PI: **McCreery, Ryan W.**	Title: COMPLEX LISTENING SKILLS IN SCHOOL-AGE HARD OF HEARING CHILDREN	
Received: 12/17/2018	Opportunity: PA-18-484 Clinical Trial:Not Allowed	Council: 05/2019
Competition ID: FORMS-E	FOA Title: NIH Research Project Grant (Parent R01 Clinical Trial Not Allowed)	
2R01DC013591-06A1	Dual: HD	Accession Number: 4249254
IPF: 1109501	Organization: [redacted]	
Former Number:	Department:	
IRG/SRG: AUD	AIDS: N	Expedited: N
Subtotal Direct Costs (excludes consortium F&A) Year 6: 437,644 Year 7: 447,190 Year 8: 457,635 Year 9: 467,765 Year 10: 476,202	Animals: N Humans: Y Clinical Trial: N Current HS Code: 30 HESC: N	New Investigator: N Early Stage Investigator: N
Senior/Key Personnel:	*Organization:*	*Role Category:*
Ryan McCreery Ph.D	[redacted]	PD/PI
Adam Bosen Ph.D	[redacted]	Co-Investigator
Elizabeth Walker Ph.D	[redacted]	Co-Investigator
Lori Leibold Ph.D	[redacted]	Co-Investigator
Dawna Lewis Ph.D	[redacted]	Co-Investigator
Monita Chatterjee Ph.D	[redacted]	Co-Investigator
Jacob Oleson Ph.D	[redacted]	Co-Investigator
Lisa Davidson Ph.D	[redacted]	Consultant

APPLICATION FOR FEDERAL ASSISTANCE
SF 424 (R&R)

3. DATE RECEIVED BY STATE | **State Application Identifier**

1. TYPE OF SUBMISSION*

❍ Pre-application ❍ Application ● Changed/Corrected Application

4.a. Federal Identifier
DC013591

b. Agency Routing Number

2. DATE SUBMITTED | **Application Identifier**

c. Previous Grants.gov Tracking Number
GRANT12761004

5. APPLICANT INFORMATION **Organizational DUNS*:** [redacted]

Legal Name*: [redacted]
Department:
Division:
Street1*: [redacted]
Street2:
City*: [redacted]
County:
State*: [redacted]
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: [redacted]

Person to be contacted on matters involving this application
Prefix: First Name*: Julie Middle Name: Last Name*: Harmon Suffix:
Position/Title: Director, Finance Grant & Contract Compliance
Street1*: [redacted]
Street2:
City*: [redacted]
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: [redacted]
Phone Number*: [redacted] Fax Number: [redacted] Email: [redacted]

6. EMPLOYER IDENTIFICATION NUMBER *(EIN) or (TIN)** [redacted]

7. TYPE OF APPLICANT* M: Nonprofit with 501C3 IRS Status (Other than Institution of Higher Education)

Other (Specify):
Small Business Organization Type ❍ Women Owned ❍ Socially and Economically Disadvantaged

8. TYPE OF APPLICATION*
❍ New ● Resubmission
❍ Renewal ❍ Continuation ❍ Revision

If Revision, mark appropriate box(es).
❍ A. Increase Award ❍ B. Decrease Award ❍ C. Increase Duration
❍ D. Decrease Duration ❍ E. Other *(specify)* :

Is this application being submitted to other agencies?* ❍Yes ●No What other Agencies?

9. NAME OF FEDERAL AGENCY*
National Institutes of Health

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER
TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT*
COMPLEX LISTENING SKILLS IN SCHOOL-AGE HARD OF HEARING CHILDREN

12. PROPOSED PROJECT

Start Date*	Ending Date*
07/01/2019	06/30/2024

13. CONGRESSIONAL DISTRICTS OF APPLICANT
[redacted]

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix: First Name*: Ryan Middle Name: W. Last Name*: McCreery Suffix: Ph.D
Position/Title: Director of Research
Organization Name*: [redacted]
Department:
Division: [redacted]
[redacted]
Street2:
City*: [redacted]
Province:
Country*: USA: UNITED STATES
ZIP / Postal Code*: [redacted]
Phone Number*: [redacted] Fax Number: [redacted] Email*: [redacted]

15. ESTIMATED PROJECT FUNDING		**16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?***
a. Total Federal Funds Requested*	[redacted]	a. YES ○ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:
[redacted]	[redacted]	DATE:
		b. NO ● PROGRAM IS NOT COVERED BY E.O. 12372; OR
		○ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

● I agree*

** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.*

18. SFLLL or OTHER EXPLANATORY DOCUMENTATION File Name:

19. AUTHORIZED REPRESENTATIVE

Prefix: Dr. First Name*: Edward Middle Name: M. Last Name*: Kolb Suffix: M.D.
Position/Title*: BT Exe. VP, Health Care; Dir., BTNRH; & CMO
Organization Name*: [redacted]
Department: Administration
Division: [redacted]
USA: UNITED STATES
ZIP / Postal Code*: [redacted]
Phone Number*: [redacted] Fax Number: [redacted] Email*: [redacted]

Signature of Authorized Representative*	**Date Signed***
Edward Kolb	12/17/2018

20. PRE-APPLICATION File Name:

21. COVER LETTER ATTACHMENT File Name:CoverLtr_RWM_R01resbm_16dec.pdf

424 R&R and PHS-398 Specific
Table Of Contents

OMB Number: 4040-0010
Expiration Date: 10/31/2019

Project/Performance Site Location(s)

Project/Performance Site Primary Location

❍ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: [redacted]

[redacted]

USA: UNITED STATES

Zip / Postal Code*: [redacted]

Project/Performance Site Congressional District*: [redacted]

Project/Performance Site Location 1

❍ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: [redacted]

[redacted]

Street2:

City*: [redacted]

[redacted]

Province:

Country*: USA: UNITED STATES

Zip / Postal Code*: [redacted]

Project/Performance Site Congressional District*: [redacted]

Additional Location(s) File Name:

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED Other Project Information

1. Are Human Subjects Involved?* ● **Yes** ○ **No**

1.a. If YES to Human Subjects

Is the Project Exempt from Federal regulations? ○ Yes ● No

If YES, check appropriate exemption number: __ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __ 8

If NO, is the IRB review Pending? ● **Yes** ○ **No**

IRB Approval Date:

Human Subject Assurance Number 00004176

2. Are Vertebrate Animals Used?* ○ **Yes** ● **No**

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ○ Yes ○ No

IACUC Approval Date:

Animal Welfare Assurance Number

3. Is proprietary/privileged information included in the application?* ○ **Yes** ● **No**

4.a. Does this project have an actual or potential impact - positive or negative - on the environment?* ○ **Yes** ● **No**

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ○ Yes ○ No

4.d. If yes, please explain:

5. Is the research performance site designated, or eligible to be designated, as a historic place?* ○ **Yes** ● **No**

5.a. If yes, please explain:

6. Does this project involve activities outside the United States or partnership with international collaborators?* ○ **Yes** ● **No**

6.a. If yes, identify countries:

6.b. Optional Explanation:

	Filename
7. Project Summary/Abstract*	4a_ProjSummAbstr_RWM_R01resbm_07dec18.pdf
8. Project Narrative*	ProjNarrative_RWM_R01resbm.pdf
9. Bibliography & References Cited	6_BibsRefsCited_RWM_R01resbm_12dec18.pdf
10.Facilities & Other Resources	8_Resources_RWM_R01resbm_12dec18.pdf
11.Equipment	8c_Equipment_RWM_R01resbm_12dec18.pdf

PROJECT SUMMARY/ABSTRACT

Many children with hearing loss (CHL) now receive early intervention within the first few months of life. Even with early intervention, however, some CHL with hearing aids do not reach their full developmental potential. Challenges are compounded in learning and social environments because most listening environments are characterized by background noise. CHL experience significantly greater difficulty than children with normal hearing (CNH) with understanding speech in noisy situations. CHL who wear hearing aids are an under-studied population, leading to substantial gaps in our knowledge regarding the underlying mechanisms for their speech in noise deficits. A limited understanding of the mechanisms for speech recognition in noise hinders the development of targeted intervention strategies to reduce these deficits. The current proposal will identify factors that underlie variability in speech recognition in noise in school-age CHL who use hearing aids. This proposal is based on the premise that selective attention, working memory, and language support processes that are crucial for speech recognition in noise. The current proposal seeks to test the hypothesis that CHL with better selective attention, working memory, and language abilities will have stronger spectral resolution, perceptual weighting for speech, and less susceptibility to informational masking. Advantages in these skills will be associated with better speech understanding in noise. Three specific aims are proposed: Aim 1. Examine the effects of selective attention, working memory, and spectral resolution on speech recognition in noise. Aim 2. Characterize the effects of selective attention and language on perceptual weighting for speech in noise. Aim 3. Evaluate selective attention as a predictor of speech recognition in speech maskers. In Aim 1, we will examine measures of selective attention, working memory, and spectral resolution on speech recognition in noise for CNH and CHL. We predict that selective attention and working memory support spectral resolution in children, which in turn support speech recognition in noise. In Aim 2, perceptual weighting functions will be measured for speech stimuli that vary in linguistic complexity. We predict that CNH and CHL with stronger selective attention, working memory, and language skills will have perceptual weights concentrated in mid-frequency bands, reflecting mature and selective listening that is less susceptible to noise. In Aim 3, we will assess the effects of selective attention on speech recognition with speech maskers that produce informational masking. We predict that CNH and CHL who have stronger selective attention skills will have less susceptibility to informational masking than peers with poorer skills, but that this effect is mediated by the child's language and working memory abilities. The data generated from this proposal will inform theoretical models regarding speech recognition in CNH and CHL. The proposed studies will also provide empirical evidence for the development of individualized strategies for prescribing hearing aids for children that are based on the child's individual cognitive and linguistic skills.

PROJECT NARRATIVE

The purpose of this research proposal is to investigate the underlying mechanisms that support speech recognition in noise for school-age children with hearing loss. The proposed research is relevant to public health because it will provide important insights into the impact of hearing loss on the ability to listen and learn in background noise. This project is highly related to the NIH's mission because the data will lead to improved and more individualized treatment options for individuals with mild to severe hearing loss and has the potential to improve how children who wear hearing aids function in every day listening environments.

[redacted]

Laboratory:

Hearing and Amplification Research Laboratory (McCreery). This laboratory is located in a large sound booth in the audiology clinic area on the 2nd floor of the main [redacted] building. The laboratory is equipped with three PCs having 24-bit A/D and D/A capabilities and a variety of analog devices. Software-based signal processing is available through external sound cards (RME Babyface, MOTU UnltraLitemk3) on the primary laboratory computer. A second computer is available for on-line monitoring and analyses during data collection. The third computer is used to program and adjust hearing aids, and is equipped with NOAH database and wireless programming capabilities. The laboratory also contains a clinical audiometer, CD player, and a variety of transducers, including supra-aural and insert earphones, bone vibrators, loudspeakers and a wide range of hearing-aid verification and programming equipment and software, including an Audioscan Verifit 1 and Verifit 2 hearing aid analyzers.

