

**Curriculum Vitae  
Harvard Medical School**

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**Education**

1990	B.A.	Psychology	Luther College (Decorah, Iowa)
1993	M.S.	Psychology/Neuroscience	University of Maryland (College Park)
1997	Ph.D.	Psychology/Neuroscience (Steven E. Brauth, Advisor)	University of Maryland (College Park)

**Faculty Academic Appointments**

1997- 2000	Instructor	Otology and Laryngology	Harvard Medical School
1998-1999	Lecturer	Communication Sciences and Disorders	MGH Institute of Health Professions
1999-2007	Adjunct Assistant Professor (non-voting)	Communication Sciences and Disorders	MGH Institute of Health Professions
2000-2003	Lecturer	Communication Sciences and Disorders	Emerson College
2000-2004	Assistant Professor	Otology and Laryngology	Harvard Medical School
2004-2006	Lecturer (non-voting)	Communication Sciences and Disorders	Boston University
2004-2016	Assistant Professor	Surgery	Harvard Medical School
2006-2011	Faculty Affiliate	Speech and Hearing Bioscience and Technology	Harvard-MIT Division of Health Sciences and Technology
2007-2011	Associate Professor (non-voting)	Communication Sciences and Disorders	MGH Institute of Health Professions
2011-present	Professor (Adjunct, non-voting)	Communication Sciences and Disorders	MGH Institute of Health Professions
2011-present	Faculty Affiliate	Speech and Hearing Bioscience and Technology	Harvard Division of Medical Sciences

2016-present	Associate Professor	Surgery	Harvard Medical School
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**Appointments at Hospitals/Affiliated Institutions**

1997-2004	Research Associate	Otolaryngology	Massachusetts Eye and Ear Infirmary
2004-2016	Assistant Neuroscientist	Surgery – Division of Laryngeal Surgery	Massachusetts General Hospital
2016-present	Associate Neuroscientist	Surgery – Division of Laryngeal Surgery	Massachusetts General Hospital

**Other Professional Positions**

2005-2006	Neuroscientist Consultant/Investigator	CACI, Inc. (for U.S. Defense Department)
2006-2014	Neuroscientist Consultant/Investigator	BAE Systems, Inc.
2015-present	Neuroscientist Consultant/Investigator	Delsys/Altec, Inc.
2017-present	Member, Board of Scientific Advisors	Delsys/Altec, Inc.

**Committee Service**

**Local**

2001-2004	Animal Care and Use Committee	Massachusetts Eye and Ear Infirmary
2003	MEEI Representative for the Public Responsibility in Medicine and Research conference, March 28-30, San Diego, CA	Massachusetts Eye and Ear Infirmary
2013-present	Surgical Research Council	MGH Department of Surgery
2014-present	Co-Chair; Research Faculty and Postdoctoral Fellow Career Development Committee	MGH Department of Surgery
2015-present	Core Curriculum Committee; Speech and Hearing Bioscience and Technology Doctoral Program	Harvard Division of Medical Sciences
2015-present	Admissions Committee; Speech and Hearing Bioscience and Technology Doctoral Program	Harvard Division of Medical Sciences

**Regional**

2008	Search Committee for Assistant Professor in Communication Sciences and Disorders	MGH Institute of Health Professions
2008	Search Committee for Associate Director in Communication Sciences and Disorders	MGH Institute of Health Professions
2008	Simulation Laboratories Planning Committee	MGH Institute of Health Professions

2011-2013	Hearings Committee (disciplinary review)	MGH Institute of Health Professions
2011-2013	Faculty Senate	MGH Institute of Health Professions
2012-2018	Executive Committee for the PhD Program in Rehabilitation Sciences	MGH Institute of Health Professions
2014-2018	Rehabilitation Sciences PhD Candidacy Qualifying Exam Committee	MGH Institute of Health Professions

### **International**

2017	Expert Review Committee	Canada Foundation for Innovation
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### **Professional Societies**

1992-present	Society for Neuroscience	Member
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### **Editorial Activities**

#### **Ad hoc Reviewer**

*Alliance for Engineering in Biology and Medicine*  
*Annals of Otolaryngology, Rhinology and Laryngology*  
*Behavioral and Brain Functions*  
*BioMedical Engineering OnLine*  
*Brain Research Bulletin*  
*Brain Structure and Function*  
*Folia Phoniatrica et Logopaedica*  
*Human Movement Science*  
*IEEE Transactions on Biomedical Engineering*  
*Innovation and Research in BioMedical Engineering*  
*Journal of Biomedical Materials Research*  
*Journal of NeuroEngineering and Rehabilitation*  
*Journal of Veterinary Clinical Practice and Pet Care*  
*Journal of Visualized Experiments*  
*Laryngoscope*  
*Muscle and Nerve*  
*Nature Protocols*  
*Neural Regeneration Research*  
*Otolaryngology – Head and Neck Surgery*  
*PLOS ONE*  
*Speech Communication*  
*Transactions of Biomedical Engineering*

