JEFFERY T. LICHTENHAN, PhD, CCC-A

CURRICULUM VITAE AND RESEARCH STATEMENT

EMAIL ADDRESSES

jlichtenhan@usf.edu

PHYSICAL and MAILING ADDRESS

Jeffery T. Lichtenhan
Global Center for Hearing and Speech Research
3802 Spectrum Blvd. Suite 210c
Tampa, FL 33612

EDUCATION

Undergraduate: The University of Kansas, BGS, Speech-Language and Hearing, 2000

Graduate: The University of Kansas Medical Center, MA, Audiology, 2002

Postgraduate: The University of Kansas, PhD, Speech-Language and Hearing Science, 2006

Postdoctoral Fellowship: Harvard Medical School, Eaton-Peabody Laboratories, 2007 – 2012

POSITIONS

Academic Positions

Research Instructor in Otolaryngology
Washington University in St. Louis, January 2012 – October 2012

Assistant Professor of Otolaryngology, Research Track (i.e., Non-Tenure Track)
Washington University in St. Louis, October 2012 – October 2017

Assistant Professor of Otolaryngology, Investigator Track (i.e., Tenure Track)
Washington University in St. Louis, October 2017 – April 2021

Assistant Professor of Otolaryngology (Tenure Track)
University of South Florida, December 2022 – Present

Adjunct, non-Compensated Academic Positions

Assistant Professor of Audiology and Communication Sciences
Washington University in St. Louis, October 2017 – April 2021

Collaborative Assistant Professor of Otolaryngology
University of South Florida, June 2021 – December 2022

Courtesy Assistant Professor of Communication Sciences and Disorders
University of South Florida, April 2022 – Present

Industry Position

Principal Scientist of Translational Research,
Frequency Therapeutics, April 4, 2021 – April 8, 2022

CLINICAL AUDIOLOGY

Clinical Audiology Certification

Certificate of Clinical Competence in Audiology (CCC-A)
American Speech-Language-Hearing Association
Account No. 12057101
Expiration Date: December 31, 2024

Clinical Audiology Licensure

Missouri Board of Registration for the Healing Arts (Provisional License for Clinical Fellowship Year)
License number: 2005002893
Issue Date: February 4, 2005
Expiration Date: February 4, 2006

Missouri Board of Registration for the Healing Arts (Full License)
License number: 2005037433
Issue Date: November 17, 2005
Expiration Date: January 31, 2009

Kansas Department for Aging and Disability Services (Full License)
License number: 2121
Issue Date: May 22, 2006
Expiration Date: October 31, 2009

Florida Board of Speech Pathology and Audiology
License number: AY 2571
Issue Date: May 5, 2022
Expiration Date: December 31, 2024

Clinical Audiology Employment

Clinical Fellowship Year, Kansas City Veterans Affairs Hospital, 2004 – 2005

Fee Basis Audiologist, Kansas City Veterans Affairs Hospital, 2005 – 2007

Audiologist, Associated Audiologists, Inc., Prairie Village, Kansas 2006 – 2007

Audiologist, University of South Florida Morsani College of Medicine, Department of Otolaryngology, Otology Division, 2023 – present

Clinical Audiology Volunteerism

Volunteer Audiologist, Heath Partnership Clinic of Johnson County, Kansas. 2001

HONORS AND AWARDS

Graduated with Departmental Honors, University of Kansas, 2000

C.P. Goetzinger Award for Outstanding Student in Audiology, University of Kansas Intercampus Program in Communicative Disorders, 2002

First place, Category: School of Allied Health, Student Research Forum, University of Kansas Medical Center (♣), 2005

First place, Category: Neuroscience, Student Research Forum, University of Kansas Medical Center (♣), 2005

> ♣ A podium presentation: "The influence of noise induced hearing loss on an analytic treatment of the compound action potential"

Debra L. Park Award as the Outstanding Student in Hearing Science, University of Kansas Intercampus Program in Communicative Disorders. 2006

Early Career Achievement in Health Professions Alumnus, School of Health Professions, University of Kansas Medical Center, 2020

RESEARCH SUPPORT

Federal Research Support

NRSA F32 NIH/NIDCD
Role: Principal investigator
Title: "Relating single-fiber tuning and delays to stimulus-frequency emissions"
Duration: 2009 – 2011
Amount: $150,000

R03 NIH/NIDCD
Role: Principal investigator
Title: "Objective measure of low-frequency inner ear function"
Duration: 2012 – 2015
Amount: $300,000

R01 NIH/NIDCD
Role: Principal investigator
Title: "Origins of physiological measurements from the ear"

Duration: 2016 – 2020
Amount: $1.6 million

Non-Federal Research Support

Biomedical Research Training Grant. The University of Kansas Medical Center
Role: Principal investigator
Title: "Estimation of the summed post-stimulus time histogram and single fiber action potential using an analytic treatment of the human compound action potential
Duration: 2005 – 2006
Amount: $22,000

Biomedical Research Training Grant. The University of Kansas Medical Center
Role: Principal investigator
Title: "Estimates of the single fiber action potential and probability of neuronal discharge obtained from human compound action potentials"
Duration: 2006 – 2007
Amount: $22,000

American Otologic Society Research Grant
Role: Principal investigator
Title: "Objective measure of low-frequency auditory thresholds: A translational study
Duration: 2012 – 2013
Amount: $51,673

McDonnell Center for Systems Neuroscience Small Grant
Role: Principal investigator
Title: "Electrophysiologic thresholds, behavioral thresholds, and olivocochlear efferent effects measured in human ears with a new technique"
Duration: 2012 – 2014
Amount: $80,000

Research Travel Funding

The University of Kansas Medical Center
Graduate School Travel Grant
Provided half of the expenses to participate in the 2003 MidWinter Meeting of the Association for Research in Otolaryngology

National Institutes of Health and the American Auditory Society
Mentored Doctoral Student Research Poster Session Grant
Provided expenses to participate in the 2007 AAS meeting

American Academy of Audiology Foundation

Audiologist Travel Award
Provided $500 to attend the 2012 MidWinter Meeting of the Association for Research in Otolaryngology

American Speech-Language-Hearing Association
Provided expenses to participate in the 2012 10th Annual Lessons for Success Conference

Conference Support

The Midwest Auditory Research Conference (MARC) held concurrently with Midwest Auditory Neuroscience Symposium (MANS) in St. Louis Missouri. July 17-19, 2014)

Barnes-Jewish Hospital Foundation Project Award Grant. Provided $10,000

Association for Research in Otolaryngology Small Grant Support. Provided $1,000

Additional support provided by industry donations: $12,950

CONSULTING

Frequency Therapeutics: 2016 – 2017

The Implementation Group: 2022

Pontifax: 2022

Cowen, Inc.: 2022

Pipeline Therapeutics: 2022

Otonomy: 2022

Decibel Therapeutics: 2022

Gateway Biotechnology, Inc.: 2022

BOARD OF DIRECTOR POSITION

University of Kansas Health Professions Alumni Association Board

At-large, two-year term, 2024-2025

PROFESSIONAL SOCIETIES AND ORGANIZATIONS

Acoustical Society of America, Member since 1999

American Speech-Language Hearing Association, Member since 1999

American Academy of Audiology, Member since 2003

Association for Research in Otolaryngology, Member since 2003

American Auditory Society, Member since 2006

EDITORIAL RESPONSIBILITIES

Section Editor, Auditory Physiology and Pathophysiology

Journal of the American Academy of Audiology, 2024 – Present

Assistant Editor

Journal of the American Academy of Audiology, 2006 – 2023

Editorial Board Memberships

American Journal of Audiology, 2020 – 2023

Guest Associate Editor

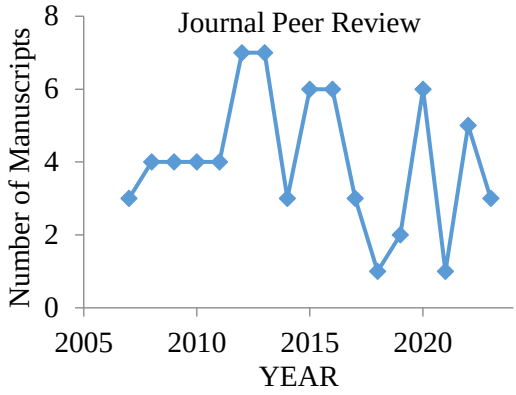
Guest Associate Editor, *Frontiers in Neuroscience*, Research Topic "New Advances in Electrocochleography for Clinical and Basic Investigation", July 2016 – July 2017. Included a total of 24 peer-reviewed publications.