Audibility, Perception and Cognition Laboratory (McCreery). The laboratory is located in the Lied Learning and Technology Center, a separate child-friendly clinical, research and outreach facility adjacent to the main [redacted] building. This laboratory is under the direction [redacted] The lab includes a large double-walled sound-treated booth. The laboratory is equipped with three PC computers having 24-bit A/D and D/A capabilities and a variety of analog devices. Software-based signal processing is available through external sound cards (MOTU Track 16) on the primary lab computer. A laptop computer is used to program and adjust hearing aids and is equipped with NOAH database and wireless programming capabilities. The laboratory also contains a clinical audiometer, tympanometer, CD player, and a variety of transducers, including supra-aural and insert earphones, bone vibrators and four loudspeakers. Probe-microphone systems (Audioscan Verifit 2) for recording and analysis of stimuli in the ear canal are available. Specialized software is available for implementing psychoacoustic paradigms, measuring acoustic stimuli, and analyzing data.

Clinical:

Audiology Clinic (McCreery). The Audiology Clinic [redacted] directed by [redacted] is located on the main floor of [redacted]. The clinic serves patients of all ages and is equipped with four double-walled, sound-treated booths and one single-walled booth. Peripheral equipment includes clinical audiometers, immittance devices, otoacoustic-emission systems, CD players, visual-reinforcement systems, and a variety of transducers, including supra-aural and insert earphones, bone vibrators and loudspeakers. The Hearing Technology Center is located adjacent to the diagnostic area and consists of four hearing-aid fitting rooms and an ear-mold laboratory. Equipment includes five Audioscan Verifit probe-microphone/hearing-aid analyzers, two video otoscopes, and PC computers equipped with hearing-aid programming software. The [redacted] Audiology Clinics had over 15,000 patient visits in 2017, and many patients with hearing loss seen in [redacted] clinics are enrolled in the human research subjects database, maintained by the Human Subjects Core.

Computer:

Central Computing Services. [redacted] has a general central computing facility that supports all computing [redacted] including general services required by investigators. [redacted] central networking equipment and servers are housed in a traditional computer room with a raised floor, appropriate air conditioning, fire alarm and extinguisher equipment, and an uninterruptible power supply. Data on most servers that are housed in the data center are backed up to a secondary data center. Computing support is provided by three groups: (1) [redacted] Corporate IT, (2) [redacted] IT, and (3) staff members dedicated to research computing. The research computing staff is supported by R01s and the COBRE Technical Core. Central servers communicate via 1- or 10-Gb backbones. All other resources are connected via 1-Gb Ethernet. Ethernet services also extend to several remote sites/clinics and to the Internet. Internet connectivity facilitates communication with other research centers and enables direct access to the library systems of major universities. Specialized network services are provided with Microsoft servers. Network application software, including Matlab and statistics software, is licensed and available for use on all lab and desktop PCs. The Matlab software also includes the signal-processing, data-acquisition, spline, symbolic-math, statistics, spreadsheet-link (between Matlab and Excel), and report-generator toolkits; all Matlab software is available to predoctoral candidates and all [redacted] research staff. Stata, R, SPSS, and Excel software packages are available for statistical analyses as needed. Other software available includes Adobe CS Master Collection (e.g., Photoshop, Acrobat, Illustrator) for preparation of figures and posters. Reference Manager, a publication database, is available through the network. BTNRH provides desktop PCs to all staff. [redacted] uses approximately 1200 Intel-based PCs. These run Windows 7 and standard applications software (Microsoft Office 2010, Internet Explorer, Outlook e-mail client, and anti-virus software).

Office:

Dr. McCreery's office is on the 3rd floor [redacted] in the Research Department. Additional desk space and computers for use by other staff (e.g., programmers, research assistants, and occasional graduate students) are available in the Hearing Aid Research Laboratory and Audibility, Perception, and Cognition Laboratory. A small conference room with computer projection equipment is available on the 3rd floor for laboratory meetings. A large conference room on the 1st floor is used for departmental meetings and seminars. Networked laser printers are located on every floor, and there are several individual printers in offices. All PCs are networked, enabling communication among PCs, between individual PCs and shared peripherals, including central computers and all printers within the Hospital. All PCs also have access to the Internet through the Ethernet network. Fax and copy machines are located within the office area.

Other:

Center for Perception and Communication in Children (Leibold). Research institutions in Nebraska are eligible for grants under the NIH Institutional Development Award (IDeA) program, including grants to develop Centers of Research Excellence (COBREs). In April 2014, [redacted] received funding for a Center for Perception and Communication in Children (CPCC) under the COBRE program. The center, directed by Dr. [redacted] supports up to five individual projects and two main cores, the Technical Core and the Clinical Measurement Core, described in more detail below. R01 and R03/R21 grants within the scope of the CPCC are eligible for core support but are expected to defray the marginal costs. The core infrastructure is supported by the CPCC. The CPCC also provides support for consultants and an active External Advisory Committee [redacted] and has further strengthened the [redacted] research environment. [redacted] also has benefitted from 15 years of core support provided through an NIDCD-funded P30 Core Center for Human Research Subjects and Laboratory Computing and Biostatistics. NIDCD has terminated the P30 program; therefore, the functions of the Human Research Subjects and Laboratory Computing and Biostatistics have been absorbed by two new cores developed as part of the CPCC: the COBRE Technical Core and the COBRE Clinical Measurement Core.

COBRE Technology Core (Chatterjee). The COBRE Technology Core (TC), currently under the direction of Dr. Monita Chatterjee, provides computer software and hardware research support to investigators on the COBRE grant and to other research faculty. The TC manages most of the shared equipment of the CPCC, but the key resource is the core staff consisting of a Systems Analyst and Coordinator of Software Development, [redacted] two Research Developers, [redacted], and a Quality Assurance Analyst, [redacted] has extensive experience in auditory and visual signal processing and was instrumental in the development of the Auditory-Visual Core Facility and technical innovations for several projects in Phase I. [redacted] has a PhD in experimental psychology, has extensive experience in auditory signal processing and developed software for the Balance and Vestibular Research Laboratory in Phase I. In addition, he manages the networked versions of MATLAB at BTNRH. Mr. Bashford specializes in real-time data collection applications. [redacted] expertise is in the use of testing techniques to identify software bugs and assist with resolution. Technology Core staff members maintain the Auditory-Visual Core Facility, and assist investigators in its use.

The Auditory-Visual (AV) Core Facility was developed with COBRE Phase I support for research on spatial effects of auditory and visual sound sources on children's speech perception and comprehension, with special emphasis on the listening needs of children with hearing loss. It includes a single-walled, acoustically isolated sound booth with inside dimensions of 19’ by 17’ with a height of 9’, a control room, office space for core personnel, and a waiting room. The control room is equipped with a second-generation Apple Mac Pro workstation, with an 8-core 3.0 GHz Intel processor, 64GB of RAM, a Dual AMD FirePro D700 GPU, and a 1TB PCIe-based flash storage system. Video is handled directly by the Mac Pro, which is capable of delivering 6 simultaneous streams of 1080p video over HDMI, which is sufficient to generate separate video on the 5 different HD television screens that are contained within the booth. The workstation connects to an equipment rack driving 28 channels of audio using an RME MADIFace, a 196-channel input/output (I/O) USB3 audio interface. The audio system includes 25 6” Elipson Planet M spherical 2-way loudspeakers and four sub-woofers (Swarm model, AudioKinesis). Video presentation is supported through the use of five 42” 1080p flat screen televisions (Vizio), or a 1080p projector (BenQ). Other computers with Microsoft and Apple operating systems are available to researchers in the facility. The AV Core also has a Knowles Electronics Manikin for Acoustic Research (KEMAR) for hearing-aid measurements, Larson-Davis sound-level meters and a 64-channel BrainVision ERP system purchased during Phase I for shared use.

Support for acoustic calibration and room acoustics is provided through a subcontract to [redacted] in the Durham School of Architectural Engineering and Construction at the University of Nebraska-Lincoln. The subcontract includes support for students in [redacted] architectural acoustics program to assist [redacted] faculty on calibration and room-acoustics issues.

Speech stimuli recordings for this project will be made in the AV Core facility sound booth using a large-diaphragm condenser microphone with a cardioid pickup pattern interfaced with a RME Babyface soundcard (to be purchased for this project). The sound card will be connected to one of the MAC-OS desktop computers. Editing will be performed using Audacity.

COBRE Human Subjects Core (McGregor). The COBRE Human Subjects Core (HSC), under the direction of [redacted] is housed within the LLTC. The HSC provides centralized support for the administration of a range of diagnostic tests. The HSC has absorbed several functions of our former P30 Human Research Subjects Core. These functions include subject recruitment, record keeping, assistance with preparation of IRB protocols, consent, assent and HIPAA forms, quality assurance in the consenting process, and assistance with preparation of NIH and IRB progress reports. The efficiency of subject recruitment has been significantly enhanced by the existence of this core, allowing researchers to focus more time on science. Of particular interest is the success in recruiting subjects from minority populations, whose representation in research programs at [redacted] either equals or exceeds their overall representation in the catchment area of [redacted]. This work is managed by a Coordinator of Subject Recruitment and Quality Assurance in the Recruitment and Quality Assurance Program (RQP).

The HSC provides centralized support for the administration of a range of diagnostic tests as well as support for subject recruitment through the Clinical Measurement Program (CMP). The program is staffed by a team of clinical experts in Audiology and Speech-Language Pathology, along with consultants in Psychology and Pediatric Ophthalmology. The HSC supports the aims of the principal investigators of COBRE CPCC projects and other research faculty through standardized collection of child and family background measures and behavioral measures that are likely to serve as predictors or covariates in analyses. Four behavioral domains examined in children and adults include: 1) comprehensive audiological measures, 2) cognition and executive function, 3) speech and language, and 4) vision screening. A centralized database allows for efficient sharing and non-duplication of measures across laboratories.

The HSC facilities are located on the main floor of the LLTC. These facilities include a double-walled, sound-treated booth, clinical audiometers, immittance devices, otoacoustic-emission systems, CD players, visual-reinforcement systems, and a variety of transducers, including supra-aural and insert earphones, bone vibrators and loudspeakers. Equipment includes two hearing-aid analyzers, two otoscopes, and PCs. The clinical research audiology testing area is adjacent to a large individual testing room for completion of speech-language, cognitive, and vision measures. This testing suite is equipped with a mounted SONY HD color digital video camera (EVI-H100V) with integrated pan head that may be controlled by remote and allows for observation and recording. The recording system includes a receiver, a Gefen MP4 recorder, and a DVD recorder. A Telex wireless lavaliere microphone with receivers and transmitters are used for audio recordings.