## Honors and Prizes

1993	Individual National Research Service Award	NIH, National Institute on Deafness and Other Communication Disorders (NIDCD)	Project title: Neural Mechanisms of Vocal and Perceptual Learning
1995	Honors Distinction for the PhD Candidacy Comprehensive Exam	University of Maryland, Department of Psychology, Neuroscience and Cognitive Science Program	Awarded when a PhD candidate completes the comprehensive exam in an exemplary manner
1998	Jack Bartlett Award	University of Maryland, Department of Psychology, Neuroscience and Cognitive Science Program	Awarded annually for excellence in dissertation experimental design
2002	Fellow of the 50 <sup>th</sup> Anniversary Program for Scholars in Medicine	Harvard Medical School	Project title: Comparison of Electrical and Magnetic Stimulation of the Vagus Nerve
2004	Faculty Award for Excellence in Teaching	Massachusetts General Hospital Institute of Health Professions Department of Communications Sciences and Disorders	
2008	Best Poster Award (co-author)	American Laryngological Association Meeting, COSM	
2009	Sir Charles Bell Poster Prize (co-author)	XI International Facial Nerve Symposium, Rome, Italy	
2009	Sir Harold Gillies Award (co-author)	American Academy of Facial Plastic and Reconstructive Surgery	Best scientific paper among Fellows
2009	Presidential Award (co-author)	American Society for Neuro Rehabilitation	Best basic science poster
2009	Partners in Excellence Award	MGH-IHP and Partners Healthcare.	In recognition of outstanding performance and commitment to excellence
2010	Broyles-Maloney Award (co-author)	American Broncho-Esophagological Association	For outstanding manuscript, thesis or accomplishments in bronchoesophagology, laryngology or related science
2010	Third Place Poster Award (co-author)	American Laryngological Association Meeting, Combined Otolaryngology Spring Meetings	
2012	Best Basic Science Poster (co-author)	American Academy of Facial Plastic and Reconstructive Surgery	
2017	Broyles-Maloney Award (co-author)	American Broncho-Esophagological Association	For outstanding manuscript, thesis or accomplishments in

bronchoesophagology,  
laryngology or related  
science

2017 Appointed to Board of Delsys Inc., Natick MA  
Scientific Advisors

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

### **Funding Information**

#### **Past**

- 1993-1996 Neural Mechanisms of Vocal Learning  
National Research Service Award: NIMH (MH1047)  
Principal Investigator  
This project examined the neural pathways and peripheral mechanisms and development of vocal production in parrots.
- 1997-2000 Voice Project: Neural Prosthesis Research Center  
W.M. Keck Foundation  
Investigator (Project PI Robert Hillman; Total direct costs \$1,035,000)  
The long-term goal of this project was to provide patients who have lost the ability to produce voice and speech because of laryngeal cancer or trauma with a substantially improved artificial larynx. These improved devices will more closely approximate normal voice and speech production than currently available electrolarynx (EL) devices that suffer from several limitations (e.g., non-human sounding, reduced loudness and intelligibility).
- 1999-2002 Development of an Improved Electrolarynx: Communication System: Subcontract from Boston VA Medical Center  
Veterans Administration: Division of Rehabilitation Research and Development  
Investigator (Site PI Robert Hillman; Total direct costs \$499,500)  
The long-term goal of this project was to provide patients who have lost the ability to produce voice and speech because of laryngeal cancer or trauma with a substantially improved artificial larynx. These improved devices will more closely approximate normal voice and speech production than currently available EL devices that suffer from several limitations (e.g., non-human sounding, reduced loudness and intelligibility).
- 2001-2005 Development of a Portable Voice Monitor with Biofeedback  
NIH-NIDCD/ R21HD41004  
Investigator (PI Robert Hillman; Total direct costs \$616,080)  
This project was aimed at developing an ambulatory monitoring and feedback system for evaluating and treating voice disorders that can: (1) reliably and unobtrusively provide long-term, continuous tracking of important parameters of vocal function, and (2) provide feedback to the user when voice parameters exceed 'safe' limits and/or target phonatory behaviors are not maintained.
- 2001-2011 Voice Restoration Subsequent to Vocal Fold Scarring  
Institute of Laryngology and Voice Restoration  
Investigator (Project PIs Steven Zeitels & Robert Hillman; Total direct costs \$7,500,000)