Guest Associate Editor, *Frontiers in Neuroscience*, Research Topic "New Advances in Electrocochleography for Clinical and Basic Investigation, **Volume II**", December 2021 – 2022.

PEER REVIEW RESPONSIBILITIES

Journal Peer Review

American Journal of Audiology
Communications Biology - Nature
Ear & Hearing
Frontiers in Systems Neuroscience
Hearing Research
International Journal of Audiology
Journal of the American Academy of Audiology
Journal of the Acoustical Society of America
Journal of the Association for Research in Otolaryngology
Journal of Neurophysiology
Neuroscience Letters
Perspectives on Hearing and Hearing Disorders: Research and Diagnostics (American Speech-Language-Hearing Special Interest Group Six)
PLOS One
Transactions on Neural Systems & Rehabilitation Engineering



Grant Peer Review

Hearing Health Foundation, Emerging Research Grants Cycle. Primary, secondary, or tertiary reviewer for:

2016: 1 application

Grant Review and Reviewer Training, American Speech-Language Hearing Association. Primary, secondary, or tertiary reviewer for:

2016: 4 applications

Czech Science Foundation. Primary, secondary, or tertiary reviewer for:

2022: 1 application

Department of Defense, Congressionally Directed Medical Research Programs, Defense Medical Research and Development Program. Primary, secondary, or tertiary reviewer for:

2017: 5 applications
2020: 6 applications
2023: 4 applications

Auditory System Study Section (AUD), National Institutes of Health

2024: 7 applications

TRAINEE REVIEW RESPONSIBILITIES

Trainee Grant Review

American Speech-Language Hearing Association's Students Preparing for Academic-Research Careers (SPARC) Award program. Reviewed and scored submissions for:

2013: 3 applications

Trainee Travel Award Review

Travel Awards Committee for the Association for Research in Otolaryngology MidWinter Meeting. 2017 – 2019. Reviewed and scored submissions for:

2017: 47 applications
2018: 49 applications

2019: 45 applications

American Speech-Language Hearing Association Audiology/Hearing Science. Research Travel Award (ARTA). Reviewed and scored submissions for:

2022: 4 applications
2023: 9 applications

Trainee Conference Abstract Review

American Academy of Audiology Student Research Forum AudiologyNOW! 2013.Reviewed, scored, and ranked abstracts for:

2012: 33 applications

American Academy of Audiology Research Podiums and Student Research Forum Subcommittee. 7/1/2022–4/30/2023. Reviewed and scored submissions for:

2022: 8 applications
2023: To be determined

American Academy of Audiology Research, Clinical, and Teaching Posters Subcommittee. 8/1/2022–4/30/2023. Reviewed and scored 26 applications:

2022: 26 applications
2023: To be determined

CONFERENCE ORGANIZATION RESPONSIBILITIES

Local Conference Organization

Co-organizer, Midwest Auditory Research Conference (MARC) Inaugural meeting, Omaha, Nebraska. 2005

Organizer and Host, the Midwest Auditory Research Conference (MARC) held concurrently with Midwest Auditory Neuroscience Symposium (MANS) in St. Louis Missouri. July 17-19, 2014

International Meeting Organization

Program Organizing Committee for the Association for Research in Otolaryngology MidWinter Meeting. 2013 – 2016. Reviewed abstracts and organized them into sessions for:

2013: 101 applications
2014: 101 applications
2015: 137 applications

Conference Service

Publication Committee for the Association for Research in Otolaryngology MidWinter Meeting. spARO Representative. 2012

Accessibility and Accommodations Committee for the Association for Research in Otolaryngology MidWinter Meeting. 2023

Moderator, Podium Session 17: *New Frontiers in Auditory Research: Exploring Middle Ear Dynamics and Tinnitus Pathophysiology* at the Association for Research in Otolaryngology MidWinter Meeting. 2024

8 podium presentations

UNIVERSITY / DEPARTMENTAL APPOINTMENTS AND COMMITTEES

University Appointments

Member, Division of Biology and Biomedical Sciences in the Neurosciences Program at Washington University School of Medicine in St. Louis. 2017 – 2021

Representative for the Department of Otolaryngology, Departmental Election of Faculty Council Representatives, University of South Florida, Morsani College of Medicine. July 1, 2023 – present

Departmental Committees

Clinical Neurotology Candidate Search Committee. Department of Otolaryngology, Washington University School of Medicine in St. Louis. 2015 - 2016

Basic Science Investigators Search Committee. Department of Otolaryngology Washington University School of Medicine in St. Louis. 2016 - 2017

Departmental Appointments

Co-Organizer, Auditory Physics Group Journal Club, the Eaton-Peabody Laboratory at the Massachusetts Eye & Ear Infirmary, Department of Otolaryngology, Harvard Medical School. 2007 – 2010

Organizer, Mechanics of Hearing Journal Club, the Eaton-Peabody Laboratory at the Massachusetts Eye & Ear Infirmary, Department of Otolaryngology, Harvard Medical School. 2007 – 2011

Organizer, Auditory & Vestibular Neuroscience (AuVeN, pronounced “oven”) Discussion Group and Journal Club, Department of Otolaryngology, Washington University School of Medicine in St. Louis. 2013 – 2014

Organizer, Department of Otolaryngology Research Seminar, Washington University School of Medicine in St. Louis. 2013 – 2020

Thesis Committees

AuD Thesis Committee Member for *Uzma S. Akhtar (Wilson)*, Missouri State University “Accuracy of tone-burst ABR & 40-Hz automated and sinusoidal ASSR thresholds in normal-hearing adults using Kalman-weighted filtering” 2014

AuD Capstone Project Reader for *Kathryn Donovan*, Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis, “Changes of cochlear function during cochlear fluids manipulations” 2015

AuD Project Committee Member for *Kaitlyn Kennedy*, Missouri State University "The spatial origin of compound action potentials varies across ears" 2015

AuD Thesis Committee Member for *Alana E. Kennedy*, Missouri State University "The Effect of Rate on Tone Burst Extratympanic Electrocochleography in Adults with Normal Hearing" 2017

AuD Capstone Project Advisor for *Rebecca Howard,* Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis, "Auditory training strengthens the medial olivocochlear reflex in ears with Hidden Hearing Loss" 2017

AuD Capstone Project Advisor for *Hannah R. Burrick* Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis, "The Influence of Circadian Rhythm of the Medial Olivocochlear Reflex" 2019