FACILITIES & OTHER RESOURCES: BTNRH

This area has two IBM laptop computers with speakers for presentation of computer-automated tasks. Two separate stations are used for data analysis and include SALT (Systematic Analysis of Language Transcripts) and CLAN (Child Language Analysis) language transcript software. The HSC professionals will assist COBRE Project Leads and other investigators with recruitment, subject testing, and transcription and coding of language samples.

Media Resources. Media support is available to all staff and represents an important institutional contribution to the research programs. The LLTC houses a well-equipped Media Resource facility, providing photographic, computer graphic, and audiovisual and illustration services to the research staff and to the Hospital as a whole. The 2-person staff prepares graphics and photographic materials for publication or presentation at scientific meetings. The LLTC also houses a well-equipped video and DVD production facility, staffed by two professional videographers, who are available for recording and editing of digital video and transfer of material to DVD. We have the capability of recording in multiple types of media (DVCPro/DVD/Mini-DV/S-VHS/VHS/MII). The LLTC is equipped with broadcast-quality cameras for recording and video-conferencing services. Upgraded A/V Equipment in the 200-seat [redacted] auditorium connects to the LLTC, allowing us to record presentations and/or broadcast lectures over the internet. The [redacted] Marketing department provides support for preparation of flyers for subject recruitment and maintains the CPCC web pages (https://www.boystownhospital.org/research/COBRE/).

BTNRH Library Services. With the advent of electronic subscriptions, investigators have access to journals published by the societies to which they belong. For those journals to which free access is not available to investigators, [redacted] staff have access to the archival literature through a service supported by the BTNRH research program. This service is staffed on a part-time basis by an Information Services Clerk, to whom requests for copies of published papers can be made. Copies of requested papers are sent electronically to the individual making the request, usually on the same day or the next day following the request, and are maintained in a shared repository on the network. The clerk has access to several local libraries including the Creighton University Health Science Library, the University of Nebraska-Lincoln Library, and the University of Nebraska Medical Center McGoogan Library of Medicine, the Regional Medical Library for Region 4 of the National Network of Libraries of Medicine.

Scientific Environment. The [redacted] research program includes 18 independent laboratories geared toward behavioral research, each directed by a Staff Scientist. Most Staff Scientists are in full-time research positions; none have significant teaching loads. In addition to postdoctoral fellows supported by individual grants, an institutional training grant (T32) provides support for three NRSA postdoctoral fellows. The research faculty, postdoctoral fellows and graduate students meet regularly for seminars and journal groups, including weekly journal groups. The research program also benefits from core services provided by the Core Center for Communication Disorders, which includes established support programs for biostatistics, laboratory computing and human subject recruitment. The biostatistics support is provided by a PhD faculty member from the Department of Biostatistics at the University of Nebraska Medical Center, College of Public Health, who spends one morning per week on site at [redacted] Laboratory computing support is provided by three research programmers. Human-subjects recruitment is provided by a coordinator who also assists with preparation of IRB protocols, annual reviews, and NIH progress reports. The proposed research program will benefit from this strong scientific environment.

FACILITIES & OTHER RESOURCES

[redacted]

Laboratories:

Pediatric Audiology Laboratory. The Pediatric Audiology Laboratory is housed in the Wendell Johnson Speech and Hearing Center in the Department of Communication Sciences and Disorders at the University [redacted]. The laboratory is under the direction of [redacted]. It consists of one large room that has been divided into smaller office modules for data entry personnel. Within the laboratory space, there is a large double-walled sound-treated booth that will be used for data collection from the research participants. The examination room is equipped with a clinical GSI-61 audiometer with speakers, supra-aural and insert earphones, two portable audiometers with supra-aural and insert earphone and bone vibrators, a GSI Tympstar tympanometer, a portable Welch Allyn Microtymp 2 tympanometer, two Audioscan Verifit probe microphone systems for presentation and analysis of stimuli in the ear canal, and two otoscopes. Two smaller rooms provide space for data entry personnel and the Iowa research staff.

Office:

Dr. [redacted] office space is located two floors below the laboratory space. It contains hardwired high-speed Internet access, as well as Internet access via the university's wireless Eduroam network.

Clinical:

Wendell Johnson Speech and Hearing Clinic (WJSHC). The WJSHC audiology clinic contains four double-walled, sound treated booths with audiometers, tympanometers, CD player, and a variety of transducers, including supra-aural and insert earphones, bone vibrators and loudspeakers. Probe-microphone systems for recording and analysis of stimuli in the ear canal are available.

Computer:

Facilities: All networking and file servers are provided by and maintained by the University [redacted] Information Technology Service. The file servers are housed in a standard computer facility with security and fire control. The file servers are equipped with a backup system, and the [redacted] ITS routinely provides sequential backup.

Networking: Work stations are all connected via high speed Ethernet to the remote file servers and also provide connections to Internet. Internet connectivity facilitates communication with other research centers and enables direct access to the library system that provides on-line access to Medline, ERIC, and Psychlit as well as electronic copies of most journal articles.

PCs: [redacted] laboratory is equipped with three Windows-based Dell personal computers, two Dell laptop computers, and two Surface laptops. The laboratory computers share an HP LaserJet Pro 400 printer as a network printer. This network provides the laboratory staff with access to a full complement of software that includes: PC-SAS and R for Windows, MPlus, Sigma Plot, Matlab, Adobe Audition and Audacity.

Telecommunications: [redacted] has access to Skype and Zoom technology that allows the use of high speed Internet II connections for video conferencing with the project consultant. The laboratory has a large monitor with HDMI capabilities to allow for video teleconferencing via Skype with intellectual collaborators.

Other Resources:

Data Management and Analysis. The Center for Public Health Statistics is a collegiate research and service center in the College of Public Health and will provide support for data management and analysis for

FACILITIES & OTHER RESOURCES: [redacted]

this project. Research in the CPHS includes collaborative projects from a variety of funding sources and over a broad array of public health concerns. Part of the mission of the Center is to facilitate access to major databases that are useful in health-related research, such as those produced by the Census Bureau and National Center for Health Statistics. The Center is located in a suite of eight rooms in the Westlawn building, on the health sciences campus. Four secured data servers and one web server are maintained to hold and transfer protected health data, as well as the usual assortment of desktop machines, printers, copy machine, etc. for the staff. The servers are securely housed in the collegiate central IT server room, and are managed by the collegiate IT staff, under the direction of [redacted]

Scientific Environment. [redacted] and her research team have access to facilities and equipment at the University [redacted] that will facilitate successful initiation and completion of the proposed research project. The University [redacted] Department of Communication Sciences and Disorders, located at the Wendell Johnson Speech and Hearing Center, is one of the top-ranked audiology training programs in the country. The research program at the University [redacted] includes 14 independent laboratories focused on communication sciences and disorders. Faculty, research associates, and students meet on a weekly basis for professional seminars and journal groups. The department benefits from multiple opportunities for interdisciplinary scholarship at the University of Iowa, including the Development and Learning from Theory to Application (DeLTA) Center, the Department of Otolaryngology, and the Psychological and Brain Sciences Department. The College of Public Health offers established support programs for biostatistics. The University of Iowa provides web-based courses and university-based services on ethical conduct of research and protection of human subjects. [redacted]. [redacted] department provides administrative support through a departmental administrative core. [redacted] also has set up her laboratory to allow for face-to-face video conferencing to maximize interactions with Dr. McCreery and the research team [redacted] has long-standing collaborations with Dr. McCreery and the [redacted] team.

EQUIPMENT

[redacted]

Audibility, Perception, and Cognition Laboratory (McCreery).

1. Large double-walled sound-treated booth.
2. Three PC computers having 24-bit A/D and D/A capabilities and a variety of analog devices. Software-based signal processing is available through external sound cards (RME Babyface, MOTU UltraLitemk3) on the primary lab computer.
3. A GSI-61 clinical audiometer with a variety of transducers, including supra-aural and insert earphones, bone vibrators, and loudspeakers.
4. Probe-microphone systems (Audioscan Verifit1 and Verifit2) for recording and analysis of stimuli in the ear canal are available.
5. R-Space speaker array with 8 amplified speakers.

[redacted]

The Resources section described a range of equipment that would support the research mission. Specific to this project is equipment needed to measure hearing in children and evaluate hearing aids.

Children will be seen in the Pediatric Audiology Laboratory at the University [redacted] This laboratory has three audiometers, three tympanometers, hearing aid fitting instruments including two Audioscan Verifit real ear systems, Biologic AudX automated OAE system, and otoscope.

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix: First Name*: Ryan Middle Name W. Last Name*: McCreery Suffix: Ph.D

Position/Title*: Director of Research
Organization Name*: [redacted]
Department:
Division: [redacted]
[redacted]
Street2:
City*: [redacted]
[redacted]
[redacted]
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number: [redacted]

E-Mail*: [redacted]

Credential, e.g., [redacted] [redacted]

Project Role*: PD/PI Other Project Role Category:

Degree Type: PhD Degree Year: 2011

Attach Biographical Sketch*: File Name: BIO_McCreery_RWM-R01resbm_12dec18.pdf

Attach Current & Pending Support: File Name:

Tracking Number: GRANT12761949 Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

PROFILE - Senior/Key Person

Prefix: First Name*: Adam Middle Name K. Last Name*: Bosen Suffix: Ph.D

Position/Title*: Scientist I & Lab Director
Organization Name*: [redacted]
Street2:
City*: [redacted]
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number: [redacted]

E-Mail*: [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PhD Degree Year: 2015

Attach Biographical Sketch*: File Name: BIO_Bosen_RWM_R01resbm_30nov18.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Monita Middle Name Last Name*: Chatterjee Suffix: Ph.D

Position/Title*: Director, Audit. Prosthes. & Percep. Lab
Organization Name*: [redacted]
Street2:
City*: [redacted]
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number: [redacted]

E-Mail*: [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PhD Degree Year: 1994

Attach Biographical Sketch*: File Name: BIO_Chatterjee_RWM_R01resbm_28nov18.pdf

Attach Current & Pending Support: File Name:

Tracking Number: GRANT12761949 Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

PROFILE - Senior/Key Person

Prefix: First Name*: Lori Middle Name J. Last Name*: Leibold Suffix: Ph.D

Position/Title*: Sr. Scientist & Center Director
Organization Name*: [redacted]

[redacted]

[redacted] USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number: [redacted]

E-Mail* [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PhD Degree Year: 2004

Attach Biographical Sketch*: File Name: BIO_Leibold_RWM_R01resbm_03dec18.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Dawna Middle Name E. Last Name*: Lewis Suffix: Ph.D

Position/Title*: Scientist I
Organization Name*: [redacted]

