
	2020-	Board of Directors

2020-	Executive Committee (elected)
2020-	Member
2021-	Chair, Pain NeuroImaging Special Interest Group

Grant Review Activities:

2006, 2009-2009	Grant Review Committee	Physicians' Services Incorporated Foundation, Toronto, Ontario, Canada
2006		Ad hoc Reviewer
2009-2009		Ad hoc Reviewer
2007	Grant Review Committee	National Health and Medical Research Council of Australia
2007		Ad hoc Reviewer
2011	MOSS-K SBIR/STTR Study Section	NIH
2011		Ad hoc Member
2014	Peer Reviewed Medical Research Program (PMRP) of the Department of Defense	DoD
2014		Ad hoc Member
2015	Special Emphasis Panel, ZCA1 RPRB-J M2 S	NCI, NIH
2015		Ad hoc Member
2015	MAPP Network EEP/Review Panel	NIDDK, NIH
2015		Invited Reviewer
2016	Special Emphasis Panel, ZRG1 BBBP-X (02) M	Motor Function, Speech and Rehabilitation (MFSR) committee, NIH
2016		Invited Reviewer

2016, 2020	Special Emphasis Panel, Myalgic Encephalomyelitis/Chronic Fatigue Syndrome ME/CFS SEP	NIH
	2016	Invited Reviewer
	2020	Invited Reviewer
2017	Fellowship, Career Development, and Research Grant Programs Review Panel, ZAT1 VS 06 KF	NCCIH, NIH
	2017	Invited Reviewer
2018	SPARC Tools & Technologies, Other Transactions (OT) 2 Review Panel	Office of Director, NIH
	2018	Invited Reviewer
2018	Small Business Innovation Research (SBIR) / Small Business Technology Transfer (STTR) Award Panel ZRG1 MOSS-D (10) B	Motor Function, Speech and Rehabilitation (MFSR) committee, NIH
	2018	Invited Reviewer
2018	Fellowship, Career Development, and Research Grant Programs Review Panel 2019/01 ZAT1 VS (12) 1	NCCIH, NIH
	2018	Invited Reviewer
2019	Exploratory Clinical Trials of Mind and Body Interventions Review Panel	NCCIH, NIH
	2019	Chair of Review Panel
2020	Special Emphasis Panel/Scientific Review Group 2020/08 ZAT1 SM (56) 1- Loan Repayment Program (LRP) Review panel at NCCIH	NCCIH, NIH
	2020	Invited Reviewer

2020	Behavioral Medicine, Interventions and Outcomes (BMIO) Study Section	NIH
	2020	Invited Reviewer
2021-	Behavioral Medicine and Health Outcomes (BMHO) Study Section	NIH
	2021-	Member
2023-	K12 Review Committee	NIH-sponsored University of Michigan HEAL Initiative National K12 Clinical Pain Career Development Program
	2023-	Grant reviewer

Editorial Activities:

Ad hoc Reviewer

BioMed Central: Complementary and Alternative Medicine

Biological Psychology

Brain

Bulletin of the Museum of Comparative Zoology, Harvard University

Clinical Journal of Pain

Clinical Science

Complementary Therapies in Medicine

European Journal of Neurology

F1000

Frontiers in Human Neuroscience

Gastroenterology

Itch

Journal of Alternative and Complementary Medicine (JACM)

Journal of Pain

Journal of Theoretical Biology

MAGMA, Magnetic Resonance Materials in Physics, Biology and Medicine

Medical Acupuncture

NeuroImage

Neurorehabilitation and Neural Repair

Neuroscience Letters

evidence-based Complementary and Alternative Medicine (eCAM)

Acupuncture in Medicine

Proceedings of the National Academy of Sciences

Arthritis and Rheumatology

Pain Reports

eNeuro

NeuroImage: Clinical

Pain Medicine

The Journal of Pain

Other Editorial Roles

2009-	Editorial Board	Journal of Alternative and Complementary Medicine
2010-	Editorial Board	Evidence-based Complementary and Alternative Medicine
2011-	Section Co-Editor	Pain Medicine
2018	Co-Editor for Special Issue: “Neural Substrates of Acupuncture: from Peripheral to Central Nervous System Mechanisms”	Frontiers in Human Neuroscience
2018-	Editorial Board	Frontiers in Human Neuroscience

Honors and Prizes:

1996-2001	Graduate Fellowship	Whitaker Foundation for Biomedical Engineering	Academic Merit
2000	Finalist	Schnitzer Prize for the Visual Arts	
2018	Excellence in Integrative Medicine Research Award	European Society for Integrative Medicine	Academic Merit
2019	Academy Distinguished Investigator Council	Academy for Radiology & Biomedical Imaging Research	Academic Merit
2020	Finalist, John T. Potts, Jr., MD, Faculty Mentoring Award	Massachusetts General Hospital	Nominated
2021	ICMART Science Award	International Council of Medical Acupuncture and Related Techniques (ICMART)	Academic Merit

Report of Funded and Unfunded Projects

Past

- 2003-2011 Neuroimaging Acupuncture Effects on Human Brain Activity
NCCAM; P01-AT002048
Co-I and Project PI (2009-2011) (PI: Rosen) (Co-PI: Rosen, \$2,395,610 annual total costs)
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.
- 2007-2014 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.
- 2008-2014 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.
- 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 biobehavioral assessment of cortical disinhibition quantified by maladaptive change in adaptation metrics will be sensitive to brain abnormalitie in CTS. In this study, we will combine biobehavioral testing with fMRI neuroimaging to better delineate the central mechanisms by which acupuncture ameliorates CTS pathology.
- 2009-2011 Core Center for Multimodal Evaluation of Acupuncture Mechanisms
NCCAM; P30-AT005895
Co-Investigator (PI: Rosen, \$1,150,000)
This Center will develop multi-modal technologies including fMRI and ultrasound to evaluate mechanisms associated with acupuncture effects, and provide support for new faculty focused on enacting these methods.
- 2011-2017 Neuroimaging Acupuncture Effects on Brain Activity in Chronic Low Back Pain
NCCAM / NIH; P01-AT006663
Project PI (PI: Rosen/Gollub, \$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.

- 2012-2013 SAR 2013: Impact of Acupuncture Research on 21st Century Health Care NCCAM; R13-AT007742
Co-PI (Co-PI: Napadow/Kuo, \$25,000)
This conference support grant will provide financial support for the 2013 Society for Acupuncture Research international conference in Ann Arbor, MI. This conference was attended by almost 300 participants from 19 different countries.
- 2012-2014 Brain Mechanisms for Autonomic Outflow and Nausea in Cyclic Vomiting Syndrome
NIDDK / NIH; R21-DK097499
Co-PI (Co-PI: Napadow/Kuo, \$478,625)
This study will evaluate altered brain processing in patients with cyclic vomiting syndrome, and investigate how this brain circuitry contributes to abnormal autonomic physiology and symptomatology.
- 2012-2017 Martinos Center / KIOM Research Program
Korean Institute for Oriental Medicine
PI (\$201,250)
This agreement with KIOM supports a broader scope for our on-going NIH-funded program project grant (P01-AT006663) and sets up continuing collaboration between our Center and the Korean Institute for Oriental Medicine.
- 2013-2019 Neuroimaging Approaches to Deconstructing Acupuncture for Chronic Pain NCCAM / NIH; R01-AT007550
NCE
Co-PI (Co-PI: Napadow/Harris, \$3,370,545)
This study will evaluate novel brain biomarker response, including resting state connectivity and magnetic resonance spectroscopic assessed glutamate and GABA, to acupuncture versus non-somatosensory sham acupuncture in fibromyalgia.
- 2014-2015 SAR 2015: Reaching across Disciplines to Broaden the Acupuncture Research Network
NCCIH / NIH; R13-AT008760
Co-PI (Co-PI: Napadow/Harris, \$30,000)
This conference support grant will provide financial support for the 2015 Society for Acupuncture Research international conference in Boston, MA.

- 2014-2016 Vagus Nerve Stimulation: Intervention for Mood and Cardiac Modulation
NIMH / NIH; R21-MH103468
Co-PI (Co-PI: Napadow/Goldstein, \$275,000)
This project will evaluate biosignatures for mood changes following transcutaneous vagus nerve stimulation in major depressive disorder patients. Neuroimaging outcomes will be used to understand autonomic control circuitry and how these physiological responses relate to changes in mood.
- 2014-2016 The Role of Neuroimmune Activation in Chronic Pain and Negative Affect
NINDS / NIH; R21-NS087472
Co-Investigator (PI: Loggia, \$275,000)
Animal studies suggest that both exposure to stressful conditions, as well as persistent pain, lead to the activation of brain microglia –the principal innate immune cells of the central nervous system. As chronic pain patients exhibit high prevalence of mood disorders, we will use integrated MR-PET imaging to investigate whether brain microglia are also involved in pain and negative affect, as well as alterations in brain physiology, in chronic low back pain patients.
- 2014-2017 An In-Vivo Investigation of Brain Inflammation in Gulf War Illness with Integrated PET/MR Imaging
DoD; GW130100
Co-Investigator (PI: Loggia, \$200,000)
The goal of this project is to demonstrate in vivo the pathological occurrence of microglial activation in the brain of GWI patients, and to document the effects of this activation on GWI symptomatology and brain anatomophysiology, using novel imaging approaches.
- 2014-2019 Brain mechanisms underlying CBT-related reductions in fibromyalgia
NIAMS / NIH; R01-AR064367
Co-PI (Co-PI: Napadow/Edwards, \$3,844,035)
We hypothesize that CBT in this study will reduce catastrophizing early in treatment, resulting in adaptive changes in the brain's responses to an externally applied noxious stimulus.
- 2015-2016 Desarrollo de un estimulador electrico transcutaneo del nervio vago regulado por movimientos respiratorios [Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS)]
ColCienias (Colombian National Science Foundation)
Co-Investigator (PI: Garcia)
This grant will aid in the development and miniaturization of the RAVANS device, invented and patented at MGH.