AuD Thesis Committee Member for *Kathryn A. Vlietstra*, Missouri State University "An Investigation of Increased Reliability and Decreased Test Time using Multiple Frequency Modulated Distortion Product Otoacoustic Emissions in Young Children with Normal Hearing" 2021

CLASSROOM TEACHING RESPONSIBILITIES

Graduate Teaching Assistant: Auditory Evoked Potentials, Anatomy and Physiology of the Auditory System, and Psychoacoustics

Department of Speech-Language-Hearing, University of Kansas:
Fall Semester 2001 – Spring Semester 2002

Personal Tutor, PRVM 806: Regression Analysis

Department of Preventative Medicine, University of Kansas Medical Center:
Fall Semester 2005

Instructor, AUD 697: Introduction to Audiology

Department of Hearing and Speech, University of Kansas Medical Center:
Summer Semesters 2002, 2004 & 2005

Co-Instructor, PACS 551 Research Seminar

Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis:
Spring Semester 2016, hosted four sessions

Co-Lecturer, Hearing Loss Minicourse

Division of Biology and Biomedical Sciences, the Lucille P. Markey Special Emphasis Pathway in Human Pathobiology, Washington University School of Medicine in St. Louis:
Fall Semester 2017, delivered 1 lecture for this minicourse

Guest Lecturer, PACS 505 Auditory Neuroscience

Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis:
Spring Semester 2016 & 2017, instructed five lectures
Spring Semester 2015, instructed four lectures
Spring Semester 2014, instructed three lectures

Instructor, PACS 551 Research Seminar
Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis:
Spring Semesters 2017 – 2021

Co-Lecturer, Otolaryngology Resident Lecture Series
University of South Florida Morsani College of Medicine:
Fall Semesters 2023, lead instruction on "Immittance and otoacoustic emission measurements" as a part of the overall lecture "Audiology for the Otolaryngologist: How to Interpret hearing evaluations and Audiogram Cases"

MENTORSHIP

Laboratory Mentorship

6/13 – 9/15: Uzma S. Akhtar (Wilson), AuD student Missouri State University and Research Assistant at Washington University School of Medicine in St. Louis
• Uzma received a 2014 Audiologist Travel Award for the *Association for Research in Otolaryngology MidWinter Meeting*
• Uzma contributed to four publications from our laboratory
• Dr. Akhatar went on to earn a PhD at Northwestern University
• Dr. Akhatar is now an Assistant Professor at Rush University

8/13 – 11/13: Kaitlyn Toner (Wenrich), AuD student Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis
• Dr. Toner's work in the lab contributed to one publication
• Dr. Toner worked as a Clinical Territory Manager at Cochlear Corporation

8/13 – 3/14: Farah Dubaybo, AuD student Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis
• Dr. Dubaybo's work in the lab contributed to one publication
• Dr. Dubaybo is now a Clinical Specialist at Advanced Bionics

6/14 – 9/15: Kate M. Sadler, M.Ed., Special School District of St. Louis and Research Volunteer at Washington University School of Medicine in St. Louis
• Kate went on to earn PhD in Special Education at the University of Missouri, Columbia
• Dr. Sadler completed a postdoctoral research fellow at the University of Virginia
• Dr. Sadler has worked as an Assistant Professor at Southern Illinois University and the University of Missouri

1/17 – 3/19: Choongheon Lee, PhD, Postdoctoral Research Fellow, Washington University School

of Medicine in St. Louis

• Dr. Lee received a 2019 Audiologist Travel Award for the *Association for Research in Otolaryngology MidWinter Meeting*

• Dr. Lee contributed to multiple publications in the laboratory, including two first author papers

• Dr. Lee is now completing a second postdoctoral fellowship at the University of Rochester

6/17 – 9/17: Deepa Suneel, AuD student, University of Texas at Austin

• Deepa earned a traineeship position in the NIH-T35 Training Program for Clinical Audiologists

• Deepa's work in our laboratory has now been published as a book chapter

6/17 – 6/20: Hannah R. Burrick, AuD student, Washington University School of Medicine in St. Louis

• As a second year AuD student, Hannah lead a podium presentation on our work at the American Academy of Audiology.

• Hannah's work in our laboratory is now published in a book chapter

• Dr. Burrick is now a Clinical Audiologist at the Medical University of South Carolina

12/18 – 4/21: Shannon M. Lefler, AuD, Postdoctoral Research Fellow, Washington University School of Medicine in St. Louis

• Dr. Lefler received an Audiologist Travel Award for the *Association for Research in Otolaryngology MidWinter Meeting* in both 2020 and 2021.

• Dr. Lefler is now a Research Audiologist in the Otolaryngology Department at Washington University School of Medicine in St. Louis

Co-Mentored with Craig A. Buchman, MD, FACS

1/16 – 6/19: Carla Valenzuela, MD, Postdoctoral Research Scholar, Washington University School of Medicine in St. Louis

• Dr. Valenzuela received a 2019 Don Henderson Travel Award, which is given to the highest scoring applicants for funds to travel to the *Association for Research in Otolaryngology MidWinter Meeting*

• Dr. Valenzuela's work in our laboratory has contributed to many publications

• Dr. Valenzuela won 1st place in the Basic Science category of the 33rd Annual Resident Research Day at Washington University School of Medicine in the Department of Otolaryngology for her talk "The Auditory Nerve Overlapped Waveform (ANOW) Can Detect Developing Endolymphatic Hydrops"

• Dr. Valenzuela is now completing a Neuro-otology fellowship at the University of Michigan

Co-Mentored with Alec N. Salt, PhD

6/14 – 8/14: James Dornhoffer, MD student University of Arkansas

• James' work in the laboratory contributed to one publication

• Dr. Dornhoffer went on to train as a Resident Physician at Medical University of South Carolina

• Dr. Dornhoffer is now a Neuro-otology fellow at the Mayo Clinic, Otolaryngology – Head & Neck Surgery, Rochester, MN

8/14 – 5/15: Katie Donovan, AuD student, Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis

• Katie's work in the laboratory contributed to one publication

6/14 – 12/15: Kaitlyn Kennedy, AuD student, Missouri State University

• Kaitlyn received a 2014 American Academy of Audiology Foundation Summer Research Fellowship to complete her research in our laboratory: "Further developing the auditory nerve overlapped waveform (ANOW) as an objective measure of low-frequency hearing"

• Kaitlyn's work in the laboratory contributed to one publication

• Dr. Kennedy is now an audiologist at Texas Ear Clinic and plays an active role in the American Academy of Audiology

Co-Mentored with Brent Spehar, PhD, CCC-A

11/14 – 5/15: Jennifer Doughan, AuD student, Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis

3/15 – 5/15: Krysta Gasser, AuD student, Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis

• Dr. Gasser is now a Clinical Specialist for Advanced Bionics, LLC

6/15 – 8/15: Saudia McCarley, MD student Meharry Medical College

6/15 – 5/17: Rebecca Howard, AuD student, Program in Audiology and Communication Sciences, Washington University School of Medicine in St. Louis

Co-Mentor with Victoria A. Sanchez, AuD, PhD, CCC-A

5/21 – 8/22: Claire Dorey, AuD. Claire is a PhD student in the Morsani College of Medical Sciences at the University of South Florida

1/22 – 5/22: Kristie Labib, BS. Kristie is an MD student in the Morsani College of Medicine at the University of South Florida

• Kristie presented a poster on our work at the 2022 David A. Paulus, MD Poster Symposium

BIBLIOGRAPHY

Submitted Peer Reviewed Manuscripts

Faubion, S.L., Lichtenhan, J.T., Jennings, S.G. (Submitted). Effects of contralateral noise of envelope-following response, auditory-nerve compound actions potential, and otoacoustic emission measured simultaneously.