[redacted]

Street2:
City*: [redacted]

[redacted]

Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number: [redacted]

E-Mail* [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PhD Degree Year: 2005

Attach Biographical Sketch*: File Name: BIO_Lewis_RWM_R01resbm_30nov18.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Elizabeth Middle Name A. Last Name*: Walker Suffix: Ph.D

Position/Title*: Assistant Professor
Organization Name*: [redacted]
[redacted] [redacted]
Division:
Street1*: [redacted]
Street2:
City*: [redacted]
County:
State*: [redacted]
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number:

E-Mail*: [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PhD Degree Year: 2010

Attach Biographical Sketch*: File Name: BIO_Walker_RWM_R01resbm_30nov18.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Jacob Middle Name J. Last Name*: Oleson Suffix: Ph.D

Position/Title*: Associate Professor
Organization Name*: [redacted]
[redacted] [redacted]
Division:
Street1*: [redacted]
[redacted] [redacted]
[redacted] [redacted]
County:
State*: [redacted]
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number:

E-Mail*: jacob-oleson@uiowa.edu

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PhD Degree Year: 2002

Attach Biographical Sketch*: File Name: BIO_Oleson_RWM_R01resbm_29nov18.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Lisa Middle Name Surber Last Name*: Davidson Suffix: Ph.D

Position/Title*: Research Associate Professor
Organization Name*: [redacted]
Department: Otolaryngology
Division:
Street1*: [redacted]

USA: UNITED STATES
Zip / Postal Code*: [redacted]

Phone Number*: [redacted] Fax Number:

E-Mail*: [redacted]

Credential, e.g., agency login:

Project Role*: Consultant Other Project Role Category:

Degree Type: PhD Degree Year: 2003

Attach Biographical Sketch*: File Name: BIO_Davidson_RWM_R01resbm_30nov18.pdf

Attach Current & Pending Support: File Name:

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: McCreery, Ryan W.

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Director of Research; Director of the Audiblity, Perception, and Cognition Laboratory

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Univ. of Northern Colorado, Greeley, CO	B.A.	05/2000	Communication Disorders
Univ. of Nebraska-Lincoln, NE	M.S.	08/2002	Audiology
Univ. of Nebraska-Lincoln, NE	Ph.D.	05/2011	Communication Disorders

A. Personal Statement

I have the scientific experience, training, and expertise to serve as the Principal Investigator for the proposed studies and the administrative leadership to guide our research team. My current research, funded by an R01 from NIDCD, examines the influences of language and working memory on speech recognition in children with normal hearing and children with hearing loss. I am a co-investigator on the longitudinal Outcomes of Children with Hearing Loss and Outcomes of School-Age Children who are Hard of Hearing projects. My contributions to this multi-center project includes a comprehensive evaluation of the effects of audibility, hearing-aid use, and language abilities on listening in noise and reverberation in children who wear hearing aids. I have established a network of successful scientific collaborations across institutions that have prepared me to extend my work into mechanistic approaches to improving speech recognition in noise for children with hearing loss. My h-index is 17 and my mean Relative Citation Ratio for my publications is currently 2.67, indicating that my previous research has had high impact in the field. I have direct clinical experience working with Dr. Pat Stelmachowicz as a research audiologist from 2007-2011 on her work related to optimizing hearing aid signal processing for children with hearing loss. My research and leadership experiences make me an ideal candidate to lead the research team for the proposed studies.

1. **McCreery, R.W.** & Stelmachowicz. P.G. (2011). Audibility-based predictions of speech recognition for children and adults with normal hearing. *J. Acoust. Soc. Am.* ***130***(6), 4070-4081. **[PMCID: PMC3257757]**
2. **McCreery, R.W.** & Stelmachowicz, P.G. (2013). The effects of limited bandwidth and noise on verbal processing time and word recall in normal-hearing children. *Ear Hear.* ***34***(5), 585-591. **[PMCID: PMC3681878]**
3. Leibold, L.J., Hodson, H., **McCreery, R.W.**, Calandruccio, L. & Buss, E. (2014). Effects of low-pass filtering on the perception of word-final plurality markers in children and adults with normal hearing. *Am. J. Audiol.* ***23***(3), 351-358. **[PMCID: PMC4282933]**
4. **McCreery, R.W.**, Alexander, J., Brennan. M.A., Hoover, B., Kopun, J. & Stelmachowicz, P.G. (2014). The influence of audibility on speech recognition with nonlinear frequency compression for children and adults with hearing loss. *Ear Hear.* ***35***(4), 440-447. **[PMCID: PMC4065641]**

B. Positions and Honors

Positions and Employment

2002-2003	Clinical Fellow in Audiology, Boys Town National Research Hospital (BTNRH), Omaha, NE
2003-2004	Audiologist, South Seattle Otolaryngology, Burien, WA
2004-2005	Pediatric Audiologist, Mary Bridge Children's Hospital, Tacoma, WA
2005-2009	Clinical Audiologist, BTNRH
2007-2011	Research Audiologist, Hearing and Amplification Research Lab, BTNRH
2009-	Adjunct Assistant Professor, Special Education & Communication Disorders, University of Nebraska - Lincoln, Lincoln, NE
2010-2012	Adjunct Faculty, Dept. of Special Education, University of Nebraska - Omaha, Omaha, NE
2011	Research Associate, BTNRH
2011-2013	Associate Director of Audiology / Staff Scientist, BTNRH

2011-	Director of the Audibility, Perception and Cognition Laboratory, BTNRH
2013-2017	Director of the Center for Audiology, BTNRH
2017-	Director of Research, BTNRH

Other Experience and Professional Memberships

2002-2016	Nebraska Audiology License
2002-2012	Nebraska Hearing Instrument Dispensing License
2016	Subject Matter Expert, Institute of Medicine (IOM) Standing Committee of Medical Experts to Assist Social Security on Disability Issues, The National Academies of Sciences, Engineering, and Medicine (NASEM).
2016	Subject Matter Expert, Committee on the Use of Assistive Devices in Eliminating or Reducing the Effects of Impairments, NASEM.

Associate Editor, Ear and Hearing 2015-

Associate Editor, Journal of Educational Audiology 2012 –

Associate Editor / Editor, American Journal of Audiology 2016 -

Ad-hoc reviewer: Ear and Hearing; Journal of the Acoustical Society of America; Journal of Speech Language and Hearing Research; American Journal of Audiology; American Journal of Speech Language Pathology; International Journal of Pediatric Otolaryngology; Journal of the American Academy Audiology; International Journal of Audiology, European Journal Signal Processing, Acta Acuistica, Journal of the American Academy of Aging (AGE), Journal of Early Hearing Detection and Intervention, Candian Journal of Speech-Language Pathology and Audiology, Current Perspectives in Psychological Sciences, and Journal of Education Audiology

Ad-hoc reviewer: Language and Communication Study Section, National Institute for Deafness and Communication Disorders (NIDCD), National Institutes of Health, 2016

Ad-hoc reviewer: Congressionally Directed Medical Research Programs (CDMRP) Hearing and Balance Research (HBR) grant review, 2017

Ad-hoc reviewer: Clinical trial cooperative agreement grants, NIDCD, 2017

Acoustical Society of America, Member

Association for Research in Otolaryngology, Member

Educational Audiology Association, Member

American Academy of Audiology (AAA), Member
- State Leaders Network, 2006–
- Licensure Portability Task Force, 2008
- Pediatric Amplification Working Group, 2008–
- Subject Matter Expert, Pediatric Specialty Recognition Group, 2009
- Counseling Guidelines Task Force, 2009
- Research Committee, Member, 2015 –
- Audiology NOW! Program Committee – Chair, Learning Labs 2016-2017

American Speech-Language Hearing Association (ASHA), Member
- Legislative Councilor, Nebraska, 2006–2007
- Resolutions Working Group, 2007
- Ad-hoc Committee on Governance Transition 2007–2008
- Political Action Committee (PAC) Board, Member, 2008–2011
- Vice-chair, 2009, Chair, 2010
- Committee on Nominations and Elections, 2008-2009
- Audiology Advisory Council Member, 2008–2009
- Consultant, National Center for Evidence-Based Practice (N-CEP), 2010-2012

Nebraska Speech-Language Hearing Association (NSLHA), Member
- Legislative Affairs Committee, Member 2005–2010
- Co-chair 2007–2010
- Honors of the Association Award, 2007

Honors

1999, 2000	Departmental Scholar, Dept. of Communication Disorders, Univ. of Northern Colorado (UNC)
2000	B.A. Awarded with Honors, UNC
2000-2002	Graduate Fellowship, University of Nebraska-Lincoln (UNL)
2001-2002	Regents Fellowship, UNL
2007-2010	Othmer Fellowship, UNL
2008	Student Research Travel Award, International Hearing Aid Conference, August
2013	Early Career Contributions to Research Award, ASHA
2015	Distinguished Alumnus, College of Natural and Health Science, UNC
2016	Barkley Memorial Center, Outstanding Alumnus in Audiology, UNL

C. Contribution to Science

1. ***The Impact of Hearing Aid Signal Processing on Perception in Children and Adults with Hearing Loss.*** Children and adults who wear hearing aids have greater difficulty listening in background noise than peers with normal hearing. My work in this area explores which signal-processing features are most beneficial and how these features should be optimized to promote listening and learning. To date, our work has focused on evaluating digital-noise reduction and frequency-lowering signal-processing strategies in adults and school-age children with hearing loss. Alhtough the distortions introduced by these strategies may not affect speech recognition in adults, our research suggests that they may negatively affect speech recognition in children. These negative effects appear to be due to children's greater reliance on the acoustic-phonetic cues in the stimulus and greater need for audibility. For digital-noise reduction, our findings with children replicate results from adults; that is, noise reduction does not change speech recognition, but it does improve listening comfort and subjective report of clarity. For frequency lowering, our team has developed an audibility-based method of prescribing frequency-compression parameters which balances increased audibility while minimizing the potential for distortion of the speech spectrum. Our team's work in these areas has been included in international clinical guidelines for selecting signal-processing features for children with hearing loss.
   a. Stelmachowicz, P.G., Lewis, D., Hoover, B., Nishi, K., **McCreery, R.W.** & Woods, W. (2010). Effects of digital noise reduction on speech perception for children with hearing loss. *Ear Hear.* ***31***(3), 345-355. **[PMCID: PMC2864336]**
   b. **McCreery, R.W.**, Brennan, M.A. Hoover, B. Kopun, J. & Stelmachowicz, P.G. (2012). Maximizing audibility and speech recognition with nonlinear frequency compression by estimating audible bandwidth. *Ear Hear.* ***34***(2), e24-27. **[PMCID: PMC3566286]**
   c. **McCreery, R.W.**, Alexander, J., Brennan. M.A., Hoover, B., Kopun, J. & Stelmachowicz, P.G. (2014). The influence of audibility on speech recognition with nonlinear frequency compression for children and adults with hearing loss. *Ear Hear.* ***35***(4), 440-447. **[PMCID: PMC4065641]**
   d. Brennan, M.A., **McCreery, R.W.**, Kopun, J., Hoover, B., Alexander, J., Lewis, D., Stelmachowicz, P.G. (2014). Paired comparisons of nonlinear frequency compression, extended bandwidth, and restricted bandwidth hearing aid processing for children and adults with hearing loss. *J. Am. Acad. Audiol.* ***25***(10), 983-998. **[PMCID: PMC4269381]**