- This project was aimed at developing and clinically testing new procedures for restoring vocal function to patients who have sustained vocal fold scarring, including the development of a bio-implant.
- 2002-2003 Comparison of Electrical and Magnetic Stimulation of the Vagus Nerve  
Harvard Medical School, Scholars in Medicine Fellow  
Principal Investigator (Total direct and indirect costs \$25,000)  
This project was aimed at validating the use of magnetic stimulation of the vagus nerve as a test of laryngeal innervation status by making direct, intraoperative comparisons of electrical and magnetic stimulation of the vagus and laryngeal motor nerves.
- 2004-2009 Development of Voice Neural Prosthesis Technology  
NIH-NIDCD/ R01DC006449  
Investigator (PI Robert Hillman; Total direct and indirect costs \$1,800,000)  
This project was aimed at developing an improved electrolarynx-based communication system (with a neural interface) that more closely approximates normal voice and speech production for patients who have lost laryngeal function.
- 2005-2008 Sub-Vocal Speech Exploration  
DARPA Contract # 6800-318  
Investigator (PI Geoffrey Meltzner; Costs confidential)  
The goal of this project was to identify the voice- and speech-related information available from face and neck surface electromyographic signals for implementation in an advanced speech recognition system.
- 2008-2010 MUTE: Mouthed-Speech Understanding and Transcription Engine  
DARPA Contract # 4WF-7175  
Investigator (PI Geoffrey Meltzner; Costs confidential)  
The goal of this project was to apply the voice- and speech-related information available from face and neck surface electromyographic signals for implementation in an advanced speech recognition system in anatomically intact individuals and people with a neural-based speech impediment (dysarthria).
- 2010-2011 Development of an Electromyographically Controlled Electrolarynx Voice Prosthesis  
NIH-NIDCD 1R41DC011212 (STTR, Phase I)  
Principal Investigator at MGH (Total direct and indirect costs \$63,961)  
The aim of this project was to produce and test an electrolarynx voice prosthesis that receives an electromyographic signal wirelessly from a neck-placed sensor, providing control signals for voice onset/offset and pitch modulation.
- 2010-2015 Surgical and Rehabilitative Management of Facial Nerve Injury  
NIH-NIDCD 1R01NS071067  
Principal Investigator (Total direct and indirect costs \$1,431,958)  
This project aimed to accelerate and improve facial nerve regeneration using a rodent model, employing computer-assisted, patient-specific sensory and motor rehabilitative therapy following facial nerve injury and repair.
- 2011-2013 Voice Restoration Subsequent to Vocal Fold Scarring  
Piramal Foundation  
Investigator (Project PIs Steven Zeitels and Robert Hillman; Total direct costs \$1,150,000)

This project was aimed at developing and clinically testing new procedures for restoring vocal function to patients who have sustained vocal fold scarring, including the development of a bio-implant.

2013-2014 MUTE-ation: Mouthed-Speech Understanding and Transcription Engine  
DARPA Contract # D13PC00074

Investigator (PI Geoffrey Meltzner; Costs confidential)

The goals of this project were to apply the voice- and speech-related information available from face and neck surface electromyographic (EMG) signals for implementation in an advanced speech recognition system, studying the impact of concurrent behaviors (e.g. walking, running, head turning, etc.) on speech recognition rates, and development of a custom EMG sensor array.

2013-2017 Development of an Electromyographically Controlled Electrolarynx Voice Prosthesis  
NIH-NIDCD R42DC011212-02 (STTR Phase II)

Principal Investigator (Total direct and indirect costs \$871,701)

The goal of this project is to finalize the development of an electrolarynx voice prosthesis that receives a wireless control signal from a neck-placed electromyographic sensor, and to test the system in the clinic and in everyday use by patients who have undergone total laryngectomy.

2017-2018 Exploiting Surface Electromyography and other Unobtrusive Measures for Robust  
Cognitive Strain Monitoring

DARPA ST16C-003 (STTR Phase I Base and Option)

Principal Investigator at MGH (Total direct and indirect cost \$44,795)

## **Current**

2013-2022 Laryngeal Research Program: Laryngeal Paralysis Project  
Voice Health Institute

Principal Investigator for Laryngeal Paralysis Project (Project annual direct cost \$1,200,000)

(Laryngeal Research Program PI is Steven Zeitels)

This is one of four projects in a large research program (similar to an NIH Program Project). The Laryngeal Paralysis Project aims to create an intrinsic/indwelling biocompatible system that reestablishes abductory-adductory (opening and closing) motion to paralyzed vocal cords for respiratory and phonatory (voice) function.

2018-2021 Exploiting Surface Electromyography and other Unobtrusive Measures for Robust  
Cognitive Strain Monitoring

DARPA ST16C-003 (STTR Phase II; 1 year Base and potential 2 year Option periods)

Principal Investigator at MGH (Total direct and indirect cost \$492,637)

## **Current Unfunded Projects**

2014-  
present *Use of an Electrolarynx to Create Tonal Distinctions*

This study explores the use of a modified electrolarynx voice prosthesis to produce tonal distinctions in Mandarin Chinese. Current electrolarynx devices are unable to make tonal distinctions, and this work will provide pilot data for an NIH small business technology transfer (STTR) grant with an electrolarynx manufacturer.

2014-  
present

*Use of Low Level Light Therapy on Paralaryngeal Neck Tissues*

This study tests the effectiveness of red and infrared light wavelengths (using an LED array) on reducing neck/laryngeal discomfort in individuals with muscle tension dysphonia and individuals experiencing vocal fatigue.