- 2016-2021 Martinos Center / KIOM Research Program: Boosting mind-body mechanisms and outcomes for migraine
Korean Institute for Oriental Medicine (KIOM)
PI (\$241,500)
This agreement with KIOM will assess mechanisms underlying potentially synergistic effects of mindfulness meditation and transcutaneous vagus nerve stimulation to reduce migraine symptomatology.
- 2016-2021 The role of brain glial activation in human knee osteoarthritis
NIAMS / NIH; R01-NS094306
Co-Investigator (PI: Loggia, \$2,057,895)
In this project, we will use PET/MR imaging to test the hypothesis that low brain levels of the translocator protein (TSPO), which is upregulated in activated glial cells, predict higher likelihood of developing post-TKA pain.
- 2016-2018 An Exploratory Randomized, 2-Part, Single-blind, 2-Period Crossover Study Comparing the Effect of Albiglutide with Exenatide on Regional Brain Activity Related to Nausea in Healthy Volunteers
Glaxo Smith Kline; study 201840
Co-Investigator (PI: Rosen, \$910,000)
The study is designed to evaluate if albiglutide and exenatide modulate nausea-related brain activity and connectivity as assessed by MRI.
- 2016-2021 In-vivo imaging of spinal and brain glial activation in low back pain patients
NINDS / NIH; R01NS095937
Co-Investigator (PI: Loggia, \$2,060,000)
In this project, we will use PET/MR imaging to image brain and spinal glial activation in patients with subacute and chronic low back pain, and the effects of its pharmacological modulation. The identification of a role for glia in the development and/or maintenance of persistent pain will have important practical implications for the management of pain, and the development of tailored preventive interventions focused on glial modulation.
- 2016-2021 New England Gastroparesis Consortium: Neurobiology of Gastroparesis
NIDDK / NIH; U01-DK112193
Co-Investigator (PI: Kuo, \$1,274,670)
This Center will develop and apply imaging approaches to better understand the brain circuitry changes in gastroparesis and how this circuitry can be targeted to make meaningful quality of life improvements for gastroparesis patients.
- 2016-2022 Mapping the linkage between auricular vagus nerve receptors and visceral organ modulation

NIH Office of Director; OT2-TR001978 (Common Fund's Stimulating Peripheral Activity to Relieve Conditions, SPARC)
PI (\$1,367,236)

Vagus nerve stimulation may be an important neuromodulatory approach to impact heart and gut function, and cutaneous vagal receptors can be targeted as a non-invasive approach to vagus nerve stimulation. Our proposal will apply non-invasive ultrahigh field MRI in humans, gastric MRI, and cervical vagus nerve activity recording in rats to map the neurophysiological pathway from the auricular branch of the vagus nerve to visceral organs including the heart and stomach.

2016-2023 Optimization of brain-based mechanism supporting psychosocial aspects of acupuncture therapy – a hyperscanning fMRI study
NCCIH / NIH; R61-AT009306 / R33-AT009306
Co-PI (Co-PI: Napadow/Kaptchuk, \$3,258,176)
The patient-clinician interaction is central to mind-body therapies, and key mechanisms of action likely include brain circuitries supporting social mirroring networks underlying clinician empathy and therapeutic alliance. We will use hyperscanning functional MRI to link patient/acupuncturist brain activity concordance in social mirror neuron regions during treatment, and relate this concordance with ratings of therapeutic alliance and analgesia. Our proposal will define an augmented acupuncture interaction style based on brain concordance to optimize healthcare outcomes for acupuncture and other medical therapies. This is a phased R61/R33 award with executed go / no-go criteria.

2016-2017 SAR 2017: Advancing the Precision Medicine Initiative through Acupuncture Research
NCCIH / NIH; R13-AT009422
Co-PI (Co-PI: Napadow/Harris, \$30,000)
This conference support grant will provide financial support for the 2017 Society for Acupuncture Research international conference in San Francisco, CA.

2017-2019 Development of an electroceutical (Cardiorespiratory-gated Auricular Vagal Afferent Nerve Stimulator) for the Treatment of the Comorbidity Between Hypertension and Major Depression
NHLBI / NIH; U54 HL119145
Co-Investigator (PI: Loscalzo/Golan/Parrish; Goldstein, Project PI, \$200,000)
Boston Biomedical Innovation Center, B-BIC, is a collaboration of academic centers, government, venture capital, and industry partners that have co-

invested to create an integrated infrastructure to improve the translation of early stage biomedical innovations into commercially viable products. Our study will extend the work on development of respiratory-enhanced tVNS to hypertension and comorbid major depression. Funding will support clinical efficacy in this population.

- 2018-2023 Imaging Neuroglial Mechanisms of neuropathic pain-opioid interaction in HIV
NIDA / NIH; R01-DA047088
Co-Investigator (PI: Loggia/Ratai, \$1,840,486)
This project will use PET/MR imaging and ultra-high field MRI and MR spectroscopy to image brain glial activation, neuronal integrity, and chemical neurotransmitter imbalance in HIV-infected patients with and without pain and chronic opioid use. Advancing our understanding of the mechanisms mediating the HIV pain-opioid interaction will have important practical implications for pain management, and toward the development of tailored interventions focused on glial modulation and neurotransmitter signaling.
- 2018-2022 Neuromodulation of the Brain-Gut Axis by Transcutaneous Vagal Nerve Stimulation in Functional Dyspepsia
NIDDK / NIH; R21-DK116029
PI (\$275,000)
Functional Dyspepsia (FD) is a common functional gastrointestinal disorder and there is a strong link between FD symptoms and compromised vagal function. We thus propose that auricular tVNS is a novel therapeutic strategy and will use gastric/autonomic measures combined with multimodal neuroimaging to interrogate the peripheral and central nervous system changes that accompany neuromodulation of brain-gut axis signaling.
- 2018-2019 SAR 2019: Acupuncture Research, Health Care Policy and Community Health - Closing the Loop
NCCIH / NIH; R13-AT010320
PI (\$30,000)
This conference support grant will provide financial support for the 2019 Society for Acupuncture Research international conference in Burlington, VT.
- 2019-2021 4D cine MRI-assessed stomach motility in diabetic gastroparesis
Diabetis Complication (DiaComp) Consortium, Pilot & Feasibility (PF2019)
Co-Investigator (PI: Kuo, \$100,000)
Diabetic autonomic neuropathy is among the least recognized and understood complications of diabetes despite its significant negative impact on survival

and quality of life. While validated cardiac clinical measures can document autonomic dysfunction, there are few tools to objectively assess autonomic dysfunction within the gastrointestinal tract. The most common clinical method of measuring gastric function, gastric emptying scintigraphy, has poor correlation with symptoms and other measures of autonomic dysfunction, in addition to requiring exposure to radiation. In this proposal, we will use a non-invasive, safe technique based on 4D cine magnetic resonance imaging (MRI), able to evaluate multiple aspects of gastric motor function simultaneously.

Current

- 2017-2027 Nutrition Obesity Research Center at Harvard (NORCH)
NIH/NIDDK; 5P30DK04056124
Co-PI (Co-PI: Grinspoon, \$696,372)
This Center grant supports the Nutrition Obesity Research Center at Harvard (NORC-H), the goals of which are to provide critical support to research in nutrition and obesity throughout the Harvard community, to facilitate novel directions in nutrition and obesity research through pilot funding and scientific exchange, to promote interactions and collaborations among investigators to advance the science of nutrition and obesity, and to foster the development of junior faculty in these research areas.
- 2018-2024 Boosting mind-body mechanisms and outcomes for chronic pain
NCCIH / NIH; P01-AT009965
MPI (PI: Napadow/Rosen, \$10,944,840)
This Program Project Grant will evaluate synergistic effects of top-down and bottom-up mind/body therapies for pain. We will apply functional MRI, MR spectroscopy, autonomic testing and PET to evaluate measures of central sensitization, dysautonomia and neuroinflammation in patients with migraine headache. Our approach will assess combined mindfulness meditation training and transcutaneous vagus nerve stimulation.
- 2020-2024 Sex Differences in Major Depression: Impact of Prenatal Stress-Immune and Autonomic Dysregulation
NIH; U54-MH118919
Co-PI (Co-PI: Goldstein, J, \$951,708)
The major goals of this project are: The scientific mission of this SCORE is to identify stress-immune pathway abnormalities, beginning in fetal development, that have shared consequences for sex differences in brain circuitry regulating mood and lifelong recurrent MDD and dysregulation of

hormone and immune responses to stress, and autonomic and neurovascular dysfunction in early midlife.

- 2020-2025 Logan University-Martinos Center Integrative Neuroimaging Training Program
Logan University
PI (\$418,620)
The Logan University-Martinos Center Integrative Neuroimaging Training Program will empower postdoctoral trainees and junior faculty who are not yet independent with individualized, mentored assistance and training to initiate careers in neuroimaging of complementary and integrative health care therapies.
- 2020-2025 Androgen Replacement to Improve Patient-Important Outcomes in Men with Opioid-Induced Hypogonadism
NIAMS / NIH; 1R01AG066921
Co-Investigator (PI: Basaria, S, \$1,452,870)
The major goals of this project are: Using Androgen Replacement therapy to Improve Patient-Important Outcomes in Men with Opioid-Induced Hypogonadism.
- 2021-2026 Neuroimaging the impact of respiration and respiratory-gated neuromodulation on human glymphatic physiology
NIH; 1R01AT011429-01
Co-Investigator (PI: Lewis, L, \$2,428,140)
The major goals of this project are: Imaging humans to assess CSF and glymphatic physiology and response to RAVANS tVNS.
- 2021-2026 Evaluation of Cannabidiol for Reduction of Brain Neuroinflammation
NIDA / NIH; 1R01DA053316
Co-Investigator (PI: Loggia, M, \$3,766,745)
Assess whether CBD reduces pain-related and negative affect-related neuroinflammation in chronic low back pain patients.
- 2021-2026 The wandering nerve: gateway to boost Alzheimer's disease related cognitive performance
NIA / NIH; 1R01AG068062-01A1
Co-Investigator (PI: Jacobs, H, \$4,195,062)
Transcutaneous vagus nerve stimulation (tVNS) may be a promising tool to delay Alzheimer's disease (AD) related cognitive decline. Here, we aim to determine the extent of the cognitive effects of tVNS in domains and time,

and to relate tVNS outcome to demographics, brainstem neurophysiological properties and burden of AD pathology.