2. ***Factors that Affect Speech Recognition in Children and Adults with Normal Hearing.*** Audibility-based predictions of adult's speech-recognition abilities have been important for a wide range of applications including telephony, auditory signal processing, and hearing aids. Until recently, audibility-based predictions of speech recognition in children were limited. Children require greater audibility than adults to reach similar levels of speech recognition, but my research in this area has expanded knowledge about the specific factors that predict individual differences in speech recognition among children with normal hearing, including working memory and vocabulary skills. I have also explored how these factors change during the school-age years and differ across stimuli that vary in linguistic context. The culmination of this work is a model of speech recognition (McCreery et al. 2017) that includes bottom-up (audibility) and top-down (cognitive and linguistic) factors, which leads to more accurate predictions of speech recognition in children with normal hearing than previous models based on adult data. These findings have contributed to an improved understanding of speech recognition mechanisms in school-age children and better predictions of speech recognition in classrooms and other environments with noise.
   a. **McCreery, R.W.**, Ito, R., Spratford, M., Hoover, B.M., Lewis, D. & Stelmachowicz, P.G. (2010). Performance-intensity functions for normal-hearing adults and children using computer-aided speech perception assessment. *Ear Hear*. ***31***(1), 95-101. **[PMCID: PMC2800171]**
   b. **McCreery, R.W.** & Stelmachowicz, P.G. (2013). The effects of limited bandwidth and noise on verbal processing time and word recall in normal-hearing children. *Ear Hear.* ***34***(5), 585-591. **[PMCID: PMC3681878]**
   c. Leibold, L.J., Hodson, H., **McCreery, R.W.**, Calandruccio, L. & Buss, E. (2014). Effects of low-pass filtering on the perception of word-final plurality markers in children and adults with normal hearing. *Am. J. Audiol.* ***23***(3), 351-358. **[PMCID: PMC4282933]**
   d. **McCreery, R.W.**, Spratford, M., Kirby, B.J., & Brennan, M. (2017). Individual differences in language and working memory affect children's speech recognition in noise. *Int. J. of Audiol.* ***56***(5), 306-315. **[PMCID: PMC5634965]**

3. ***The Influence of Hearing Aids on Longitudinal Developmental Outcomes in Infants and Children with Hearing Loss.*** Much of the previous research on developmental outcomes in children with hearing loss has focused on demographic factors, such as degree of hearing loss and the presence of additional

disabilities, or variables related to the timing of interventions, such as age of identification or age of hearing-aid fitting. Understanding these demographic factors has had an positive impact on how we identify and serve children with hearing loss. In many cases, however, these factors are not responsive to intervention. I have sought to describe the malleable aspects of amplification, including hearing-aid use, aided audibility for speech, and signal processing. Malleable factors can be modified to optimize developmental outcomes in children who wear hearing aids. This research has been part of two longitudinal, multi-center studies, the *Outcomes of Children with Hearing Loss* study and the *Outcomes of School-Age Children who are Hard of Hearing* study. In both studies, our research team has monitored the development of a large group of infants and children (n=300) with hearing loss who use hearing aids. Our team's findings from these projects are an extension of the experimental research questions that we have explored related to the effects of hearing-aid signal processing on speech recognition in children, and support clinical decisions about the specific hearing-aid features that are beneficial for infants and children who wear hearing aids.

a. **McCreery, R.W.,** Walker, E.A., Spratford, M. Olseon, J., Bentler, R., Holte, L. & Roush, P. (2015). Speech recognition and parent ratings from auditory development questionnaires in children who are hard of hearing, *Ear Hear*. ePub ahead of print. **[PMCID: PMC4703361]**
b. **McCreery, R.W.**, Bentler, R.A. & Roush, P.A. (2013). Characteristics of hearing aid fittings in infants and young children. *Ear Hear.* ***34***(6), 701-710. **[PMCID: PMC3740078]**
c. **McCreery R.W.,** Brennan M., Walker E.A., Spratford M. (2017). Perceptual implications of level- and frequency-specific deviations from hearing aid prescription in children. *J. Am. Acad. Audiol.* ***28***(9), 861-875. [**PMCID: PMC5665572]**
d. **McCreery R.W.,** Walker E.A., Spratford M., Kirby B., Oleson J.,& Brennan M. (2016). Stability of audiometric thresholds for children with hearing aids applying the american academy of audiology pediatric amplification guideline: implications for safety. *J. Am. Acad. Audiol.* ***27***(3), 252-263. **[PMCID: PMC4789775]**

4. ***The Effects of Working Memory and Language on Perception in Children with Hearing Loss.*** Children with hearing loss are at a disadvantage when trying to understand speech in background noise. Our recent research has aimed to describe the cognitive and linguistic skills that might help to support speech recognition in noise for children with hearing loss. Our findings thus far have suggested that working memory appears to facilitate speech recognition in noise for children with hearing loss. Additionally, the effects of language ability on word recognition in children with hearing loss depends on an interaction between the child's vocabulary abilities and the complexity of the words used for the task. We have also examined how audibility, working memory, and spectral resolution may interact to support speech recognition in children with hearing loss. These findings have been informative in shaping the proposed experiments in our renewal application to expand the scope of our research to include other measures of executive function in addition to working memory.

a. Spratford M., McLean H.H., **McCreery R.W.** (2017) Relationship of grammatical context on children's recognition of s/z-inflected words. *J. Am. Acad. Audiol.* ***28***(9), 799-809. **[PMCID: PMC5665565]**
b. Klein K.E., Walker E.A., Kirby B., **McCreery R.W.** (2017) Vocabulary facilitates speech perception in children with hearing aids. *J. of Sp. Lang. Hear. Res.* ***60***(8), 2281-2296. **[PMID: 28738131; PMC Journal – In Process]**
c. Lewis D., Kopun J., **McCreery R.W.,** Brennan M., Nishi K., Cordrey E., Stelmachowicz P., Moeller M.P. (2017) Effect of context and hearing loss on time-gated word recognition in children. *Ear Hear.* ***38***(3), e180-e192. **. [PMCID: PMC5405001]**
d. Kirby B.J., Browning J.M., Brennan M.A., Spratford M., **McCreery R.W.** (2015) Spectro-temporal modulation detection in children. *J. Acoust. Soc. Am.* ***138***(5), EL465-486. **[PMCID: PMC4636496]**

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/ryan.mccreery.1/bibliography/40767675/public/?sort=date&direction=descending

D. Research Support

Ongoing Research Support

5 R01 DC013591-05 McCreery (PI) 12/01/13-11/30/19 ***(no-cost ext.)***
NIH-NIDCD

Complex Listening Skills in School-Age Hard of Hearing Children

The purpose of this research is to identify the factors that support speech recognition in realistic environments with a large group of children with mild to severe hearing loss in the school years. Role: PI

Ongoing Research Support - continued

5 P20 GM109023-05 Leibold (PD) 05/15/14-03/31/19
NIH-NIGMS
Center for Perception and Communication in Children (CPCC) - The goal of the CPCC, a COBRE at the Boys Town National Research Hospital in Omaha, Nebraska, is to expand the range of the current research program by providing a unique environment for the development of junior faculty who have an interest in understanding the consequences of childhood hearing loss for speech and language perception and processing, and ultimately describing performance of children with hearing loss in the real world.
Core A: Administration - The Administration Core will provide mechanisms for management of resources within the CPCC.
Role: Internal Mentor (Project 7, Bosen)

5 R01 DC009560-10 Tomblin (PI); Moeller (PI) 08/01/13-07/31/19 ***(no-cost ext.)***
NIH-NIDCD (Subaward with UIA)
Outcomes of School Aged Children who are Hard of Hearing
This is a competitive renewal application, which proposes to continue work related to the Outcomes of Children with Hearing Loss. Role: Co-Investigator

5 R01 DC011038-09 Leibold (PI) 07/01/16-06/30/21
NIH-NIDCD
Susceptibility To and Release From Masking in Infancy and Childhood
The long-term aim of this project is to identify and explain the factors responsible for the development of hearing in complex acoustic environments that contain multiple sources of sound. Role: Co-Investigator

5 R01 DC015056-03 Leibold & Buss (MPI) 08/10/16-07/31/21
NIH-NIDCD
A Test of Children's English/Spanish Speech Perception in Noise or Speech Maskers
The goal of this project is to develop, refine and evaluate a pediatric speech perception test for use with English-speaking, Spanish-speaking and bilingual children. Role: Co-Investigator

5 R44 DC015445-03 Clavier (PI) 07/01/16-07/31/19
NIH-NIDCD SBIR Phase I & II Subaward w/Creare LLC
Open Design Tools for Speech Signal Processing
The open source library will allow researchers to evaluate novel signal-processing algorithms. The wearable device will allow for evaluations outside the laboratory setting in real-world environments and under conditions that closely mimic use of real hearing aids. Role: Collaborator

W81XWH-16-C-0187 Clavier (PI) 09/30/16-09/29/19
US Army Medical Research and Materiel Command (SBIR Phase II Subaward w/Creare LLC)
Field Deployable Otoacoustic Emissions Probe for Objective Tracking of Noise Induced Hearing Loss
Develop objective measurement tool for the detection of noise-induced hearing loss and a smart algorithm for monitoring. Role: Collaborator

Completed Research Support

4 R01 DC011806-05 Jesteadt (PI) 03/01/12-02/28/19 ***(2nd no-cost ext.)***
NIH-NIDCD
The Loudness of Broadband Sounds in Listeners with Sensorineural Hearing Loss
The goal of this research program is to establish a better framework for the use of loudness data in hearing-aid design and ultimately hearing-aid fitting. Role: Co-Investigator

5 R03 DC012635-03 McCreery (PI) 06/18/12-05/31/16 ***(no-cost ext.)***
NIH-NIDCD
Optimizing Speech Recognition for Children with Hearing Loss
The goal of this research is to quantify the impact of language and working memory skills on speech recognition in children with normal hearing. Role: PI

5 R01 DC004300-15 Jesteadt (PI) 12/01/09-11/30/15 ***(no-cost ext.)***
NIH-NIDCD
Optimizing Amplification for Infants and Young Children
The overall goal of this project is to explore ways in which to enhance auditory access and auditory experiences in young children with hearing loss. Role: Co-Investigator

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Bosen, Adam K.

eRA COMMONS USER NAME (agency login):[redacted]

POSITION TITLE: Director, Auditory Perceptual Encoding Lab

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	Completion Date MM/YYYY	FIELD OF STUDY
Rochester Institute of Technology, Rochester, NY	B.S./M.S.	08/2010	Computer Engineering
University of Rochester, Rochester, NY	M.S./Ph.D.	10/2015	Biomedical Engineering
Father Flanagan's Boys' Home d/b/a Boys Town Nat'l Research Hospital	Postdoc Fellow	03/2017	Cochlear Implants

A. Personal Statement

My long-term research goal is to improve speech recognition in listeners with cochlear implants (CIs). This goal requires a holistic view of auditory perception. To that end, I intend to conduct research that spans quality of life, speech recognition, cognitive function, and auditory psychophysics in listeners with CIs. As an early stage investigator, I am currently focused on developing experiments that will measure how aspects of executive function interact with auditory signal quality to facilitate speech recognition in difficult listening conditions. I have one paper in review at Ear and Hearing that represents the first step of this line of research. My previous postdoctoral training under the direction of Monita Chatterjee has provided me with the experience to develop a unique research direction that incorporates the research methods I learned in her lab. Our publication in JASA demonstrates a method of quantifying the contribution of each channel in a clinical CI processing strategy to a listener's ability to understand speech. This work has been adapted for use as the band importance estimation technique proposed in this grant.