Goodman, S.S., Lefler, S.M., Lee, C., Guinan, J.J., Jr., Lichtenhan, J.T. (Submitted). The origin along the cochlea of otoacoustic emissions evoked by mid-frequency tone pips.

Peer Reviewed Manuscripts

(1) Chertoff, M.E., Yi, X, Lichtenhan, J.T. (2003). "Influence of hearing sensitivity on mechano-electric transduction" Journal of the Acoustical Society of America. 114(6), 3251-3263.

(2) Lichtenhan, J.T., Chertoff, M.E., Smittkamp, S., Durham, D., Girod, D (2005). "Predicting severity of cochlear hair cell damage using DPOAE input-output functions" Hearing Research. 201, 109-120.

(3) Lichtenhan, J.T., Chertoff, M.E. (2008). "Temporary hearing loss influences post-stimulus time histogram and single neuron action potential estimates from human compound action potentials" Journal of the Acoustical Society of America. 123(4), 2200-2212.

(4) Chertoff, M.E., Lichtenhan, J.T., Tourtillott, B., Esau, K.S. (2008). "The influence of noise exposure on the parameters of a convolution model of the compound action potential" Journal of the Acoustical Society of America. 124(4), 2174-2185.

(5) Chertoff, M.E., Lichtenhan, J.T., Willis, M. (2010). "Click-and chirp-evoked human compound action potentials" Journal of the Acoustical Society of America. 127(5), 2992-2996.

(6) Lichtenhan, J. T. (2012). "Effects of low-frequency biasing on otoacoustic and neural measures suggest that stimulus-frequency otoacoustic emissions originate near the peak region of the traveling wave" Journal of the Association for Research in Otolaryngology. 13, 17-28.

(7) Lichtenhan, J.T., Cooper, N.P., Guinan, J.J. (2013). "A new auditory threshold estimation technique for low frequencies: Proof of concept" Ear & Hearing. 34, 42-51.

(8) Salt, A.N, Lichtenhan, J.T., Gill, R.M., Hartsock, J.J. (2013). "Large endolymphatic potentials from low-frequency and infrasonic tones in the guinea pig" Journal of the Acoustical Society of America. 133(3), 1561-1571.

(9) Lichtenhan, J.T., Hartsock, J.J., Gill, R.M., Guinan, J.J., Salt, A.N. (2014). "The Auditory Nerve Overlapped Waveform (ANOW) Originates in the Cochlear Apex" Journal of the Association for Research in Otolaryngology. 15(3):395-411.

(10) Chertoff, M.E., Kamerer, A.M., Peppi, M. Lichtenhan, J.T. (2015). "An Analysis of Cochlear Response Harmonics: Contribution of Neural Excitation" Journal of the Acoustical Society of America. 138(5):2957-2963.

(11) Kaf, W.A., Abdelhakiem, M., Zahirsha, Z., Lichtenhan, J.T. (2015). "Ménière's Disease: Current and Potential New Objective Measures using Electrocochleography" SIG 6 Perspectives on Hearing and Hearing Disorders: Research and Diagnostics. 19, 44-54.

(12) Lichtenhan, J.T., Wilson, U.S., Hancock, K.E., Guinan, J.J. (2016). "Medial Olivocochlear Efferent Reflex Inhibition of Human Cochlear Nerve Responses" Hearing Research. 333:216-24.

(13) Wilson, U.S., Kaf, W.A., Danesh, A., Lichtenhan, J.T. (2016). "Assessment of Low-Frequency Hearing with Narrow-Band Chirp Evoked 40-Hz Sinusoidal Auditory Steady State Response" International Journal of Audiology. 55(4):239-47.

(14) Smith, B.S., Lichtenhan, J.T., Cone, B. (2016). “Behavioral pure tone threshold shifts caused by tympanic membrane electrodes” Ear & Hearing. 37(4):e273-5.

(15) Lichtenhan, J.T., Hartsock, J.J., Dornhoffer, J., Donovan, K.M., Salt, A.N. (2016). “Drug delivery into the cochlear apex: Improved control to sequentially affect finely spaced regions along the entire length of the cochlear spiral” Journal of Neuroscience Methods.1;273:201-209.

(16) Lichtenhan, J.T., Hirose, K., Buchman, C.A., Duncan, R.K. Salt, A.N. (2017). “Direct administration of 2-Hydroxypropyl-Beta-Cyclodextrin into guinea pig cochleae: Effects on physiological and histological measurements” PLoS One. 12(4):e0175236.

(17) Smith, B.S., Lichtenhan, J.T., Cone, B. (2017). “Contralateral Inhibition of Click- and Chirp-Evoked Human Compound Action Potentials” Frontiers in Neuroscience. 11, 189.

(18) Wilson, U.S., Sadler, K.M., Hancock, K.E., Guinan, J.J. Jr., Lichtenhan, J.T. (2017). “Efferent inhibition strength is a Physiological Correlate of Hyperacusis in Children with Autism Spectrum Disorder” Journal of Neurophysiology. 118(2):1164-1172.

(19) Lichtenhan, J.T., Lee, C., Wenrich, K.A., Dubaybo, F. Wilson, U.S. (2017). “The Auditory Nerve Overlapped Waveform (ANOW) detects small endolymphatic manipulations that may go undetected by conventional measurements” Frontiers in Neuroscience. 11:405.

(20) Kennedy, A.E., Kaf, W.A, Ferraro, J.A., Delgado, R.E., Lichtenhan, J.T. (2017). “Human summating potential amplitudes vary with tone burst repetition rate and duration” Frontiers in Neuroscience. 11:429.

(21) Pienkowski, M., Adunka, O.F., Lichtenhan, J.T. (2018). Editorial: “New Advances in Electrocochleography for Clinical and Basic Investigation” Frontiers in Neuroscience. 12:310.

(22) Spehar, B., Lichtenhan, J.T. (2018). “Patients with normal hearing thresholds but difficulty hearing in noisy environments: A study on the willingness to try auditory training” Otology & Neurotology. 39(8):950-956.

(23) Lee, C., Guinan, J.J., Jr., Rutherford, M.A., Kaf, W.A., Kennedy, K.M., Buchman, C.A., Salt, A.N., Lichtenhan, J.T. (2019). “Cochlear compound action potentials from high-level tone bursts originate from wide cochlear regions that are offset toward the most sensitive cochlear region” Journal of Neurophysiology. 121(3):1018-1033.

(24) Lee, C., Valenzuela, C.V., Goodman, S.S., Kallogjeri, D., Buchman, C.A., Lichtenhan, J.T. (2020). “Early Detection of Endolymphatic Hydrops using the Auditory Nerve Overlapped Waveform (ANOW)” Neuroscience. 15;425:251-266.

(25) Goodman, S.S., Lee, C., Guinan, J.J. Jr., Lichtenhan, J.T. (2020). “The Spatial Origins of Cochlear Amplification Assessed by Stimulus-Frequency Otoacoustic Emissions” Biophysical Journal, 118(5):1183-1195.

(26) Valenzuela, C.V., Lee, C., Buchman, C.A., Lichtenhan, J.T. (2020). “Revised surgical approach to induced endolymphatic hydrops in the guinea pig” Journal of Visualized Experiments. Jun 4;(160).