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

### **Teaching of Students in Courses**

2005-2008	Anatomy of Speech and Hearing (HST-718)  Doctoral Students in the Speech and Hearing Bioscience and Technology program	Harvard-MIT Health Sciences and Technology Single lecture and lab given annually for 4 years. Student contact per year was 5 hours.
2009-present	Anatomy of Speech and Hearing (HST-718; SHBT-203)  Doctoral Students in the Speech and Hearing Bioscience and Technology program	Harvard-MIT Health Sciences and Technology; Harvard Division of Medical Sciences Course taught 7 times (three instructors). Student contact per year has been approximately 32 hours over a 4-week period.

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

1998-2004	Advanced Basic Sciences Course in Otolaryngology (Neurolaryngology lecture) HMS Residents in Otolaryngology	HMS-Massachusetts Eye and Ear Infirmary 2 hour lecture, once per year for 7 years.
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### **Laboratory and Other Research Supervisory and Training Responsibilities**

1990-1997	Supervision of undergraduate research assistants and undergraduate honors program thesis projects (approximately 4 students annually), University of Maryland, College Park.	6-8 hours per week for 7.5 years.
2000	Otolaryngology Resident research supervisor, HMS-Massachusetts Eye and Ear Infirmary.	1 hour per week for 3 months.
2004-present	Supervision of Laryngeal Surgery Clinical and Research Fellows (1-3 Fellows per year).	2 hours per month, annually.

### **Formally Supervised Trainees**

2004-2009	Cara E. Stepp, Ph.D. from MIT (HST) / Assistant Professor, Department of Speech, Language, and Hearing Sciences, Boston University. Research projects and dissertation supervisor (SHBT Program), resulting in 12 publications as co-authors in leading speech research journals and a Postdoctoral Fellowship at the University of Washington.	
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- 2005-2006 Heather Kubert, M.S. CCC-SLP / Practicing Speech Language Pathologist for Speech and Voice Enterprises, Denver, CO. Supervised her master's research thesis during graduate school at the MGH-IHP in Speech-Language Pathology, resulting in one paper as co-authors.
- 2006-2007 David Lo, M.D. / General Surgery Resident, Duke University Medical Center. Supervised full-time laboratory experience weekly for 16 months at MEEI. Two papers co-authored during mentored period.
- 2008 Rebecca Givens Rolland, M.S., CCC-SLP / Ph.D. Candidate at the Harvard Graduate School of Education. Supervised a 9 month clinical research experience during graduate school at the MGH-IHP in Speech-Language Pathology, resulting in one paper as co-authors.
- 2008-2009 Christopher Smitson M.D. / Internal Medicine Resident, UCSF Department of Medicine. Supervised for full-time laboratory experience weekly for 12 months at MEEI. Four papers co-authored from mentored work.
- 2008-2009 Robin Lindsay M.D. / Assistant Professor of Otolaryngology, MEEI. Supervised laboratory research experience weekly for 12 months during Fellowship in Facial Plastic and Reconstructive Surgery at MEEI. Coached in written skills and experimental design, resulting in 5 papers co-authored from mentored work.
- 2008-2009 Kalpesh T. Vakharia, M.D. / Assistant Professor, Otorhinolaryngology – Head & Neck Surgery, University of Maryland School of Medicine. Supervised two of his HMS Otolaryngology resident research projects across two years at MEEI, guiding writing skills and experimental design, resulting in 4 co-authored papers.
- 2009-2010 Juan Malo M.D. / Surgery Resident at Hospital Universitario del Rio. Supervised full-time laboratory experience weekly for 12 months at MEEI. Four papers co-authored from mentored work.
- 2009-2011 Douglas Henstrom M.D. / Assistant Professor, Director of the Facial Nerve Center within Otolaryngology, Otolaryngology - Head and Neck Surgery, University of Iowa. Supervised laboratory experience weekly for 12 months during Fellowship in Facial Plastic and Reconstructive Surgery at MEEI. Coached in written skills and experimental design, resulting in 2 papers co-authored during mentored period.
- 2009-2013 Julie Weinberg, B.A. / Clinical Research Associate at Massachusetts General Hospital. Supervised full-time laboratory experience weekly for 4 years at MEEI. Coached in written skills and experimental design, resulting in successful abstract acceptance for national presentation, and 7 papers co-authored from mentored work.
- 2010-2011 Sang W. Kim, M.D. / Board-certified head and neck cosmetic and reconstructive surgeon in private practice. Supervised two of his HMS Otolaryngology resident research projects across two years at MEEI, guiding writing skills and experimental design, resulting in 3 co-authored papers.
- 2011-2012 Ingrid Kleiss M.D. / Resident in Otolaryngology, Njemin, The Netherlands. Supervised full-time laboratory experience weekly for 16 months at MEEI. Coached in written skills and experimental design, resulting in 5 papers co-authored from mentored work.
- 2011-2012 Alice Frigerio, M.D., Ph.D. / Instructor in Otology and Laryngology, MEEI, Harvard Medical School. Supervised full-time laboratory experience bi-weekly for 9 months at MEEI. Coached in written skills and experimental design, resulting in three papers co-authored from mentored work.
- 2011-2013 Marc Hohman M.D. / Assistant Professor, Facial Plastic and Reconstructive Surgery, Madigan Army Medical Center, Washington. Supervised laboratory experience weekly for 12 months during Fellowship in Facial Plastic and Reconstructive Surgery at MEEI.