- 2022-2024 Martinos Center / KIOM Research Program
Korean Institute for Oriental Medicine (KIOM)
PI (\$320,000)
This agreement with KIOM will support ongoing tVNS and neuroimaging research
- 2022-2027 Force-Based Manipulations Research Network
NCCIH / NIH; U24-AT011969
Co-Investigator (PI: Reed, William)
Specific Aims of this research project are 1) to build an interdisciplinary collaborative network to advance Force-Based Manipulations knowledge and research, 2) to advance FBM research via overseeing a multi-faceted pilot project program, and 3) provide opportunities, research products, and resources at large to accelerate and sustain this newly developed network's (Force-Net) growth.
- 2022-2027 The role of neuroinflammation in human peripheral neuropathic pain
NIAMS / NIH; R01-AR079110
MPI (PI: Loggia/Napadow, \$2,174,640)
This project will evaluate the role of neuroinflammation and neuroplasticity in human carpal tunnel syndrome, and the impact of carpal tunnel release surgery on these factors.
- 2022-2025 BACPAC- Biomarkers for Evaluating Spine Treatments (BEST) Study
NIAMS / NIH; U24-AR076730
Co-Investigator (PI: Matt Mauck, MD; University of North Carolina)
The BEST (Biomarkers for Evaluating Spine Treatment)-BACPAC brain imaging study will collect brain neuroimaging metrics from chronic low back pain participants that undergo deep phenotyping. This will include T1, DTI, and resting state fMRI data. The MRI scanners will be harmonized across platforms which will allow data pooling when the study is completed. The Spaulding Rehabilitation Hospital site will play an integral role in organizing the neuroimaging data collection and analyzing DTI and fMRI data collected across the consortium. Data will be transferred from a centralized repository to our computer network for analyses. Dr. Napadow will work with Dr. Harris to assure successful analysis of data collected by the imaging sites of the BACPAC consortium.
- 2022-2025 Non-Invasive Microstructural Assessment of Neuroinflammation in Chronic Pain

Department of Defense, U.S. Army Medical Research Acquisition Activity
; W81XWH-22-1-1003

Co-Investigator (PI: Loggia/Toschi)

This study will assess MCM-based markers of pain-related neuroinflammation as an objective indicator of pain and predictor of long-term (6-months) pain response following total knee arthroplasty.

2023-2024

Neurophysiological Effects of Interoceptive Compassion Training

Co-Investigator (PI: Schuman-Olivier, Zev)

This pilot study will explore the brain-based mechanisms of a novel form of mindfulness training for a psychiatric patient population, using advanced electroencephalography methods to assess interoceptive processing.

2023-2024

Non-invasive assessment and modulation of brain-gut interoception in humans

NCCIH / NIH; R21-AT011918

MPI (PI: Sclocco/Napadow, \$272,748)

Using 4D cine-Magnetic Resonance Imaging (MRI) and functional MRI, we will probe the neural circuitry of gastric afference and link it to gastric motility outcomes. We will modulate gastric afference at the peripheral level - varying ingested meal volumes - and at the central level - targeting the brainstem primary afference nuclei with transcutaneous auricular vagus nerve stimulation (taVNS).

2023-2028

Impact of Theory of Mind Training on Brain-to-Brain Patient-Clinician Concordance

NCCIH / NIH; R01-AT012144

PI (\$2,240,388)

This project will test the benefits and brain-to-brain concordance mechanisms of a theory of mind training program for patients with chronic pain. Fibromyalgia patients will experience several weeks of behavioral training with an adapted theory of mind training program delivered by a pain psychologist, prior to acupuncture therapy. Hyperscan fMRI outcomes will assess brain-to-brain concordance at baseline and following theory-of-mind training to explore the impact of pro-social training on the patient-clinician relationship.

2023-2028

Topological Atlas and Repository for Acupoint research (TARA)

NCCIH / NIH; U24-AT012560

MPI (PI: Napadow/Harris/Helmer, \$5,844,949)

Topological Atlas and Repository for Acupoint research (TARA), forms an invaluable Research Resource Center for the acupuncture research and

clinical community by strengthening the biological basis of acupoints, facilitating acupuncture integration into clinical care.

Report of Local Teaching and Training

Teaching of Students in Courses:

2005-2017	Neuroimaging applications to acupuncture, HMS AP101 - Structural Acupuncture for Physicians Physicians	HMS 1.5 hours / year
2006	HST-583: Functional Magnetic Resonance Imaging: Data Acquisition and Analysis Graduate and undergraduate students	Massachusetts Institute of Technology 1.5 hours / year
2008	HST-583: Functional Magnetic Resonance Imaging: Data Acquisition and Analysis Graduate and undergraduate students	Massachusetts Institute of Technology 1 hour / year
2008-2010	Resting State Brain Connectivity with fMRI – State or Trait? Advanced Neuroimaging Techniques, Continuing Education Department Continuing Education Department	Harvard Medical School 1 hour / year
2021	Introduction to Imaging for Researchers: Mechanisms & Methods. Introductory online course for imaging technologies Continuing Medical Education	Online CME course for Harvard Catalyst 1 hour / year

Formal Teaching of Residents, Clinical Fellows and Research Fellows (post-docs):

2007-	Lecturer on the role of acupuncture in pain medicine, ad hoc mentorship Pain Fellowship, Pain Management Center, Dept. Anesthesiology	BWH 1 hour / week
2008-2012	MIT Traditional Medicine Society advisory board Undergraduate student mentorship	MIT 1 hour / week

2020-2022	Inter-institutional Pain Fellowship COVID-19 seminar series, University of Washington and Pain Management Center, Dept. Anesthesiology; Lecturer on pain neuroimaging and the role of acupuncture in pain medicine, ad hoc mentorship Fellows	Dept. Anesthesiology, BWH 1 hour / week
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Research Supervisory and Training Responsibilities:

2005-2021	Supervision Post-doctoral fellows, research assistants, undergraduate summer students, high school students, visiting faculty (see below for detail)	Martinos Center for Biomedical Imaging, MGH 3 hours / week
2023-	Mentorship Early career researchers	University of Michigan (UM) HEAL Initiative National K12 Clinical Pain Career Development Program (supported by K12 NS130673; MPI: Williams, DA, Clauw, DJ; Harte, SE) 20 hours / year

Other Mentored Trainees and Faculty:

2005-2007	Rupali Dhond, PhD / Post-doctoral Research Fellow Career stage: Research Fellow. Mentoring role: primary Postdoctoral mentor Accomplishments: Multiple first-authored publications of mentored research in top peer-reviewed journals including Brain, Pain. Mentored her successful transition to faculty and K01 training grant submission to NCCAM, NIH.
2006-2007	Calvin Yeh, MS / Research Assistant Career stage: Research technologist. Mentoring role: primary Research Assistant mentor Accomplishments: co-authored publications of mentored research, transitioned to industry position.
2006-2009	Kyungmo Park, PhD / Associate Professor, Dept. Biomedical Engineering, Kyunghee University, Korea Career stage: Visiting Professor. Mentoring role: Supervisor / Collaborator Accomplishments: Multiple co-authored publications of mentored research.

Collaboration continues through joint research and student mentorship, leading to funded KIOM / Martinos Collaboration Center.

- 2007-2010 Lauren LaCount, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: first- and co-authored publications of mentored research and successfully transitioned to DO program.
- 2007-2015 Jieun Kim, PhD / Post-Doctoral Research Fellow
Career stage: Post-Doctoral Research Fellow. Mentoring role: PhD Thesis Committee and primary Postdoctoral mentor
Accomplishments: Multiple first-authored publications of mentored research in top peer-reviewed journals including Pain, Arthritis and Rheumatology, etc. Jieun successfully transitioned to KIOM in Korea as a leading member of their NeuroImaging team.
- 2007-2015 Steve Cina, LAc / Research Assistant
Career stage: Research assistant and acupuncturist. Mentoring role: primary RA mentor
Accomplishments: co-authored publications of mentored research and transitioned to leadership academic faculty role at New England School of Acupuncture, MCPHS.
- 2008-2015 Yumi Maeda, DDS PhD / Post-Doctoral Research Fellow
Career stage: Post-Doctoral Research Fellow. Mentoring role: primary Postdoctoral mentor
Accomplishments: Multiple first-authored publications of mentored research and transitioned to clinical dentistry fellowship at Boston University.
- 2008-2021 Jeungchan Lee, PhD / Doctoral Student at Kyunghee University, Korea; Post-doctoral Fellow
Career stage: PhD student and Post-Doctoral Research Fellow. Mentoring role: PhD Thesis Committee and primary Postdoctoral mentor
Accomplishments: Multiple first-authored publications of mentored research in top peer-reviewed journals. Awarded Martinos Center post-doctoral fellow research grant. Transitioned to faculty at Harvard Medical School.
- 2010-2011 Ang Li, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor

Accomplishments: Co-authored publications of mentored research and successfully transitioned to MD program

- 2010-2012 Florian Pfab MD PhD / visiting Associate Professor, TU-Munich, Germany
Career stage: Visiting Professor. Mentoring role: primary Supervisor / Collaborator
Accomplishments: Multiple first- and co-authored publications of mentored research and successfully transitioned to head physician of Ingolstadt Futbol Club, Bundesliga, Germany and private practice.
- 2011-2012 Jaehyun Im, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: Co-authored publications of mentored research.
- 2011-2012 Wei-Ta Chen, MD / visiting fellow from Taiwan
Career stage: Visiting Post-Doctoral Fellow. Mentoring role: co-mentor
Accomplishments: A co-authored publication of mentored migraine imaging research and successfully transitioned to faculty position in Taiwan.
- 2011-2013 Marco Loggia, PhD / Post-Doctoral Research Fellow
Career stage: Post-Doctoral Research Fellow. Mentoring role: Postdoctoral mentor
Accomplishments: Multiple first-authored publications of mentored research and successful transition to independent faculty at the Martinos Center where he supervises his own Lab. Marco also co-founded the Center for Integrative Pain NeuroImaging (CiPNI) with myself, where he serves as Associate Director.
- 2012-2014 Alexandra Libby, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: Co-authored publications of mentored research and successfully transitioned to PhD program at Princeton University.
- 2012-2017 Jessica Gerber, MS / research coordinator
Career stage: Research assistant and Clinical coordinator. Mentoring role: primary RA supervisor
Accomplishments: Co-authored publications of mentored research, coordination of complex Program Project grant, transition to lead coordinator for IBC in Dept. Neurology, MGH.