(27) Valenzuela, C.V., Lee, C., Mispagel, A., Bhattacharyya, A., Lefler, S.M., Payne, S., Goodman, S.S., Ortmann, A.J., Buchman, C.A., Rutherford, M.A., Lichtenhan, J.T. (2020) “Is Cochlear Synapse Loss the Origin of Low-Frequency Hearing Loss Associated with Endolymphatic Hydrops?” Hearing Research. 398, 108099.

(28) Goodman, S.S., Boothalingam, S., Lichtenhan, J.T. (2021). “Medial olivocochlear reflex effects on amplitude growth functions of long- and short-latency components of click-evoked otoacoustic emissions in humans” Journal of Neurophysiology.125(5): 1938-1953

(29) Guinan, J.J. Jr., Lefler, S.M., Buchman, C.A., Goodman, S.S., Lichtenhan, J.T. (2021). “Altered mapping of sound frequency to cochlear place in ears with endolymphatic hydrops provide insight into the pitch anomaly of diplacusis” Scientific Reports. 11(1):10380.

(30) Valenzuela, C.V., Lichtenhan, J.T., Lefler, S.M., Koka, K., Buchman, C.A., Ortmann, A.J. (2021). “Intracochlear Electrocochleography and Speech Perception Scores in Cochlear Implant Recipients” Laryngoscope. 131:E2681-E2688.

(31) Walia, A., Lee, C., Hartsock, J., Goodman, S.S., Dolle, R., Salt, A.N., Lichtenhan, J.T., Rutherford, M.A. (2021). “Reducing auditory nerve excitability by acute antagonism of Ca2+-permeable AMPA receptors” Frontiers of Synaptic Neuroscience. 13:680621.

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Invited Publications

(1) Lichtenhan, J.T., Brown, D.J., McLean, W.J., Chertoff, M.E., Salt, A.N. (2011). "A source of cochlear distortion and its utility for differential diagnosis of sensorineural hearing loss" Audiology Today Nov/Dec.

(2) Salt, A.N., Lichtenhan, J.T. (2014). "How does wind turbine noise affect people?" Acoustics Today Winter.

(3) Spehar, B., Lichtenhan, J.T. (2019). "Surveying Patients with "Hidden Hearing Loss" The Hearing Journal.

Book Chapter

(1) Burrick, H.R., Suneel, D., Chole, R.A., Buchman, C.A., Smith, S.B., Lee, C., Hancock, K.E., Long, G.R., Dhar, S., Ortmann, A.J., Ward, B.K., Lichtenhan, J.T. (2020). "On the origins of physiologic modulation of a low-noise microphone in a human ear canal" M. Valented, L.M. Valente (Eds.) Adult Audiology Casebook, Second Edition. Thieme Medical Publishers, Inc (New York). p80-83.

Conference Proceedings

(1) Salt, A.N., Lichtenhan, J.T. (2011). "Responses of the inner ear to infrasound" Proceedings of the Fourth International Conference on Wind Turbine Noise. Rome Italy. April 12-14.

(2) Salt, A.N., Lichtenhan, J.T. (2012). "Perception-based protection from low-frequency sounds may not be enough" Proceedings of the Fourth International INTER-NOISE, the 41st International Congress and Exposition on Noise Control Engineering, New York, New York. August 19-21.

(3) Lichtenhan, J.T., Salt A.N. (2013). "Amplitude modulation of audible sounds by non-audible sounds: Understanding the effects of wind turbine noise" Proceedings of Meetings on Acoustics, Vol. 19: Journal of the Acoustical Society of America. 133(5), 3419.

(4) Lichtenhan, J.T., Salt A.N., Guinan, J.J. (2015). "The auditory nerve overlapped waveform (ANOW): A new objective measure of low-frequency hearing" In Mechanics of Hearing: Protein to Perception, Proceedings of the 12th International Workshop on the Mechanics of Hearing. Karavitaki KD, Corey DP (eds). American Institute of Physics, Melville, NY, pp. 040008-1 through -5.

(5) Goodman, S.S., Tay, D., Lichtenhan, J.T., Guinan, J.J. Jr. (2023). "Stimulus Frequency Otoacoustic Emissions Extracted by Pharmacologic Blocking of Outer Hair Cells Without Sound Suppression or Subtractive Scaling." Proceedings of the 13th International Workshop on the Mechanics of Hearing. *In Press.*

Abstracts

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(3) Lichtenhan, J.T., Chertoff, M.E., Esau, K.S. (2005). "Influence of hearing loss on the summed post-stimulus time histogram and unit response obtained from an analytic treatment of the compound action potential" Association for Research in Otolaryngology Abstracts 28, 77.

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(8) Lichtenhan, J.T., Chertoff, M.E., Willis, M. (2008). "Comparing click- and chirp-evoked human compound action potentials" Association for Research in Otolaryngology Abstracts 31, 233.

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(13) Salt, A.N., Lichtenhan, J.T. (2013). “Endolymphatic microphonics to low-frequency tones and noise, and their suppression by higher-frequency sounds: A study relevant to wind turbine noise” Association for Research in Otolaryngology Abstracts 36, 125.

(14) Lichtenhan, J.T., Hartsock, J.J., Guinan, J.J., Jr., Salt, A.N. (2013). "Gross Neural Responses Shown to be from the Cochlear Apex by Ototoxic Injections" Association for Research in Otolaryngology Abstracts 36, 1107. (Podium)

(15) Wilson, U.S., Kaf, W., Lichtenhan, J.T., Danesh, A. (2014). “Sinusoidal ASSR is better than tone-burst evoked ABR for estimating low-frequency hearing thresholds” Association for Research in Otolaryngology Abstracts.

(16) Lichtenhan, J.T., Wilson, U.S., Guinan, J.J. (2014). “Quantifying Efferent-Induced Inhibition of Cochlear Amplifier Gain from Changes in Human Compound Action Potentials” Association for Research in Otolaryngology Abstracts. (Podium)

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(19) Smith, S.B., Lichtenhan, J.T., Cone, B. (2016). “Contralateral Inhibition of Click- and Chirp-Evoked Human Compound Action Potentials” Association for Research in Otolaryngology Abstracts.

(20) Spehar, B., Lichtenhan, J.T. (2016). “Patients with normal auditory thresholds but difficulty listening in noisy environments: Willingness to complete auditory training” Association for Research in Otolaryngology Abstracts.

(21) Lichtenhan, J.T., Duncan, R.K., Salt, A.N. (2016). “Direct administration of 2-Hydroxypropyl-Beta-Cyclodextrin into intact cochleae: Effects on objective auditory measurements” Association for Research in Otolaryngology Abstracts.

(22) Lee, C., Buchman, C.A, Salt, A.N., Lichtenhan, J.T. (2017). “On the spatial origins of compound action potentials to various tone burst levels in normal and cochlear implanted guinea pig ears” the 13th International Workshop on the Mechanics of Hearing, Brock University, Canada.

(23) Lee, C., Goodman, S.S., Guinan, J.J., Lichtenhan, J.T. (2018). “Identifying the origins of cochlear action potentials and transient evoked otoacoustic emissions” Association for Research in Otolaryngology Abstracts.

(24) Lee, C., Valenzuela, C., Hirose, K., Goodman, S.S., Buchman, C.A., Lichtenhan J.T. (2019). "The Auditory Nerve Overlapped Waveform (ANOW) as a detector of early-onset, chronic endolymphatic hydrops" Association for Research in Otolaryngology Abstracts.

(25) Valenzuela, C., Lichtenhan, J.T., Koka, K., Buchman, C.A., Ortmann, A.J. (2019). "Correlation of intracochlear electrocochleography responses with cochlear implant speech perception" Association for Research in Otolaryngology Abstracts.