- Coached in experimental design and instrumentation, resulting in 7 papers co-authored during mentored period.
- 2012-2013 Elizabeth Murray, M.S., CCC-SLP / Doctoral candidate, Department of Speech, Language, and Hearing Sciences, Boston University. Supervised her master's research thesis during graduate school at the MGH-IHP in Speech-Language Pathology, resulting in one conference poster and two papers as co-authors from mentored work.
- 2014-2015 Kathleen F. Nagle, Ph.D. CCC-SLP / Assistant Professor, Department of Speech-Language Pathology, School of Health & Medical Sciences, Seton Hall University. Supervised her post-doc position for 18-months, collaborating on NIH-funded research resulting in several conference presentations and manuscripts.
- 2018-present Jonathan Z. Zin, B.S.E, A.L.M., J.D. / Research Fellow at the MGH Center for Laryngeal Surgery and Voice Rehabilitation. Supervised his post-doc position for a planned period of 2018-2020, collaborating on DARPA-funded (STTR Phase II) research of surface electromyography and other unobtrusive measures for robust cognitive strain monitoring.

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

No presentations listed below were sponsored by outside entities

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|------|---|--|
| 2005 | Innovative Future Technologies<br>Laryngeal Surgery and Voice Rehabilitation (Harvard Medical School)   | 1 lecture (1.5 hours)<br>Cambridge, MA |
| 2006 | Use of Photoangiolytic Lasers in the Chick Chorioallantoic Membrane (hands-on lab)<br>Office-Based Laser Laryngeal Surgery (Harvard Medical School)   | 1 lab (2.5 hours)<br>Boston, MA        |
| 2007 | Cricoarytenoid Joint Anatomy, Arytenoid Medialization Procedures, Augmentation of the Paraglottic Space, Cricoarytenoid Subluxation (hands-on labs)<br>Laryngeal Framework Voice Surgery (Harvard Medical School) | 2 labs (3.5 hours)<br>Boston, MA       |

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

### Invited Presentations and Courses

No presentations listed below were sponsored by outside entities

#### **Regional**

- 1998-present Course: Neuroanatomy and Neurophysiology (CD-722). One, 3-hour session per week for 15 weeks taught once per year to Masters of Science students in Speech-Language Pathology.  
MGH Institute of Health Professions
- 1999 Invited Lecture: An EMG-EL Interface System Provides Hands-Free Control of Prosthetic Voice Pitch, Onset and Offset.  
MIT Speech Communication Group, Cambridge, MA.

- 2000-2003 Course: Neuroanatomy and Neurophysiology (CD-683). Taught 4 times to graduate students in Speech-Language Pathology. One, 3-hour session per week for 15 weeks.  
Emerson College
- 2001-2013 Course: Anatomy and Physiology (CD-552). Taught 13 times to graduate students in Speech-Language Pathology. One, 4-hour session per week for 10 weeks.  
MGH Institute of Health Professions
- 2003-2005 Course: Alaryngeal/Laryngectomy Seminar (CD-834). Single lecture given annually for 3 years to graduate students in Speech-Language Pathology. Student contact per year was 2 hours.  
MGH Institute of Health Professions
- 2004-2006 Course: Anatomy and Physiology (CD-522). Taught 3 times to graduate students in Speech-Language Pathology. One, 4-hour session per week for 10 weeks.  
Boston University
- 2007 Invited Lecture: New Innovations in Rehabilitation of the Laryngectomy Patient.  
Surgical Grand Rounds, VA Boston Healthcare System, Jamaica Plain, MA.
- 2007-2013 Course: Physiology, Acoustics & Perception of Speech (CD-721). Taught 7 times times to graduate students in Speech-Language Pathology. One, 3-hour session per week for 15 weeks.  
MGH Institute of Health Professions
- 2008 Invited Judge: Imaging, Acoustics and Optics panel for the annual Harvard/MIT HST Research Forum.
- 2009 Course: Neuroscience IV (PT-724). Single lecture, 2 hours, given to graduate students in Physical Therapy.  
MGH Institute of Health Professions
- 2011-present Course: Advanced Seminar in Voice Disorders (CD-861). One, 4-hour lab taught once per year to graduate students in Speech Language Pathology.  
MGH Institute of Health Professions
- 2013-15 Course: Interdisciplinary Seminal in Rehabilitation Science (HRS-960). One, 1-hour lecture given annually to Doctoral students in Rehabilitation Sciences.  
MGH Institute of Health Professions
- 2014 Invited Lecture: Development of an Electrolarynx Voice Prosthesis Controlled by Neck Muscle EMG.  
Grand Rounds, Spalding Rehabilitation Hospital, Boston, MA.
- 2015 Course: Adult Neurogenic Disorders (CD-857). Single lecture, 2 hours, given to graduate students in Speech Language Pathology.  
MGH Institute of Health Professions