- 2013-2014 Florian Beissner, PhD / visiting Post-doctoral fellow, University of Hannover, Germany
 Career stage: Visiting fellow. Mentoring role: primary supervisor
 Accomplishments: Multiple first- and co-authored publications of mentored research. Transitioned to lead his own Lab at University of Hannover
- 2013-2015 Hyungjun Kim, PhD / visiting fellow from KIOM, Korea
 Career stage: Visiting fellow. Mentoring role: primary supervisor
 Accomplishments: Multiple first- and co-authored publications of mentored research. Transitioned to lead his own Lab at Korean Institute of Oriental Medicine, Daejeon, Korea
- 2013-2020 Roberta Sclocco, PhD / visiting fellow from Milan Polytechnic, post-doctoral fellow
 Career stage: Post-Doctoral Research Fellow. Mentoring role: primary mentor
 Accomplishments: Multiple first-authored publications of mentored research. Transitioned to faculty at Harvard Medical School.
- 2014-2017 Ekaterina Protsenko, BA / Research Assistant
 Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
 Accomplishments: Co-authored publications of mentored research and successfully transitioned to MD program at University of California San Francisco
- 2014-2017 Ishtiaq Mawla, BA / Research Assistant
 Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
 Accomplishments: First-authored publications of mentored research and successfully transitioned to PhD program at University of Michigan
- 2014-2020 Ronald Garcia, MD PhD / Post-doctoral Research Fellow
 Career stage: Post-Doctoral Fellow. Mentoring role: co-postdoctoral mentor
 Accomplishments: Multiple first-authored publications of mentored research and successful transition to faculty in the Department of Psychiatry, MGH. Served as PI for grants from National Science Agency in Colombia and foundation grant from NARSAD
- 2015-2018 Dan-Mikael Ellingsen PhD / Post-doctoral Research Fellow
 Career stage: Post-Doctoral Fellow. Mentoring role: Post-doctoral mentor
 Accomplishments: Multiple first-authored publications of mentored research

and awarded EU grant support through the University of Oslo, Norway under my supervision. Transitioned to faculty at University of Oslo, Norway.

- 2016-2018 Catherine Hubbard, PhD / post-doctoral research fellow
Career stage: post-doctoral fellow. Mentoring role: primary supervisor
Accomplishments: Multiple first- and co-authored publications of mentored research. Transitioned to faculty position at Martinos Center, MGH and University of South Carolina.
- 2016-2018 Changjin Jung, MS / visiting fellow from KIOM, Korea
Career stage: Visiting fellow. Mentoring role: primary supervisor
Accomplishments: Co-authored publications of mentored research.
Transitioned to researcher position at Korean Institute of Oriental Medicine, Daejeon, Korea
- 2016-2018 Jacqueline Lutz, PhD / post-doctoral research fellow
Career stage: Post-Doctoral Fellow. Mentoring role: co-postdoctoral mentor
Accomplishments: Multiple first- and co-authored publications of mentored research and successfully transitioned to industry position and faculty at Boston University.
- 2016-2020 Kylie Isenburg, BA / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: First and co-authored publications of mentored research.
Transitioned to PhD program at Boston University.
- 2017-2021 Harrison Fisher, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: First and co-authored publications of mentored research.
Transitioned to PhD program at Boston University.
- 2018-2021 Rowan Staley, BS / Research Assistant
Career stage: Research technologist. Mentoring role: co-Research Assistant mentor
Accomplishments: Poster presentations at GI conferences. Co-authored publications.
- 2018-2022 Kyungsun Han, PhD / visiting fellow from KIOM, Korea
Career stage: Visiting fellow. Mentoring role: primary supervisor

Accomplishments: Co-authored publications of mentored research.
Transitioned to senior research position at KIOM, Korea.

- 2018- Michael Datko, PhD / Post-doctoral Research Fellow
Career stage: post-doctoral fellow. Mentoring role: co-supervisor
Accomplishments: Presentations at multiple annual meetings and first-authored manuscripts.
- 2018- Alessandra Anzolin, PhD / Post-doctoral Research Fellow
Career stage: post-doctoral fellow. Mentoring role: primary supervisor
Accomplishments: Presentations at multiple annual meetings, first-authored publications.
- 2019-2021 Mackenzie Hyman, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: instrumental in hardware development for the Lab, co-authored a paper on brain response to taVNS in migraine. Transitioned to PhD program at Boston University.
- 2019-2022 Maya Barton Zuckerman, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: Several poster presentations in Local/National conferences, co-authored publications. Transitioned to PhD program at Northeastern University.
- 2019- Arvina Grahl, PhD / Post-doctoral Research Fellow
Career stage: post-doctoral fellow. Mentoring role: primary supervisor
Accomplishments: Oral presentations at several annual meetings
- 2021- Sarasa Tohyama, PhD / Post-doctoral Research Fellow
Career stage: post-doctoral fellow. Mentoring role: primary supervisor
Accomplishments: Presentations at several annual meetings, awarded prestigious CIHR training grant from Canada.
- 2021- Andy Bolender, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research Assistant mentor
Accomplishments: first-authored manuscript currently under review.
- 2021- Alison Goldstein, BS / Research Assistant
Career stage: Research technologist. Mentoring role: primary Research

Assistant mentor

Accomplishments: multiple abstract presentations at conferences.

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

No presentations below were sponsored by 3rd parties/outside entities

2018	Neuroimaging Pain Circuitry: Advanced applications for pain management Comprehensive Review of Pain Medicine	45 Lectures Boston, MA
2022	Imaging pain in the brain with functional MRI Comprehensive Review of Pain Medicine	45 Lectures Boston, MA
2023	Psychedelics and Pain: Understanding the Role of Psychedelics Clinicians in Facilitating Brain Change 3rd Annual Conference on Psychedelics and Psychedelic Medicine	25 Lectures Boston, MA

Local Invited Presentations:

No presentations below were sponsored by 3rd parties/outside entities

2004	Employing functional MRI for the study of acupuncture: Experiment design and the neurocorrelates of acupuncture deqi sensation / Invited Lecture Osher Institute, Harvard Medical School
2006	Evidence of Somatosensory Cortical Plasticity in Carpal Tunnel Syndrome Treated with Acupuncture - an fMRI Assessment / Invited Lecture Martinos Center for Biomedical Imaging, Dept. Radiology, MGH
2006	Sham and Placebo Acupuncture in Clinical Trials: The Neuroimaging Evidence / Invited Lecture Harvard Medical School
2006, 2009	The Role of Acupuncture in Chronic Pain Management / Invited Lecture Pain Management Center, Brigham and Women's Hospital, Harvard Medical School

- 2007 Acupuncture Modulation of Resting State Networks / Invited Lecture
Martinos Center for Biomedical Imaging, Dept. Radiology, MGH
- 2011 How does Acupuncture work? Brain activity underlying acupuncture efficacy / Invited Lecture
Massachusetts General Hospital CSSA
- 2012 Acupuncture for the Treatment of Chronic Pain: Integrating Clinical and Neuroimaging Research / Invited Lecture
Osher Center for Integrative Medicine at Harvard Medical School and Brigham and Women's Hospital
- 2012 Neuroimaging markers for chronic pain disorders - objective outcomes for evaluating acupuncture therapy / Invited Lecture
Brainmap Lecture, Martinos Center for Biomedical Imaging, MGH
- 2013 Investigating the autonomic brain and pain / autonomic interactions with neuroimaging / Invited Lecture
Children's Hospital, Waltham, MA
- 2013 Neuroimaging evaluation of acupuncture mechanisms - from carpal tunnel syndrome to fibromyalgia / Invited Lecture
The Fellowship in Integrative Medicine at Beth Israel Deaconess Medical Center, Boston MA
- 2014 Overview of Integrative Medicine Programs / Osher Inaugural Integrative Medicine Research Forum / Session Chair
Joseph B. Martin Conference Center, Harvard Medical School, Boston, MA
- 2014 Sex-differences in brain circuitry supporting nociception, pain, and pain empathy: the neuroimaging evidence / Invited Lecture
Conference on pain in women, Connors-Bri Center for Research on Women's Health and Gender Biology, Brigham and Women's Hospital, Boston, MA
- 2017 Brain Imaging at the MGH Martinos Center / Invited Lecture
Lunch and Learn series, Partners Healthcare Research Management, Somerville MA
- 2017 Neuroimaging applied to assess objective outcomes for acupuncture in carpal tunnel syndrome / Invited Grand Rounds Lecture

Osher Center for Integrative Medicine at Harvard Medical School and Brigham and Women's Hospital, Boston, MA

- 2017 Ultrahigh Field (7T) fMRI Approaches to Brainstem Neuroimaging for Targeted Neuromodulation / Invited Lecture
7T MRI Scientific Symposium, Brigham and Women's Hospital, Boston, MA
- 2018 Sex Differences and Pain: Do different brain circuitries contribute to differences in pain sensitivity? / Panel and Invited Lecture
Radcliffe Seminar, Radcliffe College, Cambridge MA
- 2018 The Role of Acupuncture in the Treatment of Chronic Pain / Invited Lecture
Pain Management Center, Department of Anesthesiology, Brigham and Women's Hospital
- 2019 Neuromodulation in Tune with the Body's Rhythms: Enhancing Clinical Outcomes with Respiratory-Gated Auricular Vagal Afferent Nerve Stimulation (RAVANS) / Grand Rounds invited lecture
Osher Center for Integrative Medicine, Brigham and Women's Hospital, Boston, MA

Report of Regional, National and International Invited Teaching and Presentations