My educational background in computer engineering, postdoctoral training in CI psychophysics, and ongoing connection with the center for Childhood Deafness, Language, and Learning at Boys Town National Research Hospital have provided me with the computational, experimental, and clinical skills necessary to conduct this research program. The work proposed here allows me to apply my existing skill set to a new research domain in collaboration with other researchers. This experience will support the holistic development of my research program, which will prepare me for my own grant applications. In addition to this grant, Sarah Yoho (Utah State) and I have a manuscript in revision with JASA, in which we measured band importance functions in adults with hearing loss. This collaboration has helped validate my methodology and will provide a reference for comparison to the data collected in this grant.

My first publication with Monita is listed here:

1. **Bosen AK**, Chatterjee M (2016). Band importance functions of listeners with cochlear implants using clinical maps. *The Journal of the Acoustical Society of America*, ***140***(5), 3718-3727. **(PMCID: PMC5392084)**

B. Positions and Honors

Positions and Employment

April 2017 - Scientist I, Auditory Perceptual Encoding Laboratory, Center for Hearing Research, Boys Town National Research Hospital, Omaha, NE

Other Experience and Professional Memberships

2010 - 2015 **Teaching Assistantships:** Biosystems and circuits (x2), Biomedical Signals and Measurements, Physiological Control Systems, Introduction to Neuroengineering, Quantitative Physiology

2016 - 2017 **Software workshops:** Co-developed code sharing workshops for the Association for Research in Otolaryngology Midwinter Meetings in 2016-2018.

2016 - Association for Research in Otolaryngology, Member

2017 - Acoustical Society of America, Member

2018 - Psychonomic Society, Member

Ongoing **Ad-hoc reviewer:** American Journal of Audiology, Journal of the Association for Research in Otolaryngology, Ear and Hearing, Experimental Brain Research, Hearing Research, Journal of the Acoustical Society of America, Journal of the American Academy of Audiology, Journal of Communication Disorders, Journal of Speech, Language, and Hearing Research, Trends in Hearing

C. Contribution to Science

1. Spectral Components That Contribute to Speech Recognition in Listeners with CIs

Speech comprehension ability widely varies across listeners with CI, and the mechanisms that limit speech comprehension are poorly understood. Under the direction of Dr. Monita Chatterjee, I have developed measures of the extent to which listeners rely on the information carried by each channel within their clinically programmed processors. Our findings indicate that there is a trend that listeners tend to rely on channels with input frequency ranges around 1 – 2 kHz, which is similar to listeners with normal hearing, and also around 200 – 400 Hz, which differs from results observed in listeners with normal hearing. Additionally, the channels that provide good speech comprehension vary across listeners with CIs. These results indicate that listeners with CIs use a speech recognition strategy that is different from the one used by listeners with normal hearing, and that each listener adapts to the cues that their clinical processor provides. This work forms a foundation for continuing research to identify the specific properties of each channel that limit their ability to contribute to speech comprehension, and has subsequently been adapted to estimate band importance in listeners with sensorineural hearing loss in this grant and in collaboration with Sarah Yoho at Utah State University.

a. **Bosen AK**, Chatterjee M (2016). Band importance functions of listeners with cochlear implants using clinical maps. *The Journal of the Acoustical Society of America*, ***140***(5), 3718-3727. **(PMCID: PMC5392084)**

2. Auditory Quality and Test Material Interact in Short-term Memory

Serial recall of digits is often used to measure short-term memory span in various listening conditions. However, digits are easy to identify even with low quality auditory input, and as a result using digits masks the effects of auditory quality on memory span. We have developed within-subject comparisons of auditory serial recall of digits with recall of large sets of words and non-words in adults with typical hearing. These comparisons have shown that difficult listening conditions differentially impair serial recall across words and non-words. Specifically, recall of non-word lists is predominantly limited by phonetic confusion of items during both identification and recall, whereas recall of words is limited by interference between word identification and memory maintenance. This work shows that testing serial recall with different stimulus sets can isolate the distinct effects of intrinsic memory capacity and auditory input quality on serial recall. A manuscript on this topic is currently under review at Ear and Hearing.

3. Visual Influences on Auditory Spatial Perception

Perception of audio-visual object location is weighted based on the reliability of each sense, which can be altered by prior audio-visual experience. We have demonstrated that prior expectation is influenced by the experimental task that listeners perform, and that audio-visual experience can induce shifts in auditory spatial perception on multiple time scales. Changes in prior expectation across tasks are important because they preclude quantitative comparison across experimental setups without measuring and adjusting for these changes. Multiple time scales of shifts in auditory spatial perception are important because previously it was believed that the "ventriloquism aftereffect" comprised a single adaptive process with one time constant.

a. **Bosen AK**, Fleming JT, Brown SE, Allen PD, O'Neill WE, Paige GD (2016). Comparison of congruence judgment and auditory localization tasks for assessing the spatial limits of visual capture. *Biological Cybernetics*, ***110***(6), 455-471. **(PMCID: PMC5115967)**

b. **Bosen AK**, Fleming JT, Allen PD, O'Neill WE, Paige GD (2017). Accumulation and decay of visual capture and the ventriloquism aftereffect caused by brief audio-visual disparities. *Experimental Brain Research*, ***235***(2), 585-595. **(PMCID: PMC5274572)**

c. **Bosen AK**, Fleming JT, Allen PD, O'Neill WE, Paige GD (2018). Multiple time scales of the ventriloquism aftereffect. *PLoS ONE*, ***13***(8), e0200930. **(PMCID: PMC6070234)**

Complete List of Published Work in MyBibliography:
https://www.ncbi.nlm.nih.gov/sites/myncbi/adam.bosen.1/bibliography/52069404/public/?sort=date&direction=descending

D. Research Support

Ongoing Research Support

5 P20 GM109023-05 Leibold (PD) 05/15/14-03/31/19
NIH-NIGMS
Center for Perception and Communication in Children (CPCC) - The goal of the CPCC, a COBRE at the Boys Town National Research Hospital in Omaha, Nebraska, is to expand the range of the current research program by providing a unique environment for the development of junior faculty who have an interest in understanding the consequences of childhood hearing loss for speech and language perception and processing, and ultimately describing performance of children with hearing loss in the real world.
Project 7: Cognitive mechanisms that facilitate speech comprehension in listeners with cochlear implants: The goal of this project is to identify the specific cognitive and linguistic skills that listeners who have used cochlear implants from an early age use to identify speech cues.
Role: Project Lead Investigator, Project 7

96862-Startup Funding Bosen (PI) 04/01/17-03/31/20
Auditory Perceptual Encoding Lab, Boys Town National Research Hospital
Speech Comprehension with Cochlear Implants
The goal of this work is to identify the specific psychophysical, cognitive, and linguistic factors that limit speech comprehension in listeners with cochlear implants.
Role: PI

Completed Research Support

5 T32 DC00013-37 Keefe (PD) 07/01/15-06/30/20
NIH-NIDCD
Research in Human Communication and Its Disorders
This is a grant that provides institutional training support for three postdoctoral fellows.
Role: Postdoctoral Fellow (09/01/15-03/31/17)

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Chatterjee, Monita

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Director, Auditory Prostheses and Perception Laboratory

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Jadaypur University, Calcutta, India	B.E.E.	06/1987	Electrical Engineering
Syracuse University, Syracuse, NY	Ph.D.	12/1994	Neuroscience
House Ear Institute, Los Angeles, CA	Postdoc	12/1998	Cochlear Implants

A. Personal Statement

I am excited to work on the research proposed by Dr. McCreery in this application. My technical and scientific expertise, including two decades of experience as an NIH-funded principal investigator make me well-suited as a contributor to the aims of this grant proposal. I have a strong interest in the interplay of bottom-up and top-down mechanisms in different aspects of speech perception, a central theme of this application. My laboratory investigates two broad areas of research. One key project focuses on complex pitch perception by school-aged children with cochlear implants, and its relation to their processing of prosodic cues and lexical tones. A second area of research focuses on psychophysical measures of spectral and temporal coding by adult cochlear-implant listeners. Recently, we have expanded our studies to include listeners with mild to severe hearing loss, and Dr. McCreery's input has greatly enriched our thinking in this area. In collaboration with students, postdocs, and colleagues, I have led and contributed to many studies on the processing of degraded auditory inputs by the normally hearing system, in children and in adults. Below I list four recent publications relevant to the work proposed here.