### **National**

- 2002 Invited Lecture: Voice Replacement: Laryngeal Prosthesis.  
NIH Thirty-Third Neural Prosthesis Workshop in Bethesda, Maryland.
- 2003 Invited Lecture: Development of Voice Neural Prosthesis Technology.  
Grand Rounds, Departments of Otolaryngology - Head & Neck Surgery, Johns Hopkins School of Medicine.
- 2006 Invited Lecture: Development of Voice Neural Prosthesis Technology.  
Center for the Neural Basis of Cognition and the IGERT on Assistive Technology at Carnegie Mellon University, Pittsburgh, PA.

- 2006 Invited Lecture: Using the Recurrent Laryngeal Nerve to Control a Hands-Free Voice Prosthesis after Total Laryngectomy.  
Communications Sciences and Disorders Doctoral Program, University of Pittsburgh, PA.
- 2011 Live Hardware Demonstration: Silent Speech Recognition System.  
United States Special Operations Command NPS TNT 11-2 conference at the Avon Park Air Force Base, Avon FL, February 22<sup>nd</sup> 2011.
- 2011 Live Hardware Demonstration: Non-Acoustic, Noise-Robust, Silent Speech Recognition and Communication.  
United States Special Operations Command NPS TNT 11-4 conference at Camp Roberts, CA, August 8-10<sup>th</sup> 2011.
- 2011 Co-Chair of Conference Session: Assistive Technology for Human Communication.  
IEEE Engineering in Medicine and Biology Society, Boston, MA.
- 2013 Invited Panelist: Bionic and Bio-Artificial Approaches to Facial Reanimation: The Future of Facial Nerve Management.  
American Academy of Facial Plastic and Reconstructive Surgery, Combined Otolaryngology Spring Meeting, Orlando FL.
- 2013 Platform Presentation: Rat whisker movement after facial nerve denervation: Evidence for autonomic contraction of striated muscle.  
American Academy of Facial Plastic and Reconstructive Surgery, Combined Otolaryngology Spring Meeting, Orlando, FL.
- 2015 Invited Lecture and Panelist: Current Issues & Advances in Post-laryngectomy Voice & Speech Rehabilitation.  
American Speech-Language-Hearing Association Convention, Denver, CO.
- 2015 Invited Lecture: Skin Surface Electromyography of Neck and Face Muscles for Alaryngeal Speech Applications.  
Neurology Study Group of the American Laryngological Association, Combined Otolaryngology Spring Meeting, Boston, MA.
- 2016 Platform Presentation: Identification of paralyzed laryngeal muscles using low-frequency transcutaneous stimulation.  
American Laryngological Association, Combined Otolaryngology Spring Meeting, Chicago, IL.
- 2018 Invited Lecture: Use of Electromyography in Laryngectomy Speech Rehabilitation.  
Program in Neuroscience & Cognitive Sciences (NACS Seminar Series), University of Maryland, College Park, MD.

### **International**

- 2011 Platform Presentation: A system for delivering mechanical stimulation to the rat whisker pad during facial nerve regeneration.  
5th International IEEE EMBS Conference on Neural Engineering, Cancun, Mexico.

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

Voice Prosthesis with Neural Interface      U.S. Patent Application US20050281412 A1 (apparatus and method) published on 12/22/2005.

I was part of the team that developed the first-ever neural prosthesis for voice (using Keck Foundation, VA, and NIH funding). This device was designed to more closely approximate normal voice and speech production for laryngectomy

patients. The latest version of the device senses and processes neck surface electromyographic (EMG) signals from a wireless sensor to turn the artificial larynx on and off and to modulate its pitch, making the device potentially hands-free (if braced to the neck) and more human-sounding than previous devices. I am Principal Investigator of an NIDCD STTR Phase I & II effort to finalize the testing and development of this system for widespread availability as a commercial device.

**Aerodynamic Vocal Fold Driver** U.S. Patent Applications US7811235 B2 (apparatus) and US8475390 B2 (method) published on 10/12/2010 and 07/02/2013, respectively.

I am the first of two inventors of a system for phonating individual vocal folds in phonosurgical patients under general anesthesia. We call the tool and associated apparatus the aerodynamic vocal fold driver (AVFD) and have published results from excised larynx testing which indicate that it will enable surgeons to test the mechanical properties of vocal folds intraoperatively. Use of AVFD could therefore enhance surgical decision-making, such as guiding scar treatment or the injection volume of hydrogels intended to enhance vocal fold pliability.