No presentations below were sponsored by 3rd parties/outside entities

Regional

- 2004 The Modulatory Effects of Acupuncture on the Brain as Imaged by fMRI / Invited Lecture
Tufts School of Medicine, Boston, MA
- 2004 What can functional MRI tell us about acupuncture and the "Sea of Marrow" that we don't already know? / Invited Lecture
New England School of Acupuncture, Newton, MA
- 2005 Pain Relief and Acupuncture Research: from Endorphins to fMRI / Invited Lecture at Biomatrix Evening Colloquium
Massachusetts Institute of Technology, Cambridge, MA

- 2006 22.013 MIT: Freshman Seminar: Careers in Biomedical Engineering /
Invited Lecture
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 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)
- 2007 Neuroimaging the Effects of Acupuncture for Carpal Tunnel Syndrome /
Grand Rounds
Massachusetts Institute of Technology Medical Clinic, Cambridge, MA
- 2008-2010 The Neuroscience of Acupuncture / Invited Lecture in course: Evidence-
based Complementary and Alternative Medicine
Tufts Medical School, Boston, MA
- 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
- 2013 Neuroimaging Approaches to Acupuncture Research: from localized to
widespread pain syndromes / Invited Lecture
Tufts University School of Medicine, Boston, MA

- 2013 Neuroimaging for non-invasive assessment of brain circuitry supporting nausea in humans / Invited Lecture
Man Vehicle Laboratory Seminar, Massachusetts Institute of Technology, Cambridge, MA
- 2015 Integrated Care: Exploring Diverse Approaches to Health / Tufts University Chapter of Minority Association for Pre-Health Students (MAPS) / Invited Panelist
Tufts University, Medford, MA
- 2016 What is acupuncture? From research to clinical practice / Course CPSYC-1451-BH01, Bunker Hill Community College / Invited Speaker
Charlestown, MA
- 2017, 2022 The Neuroscience of Acupuncture / Invited Lecture in course: Medical Acupuncture elective
Tufts Medical School, Boston, MA
- 2018 Boosting Mindfulness-based Interventions with Neuromodulation / Invited Lecture
Symposium for Technology-Assisted Meditation, Harvard University, Cambridge MA
- 2018 From somatosensory neuromodulation to therapeutic alliance: Neuroimaging applications to better understand how acupuncture alleviates pain / The John B. Pierce Laboratory seminar series
Yale University, New Haven, CT
- 2019 Neuromodulation in tune with the body's rhythms: Pain neuromodulation with respiratory-gated auricular vagal afferent nerve stimulation (RAVANS) / Atlanta Department of Veterans Affairs CVNR Seminar Series
Atlanta, GA
- 2020 Acupuncture as a Mind Body Tool: Neuroimaging brain mechanisms - from somatosensation to therapeutic alliance / Invited Lecture
The Herbert Benson, MD Course in Mind Body Medicine (Online, Covid19-modified), Boston, MA
- 2020 Neuroimaging brain mechanisms of acupuncture: from somatosensation to therapeutic alliance / Invited Lecture
New England School of Acupuncture (Online, Covid19-modified), Worcester, MA

- 2020 Neuroimaging the pain experience and brain mechanisms of acupuncture efficacy: A 20-year LoganMartinos collaboration / Invited Keynote Lecture 13th Annual Joseph W. Howe Oration in Diagnostic Imaging, Logan University (Online, Covid19-modified), Chesterfield, MO
- 2020 Rewiring the primary somatosensory cortex in carpal tunnel syndrome with acupuncture / Invited Lecture in course: Medical Acupuncture elective Tufts Medical School (Online, Covid19-modified), Boston, MA
- 2021 Neuroimaging Brain Mechanisms of Acupuncture: from Somatosensation to Therapeutic Alliance / Invited Lecture UCSF Osher Center (Online, Covid19-modified), San Francisco, CA
- 2023 Hyperscan neuroimaging the brain circuitry supporting patient/clinician therapeutic alliance in pain care Department of Anesthesiology, Duke University, Durham, NC
- 2023 A social neuroscience perspective of the patient/clinician relationship: the role of hyperscan neuroimaging in the art of medicine Dartmouth College, Hanover, NH
- 2023 Brain Circuitry Supporting Patient/Clinician Therapeutic Alliance and the "Art of Medicine": a Hyperscan Neuroimaging Approach NIH Pain Seminar Series, Bethesda, MD
- National**
- 2003, 2003 A Biomechanical Investigation of the Structure-Function Relationships in the Tongue / Grand Rounds Physical Rehabilitation Branch, National Institutes of Health, Bethesda, MD
- 2003 The Modulatory Effects of Acupuncture on the Brain as Imaged by fMRI / 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
- 2006 Acupuncture for Carpal Tunnel Syndrome: Neuroimaging Cortical Plasticity and Acupuncture Processing for Chronic Pain / Oral abstract presentation

- North American Research Conference on Complementary and Integrative Medicine. Edmonton, Alberta, Canada
- 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 Acupuncture for Carpal Tunnel Syndrome: Neuroimaging Cortical Plasticity and Acupuncture Processing for Chronic Pain / Keynote Lecture
American Academy of Medical Acupuncture 19th Annual Symposium, Baltimore, MD
- 2007 NCCAM Center of Excellence: Neuroimaging Acupuncture Effects on Brain Activity / Invited Lecture
NCCAM Centers Meeting. Bethesda, 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 3rd National Symposium on Complementary & Alternative Geriatric Health Care
Logan College of Chiropractic, Chesterfield, MO
- 2011 Acupuncture relief of itch in Atopic Dermatitis associated with reduced fMRI activation of salience and affective brain circuitries / Oral abstract presentation
Society for Neuroscience annual meeting, Washington DC
- 2013 Functional Brain Connectivity: A Potential Biomarker for the Chronic Pain State? / Invited plenary
Lecture in the American Academy of Pain Management annual meeting, Fort Lauderdale, FL

- 2013 Martinos Center CERC for Acupuncture Neuroimaging: Application of MRI Biomarkers to Better Understand Acupuncture Analgesia / Invited plenary Lecture at the CAM preconference symposium of the American Pain Society annual conference, New Orleans, LA
- 2014 As We Better Understand the Brain, We Better Understand Acupuncture: Neuroimaging Approaches to Acupuncture Research / Invited keynote lecture 26th Annual American Academy of Medical Acupuncture Symposium, Denver, CO
- 2014 Brain neuroplasticity in carpal tunnel syndrome treated by acupuncture / Invited symposium lecture in “Neural Basis of Nonpharmacological Pain Treatments”
American Pain Society Annual Meeting, Tampa, FL
- 2014 Neuroimaging Approaches to Acupuncture and CAM Research: What Do We Know? What Lies Ahead? / Invited keynote lecture
New York Chiropractic College, Seneca Falls, NY
- 2014 Neuroimaging outcomes as biomarkers for acupuncture analgesia / Invited symposium lecture
American Academy of Pain Management, Phoenix, AZ
- 2015 Neuroimaging altered brain circuitries and neurotransmitter levels in cyclic vomiting syndrome / Invited symposium lecture
Biology and Control of Nausea and Vomiting 2015, Pittsburgh, Pennsylvania
- 2016 A view from above: Investigating acupuncture mechanisms for chronic pain with brain functional MRI / Invited lecture
Integrative Medicine Lecture Series, University of Texas MD Anderson Cancer Center, Houston, TX
- 2016 Acupuncture - a somatosensory conditioning neuromodulatory therapy / Invited lecture
National Center for Complementary and Integrative Health, NIH, Bethesda, Maryland
- 2016 Neuroimaging acupuncture mechanisms in Carpal Tunnel Syndrome: can targeting the brain affect pain in the wrist? / Invited lecture
Pain Week, Las Vegas, NV

- 2016 Non-invasive neuromodulatory approaches to the treatment of chronic pain /
Invited lecture
Pain Week, Las Vegas, NV
- 2017 Is brain concordance linked with therapeutic alliance & pain relief?
Hyperscan fMRI applied to decipher the brain circuitry of patient/clinician
interactions / Invited webinar presentation for Director's Webinar Series
Office of Behavioral and Social Sciences Research, National Institutes of
Health (NIH)
- 2017 Neuroimaging Acupuncture Effects for Neuropathic Pain and the Role of
Objective Outcomes in CTS / Invited keynote lecture
American Academy of Medical Acupuncture 30th Annual Symposium,
Pittsburgh, PA
- 2018 Applications of respiratory-gated auricular vagal afferent nerve stimulation
(RAVANS) / Invited lecture
Cardiac Autonomics Group, University of California Los Angeles, Los
Angeles, CA
- 2018 Neuroimaging to assess S1 neuroplasticity following acupuncture therapy for
neuropathic pain / Selected Session (competitive, chair)
Neurobiological Mechanisms Supporting Integrative and Mind-Body
Therapies for Pain, American Pain Society annual meeting, Anaheim, CA
- 2018 Respiratory-gated Auricular Vagal Afferent Nerve Stimulation for Pain
Disorders / Invited Lecture
2018 NYC Neuromodulation & North American Neuromodulation Society
Summer Series, New York City, NY, USA
- 2019 Brain imaging to assess neuroplasticity following acupuncture for neuropathic
pain / Invited Lecture
College on Problems of Drug Dependence (CPDD) Symposium, San Antonio,
TX
- 2019 Neuroimaging and Functional Gastric Response to Respiratory-gated
Transcutaneous Vagus Nerve Stimulation / Invited Lecture
Joint meeting of NYC Neuromodulation and the Neuromodulation: The
Science symposia, Napa, CA
- 2019 Neuroimaging the brain circuitry underlying pain catastrophizing and its
influence on pain processing / Selected Session (competitive)

Multimodal Contributors to the Negative Impact of Pain Catastrophizing,
American Pain Society annual meeting, Milwaukee, WI