1. Tinnemore AR, Zion DJ, Kulkarni AM, **Chatterjee, M.** (2018). Children's recognition of emotional prosody in spectrally degraded speech is predicted by their age and cognitive status. *Ear Hear.* doi: 10.1097/AUD.0000000000000546 **[PMCID: PMC6046271, Available on 2019/9/1]**
2. Bosen, A.K., **Chatterjee, M.** (2016). Band importance functions of listeners with cochlear implants using clinical maps. *J. Acoust. Soc. Am.* ***140***(5), 3718-3727. **[PMCID: PMC5392084]**
3. Peng SC, Lu HP, Lu N, Lin YS, Deroche MLD, **Chatterjee, M.** (2017). Processing of acoustic cues in lexical-tone identification by pediatric cochlear-implant recipients. *J Speech Lang. Hear. Res.* ***60***(5), 1223- 1235. **[PMCID: PMC5755546]**
4. Deroche, M.L., Kulkarni AM, Christensen JA, Limb CJ, **Chatterjee, M.** (2016). Deficits in the sensitivity to pitch sweeps by school-aged children wearing cochlear implants. *Front. Neurosci.* ***10***, 73. **[PMCID: PMC4776214]**

B. Positions and Honors

Positions and Employment

1998-2003	Scientist I, House Ear Institute, Los Angeles, CA
2003-2004	Scientist II, House Ear Institute, Los Angeles, CA
2005-2009	Assistant Professor, Hearing & Speech Sciences Dept., Univ. of Maryland, College Park, MD
2009-2012	Associate Professor, Hearing & Speech Sciences Dept., Univ. of Maryland, College Park, MD
2012-2015	Staff Scientist IV and Director, Auditory Prostheses and Perception Laboratory, Boys Town National Research Hospital, Omaha, NE
2015-present	Director, Auditory Prostheses and Perception Laboratory, and Senior Scientist, Boys Town National Research Hospital, Omaha, NE

Other Experience and Professional Memberships

2006-2009	Elected Member, P&P Technical Committee, Acoustical Society of America
2009	University Research Leader, University of Maryland
2009-present	Member, Editorial Board, Trends in Amplification
2009-2011	Associate Editor, International Journal of Audiology
2010-2011	Guest Editor, Ear and Hearing
2011-2012	Section Editor, Cochlear Implants, Ear and Hearing
2011-2013	Elected Scientific Chair, 2013 Conference on Implantable Auditory Prostheses
2011-2014	Elected Member, P&P Technical Committee, Acoustical Society of America
2012-2016	Standing Member, CDRC panel, NIH/NIDCD
2013	Mentor, ASHA Pathways Program
2015-present	Review Editor, Frontiers in Auditory & Cognitive Neuroscience
2017-present	Editor, American Journal of Audiology
2017-2020	Member, Program Committee, Association for Research in Otolaryngology
2019-	Associate Editor, Journal of the Acoustical Society of America Express Letters

Honors

1992	Di Carlo Fellowship, Syracuse University
1994-1995	Doctoral Prize, Syracuse University
2009	University Research Leader, University of Maryland, College Park
2013	Elected Scientific Chair, Conference on Implantable Auditory Prostheses
2017	CI 2017 Conference Keynote Speaker
2018	American Auditory Society Translational Research Speaker
2017	Elected Fellow of the Acoustical Society of America "for contributions to cochlear implant psychophysics and speech perception"

C. Contribution to Science

1. Auditory Perception with Cochlear Implants: Spread of Excitation and Loudness My early work with Dr. Robert V. Shannon and others at House Ear Institute laid important groundwork for measures of spatial selectivity (or lack thereof) in cochlear-implanted listeners. As a post-doc at House Ear Institute, I conducted some of the first detailed measures of the relations between loudness growth and pulsatile-stimulation parameters such as current amplitude, electrode separation and pulse-phase duration. Based on psychophysical measures, I derived fundamental equations for single-channel loudness growth, building on previous work and adding new information about the effects of stimulation parameters.

a. **Chatterjee, M.** & Shannon, R.V. (1998). Forward masked excitation patterns in multielectrode electrical stimulation. *J. Acoust. Soc. Am.* ***103***(5), 2565-2572.

b. **Chatterjee, M.** (1999). Effects of stimulation mode on threshold and loudness growth in multielectrode cochlear implants. *J. Acoust. Soc. Am.* ***105***(2 Pt 1), 850-860.

c. **Chatterjee, M.**, Fu, Q.J. & Shannon, R.V. (2000). Effects of phase duration and electrode separation on loudness growth in cochlear implant listeners. *J. Acoust. Soc. Am.* ***107***(3), 1637- 1644.

d. **Chatterjee, M.**, Galvin, J.J. 3rd, Fu, Q.J. & Shannon, R.V. (2006). Effects of stimulation mode, level, and location on forward-masked excitation patterns in cochlear implant patients. *J. Assoc. Res. Otolaryngol.* ***7***(1), 15-25. **[PMCID: PMC2504584]**

2. Auditory Perception with Cochlear Implants: Temporal Processing and Modulation Interference: In the late 1990-s and early 2000-s, ours was one of the few labs conducting cochlear-implant research with controlled electrical stimuli via research interface. Little was known about complex temporal processing in cochlear-implant listeners. Bob Shannon's published work had shown an exponential recovery from forward masking in electrical stimulation. With more detailed measurements, I showed that recovery from forward masking follows a two-time constant exponential function. This was later corroborated in cortical measures by Kirby and Middlebrooks (*J Neurophys 103*(1), 531-542, 2010). My work provided the first quantification of effects of noise on modulation coding in electrical stimulation, showing that under some conditions, envelope noise can act to enhance modulation sensitivity while in other conditions, modulation interference occurs across channels. A recently published study shows that modulation interference occurs in cochlear-implant listeners even when the masker and the target are presented sequentially in time.

a. **Chatterjee, M.** (1999). Temporal mechanisms underlying recovery from forward masking in multielectrode-implant listeners. *J. Acoust. Soc. Am.* ***105***(3), 1853-1863.

b. **Chatterjee, M.** & Robert, M.E. (2001). Noise enhances modulation sensitivity in cochlear implant listeners: stochastic resonance in a prosthetic sensory system? *J. Assoc. Res. Otolaryngol.* ***2***(2), 159-171. **[PMCID: PMC3201182]**

c. **Chatterjee, M.** (2003). Modulation masking in cochlear implant listeners: envelope versus tonotopic components. *J. Acoust. Soc. Am.* ***113***(4), 2042-2053.

d. **Chatterjee, M.** & Kulkarni, A.M. (2018). Modulation detection interference in cochlear implant listeners under forward masking conditions. *J. Acoust. Soc. Am.* ***143***(2), 1117-1127. **[PMCID: PMC5821512]**

3. Perception of Degraded Speech by Normally Hearing Listeners Across the Lifespan: Cochlear-implant simulations have shown that normally-hearing listeners can process degraded speech with remarkable accuracy. In quiet, experienced listeners can achieve excellent performance with 4 bands of band-limited noise carrying basic temporal amplitude information derived from the original speech signal (Shannon et al, *Science 270*(5234), 303-304). In noise, however, larger numbers of spectral bands become necessary (Friesen et al, *J. Acoust. Soc. Am. 110*(2), 1150-1163). In her PhD work in my lab, Kara Schvartz-Leyzac found that middle-aged and older listeners had greater difficulty with cochlear- implant-simulated speech than younger listeners, and that this was related to cognitive status, underscoring the importance of top-down processing in the perception of degraded speech. In addition, older listeners had greater difficulty in extracting voice-pitch cues from degraded speech. At the other end of the age range, my collaboration with Rochelle Newman has shown that even toddlers can recognize cochlear-implant-simulated speech at levels above chance, pointing to the robustness of human speech recognition. In collaborative work with Jonathan Simon's group, we have found that cortical entrainment of the MEG signal to speech in background noise requires the spectro-temporal fine structure of the original speech signal to be preserved, consistent with difficulties faced by cochlear-implant listeners.

a. Schvartz, K.C., **Chatterjee, M.** & Gordon-Salant, S. (2008). Recognition of spectrally degraded phonemes by younger, middle-aged, and older normal-hearing listeners. *J. Acoust. Soc. Am.* ***124***(6), 3972-3988. **[PMCID: PMC2662854]**

b. Schvartz, K.C. & **Chatterjee, M.** (2012). Gender identification in younger and older adults: use of spectral and temporal cues. *Ear Hear.* ***33***(3), 411-420. **[PMCID: PMC3340495]**

c. Newman, R. & **Chatterjee, M.** (2013). Toddlers' recognition of noise-vocoded speech. *J. Acoust. Soc. Am.* ***133***(1), 483-494. **[PMCID: PMC3548833]**

d. Ding, N., **Chatterjee, M.** & Simon, J.Z. (2013). Robust cortical entrainment to the speech envelope relies on the spectro-temporal fine structure. *Neuroimage* ***88c***, 41-46. **[PMCID: PMC4222995]**

4. Voice-pitch Discrimination and Prosodic-Cue Perception by Normally Hearing and Cochlear-Implanted Children and Adults: Voice-pitch changes in speech carry information about communicative intent and mood, as well as linguistic information. This information is particularly important for children to acquire as they learn their language and develop socially. Cochlear-implanted listeners must glean voice-pitch information from the periodicity in the temporal envelope. Work in my lab has quantified adult cochlear-implanted listeners' sensitivity to pitch information in the temporal envelope, and shown that this sensitivity is correlated with their performance in a speech-intonation recognition task. Our work has also shown that early-implanted children show a deficit in pitch sensitivity relative to their normally hearing peers, but that there is no difference when both groups are forced to rely on temporal-envelope cues for complex pitch discrimination. In recent work, we have quantified voice-emotion recognition by school-aged children with cochlear implants, and shown that performance is correlated with their sensitivity to static and dynamic changes in complex pitch.

a. **Chatterjee, M.** & Peng, S.C. (2008). Processing F0 with cochlear implants: Modulation frequency discrimination and speech intonation recognition. *Hear. Res.* ***235***(1-2), 143-156. **[PMCID: PMC2237883]**

b. Deroche, M.L., Lu, H.P., Limb, C.J., Lin, Y.S. & **Chatterjee, M.** (2014). Deficits in the pitch sensitivity of cochlear-implanted children speaking English or Mandarin. *Front. Neurosci.* ***8***, 282. **[PMCID: PMC4158799]**

c. **Chatterjee, M.**, Zion, D.J., Deroche, M.L., Burianek, B.A., Limb, C.J., Goren, A.P., Kulkarni, A.M. & Christensen, J.A. (2015). Voice emotion recognition by cochlear-implanted children and their normally-hearing peers. *Hear. Res.* ***322***, 151-162. **[PMCID: PMC4615700]**

d. Deroche, M.L., Kulkarni, A.M., Christensen, J.A., Limb, C.J. & **Chatterjee, M.** (2016). Deficits in the sensitivity to pitch sweeps by school-aged children wearing cochlear implants. *Front. Neurosci.* ***10***, Article 73, 1-15. doi: 10.3389/fnins.2016.00073. **[PMCID: PMC4776214]**

5. Acoustic Cue-Weighting by Normally Hearing and Cochlear-Implanted Listeners: Speech is a redundant signal, and this property makes it robust to degradation. Work in my lab led by my former post-doc Shu-Chen Peng and my former PhD student Matthew Winn has shown that both normally hearing and cochlear-implanted adult listeners shift their attention to secondary cues for speech intonation and for phonetic identification when primary cues are degraded. In addition, collaborative work with William Idsardi and Ariane Rhone has shown that visual context can shift the category boundary in a phonetic-identification task when the auditory cue is degraded, as in cochlear-implanted listeners. In a paper accepted for publication, we report on cue-weighting mechanisms in lexical-tone recognition by children with cochlear implants living in Taiwan. This line of work underscores the importance of listening strategy and linguistic knowledge in speech perception.