**Facial Movement and Expression Detection and Stimulation** U.S. Patent Application WO2014110575 (apparatus and method) published on 7/17/2014.

I am first of two inventors of a system for detecting and stimulating facial movements. Unilateral facial nerve dysfunction affects 0.3% of the population per year in the United States and Western Europe. Many of the affected would benefit from a system that detects healthy movement on one side of the face and uses that information to electrically stimulate symmetrical movement on the paretic (nerve-injured) side. My colleagues and I have (1) studied observer response to different degrees of facial movement asymmetry to define system requirements for restoring naturalistic movement, (2) created a novel apparatus for non-invasive detection of blinking and other facial movements, and (3) tested blink stimulability and acceptability in a large group of individuals with unilateral facial nerve palsy. Our findings indicate that slightly more than half of individuals with acute, complete unilateral facial palsy can achieve full blink restoration when using our system.

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

### **Activities**

2007

Invited Interview: Voice Disorders.

Television show *Healthline* on the Retirement Living Channel - a thirty minute program focusing on health issues of particular concern to the elderly.

## **Report of Scholarship**

### **Peer-reviewed scholarship in print or other media**

#### **Research investigations**

1. **Heaton JT**, Brauth SE. Effects of yohimbine as a reversing agent for ketamine-xylazine anesthesia in budgerigars. *Lab Anim Sci.* 1992 Feb;42(1):54-6.
2. Brauth SE, **Heaton JT**, Durand SE, Liang W, Hall WS. Functional anatomy of forebrain auditory pathways in the budgerigar (*Melopsittacus undulatus*). *Brain Behav Evol.* 1994;44(4-5):210-33.
3. Hall WS, Brauth SE, **Heaton JT**. Comparison of the effects of lesions in nucleus basalis and field 'L' on vocal learning and performance in the budgerigar (*Melopsittacus undulatus*). *Brain Behav Evol.* 1994;44(3):133-48.
4. **Heaton JT**, Farabaugh SM, Brauth SE. Effect of syringeal denervation in the budgerigar (*Melopsittacus undulatus*): the role of the syrinx in call production. *Neurobiol Learn Mem.* 1995 Jul;64(1):68-82.
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#### **Proceedings of Meetings**

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## Reviews, chapters, monographs and editorials

1. Hillman RE, Walsh M, **Heaton JT**. (2005). Laryngectomy speech rehabilitation: A review of outcomes, *Contemporary Considerations in the Treatment and Rehabilitation of Head and Neck Cancer*, (P. Doyle: Ed.) pp 75-90. ProEd: Austin, TX.
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### Thesis

**Heaton JT**. The role of descending forebrain projections and auditory feedback in budgerigar vocal development [Dissertation]. College Park, Maryland, University of Maryland, 1997. 217 pp.

### Abstracts, Poster Presentations and Exhibits Presented at Professional Meetings

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2. Guo L, Nagle K, **Heaton JT**. Use of an electrolarynx to create tonal distinctions. Poster presentation for the Annual Convention of the American Speech-Language-Hearing Association. 2014. Orlando, FL.
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5. **Heaton JT**, Murray E. Preliminary testing of a wireless electromyographically controlled electrolarynx voice prosthesis. Poster D042 at the American Laryngological Association, Combined Otolaryngology Spring Meeting, April 22-26<sup>th</sup>, 2015, Boston, MA.
6. **Heaton JT**, Kobler, JB, Hillman, RE, Zeitels, SM. Identification of paralyzed laryngeal muscles using low-frequency transcutaneous stimulation. Abstract at the American Laryngological Association, Combined Otolaryngology Spring Meeting, May 18-19<sup>th</sup>, 2016, Chicago, IL.
7. Nagle K, **Heaton JT**. Comparison of thumb-pressure vs. electromyographic modes of frequency modulation for electrolaryngeal speech. Poster at the Acoustical Society meeting, June 28, 2017, Boston, MA.

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10. **Heaton JT**, Kobler, JB, Ottensmeyer, MP, Petrillo, RH, Tynan, MA, Hillman, RE, Zeitels, SM. Intraoperative phonation testing of individual vocal folds in the dog larynx. Abstract at the American Bronchoesophagological Association, Combined Otolaryngology Spring Meeting, May 1-3, 2019, Austin, TX.

## Narrative Report

**Introduction:** I am a neuroscientist investigator who specializes in the field of communication science. Currently, I am affiliated with the Center for Laryngeal Surgery and Voice Rehabilitation at Massachusetts General Hospital (MGH Voice Center). I hold faculty appointments as an Associate Professor of Surgery at Harvard Medical School and an Adjunct Professor of Communication Sciences and Disorders at the MGH Institute of Health Professions (MGH-IHP). In these positions, I divide the majority of my time between research and teaching. In my role as a research scientist, I work closely with an interdisciplinary team of physicians, clinicians, and engineers. Our team is investigating cutting-edge approaches to restore communication abilities in individuals who have lost normal function owing to trauma or disease. As an educator, I serve as a research advisor and mentor to graduate students in masters and doctorate-level programs in communication science, as well as medical fellows and residents receiving their training through MGH and other Harvard-affiliated hospitals.