- 2019 Therapeutic engagement of interoceptive pathways with respiratory-gated vagus nerve stimulation / Invited Lecture
The Science of Interoception and its Roles in Nervous System Disorders, NIH Blueprint Workshop, NIH, Lister Hill Auditorium, Bethesda MD
- 2019 What has fMRI revealed about central sensitization and chronic pain? / Invited lecture
Analgesic, Anesthetic, and Addiction Clinical Trial Translations, Innovations, Opportunities and Networks (ACTTION), IMMPACT-XXIII meeting, Research Design Considerations for Chronic Pain Clinical Trials Addressing Central Sensitizations/Somatosensory Amplification and Multiple Comorbidities, Washington DC
- 2020 Functional Neuroimaging of Psychosocial States: Brain circuitries supporting pain and catastrophizing / Invited Lecture
Measurement of Pain: Behavioral, Social and Biological Factors Office of Behavioral and Social Sciences Research National Institutes of Health, Bethesda, MD
- 2020 Neuromodulation in Tune with the Body's Rhythms: Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS) / Invited Lecture
National Center of Neuromodulation for Rehabilitation Advanced Transcutaneous Auricular Vagus Nerve Stimulation (taVNS) Symposium, Charleston, SC
- 2020 Underlying Physiology, Clinical Applications, and Technology Transfer of a Novel Technique for Transcutaneous Respiratory-Gated Auricular Vagus Afferent Nerve Stimulation (RAVANS) / Oral zoom presentation
NYC Neuromodulation 2020 Online Conference (Covid19-modified)
- 2022 Mechanisms of Acupuncture: fMRI research / Keynote Lecture
American Association for Medical Acupuncture annual meeting, Cincinnati OH
- 2022 Understanding the Brain Mechanisms of Therapeutic Alliance in Acupuncture with Hyperscan fMRI / Selected symposia lecture
2022 United States Association for the Study of Pain (USASP) Annual Scientific Meeting, Cincinnati OH

- 2022 Hyperscan neuroimaging for a mechanistic understanding of therapeutic alliance and the art of medicine / Invited Lecture
Napa Pain Conference; Napa, CA
- 2022 Imaging the brain circuitry underlying pain catastrophizing and its influence on pain processing / Invited Lecture
Napa Pain Conference; Napa, CA
- 2022 Hyperscan neuroimaging brain mechanisms underlying the patient/clinician relationship / Invited Lecture
University of Pittsburgh Anesthesiology Grand Rounds, Pittsburgh, PA
- 2022 Hyperscan neuroimaging brain mechanisms underlying the patient/clinician relationship / Invited Lecture
"Neurobiological Mechanisms Underpinning Empathy, Social Interactions, and Pain: Playing the Scales from Rodents to Humans," Sanford Institute for Empathy and Compassion, UCSD; San Diego, CA
- 2023 Hyperscan neuroimaging for a mechanistic understanding of patient-clinician therapeutic alliance in pain management / Selected symposia lecture
2023 United States Association for the Study of Pain (USASP) Annual Scientific Meeting, Durham NC
- 2023 Brain mechanisms supporting patient / clinician therapeutic alliance in pain care – a hyperscan approach
Stanford Pain Relief Innovations Lab online lecture series, Stanford University, Stanford, CA
- 2023 Neural Mechanisms of Force-Based Manipulations: The Role of Neuroimaging in Clinical Research / Invited Lecture
Online, Webinar sponsored by ForceNET organization

International

- 2005 Correlating Acupuncture fMRI in the Human Brainstem with Heart Rate Variability / Oral abstract presentation
27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Shanghai, China
- 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 für Wissenschaftsförderung)
- 2010 Acupuncture Neuroimaging Research / Invited lecture
Kyunghee University, Seoul, Republic of Korea
- 2010 Acupuncture modulates intrinsic brain connectivity in fibromyalgia – a potential neuroimaging marker for disease severity and therapeutic efficacy / Oral abstract presentation
International Congresses in Complementary Medicine Research, Tromsø, Norway
- 2010 Neuroimaging in Basic and Translational Acupuncture Research / Invited lecture
York Neuroimaging Centre, University of York, York, United Kingdom
- 2010 Neuroimaging in Basic and Translational Acupuncture Research / Invited plenary lecture
International Symposium on Acupuncture and Meridian Studies (ISAMS), Pusan, Republic of Korea
- 2011 Neuroimaging Acupuncture: acupoint specificity and potential mechanisms of action / Invited Keynote Lecture
DAGfA (Deutsche Ärztegesellschaft für Akupunktur, German Medical Acupuncture Association), Bad Nauheim, Germany
- 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
- 2012 Brain Circuitry Subserving Acupuncture Relief of Itch in Atopic Dermatitis: an fMRI Study / Selected Session (chair, competitive)
“A Window to the Brain: Neuroimaging Technologies for Integrative Medicine Research” at International Research Congress on Integrative Medicine and Health, Portland, OR, USA

- 2012 Neuroimaging evaluation of acupuncture mechanisms / Invited Plenary Lecture
Korean Institute for Oriental Medicine Acupuncture Neuroimaging Symposium,
Daejeon, Korea
- 2013 Brain circuitry supporting nocebo itch perception in atopic dermatitis / Invited
plenary lecture
7th World Congress on Itch, Boston, MA
- 2013 Brain mechanisms supporting anti-pruritic effects of acupuncture / Invited plenary
lecture
International Scientific Acupuncture and Meridian Symposium, Stockholm,
Sweden
- 2013 Neuroimaging Approaches to Acupuncture Research: What Do We Know? What
Lies Ahead? / Invited Keynote Lecture
Society for Acupuncture Research International Conference, Ann Arbor, MI
- 2014 Acupuncture modulates brain neuroplasticity in carpal tunnel syndrome / Invited
Lecture
Chengdu University of Traditional Chinese Medicine, Chengdu, China
- 2014 International Scholar: Visiting Professorship
Department of Biomedical Engineering at Kyunghee University, Yongin, Korea
- 2014 Neuroanatomy and Neurophysiology of the Human Brain: functional MRI
applications / Kyunghee University lecture series
Kyunghee University, Yongin, Korea
- 2014 Neuroimaging Correlates of Acupuncture: What Do We Know? What Lies
Ahead? / Invited Keynote Lecture
CAAM and SAR International Symposium on Acupuncture Research, Beijing,
China
- 2014 Neuroimaging approaches to acupuncture research: from carpal tunnel syndrome
to fibromyalgia / Invited Lecture
The University of Hong Kong, Hong Kong, China
- 2014 Neuroimaging in acupuncture research: background and applications / Invited
Lecture
Korean Institute of Oriental Medicine, Daejeon, Korea

- 2015 Brain circuitry supporting placebo and nocebo effects of itch / Invited Lecture
Summer School Allergy and the Brain“ The Christine Kühne Center for Allergy
Research and Education (CK-CARE), Davos, Switzerland
- 2015 Neuroimaging in Multicenter Trials / Invited Lecture
1st Annual International Conference, Kyunghee University Clinical Trials Center,
Kyunghee University Korean Medicine Hospital, Seoul, Korea
- 2015 Neuroimaging nausea to better understand CAN physiology – a multimodal
approach / Oral presentation at selected session (competitive)
37th Annual International Conference of the IEEE Engineering in Medicine and
Biology Society, Milan, Italy
- 2016 Brainstem processing in migraine: can the gateway to chronic pain be down-
regulated? / Selected Session (competitive)
“Neuroimaging pain-related circuitries in the human brainstem with functional
MRI” at Organization for Human Brain Mapping annual meeting, Geneva,
Switzerland
- 2016 Evaluating acupuncture-associated neuroplasticity in carpal tunnel syndrome with
brain imaging / Invited Plenary Lecture
International Scientific Acupuncture and Meridian Symposium (ISAMS), Hong
Kong, China
- 2017 Functional Neuroimaging as a Window into Human Brain Function: Applications
to Better Understand and Optimize Neuromodulatory Therapies / Invited Keynote
Lecture
International Society for Neurofeedback Research, Ledyard, CT, USA
- 2017 Neuroimaging Acupuncture Effects for Neuropathic Pain and the Role of
Objective Outcomes in CTS / Invited Plenary Lecture
Society for Acupuncture Research International Conference, San Francisco CA
- 2017 When perception is reality: How nocebos mimic real pruritogens in brain
processing of clinically-relevant itch / Invited Plenary Lecture
Society for Interdisciplinary Placebo Studies (SIPS) Conference, Leiden,
Netherlands
- 2018 Neural mechanisms of non-specific effects of mind and body approaches / Invited
Plenary Lecture
“Chronic Pain: The Science of Complementary and Integrative Health

Approaches”, Satellite to the 17th IASP World Congress on Pain, Boston, MA, USA

- 2018 Rewiring the primary somatosensory cortex in carpal tunnel syndrome with acupuncture / Invited Keynote Lecture
World Congress on Medical Acupuncture, Munich, Germany
- 2018 Rewiring the primary somatosensory cortex in carpal tunnel syndrome with acupuncture / Invited Keynote Lecture
British Medical Acupuncture Society Autumn Scientific Meeting, London, UK
- 2018 Rewiring the primary somatosensory cortex in carpal tunnel syndrome with acupuncture / Invited Lecture
Annual Meeting for the Chinese Society of Integrative Anesthesiology, Shenyang, China
- 2018 Role of neuroimaging to assess acupuncture-induced neuroplasticity in pain relief / Invited Plenary Lecture
6th International Scientific Symposium at the Institute for Complementary and Integrative Medicine, Zurich, Switzerland
- 2018 Role of neuroimaging to assess acupuncture-induced neuroplasticity in pain relief / Invited Plenary Lecture
A.M.A.B. ASSOCIAZIONE MEDICI AGOPUNTORI BOLOGNESI 2nd International Symposium on Research in Acupuncture, Bologna, Italy
- 2019 Brain concordance supports patient/clinician therapeutic alliance and modulates placebo analgesia: a hyperscan fMRI approach / Invited Plenary Lecture
Society for Interdisciplinary Placebo Studies (SIPS) Conference, Leiden, Netherlands
- 2019 The role of neuroimaging in developing acupuncture and other neuromodulatory approaches for chronic pelvic pain / Invited Plenary Lecture
2019 Annual Scientific Meeting on Pelvic Pain, International Pelvic Pain Society (IPPS), Toronto, Canada
- 2020 Advanced neuroimaging applications to assess patient / clinician interactions / Invited Lecture
PSYCHEDELICS AND MENTAL HEALTH: NEUROIMAGING THE MIND BRAIN CONNECTION, Department of Psychiatry, MGH (Online, Covid19-modified), Boston, MA