(26) Goodman, S.S., Lee, C., Guinan, J.J., Lichtenhan, J.T. (2019). "Identifying the origin along the cochlea of stimulus frequency otoacoustic emissions" Association for Research in Otolaryngology Abstracts.

(27) Lefler, S.M, Goodman, S.S., Lee, C., Guinan, J.J., Jr., Lichtenhan, J.T. (2020). "Spatial origins of click-evoked cochlear compound action potentials" Association for Research in Otolaryngology Abstracts.

(28) Valenzuela, C.V., Lee, C., Goodman, S.S., Ortmann, A.J., Buchman, C.A., Rutherford, M.A., Lichtenhan, J.T. (2020). Quantifying type 1 afferent cochlear synapses in experimental endolymphatic hydrops. American Academy of Otolaryngology-Head and Neck Surgery Annual Meeting abstracts.

(29) Lefler, S.M, Guinan, J.J., Jr., Buchman C.A., Goodman, S.S., Lichtenhan, J.T. (2021). "Endolymphatic Hydrops Can Produce Shifts in the Cochlear Frequency-Place Map That Can Account for Diplacusis in Ménière's Disease" Association for Research in Otolaryngology Abstracts.

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(31) Lichtenhan, J.T., Guinan, J.J., Jr., Sanchez, V.A., Goodman, S.S. (2022). "Innovative approaches to studying and diagnosing endolymphatic hydrops" The 9th Midwest Auditory Research Conference presented by the Kresge Hearing Research Institute, Ann Arbor, Michigan, June 23-25, 2022.

(32) Goodman, S.S., Lichtenhan, J.T., Jennings, S. (2023). "Evidence-based recommendations for determining sample sizes for experiments assessing auditory nerve function using electrocochleography." Association for Research in Otolaryngology Abstracts.

(33) Goodman, S.S., Tay, D., Lichtenhan, J.T., Guinan, J.J. Jr. (2023). "Does near-frequency suppression extract the complete stimulus frequency otoacoustic emission?" Association for Research in Otolaryngology Abstracts.

(34) Goodman, S.S., Khalili, E., Roemen, J., White, R., Wright M., Lichtenhan, J.T. (2024). "Rapid Evaluation of Middle Ear Muscle Reflex Level Growth Functions Using a Swept Elicitor." Association for Research in Otolaryngology Abstracts.

Major invited Professorships and Lectureships

(1) *Sigma Xi Scientific Research Society, Annual Banquet, the University of Kansas Medical Center:* "The influence of noise induced hearing loss on an analytic treatment of the compound action potential" 2005.

(2) *Boys Town National Research Hospital:* "Estimation of the Summed Post-Stimulus Time Histogram and Single Fiber Action Potential Using an Analytic Treatment of the Compound Action Potential" April 30, 2006.

(3) *National Center for Rehabilitative Auditory Research, Veterans Affairs Medical Center, Portland, Oregon:* "A discourse on the translation of a post-stimulus time histogram and single fiber action potential estimation technique developed in gerbil to human utility" March 30, 2007.

(4) *Eaton-Peabody Laboratories at the Massachusetts Eye & Ear Infirmary, Harvard Medical School, Department of Otolaryngology*: "Models and measurements of the compound action potential: Translating gerbil studies to humans." April 23, 2007.

(5) *Starkey Hearing Research Center, Berkley California:* "Using low-frequency biasing to locate the source region of stimulus-frequency otoacoustic emissions" September 28, 2010.

(6) *Columbia University, Department of Otolaryngology: Fowler Memorial Lab (Elizabeth S. Olson: PI):* "A new technique to objectively quantify low-frequency auditory thresholds." June 21, 2012.

(7) *Eaton-Peabody Laboratories at the Massachusetts Eye & Ear Infirmary, Harvard Medical School, Department of Otolaryngology*: "A new measure of low-frequency auditory thresholds" July 19, 2012.

(8) *Missouri Academy of Audiology 20th Annual Scope of Practice Meeting, St. Louis, Missouri:* "Objective assessment of low-frequency hearing" September 14, 2012.

(9) *The Interdisciplinary Collaborative Research Center Colloquium Series, University of Göttingen Medical Center, Inner Ear Lab (Tobias Moser: PI), Göttingen, Germany:* "A new objective measure of low-frequency hearing: The auditory nerve overlapped waveform" September 25, 2012.

(10) *Seminars in Hearing Research at Purdue University, Department of Speech, Language, & Hearing Sciences: Two different presentations:* i) "Using compound action potentials to quantify efferent-induced inhibition of human cochlear amplifier gain", and ii) "The auditory nerve overlapped waveform (ANOW) as a new measure of low-frequency hearing: tutorial and experiments". October 17, 2013.

(11) *The Ohio State University, Department of Otolaryngology:* "A potpourri: hyeracusis in Autism and objective measure of low-frequency hearing". June 28, 2016.

(12) *Creighton University School of Medicine, Department of Biomedical Sciences:* "Pharmaceutical Manipulation of the cochlea." September 22, 2016.

(13) *Johns Hopkins University School of Medicine, Department of Otolaryngology:* "Two brief talks: Hyperacusis in Autism and pharmaceutical manipulation of the entire length of the cochlear spiral." September 27, 2016.

(14) *Saint Louis University, School of Engineering:* "The origin of otoacoustic emission and their measure of hyperacusis in Autism." April 3, 2018.

(15) *American Auditory Society, Annual Scientific and Technology Conference:* "Identifying the spatial and cellular origins of objective measures of the ear." Special Session supported by an NIDCD Conference Grant – Cells to Signals: Electrophysiological Interrogation of the Auditory System. March 7, 2020.

(16) *University of Kansas Medical Center*: "Understanding the origin of symptoms and measurements of inner ear disease." September 30, 2020.

(17) *Kresge Hearing Research Institute at the University of Michigan, Hearing, Balance, and Chemical Senses Program Seminar Series:* "Identifying the origins of symptoms and measurements of inner ear dysfunction." June 9, 2022.

(18) *University of West Virginia:* "Current research plans for a programmatic line of research." June 13, 2022.

(19) *Nova Southeastern University, Department of Audiology:* "Identifying the origins of symptoms and measurements of inner ear dysfunction." June 17, 2022.

(20) *University of Rochester, Department of Otolaryngology:* "Identifying the origins of symptoms and measurements of inner ear dysfunction." July 18, 2022.

(21) *University of South Florida, Department of Otolaryngology:* "Identifying the origins of symptoms and measurements of inner ear dysfunction." September 20, 2022.

(22) *Eaton-Peabody Laboratories at the Massachusetts Eye & Ear, Harvard Medical School, Department of Otolaryngology:* "Identifying the origins of symptoms and measurements of inner ear dysfunction." September 27, 2022.

Conference Podium Presentations

(1) *The Student Research Forum, the University of Kansas Medical Center:* "Estimates of the single fiber action potential and probability of neuronal discharge obtained from human compound action potentials" 2006.

(2) *The Biomedical Research Training Program Annual Spring Symposium, the University of Kansas Medical Center:* "Estimates of the single fiber action potential and probability of neuronal discharge obtained from human compound action potentials" 2006.

(3) *Midwest Auditory Conference 4th Biennial meeting, Kansas City, Kansas:* "The auditory nerve overlapped waveform is generated in the cochlear apex: A validation study" July 13, 2012.

(4) *Inner Ear Biology 49th Workshop, Tübingen, Germany:* "A new physiologic technique for assessing apical cochlear function: The auditory nerve overlapped waveform (ANOW)" October 1, 2012.