**Area of Expertise:** My research on the neural control of communication has evolved over time and covers a broad range of activities, from groundbreaking work on the identification of forebrain neural pathways that support vocal production in a vocal-learning animal model (the parrot), to motor innervation of the vocal and articulatory apparatus in animal models and human participants. Most recently, my work has focused on the development of computer-neuromotor interfaces that support communication through (1) automatic electromyographic (EMG) control of a voice prosthesis, (2) neck and face surface EMG signal analysis for automatic speech recognition, and (3) functional electrical stimulation of the face and larynx muscles to restore movement after motor nerve impairment. I have been funded as a Principal Investigator on multiple NIH research grants, including an R01 from the National Institute of Neurological Disorders and Stroke (NINDS) to investigate strategies for improving facial nerve regeneration, and a small business technology transfer grant (STTR Phase I & II) from the National Institute on Deafness and Other Communication Disorders (NIDCD) to develop a voice neural prosthesis that can be controlled by neck muscle signals. Over the past 10 years I have also served as a neuroscientist consultant/investigator for the Defense Advanced Research Projects Agency (DARPA) on an initiative to achieve automatic speech recognition from neck and face muscle signals (rather than acoustics), and I continue this work with multiple industrial and academic partners in the Boston area under NIH small business innovation research (SBIR) funding.

Each year thousands of individuals lose the use of their larynx from disease or injury and consequently must use an artificial voice source in order to speak. My colleagues and I have demonstrated the feasibility of using neck surface EMG signals as an intuitive control source for the onset/offset and pitch modulation of an electrolarynx (EL) voice prosthesis, and I have secured NIH funding to develop a commercial version of an EMG-controlled electrolarynx. I am also investigating the use of face and neck surface EMG signals for speech encoding in both vocally normal and vocally compromised individuals to be implemented on a smartphone for real-time automatic speech recognition (for speech synthesis, speech-to-text, etc.). Most recently, I have investigated approaches for stimulating the muscles of the face and larynx to restore function in individuals who have reduced or absent mobility in muscles innervated by the facial and laryngeal nerves. This work has included animal models of nerve regeneration and neuromuscular stimulation, as well as volitional movement detection and stimulation in nerve-lesioned patients (e.g. individuals with Bell's palsy). My ultimate goal is to develop a closed-loop neural prosthesis to restore natural movement in the face and larynx, and I have a patent pending for a facial reanimation system using non-invasive (external) hardware components to detect facial movement and stimulate muscle transcutaneously to restore lost movements.

**Teaching:** Throughout my career, I have maintained an active role in education. Since 1998, I have taught two or three communication-science-related courses yearly at leading Boston area postgraduate institutions, including Harvard/MIT (Health Sciences and Technology program), Boston University, Emerson College, and the MGH Institute of Health Professions. Specifically, I have taught Neuroanatomy and Neurophysiology (18 years), Anatomy and Physiology (13 years), Physiology, Acoustics and Perception of Speech (8 years), in addition to conducting advanced laryngeal anatomy and physiology labs for additional Voice Disorders courses (11 years). For 7 years, I have taught Anatomy and Speech Hearing as part of the core curriculum for Harvard's Speech and Hearing Bioscience and Technology (SHBT) program. This course is a combination of classroom lectures and hands-on intensive cadaver dissection, focusing on structures of the head, neck, and thorax related to communication. Although I primarily teach required courses, covering material that is unfamiliar and therefore challenging for many graduate students, the feedback I have received has consistently validated my efforts to provide a positive and effective educational experience while maintaining high standards. In addition to teaching, I also serve as a research mentor for doctoral candidate graduate students in the SHBT program, fellows and post-doctoral staff in laryngology at the MGH Voice Center, and fellows and residents in otolaryngology at the Massachusetts Eye and Ear Infirmary (MEEI).

**Summary:** I feel extremely fortunate to have spent my post-graduate career in hospital/clinical settings at MEEI and MGH, where I have been able to contribute my basic science training to research aimed at improving therapies for individuals and families seeking a better quality of life and improved communication. My work has involved the development of novel surgical and research instruments, bench-top testing of excised tissues, mathematical modeling of physiological processes, development of animal models for human disease states, and investigations of laryngeal physiology and neuromuscular control of communication in human research participants. In addition to publishing my findings in top-tier journals and securing funding to expand these efforts, I incorporate this work into the courses I teach, with the goal of providing accurate, engaging science to the next generation of professionals working in the field of communication science. The interaction between instruction and research has enriched both endeavors, and has advanced my contributions to communication science and the education of hundreds of researchers and healthcare professionals.