- 2020 Brain concordance supports patient/clinician therapeutic alliance and modulates analgesia: a hyperscan fMRI approach / Accepted panel submission titled “Neuroimaging Applications for Social and Affective Modulation of Pain” Winter Conference on Brain Research (WCBR), Big Sky, Montana, USA
- 2020 Functional Neuroimaging Biomarkers for Pain: The Role of Pain Catastrophizing / Invited Keynote Lecture CINDOR - CONGRESSO INTERDISCIPLINAR DE DOR DA USP, Interdisciplinary Conference on Pain (Online, Covid19-modified), São Paulo, Brazil
- 2020 Rewiring the primary somatosensory cortex in carpal tunnel syndrome with acupuncture / Invited Lecture University of São Paulo Medical Acupuncture Grand Rounds (Online, Covid19-modified), São Paulo, Brazil
- 2021 A picture is worth a thousand words: linking fibromyalgia pain widespreadness from digital pain drawings with pain catastrophizing and brain cross-network connectivity / Invited Lecture Human Pain Seminar Series (Online, Covid19-modified), Toronto, Canada
- 2021 Acupuncture-Inspired Therapies Targeting Interoceptive Pathways / Invited Lecture Society for Acupuncture Research International Research Conference (Online, Covid19-modified), Ann Arbor, MI
- 2021 Neuroimaging Brain Mechanisms of Acupuncture: from Somatosensation to Therapeutic Alliance / Invited Lecture ICMART World Medical Acupuncture Congress (Hybrid, Covid19-modified), Athens, Greece
- 2021 Hyperscan neuroimaging for a mechanistic understanding of therapeutic alliance and the art of medicine / Invited Lecture Krembil Research Institute's Neuroimaging Rounds. University Health Network. Toronto Western Hospital. (Online, Covid19-modified), Toronto, Canada
- 2022 Vagus Nerve Stimulation: Enhancing outcomes with Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS) / Invited Lecture 33RD INTERNATIONAL SYMPOSIUM ON THE AUTONOMIC NERVOUS SYSTEM, Maui, Hawaii

- 2023 Neuroimaging the brain circuitry underlying pain catastrophizing and its influence on pain processing / Selected Panel Lecture
Winter Conference for Brain Research; Snowbird, Utah
- 2023 **Exploring the biopsychosocial model of pain with neuroimaging**
University of Toronto, Center for the Study of Pain 2023 Scientific Meeting;
Toronto, Canada
- 2023 How the patient/clinician relationship affects placebo analgesia: a hyperscan neuroimaging approach
Society for Interdisciplinary Placebo Studies (SIPS) Conference, Duisberg, Germany
- 2023 The patient / acupuncturist relationship and the role of brain-to-brain concordance for therapeutic alliance
Society for Acupuncture Research International Research Conference, New York, NY
- 2023 Neuroimaging brain mechanisms of acupuncture: from somatosensation to therapeutic alliance / Invited Lecture
UST Program, Korean Institute of Oriental Medicine, Daejeon Korea (Online)

Report of Clinical Activities and Innovations

Past and Current Licensure and Certification:

- 2002- Acupuncture
Committee on Acupuncture, Board of Registration in Medicine, Executive Office of Health and Human Services, Commonwealth of Massachusetts

Practice Activities:

- 2006- Acupuncturist Pain Management Center, Dept.
Anesthesiology, BWH

Clinical Innovations:

- Protocol for the treatment of carpal tunnel syndrome with electro-acupuncture Since our published protocol in 2007, in which we evaluated acupuncture induced neuroplasticity in primary somatosensory cortex in carpal tunnel syndrome patients, multiple acupuncturists around the nation have successfully used this protocol in their own clinic (personal communication). I was involved in the development of this clinical protocol, and have been

(2007) principally responsible for the dissemination of the protocol in the medical community.

Novel approach for transcutaneous vagus nerve stimulation (2009) Innovative approach to transcutaneous auricular neuromodulation, which has been researched for multiple clinical applications (due to the broad innervation of the vagus nerve), from gastroparesis and hypertension, to mild cognitive impairment, migraine and depression. Our approach has been issued a patent, which is licensed and being developed as a potential FDA-approved device by a medical device company (Cala Health, Inc.). I was the inventor of the technology and am listed as such on the primary patent, and follow-up patent applications stemming from this innovation.

Report of Technological and Other Scientific Innovations

Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS) (2013) 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 technology was licensed to Cala Health, Inc in 2018 and a commercial prototype is currently being evaluated for clinical efficacy.
US Patent awarded (2013): US Patent 8,428,719

US Provisional Patent: 62/530,913

PCT/US2018/041485 (WO, PCT)

“SYSTEMS AND METHODS FOR RESPIRATORY-GATED NERVE STIMULATION” Application of RAVANS for cardiovascular and gastrointestinal disorders.

Systems and Methods for Respiratory-Gated Nerve Stimulation (2018) System and methods for further development of respiratory-gated auricular vagal afferent nerve stimulation (RAVANS), a form of transcutaneous auricular vagus nerve stimulation (taVNS). This approach has been licensed by Cala Health, Inc. and is being developed as a device which will hopefully benefit a wide range of patients, including chronic pain, moderate depression, neuroimmune/inflammatory disorders.
US patent application 16/629,395

Based on PCT/US2018/041485 (Q&B 125141.03014)

System and method to evaluate upper gastrointestinal tract Development of a non-invasive 4D cine MRI assessment of gastric motility using a naturalistic contrast meal and ultrafast 3D MRI sequence.
Patent application with Braden Kuo, Christopher Nguyen, Roberta Sclocco.

motility and emptying using magnetic resonance imaging (MRI) (2020)

MGH Application for Provisional Patent application in process (US20220214413A1), patent application submitted May 2020.

Report of Education of Patients and Service to the Community

No presentations below were sponsored by 3rd parties/outside entities

Recognition:

2005	Presented research talk to acupuncturists and lay public entitled “Cortical Plasticity in Carpal Tunnel Syndrome Treated with Acupuncture”	Acupuncture and Oriental Medicine Society of Massachusetts Annual Meeting
2006	Presented research talk to bodyworkers and lay public entitled “Neuroimaging of Acupuncture for Carpal Tunnel Syndrome.”	American Organization for Bodywork Therapies of Asia
2009	Authored a review for acupuncture professionals entitled “Promise of Neuroimaging for Acupuncture Research.”	American Acupuncturist Journal
2017	Publicity for 2017 Brain publication on brain mechanisms of acupuncture treatment of Carpal Tunnel Syndrome	New York Times, The Guardian (UK), Popular Science, Time magazine, Boston Magazine, Daily Mail (UK), Korean Broadcasting Service (Korea), Arirang TV (Korea), Le Figaro (France)
2019	Publicity for hyperscan fMRI study investigating mechanistic role of patient / clinician relationship in clinical pain outcomes	National Geographic magazine

Report of Scholarship

Peer-Reviewed Scholarship in print or other media:

Research Investigations

*=equal contribution

#=first/co-first author is a mentee

1. **Napadow VJ**, Chen Q, Wedeen VJ, Gilbert RJ. Intramural mechanics of the human tongue in association with physiological deformations. *J Biomech.* 1999 Jan;32(1):1-12. PMID: 10050946
2. **Napadow VJ**, Chen Q, Wedeen VJ, Gilbert RJ. Biomechanical basis for lingual muscular deformation during swallowing. *Am J Physiol.* 1999 Sep;277(3):G695-G701. PMID: 10484396. <https://doi.org/10.1152/ajpgi.1999.277.3.G695>
3. Chen Q, Mai VM, Bankier AA, **Napadow VJ**, Gilbert RJ, Edelman RR. Ultrafast MR grid-tagging sequence for assessment of local mechanical properties of the lungs. *Magn Reson Med.* 2001 Jan;45(1):24-28. PMID: 11146481
4. Wedeen VJ, Reese TG, **Napadow VJ**, Gilbert RJ. Demonstration of primary and secondary muscle fiber architecture of the bovine tongue by diffusion tensor magnetic resonance imaging. *Biophys J.* 2001 Feb;80(2):1024-1028. PMID: 11159469. PMCID: PMC1301300
5. **Napadow VJ**, Mai V, Bankier A, Gilbert RJ, Edelman R, Chen Q. Determination of regional pulmonary parenchymal strain during normal respiration using spin inversion tagged magnetization MRI. *J Magn Reson Imaging.* 2001 Mar;13(3):467-474. PMID: 11241824
6. **Napadow VJ**, Chen Q, Mai V, So PT, Gilbert RJ. Quantitative analysis of three-dimensional-resolved fiber architecture in heterogeneous skeletal muscle tissue using nmr and optical imaging methods. *Biophys J.* 2001 Jun;80(6):2968-2975. PMID: 11371469. PMCID: PMC1301480
7. **Napadow VJ**, Kamm RD, Gilbert RJ. A biomechanical model of sagittal tongue bending. *J Biomech Eng.* 2002 Oct;124(5):547-556. PMID: 12405598
8. **Napadow V**, Kaptchuk TJ. Patient characteristics for outpatient acupuncture in Beijing, China. *J Altern Complement Med.* 2004 Jun;10(3):565-572. PMID: 15253864
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):209-216. PMID: 15649834