(5) *Midwest Auditory Research Conference – Midwest Auditory Neuroscience Symposium (MARC-MANS), Washington University School of Medicine in St. Louis:* "The new Auditory Nerve Overlapped Waveform (ANOW) is more sensitive than established physiological measures to subtle cochlear manipulations" July 19, 2014.

(6) *Otoacoustic Emissions: Evoking the Future, San Marino, California:* "Identifying the Origin(s) of Transient, Tone-Pip Evoked Otoacoustic Emissions". Presented with Shawn S. Goodman, PhD., February 7-8, 2018.

(7) *American Academy of Audiology 2018, Nashville, Tennessee:* "The Auditory Nerve Overlapped Waveform: A new objective measure of low-frequency hearing" April 20, 2018.

Internal Podium Presentations at Washington University School of Medicine in St. Louis

(1) *Otolaryngology Research Seminar,* "A new objective measure of low-frequency hearing" April 20, 2012.

(2) *Audiology Grand Rounds at Children's Hospital St. Louis,* "Assessment of Low-Frequency Hearing Loss for the Audiologist" January 2, 2013.

(3) *Auditory and Vestibular Neuroscience Discussion Group,* "Studies of the Human Medial Olivocochlear Reflex" October 8, 2014.

(4) *Auditory and Vestibular Neuroscience Discussion Group,* "Direct administration of 2-Hydroxypropyl-Beta-Cyclodextrin (HPβCD) into intact cochleae: Effects on objective auditory measurements" November 11, 2015.

(5) *Autism Seminar Series,* "Strong medial olivocochlear reflexes in children with Autism are mediated by hyperacusis, not Autism *per se*" November 16, 2015.

(6) *Otolaryngology Research Seminar,* "Cochlear mechanics are not everywhere constant" October 21, 2016.

(7) *Audiology Grand Rounds at Children's Hospital St. Louis,* "Objective Assessment of Hyperacusis in Children with Autism Spectrum Disorder (and Preliminary Results from a Study on Hidden Hearing Loss)" December 7, 2016.

(8) *Auditory and Vestibular Neuroscience Discussion Group,* "On the spatial origins of compound action potential to various tone burst levels" June 29, 2017.

(9) *Otolaryngology Research Seminar,* "Identifying the spatial origin of reflection-source otoacoustic emissions" August 17, 2018.

(10) *Auditory and Vestibular Neuroscience Discussion Group,* "The Auditory Nerve Overlapped Waveform (ANOW) can Detect the Early-Onset Endolymphatic Hydrops" April 4, 2019.

(11) *Audiology Grand Rounds at Children's Hospital St. Louis,* "Cochlear compound action potentials (CAPs) from high-level tone bursts originate from wide cochlear regions that are offset toward the most sensitive cochlear region" May 1, 2019.

(12) *Audiology Grand Rounds at Children's Hospital St. Louis,* "New approaches to functionally assess endolymphatic hydrops and related symptoms" April 7, 2021.

Internal Podium Presentations at University of South Florida

(1) *Communication Sciences and Disorders Colloquium Series*, "Identifying the spatial origin along the cochlear length of electrophysiologic measurements evoked from ears with cochlear implants using acoustical stimuli: 'Nothing Shocking'", May 17 & 22, 2023.

PERSONAL AND PROFESSIONAL REFERENCES

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RESEARCH STATEMENT

The overarching goal of my research is to improve how clinical otology and audiology are performed. Toward this goal, I have successfully run laboratories that use animal models and human participants. My future research will continue the theme of my previous research on identifying the origins of physiologic measurements from normal and diseased ears with the goal of improving their interpretation and usefulness for clinic and laboratory purposes. Much progress has been made utilizing physiologic measurements from the ear, but their interpretations and usefulness could be vastly improved if the precise cellular and spatial origins were actually known. While my immediate goals are to understand the origin of objective measurements of hearing, future efforts could also address the origin of behavioral responses in animals and humans as well as responses from the vestibular system.

My planned experiments should provide fresh insight into unresolved questions that remain the focus of high scientific and clinical interest: What is the origin of the symptoms of Ménière's disease? Additionally, what is the spatial origin of cochlear amplification in the low-frequency apical half of the cochlear length? I am well-situated to lead the efforts on addressing these questions because of techniques I developed, such as an objective measure low-frequency measurement of hearing (the Auditory Nerve Overlapped Waveform), the drug perfusion technique into the cochlear apex that can assess the origin of responses across the entire cochlear length, and a revised approach to classic ablation of the endolymphatic sac that greatly improves the success rate of creating endolymphatic hydrops in guinea pigs to near one hundred percent. Moreover, my body work with animals has produced several results that are the foundation of *translational research to be completed in humans* to improve the differential diagnosis, and treatment monitoring, of humans Ménière's disease. Following a brief stint working in the biotechnology industry that develops therapeutics for hearing loss, I am convinced even more than before that identifying the origin of all hearing measurements is essential for comprehensive interpretation of clinical trial results. My extensive academic experience with developing new diagnostic techniques and surgical approaches, combined with my recent industry experience overseeing all aspects of a clinical trial, has enabled me with a sincere understanding of how to work throughout the pipeline of moving an innovation from bench to bedside to see theories into reality. Here I describe five areas of my research that have led me to my current research questions, with the associated citations provided in the Bibliography section of my CV.

1. Developed a new objective measurement of low-frequency hearing: the Auditory Nerve Overlapped Waveform (ANOW).

During my postdoctoral research fellowship at the Eaton-Peabody Laboratory at Harvard Medical School, we developed a new objective measurement of low-frequency hearing that we call the Auditory Nerve Overlapped Waveform (ANOW). We found that ANOW thresholds relate to low-characteristic frequency single-auditory-nerve-fiber threshold in cat just as well as classical auditory-nerve compound action potential (CAP) thresholds relate to high-characteristic frequency single-auditory-nerve-fiber thresholds (Lichtenhan et al. 2013). Then, to further elucidate this relationship, as a Principal Investigator at Washington University School of Medicine in St. Louis we developed a drug-perfusion technique into the cochlear apex (Lichtenhan et al. 2016) and found that i) ANOW originates from afferent auditory nerve fibers in the apical half of the cochlear spiral, ii) ANOW does not originate from phase locking in low-frequency tails of high-characteristic frequency auditory nerve fibers, and iii) measurement from high stimulus levels is the Auditory Nerve Neruophonic that originates from a blend of neural phase locking and hair-cell based cochlear microphonic throughout unknown cochlear locations (Lichtenhan et al. 2014).

The ANOW measurement technique is useful because it overcomes a long-standing problem in our field of how to objectively measure low-frequency hearing. Conventional objective measures like wave I of the auditory brainstem response (i.e., the CAP) and auditory steady state response do not work adequately below ~1 kHz. As a result, much more is known about normal and diseased cochlear mechanics in the high-frequency basal half of the cochlear spiral, and far less

is known about the apical half that codes most speech sounds, music, and background noise. Our initial work on the ANOW has opened many lines of basic and clinically motivated research that have until now been difficult to pursue.

2. Early identification of endolymphatic hydrops.

Endolymphatic hydrops is a defining feature of Ménière's disease. The symptoms of Ménière's disease are some of the most debilitating disorders of the inner ear and include vertigo, tinnitus, sensations of aural fullness, and low-frequency sensorineural hearing loss. Most clinical treatments for Ménière's disease that preserve hearing and vestibular function do little to alleviate the symptoms long term. One reason for this shortcoming is thought to be that treatment often does not begin until the ear is permanently damaged. But, if the condition could be identified early, some of the treatments that should work in theory, but do not in clinical practice, could help alleviate the patient's symptoms. We recently induced small volumes of artificial endolymph into the high-frequency base of the guinea pig cochlea and found that measurements of low-frequency hearing (i.e., the ANOW) changed while traditional objective measurements of hearing were unaffected (Lichtenhan et al. 2017). This suggested that excess endolymph collects in the distensible cochlear apex, and that the ANOW could be used to early detect a dysfunction associated with the development of endolymphatic hydrops. Since humans present to the clinic with permanent, not chronic, conditions, we developed a robust chronic guinea pig model of endolymphatic hydrops (Valenzuela et al. 2020). We found that, indeed, the ANOW can detect low-frequency chronic dysfunction before endolymphatic hydrops developed to an extent that could be measured with the classic gold-standard histological assessment of scala media cross sectional area (Lee et al. 2020). Moreover, once endolymphatic hydrops becomes more long term and is histologically measurable, the severity of hearing loss correlates with the degree of endolymphatic hydrops. Our body of work on endolymphatic hydrops have led us to our current research that will move us closer to understanding the origin of symptoms associated with Ménière's disease.

Numerous findings from our research with animals is the foundation for ***translational research in humans***. In particular, our work has shown that functional measurements of hearing should help improve the early identification, differential diagnosis, and treatment monitoring of endolymphatic hydrops. These functional measurements include low-frequency hearing loss, diplacusis, loudness recruitment, and a joint otoacoustic emission (OAE) profile showing that endolymphatic hydrops has differing effects on reflection-source and distortion-source OAEs (Guinan et al. 2021; Lefler et al. 2021). Magnetic Resonance Imaging (MRI) will be used to identify endolymphatic hydrops in human participants. We aim to complete this translational research in a human clinical laboratory.

3. Identifying the spatial origins along the cochlear length of otoacoustic emissions.

As a PhD student at the University of Kansas Medical Center we found that distortion product otoacoustic emissions (DPOAEs) in chickens do not entirely originate from the cochlear characteristic frequency place associated with the primary stimulus tones (Lichtenhan et al. 2005). Given that we now know DPOAEs originate from at least two mechanisms, our findings

at that time were not “negative” but instead support current theories on DPOAE generation. Our approach was to compare attributes of DPOAEs to scanning electron microscopy images of aged broiler chickens that lose the ability to regenerate hair cells. The usefulness of our findings is that simple DPOAEs cannot be used to identify cochlear regions with non-functioning hair cells.

As a postdoc I found evidence that stimulus frequency otoacoustic emissions (SFOAEs) in cats and guinea pigs originate in the peak region of the traveling wave (Lichtenhan 2012). This finding addressed an ongoing controversy on theoretical and empirical evidence on SFOAE generation. The approach was to use intense, very low-frequency tones to manipulate the peak region of the traveling wave of a higher frequency probe tone. In the basal half of the cochlea, mechanical amplification is likely most robust at the peak of the traveling wave. Until the time of my study, others had used high-frequency sounds to manipulate SFOAE generators and these sounds arguably create additional distortion sources that complicate the measurements and interpretation. While the results of my study were consistent with what theoretical models of SFOAE origination suggested, the results were not definitive. As a Principal Investigator, my lab developed an apical perfusion technique in guinea pig that provided a coveted approach of manipulating characteristic-frequency regions in a manner that is independent of more basal regions and brought the debate towards an end. We found that SFOAEs from the basal half of the cochlear spiral originate approximately one half octave basal to the associated cochlear characteristic frequency place (Goodman et al. 2020). Our future work will identify the origin of SFOAEs in the apical half of the cochlea, which was not possible before we invented the ANOW and drug-perfusion technique into the cochlear apex.

4. Identified the spatial origin of auditory-nerve compound action potentials.

Wave I of the auditory brainstem response, or the auditory-nerve compound action potential (CAP), is used worldwide in clinics and laboratories. A clinical example is that the CAP is one component of a response that can be used to identify hearing loss in human newborns and to set prescriptive targets for hearing aid amplification. A laboratory example is that, compared to controls, the amplitude of the CAP in response to supra-threshold sound stimuli is decreased in ears with cochlear synaptopathy that may be related to “hidden hearing loss”. Despite the wide use of the CAP and the progress that has been made on diagnosing hearing loss in the clinic and addressing basic science questions, no experiment had ever directly identified the spatial origins. We recently used the apical perfusion technique developed in our lab to address this gap in knowledge (Lee et al. 2019). We found that CAPs evoked from low-level tone bursts originate from the cochlear characteristic frequency (CF) place associated with the tone burst, which had never before been empirically demonstrated. As sound pressure level of lower-frequency tone bursts increases, we found that the spatial origin of the CAP shifts away from the CF place and toward the cochlear base by up to two octaves of CF place. In contrast, as the stimulus level of high frequency tone bursts increased, the origin of the CAP shifts toward the cochlear apex. That is to say, regardless of the frequency of the evoking tone burst, the spatial origin of the CAP shifts toward the most sensitive region of the audiogram where thresholds are lowest and neural innervation density is greatest. The CAP does not shift continuously toward the cochlear base as level increases. The information gained from this line of our research is greatly advancing the

interpretation of any objective or psychophysical measure of hearing, both in normal ears for studies of cochlear mechanics and in ears with overt or hidden hearing loss. We have designed additional studies in this area that we will complete.

5. Understanding the properties of the *human* medial olivocochlear (MOC) reflex.

Human experiments completed in my human lab found that the strength of the medial olivocochlear **(**MOC) reflex is greater on cochlear-nerve compound action potentials (CAPs) than on otoacoustic emissions (OAEs; Lichtenhan et al. 2016). We were the first to quantify the strength of the MOC reflex on OAEs and CAPs from individual human ears, and our follow-up work confirmed this finding (Smith et al. 2017). The human MOC reflex has been studied almost exclusively by measuring changes in OAEs. To help understand how the MOC system influences what we hear, it is important to have measurements on the MOC effect on auditory nerve responses that couple sounds to the brain. While our findings are consistent with previous reports from other labs using animal models (Puria et al. 1996 J Acoust Soc Am. Jan;99(1):500-7), they are interesting because MOC fibers synapse on outer hair cells that give rise to OAEs and not auditory nerve fibers. These results are informative on how the MOC reflex attenuates the entire process of mechanical amplification in the human cochlea, not solely the outer hair cells.

In another human study we found that hyperacusis is the origin of anomalous MOC reflexes in children with Autism, not Autism per se (Wilson et al. 2017). Children with Autism often have hyperacusis that can significantly disrupt their ability to function on a daily basis. For example, intolerance to industrial-quality toilet flushing at school can lead to physical rage on their teachers who foster them to use the toilet instead of retaining urine and causing continuous infections. We measured MOC reflexes in three groups of children: those with Autism and hyperacusis, those with Autism but no hyperacusis, and those who are neurotypical (i.e., normal controls). We found that children with Autism and hyperacusis have stronger MOC reflexes than children in the other two groups. These results are consistent with findings from another lab showing that MOC reflexes are stronger, not weaker, on people with hyperacusis who are otherwise neurotypical (i.e., typical people who do not have Autism [Knudson et al. 2014 J Neurophysiol. 112(12):3197]). Our results are the foundation for future research that will develop a technique to objectively monitor behavioral treatment of hyperacusis in children with Autism. Additionally, these results motivate and inform the design of our future studies on Alzheimer’s disease.