10. Gilbert RJ, **Napadow VJ**. Three-dimensional muscular architecture of the human tongue determined in vivo with diffusion tensor magnetic resonance imaging. *Dysphagia*. 2005;20(1):1-7. PMID: 15886960
11. **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. PMID: 15499576. PMCID: PMC6871725
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):479-496. PMID: 16046146
13. **Napadow V**, Kettner N, Ryan A, Kwong KK, Audette J, Hui KK. Somatosensory cortical plasticity in carpal tunnel syndrome--a cross-sectional fMRI evaluation. *Neuroimage*. 2006 Jun;31(2):520-530. PMID: 16460960. Epub 2006 Feb 03
14. Gilbert RJ, Magnusson LH, **Napadow VJ**, Benner T, Wang R, Wedeen VJ. Mapping complex myoarchitecture in the bovine tongue with diffusion-spectrum magnetic resonance imaging. *Biophys J*. 2006 Aug 1;91(3):1014-1022. PMID: 16679361. PMCID: PMC1563766. Epub 2006 May 05
15. **Napadow V**, Dhond R, Kennedy D, Hui KK, Makris N. Automated brainstem co-registration (ABC) for MRI. *Neuroimage*. 2006 Sep;32(3):1113-1119. PMID: 16839781. Epub 2006 Jul 12
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 Nov;288(11):1173-1182. PMID: 17031810
17. **Napadow V**, Liu J, Li M, Kettner N, Ryan A, Kwong KK, Hui KK, Audette JF. Somatosensory cortical plasticity in carpal tunnel syndrome treated by acupuncture. *Hum Brain Mapp*. 2007 Mar;28(3):159-171. PMID: 16761270. PMCID: PMC6871379
18. **Napadow V**, Kettner N, Liu J, Li M, Kwong KK, Vangel M, Makris N, Audette J, Hui KKS. Hypothalamus and amygdala response to acupuncture stimuli in Carpal Tunnel Syndrome. *Pain*. 2007 Aug;130(3):254-266. PMID: 17240066. PMCID: PMC1997288. <https://doi.org/10.1016/j.pain.2006.12.003>. Epub 2007 Jan 19
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 Oct 31;7:33. PMID: 17973984. PMCID: PMC2200650.
Epub 2007 Oct 31

20. Dhond RP#, Yeh C, Park K, Kettner N, **Napadow V**. Acupuncture modulates resting state connectivity in default and sensorimotor brain networks. *Pain*. 2008 Jun;136(3):407-418. PMID: 18337009. PMCID: PMC2440647. <https://doi.org/10.1016/j.pain.2008.01.011>. Epub 2008 Mar 11
21. 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):679-688. PMID: 18684075. PMCID: PMC2556220. <https://doi.org/10.1089/acm.2007.0824>
22. **Napadow V**, Dhond R, Conti G, Makris N, Brown EN, Barbieri R. Brain correlates of autonomic modulation: combining heart rate variability with fMRI. *Neuroimage*. 2008 Aug 1;42(1):169-177. PMID: 18524629. PMCID: PMC2603289. <https://doi.org/10.1016/j.neuroimage.2008.04.238>. Epub 2008 Apr 30
23. 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. PMCID: PMC2863354
24. **Napadow V**, Dhond R, Park K, Kim J, Makris N, Kwong KK, Harris RE, Purdon PL, Kettner N, Hui KK. Time-variant fMRI activity in the brainstem and higher structures in response to acupuncture. *Neuroimage*. 2009 Aug 1;47(1):289-301. PMID: 19345268. PMCID: PMC2692758. <https://doi.org/10.1016/j.neuroimage.2009.03.060>. Epub 2009 Apr 01
25. **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 Sep;47(3):1055-1065. PMID: 19500677. PMCID: PMC2733781. <https://doi.org/10.1016/j.neuroimage.2009.05.079>. Epub 2009 Jun 13
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 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 Apr 8;1190. PMID: 20379133. PMCID: PMC3149981. <https://doi.org/10.3791/1190>. Epub 2010 Apr 08
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 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 Jan;112(1):150-155. PMID: 21081772. PMCID: PMC3133450. <https://doi.org/10.1213/ANE.0b013e3181fdfac8>. Epub 2010 Nov 16
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trial. *Allergy*. 2012 Apr;67(4):566-573. PMID: 22313287. PMCID: PMC3303983.
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37. As-Sanie S, Harris RE, **Napadow V**, Kim J, Neshewat G, Kairys A, Williams D, Clauw DJ, Schmidt-Wilcke T. Changes in regional gray matter volume in women with chronic pelvic pain: a voxel-based morphometry study. *Pain*. 2012 May;153(5):1006-1014. PMID: 22387096. PMCID: PMC3613137. <https://doi.org/10.1016/j.pain.2012.01.032>. Epub 2012 Mar 02
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Letters to the Editor

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Other non-peer reviewed scholarship

1. Kodituwakku, Kim J, **Napadow V**, Loggia ML, Barbieri R. Point Process Respiratory Sinus Arrhythmia Analysis during Deep Tissue Pain Stimulation. *Comput Cardiol* (2011). Conference Publication.
2. Sclocco R#, Loggia ML, Garcia RG, Edwards RR, Kim J, Cerutti S, Bianchi AM, **Napadow V**, Barbieri R. Nonlinear relationship between perception of deep pain and medial prefrontal cortex response is related to sympathovagal balance. XIII Mediterranean Conference on Medical and Biological Engineering and Computing (2013). Conference Publication.

Thesis:

1. A biomechanical investigation of the structure – function relationships in the human tongue [dissertation]. Cambridge (MA): Massachusetts Institute of Technology; 2001.

*Co-author, # Mentee

Narrative Report

In my career, my main role has been in Investigation, though I have also made significant contributions to Teaching and Educational Activities. My research is aimed at elucidating the neural mechanisms underlying chronic pain and promising non-pharmacological analgesic therapies, such as acupuncture, peripheral nerve neuromodulation, and psychosocial interventions such as cognitive behavioral therapy and mindfulness meditation training. I have been awarded multiple R01 and P01 level grants from NIH and other non-profit and for-profit sponsors. While my efforts are mainly focused on research, significant supporting activities include maintaining a clinical acupuncture service at the Pain Management Center in the Department of Anesthesiology at BWH. In fact, I was the first formally credentialed acupuncturist at BWH and helped develop their credentialing and scope of practice guidelines. Additionally, I have authored patents on transcutaneous vagus nerve stimulation (tVNS), which have led to the licensing of MGB-held patents by Cala Health, Inc., a medical device company commercializing several closed-loop feedback neuromodulatory devices.

Area of Excellence – Investigation

My laboratory is focused on application of structural and functional magnetic resonance imaging (fMRI) to probe brain changes associated with chronic pain. For instance, a publication in *Arthritis and Rheumatology* [30] detailed a potential functional connectivity biomarker for spontaneous clinical pain. This finding has been corroborated in further studies by our group [45, 53, 60, 101] and others around the world. Moreover, our recent study [98], which was featured on the cover of *Pain*, extended this finding by applying machine learning to characterize and predict clinical pain intensity in low back pain patients.

To better understand how chronic pain impacts brain physiology, and how non-pharmacological therapies can effectively and safely induce beneficial neuroplasticity, my laboratory has also pushed

technological and experimental design boundaries in neuroimaging research by incorporating brain imaging outcomes within longitudinal clinical trials. For example, acupuncture is an effective non-pharmacological probe for chronic pain reduction and my Lab has produced the most extensive publication record for acupuncture neuroimaging research in the world, continuing to move this nascent field forward. Included in our many findings, my group has found that acupuncture modulates the pain-associated functional brain connectivity biomarker noted above [35], supporting a central mechanism of action. Our studies were also the first to apply fMRI to assess somatosensory cortex neuroplasticity in carpal tunnel syndrome (CTS), finding more overlapped S1 representations for adjacent, median nerve-innervated fingers [13]. Acupuncture therapy was then found to increase separation in S1 finger representations [17], which was linked with clinical improvements. Following continued NIH R01-funded research, these results were replicated with a much larger longitudinal neuroimaging trial resulting in close to 10 publications, 3 in the high impact factor Neurology journal *Brain* [42, 59,88]. The main longitudinal results demonstrated both functional and microstructural plasticity in S1 and S1-adjacent white matter pathways following acupuncture, and were published in *Brain* in 2017. This study was highlighted by popular press and television coverage, leading to a prestigious, funded competitive Award by the European Society for Integrative Medicine.

Other ongoing projects in my Lab investigate the brain circuitry underlying pathological interoceptive states such as visceral pain, nausea and itch and other non-pharmacological approaches (e.g. neuromodulation, cognitive behavioral therapy, mindfulness meditation, placebo) to ameliorate such states. For example, in 2009 I invented a novel, enhanced form of transcutaneous vagus nerve stimulation (tVNS), called Respiratory-gated Auricular Vagal Afferent Nerve Stimulation (RAVANS), which was subsequently issued a US patent. Ongoing studies of this closed-loop neuromodulatory feedback approach are applying advanced neuroimaging techniques to assess brainstem targeting [86, 102, 116] and peripheral (e.g. heart, gastric) autonomic regulation, as we explore other promising clinical applications.

Teaching and Educational Activities

In addition to lecturing both locally and internationally, I continue to mentor other investigators at our institution. Currently, I am fortunate to be able to mentor multiple post-doctoral research fellows, research assistants, and visiting professors on various neuroimaging projects related to pain and neuromodulation.

Clinical Expertise and Innovation

I have also been engaged in clinical expertise, a significant supporting activity (SSA). After starting in private practice following graduation from the New England School of Acupuncture, I have been leading the acupuncture service at the Pain Management Center in the Department of Anesthesiology at BWH since 2006. I have been able to directly translate findings from my research to my clinic's chronic pain patients via innovative treatment protocols within my scope of practice. Further, numerous clinicians have reported successfully using our published carpal tunnel syndrome protocol in their own clinic. Also, our enhanced approach to transcutaneous vagus nerve stimulation promises to also push clinical treatment forward, once more fully developed through research in conjunction with industry partners and approved by the FDA.

In summary, while my academic focus lies squarely within Investigation and biomedical and human

neuroscience research, I continue to support both clinical and teaching obligations. I have built and direct an internationally renowned pain neuroimaging program at Spaulding Rehabilitation Hospital and the Martinos Center at MGH. My focus on brain-based mechanisms and non-pharmacological therapies for pain foreshadowed the growing interest in this topic by academic and governmental agencies, as society grapples with the chronic pain and opioid epidemics. My research has made seminal contributions in this field and has catalyzed others toward neuroscience-informed solutions for chronic pain.