a. Peng, S.C., Lu, N. & **Chatterjee, M.** (2009). Effects of cooperating and conflicting cues on speech intonation recognition by cochlear implant users and normal hearing listeners. *Audiol. Neurotol.* ***14***(5), 327-337. **[PMCID: PMC2715009]**

b. Winn, M.B., **Chatterjee, M.** & Idsardi, W.J. (2012). The use of acoustic cues for phonetic identification: effects of spectral degradation and electric hearing. *J. Acoust. Soc. Am.* ***131***(2), 1465-1479. **[PMCID: PMC3292615]**

c. Winn, M.B., Rhone, A.E., **Chatterjee, M.** & Idsardi, W.J. (2013). The use of auditory and visual context in speech perception by listeners with normal hearing and listeners with cochlear implants. *Front. Psychol.* ***4***, 824. **[PMCID: PMC3817459]**

d. Peng, S.C., Lu, H.P., Lu, N., Lin, Y.S., Deroche, M.L.D. & **Chatterjee, M.** (2017). Processing of acoustic cues in lexical-tone identification by pediatric cochlear-implant recipients. *J. Sp. Lang. Hear. Res.* ***60***(5), 1223-1235. **[PMCID: PMC5755546]**

Complete List of Published Work in MyBibliography:
https://www.ncbi.nlm.nih.gov/myncbi/browse/collection/41074154/?sort=date&direction=descending

D. Research Support

Ongoing Research Support

5 P20 GM109023-05 Leibold (PD) 05/15/14-03/31/19
NIH-NIGMS
Center for Perception and Communication in Children (CPCC) - The goal of the CPCC, a COBRE at the Boys Town National Research Hospital in Omaha, Nebraska, is to expand the range of the current research program by providing a unique environment for the development of junior faculty who have an interest in understanding the consequences of childhood hearing loss for speech and language perception and processing, and ultimately describing performance of children with hearing loss in the real world.
Core A: Administration - The Administration Core will provide mechanisms for management of resources within the CPCC.
Core B: Technology Core - The Technology Core will provide technical expertise to support the CPCC.
Role: Core A-Internal Mentor; Core B-Director, Technology Core

5 R01 DC014233-05 Chatterjee (PI) 07/01/14-06/30/19
NIH-NIDCD
Cochlear-Implanted Children's Use of Acoustic Cues in Prosody and Lexical Tones
Voice pitch changes in speech convey important prosodic aspects of communication, play a critical role in language acquisition, and carry additional semantic information in tonal languages such as Mandarin. However, present-day cochlear implants (CIs) do not provide adequate information about voice pitch to the listener. This work will examine how English- and Mandarin-speaking school-aged child users of CIs perceive and express such information. The work has implications for CI design and rehabilitative strategies.
Role: PI

Ongoing Research Support - continued

5 R01 DC014233-05S1 Chatterjee (PI) 07/01/17-06/30/19
NIH-NIDCD
Diversity Supplement: Cochlear-Implanted Children's Use of Acoustic Cues in Prosody and Lexical Tones
Research supplement of the parent grant (R01DC014233) to support the eligible candidate, Dr. Shauntelle Cannon, to improve the diversity of the research workforce.
Role: PI

5 R01 HD081127-04 Newman (PI) 08/03/15-06/30/20
NIH-NICHD (Subaward with UMD)
Toddlers' Listening and Learning in Noise: Distraction vs Signal Degradation
Research on infants' and toddlers' perception of speech in challenging auditory conditions.
Role: Consortium Lead Investigator

5 T32 DC000013-39 Keefe (PD) 07/01/15-06/30/20
NIH-NIDCD
Research in Human Communication and Its Disorders
This grant provides institutional training support for three postdoctoral fellows.
Role: Co-Program Director

5 R01 DC016038-03 He (PI) 01/15/18-06/30/22
NIH-NIDCD (Subaward with OSU)
Neural Encoding and Auditory Perception in Cochlear Implant Users
This study is designed to better understand underlying neurophysiological mechanisms of speech perception deficits in older CI users. Older listeners are known to have temporal processing deficits, and temporal cues are particularly important for discriminating speech in CI users.
Role: Consortium Lead Investigator

Completed Research Support

No Grant # Chatterjee (PI) 01/01/17-12/31/17
American Hearing Research Foundation (AHRF)
Modulation Interference in Listeners with Cochlear Implants
The goal of this grant is to quantify modulation interference in cochlear implant listeners, and to investigate the relation between this form of interference and speech recognition by cochlear implant patients in background noise. The focus is on interference between sine-wave modulated signals and on interference in forward-masked conditions. Overlap with the present proposal is minimal to nil, although the broad research areas are related. Role: Principal Investigator

COBRE Pilot Project-01 He (PI) 01/01/16-12/31/16
BTNRH COBRE – NIH/NIGMS
Cortical Auditory Event-Related Potentials in Patients with Auditory Brainstem Implants
The overall objective of this proposed study is to evaluate the association between subjective perception and electrophysiological measures of electrically evoked auditory event-related potentials (eERPs), including the onset eERP and the electrically evoked auditory change complex (eACC), in adult ABI users. Role: Consultant

5 R13 DC013522-03 Shannon (PI) 07/01/13-06/30/16
NIH-NIDCD
2013 and 2015 Conferences on Implantable Auditory Prostheses
This proposal seeks partial support for a biennial international conference on basic research on cochlear implants and other forms of prosthetic hearing. This conference provides a unique forum for scientists to share their latest research and to brainstorm about future directions in research. Role: Co-Investigator

1 F32 DC015159-01A1 Kirby (PI) 12/09/15-07/28/16
NIH-NIDCD
Development of Spectral Resolution in Children
The primary goal of this work to determine the extent to which children's performance on these two measures of spectral resolution is dependent on cognitive abilities and the listener's age. The secondary goal is to determine whether the relationship of spectral resolution to speech perception in noise is mediated by cognitive abilities and listener age. Role: Co-Sponsor

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES**.

NAME: Leibold, Lori J.

eRA COMMONS USER NAME (agency login): [redacted]

POSITION TITLE: Director, Center for Hearing Research

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE (*if applicable*)	Completion Date MM/YYYY	FIELD OF STUDY
McMaster University, Hamilton ON	B.S.	01/1994	Biology
University of Western Ontario, London ON	M.S.	01/1997	Audiology
University of Washington, Seattle WA	Ph.D.	01/2004	Auditory Development
Father Flanagan's Boys' Home doing business as Boys Town National Research Hospital, Omaha NE	Postdoctoral	07/2006	Psychoacoustics

A. Personal Statement

My research interest is auditory development, with a focus on understanding how children learn to hear and process important target sounds such as speech in the presence of competing background sounds. I have extensive experience studying the effects of auditory masking across the age continuum from infancy to childhood, with a focus on how children learn to separate speech produced by one talker when multiple people are talking at the same time. One of my long-term interests has been to determine the factors responsible for the substantial speech recognition difficulties experienced by children with hearing loss in the presence of competing background sounds. I am excited and well qualified to serve as an investigator on the worked proposed by Dr. McCreery. We have worked closely on several research projects over the past several years, taking advantage of our complimentary expertise to address questions of both theoretical and clinical importance. The work proposed by Dr. McCreery in the present application will provide a much-needed and comprehensive model of the myriad factors responsible for the variable speech recognition outcomes observed for children with hearing loss. I will work closely with Dr. McCreery to support this important work, with a specific emphasis on experiments investigating children's recognition of speech in competing speech or noise.

1. **Leibold, L.J.** & Buss, E. (2013). Children's identification of consonants in a speech-shaped noise or a two-talker masker. *Journal of Speech, Language, and Hearing Research*, ***56***(4), 1144-1155. **[PMCID: PMC3981452]**
2. Calandruccio, L., Gomez, B., Buss, E., & **Leibold, L.J.** (2014). Development and preliminary evaluation of a pediatric Spanish-English speech perception task. *American Journal of Audiology*, ***23***(2), 158-172. **[PMCID: PMC4282934]**
3. Corbin, N.E., Bonino, A.Y., Buss, E., & **Leibold, L.J.** (2015). Development of open-set word recognition in children: Speech-shaped noise and two-talker speech maskers. *Ear and Hearing,* ***37***(1), 55-63. **[PMCID: PMC4864436]**
4. **Leibold, L.J.**, Buss, E., & Calandruccio, L. (2018). Developmental effects in masking release for speech-in-speech perception due to a target/masker sex mismatch. *Ear and Hearing*, ***39***(5), 935-945. **[PMCID: PMC6056341]**

B. Positions and Honors

<u>Positions and Employment</u>

1997 - 1998 Clinical Audiologist, Royal Victoria Hospital, Barrie ON

2006 - 2012 Assistant Professor, Dept, of Allied Health Sciences, Univ. of North Carolina, Chapel Hill, NC

Positions and Employment - continued

2012 - 2015	Associate Professor, Department of Allied Health Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC
2015 -	Adjunct Associate Professor, Department of Allied Health Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC
2015 -	Director, Center for Hearing Research, Boys Town National Research Hospital, Omaha, NE
2016 -	Director, Center for Perception and Communication in Children, Boys Town National Research Hospital, Omaha, NE

Other Experience and Professional Memberships

1994 -	Member, Speech, Language and Audiology Canada
1997 -	Clinical Certification in Audiology, Speech, Language and Audiology Canada
1998 -	Member, Acoustical Society of America
2005 -	Member, American Auditory Society
2005 -	Member, Association for Research in Otolaryngology
2010 - 2014	Elected Member, P&P Technical Committee, Acoustical Society of America
2012 - 2015	Selection Committee Member, Judith Gravel Fellowship in Pediatric Audiology
2012 -	Grant Reviewer, American Speech-Language-Hearing Foundation
2012	Reviewer, National Institutes of Health (NIDCD)
2014 - 2016	State Licensure in Audiology, Board of Examiners for Speech Language Pathology and Audiology, State of North Carolina
2017 -	Editor, Journal of Speech, Language, and Hearing Research
2017 -	Member, Research and Scientific Affairs Committee, American Speech-Language-Hearing Association
2017 -	Member, Steering Committee, Great Plains IDeA-CTR Network
2017 -	Elected Member, Speech Communication Technical Committee, Acoustical Society of America
2018	Reviewer, National Institutes of Health (NIDCD)
2005 -	Ad Hoc Review for over 10 journals, including: *American Journal of Audiology; Attention, Perception, and Psychophysics; Cognition; Current Directions in Psychological Science; Developmental Science; Ear and Hearing; Journal of the Acoustical Society of America; Journal of the Association for Research in Otolaryngology; Journal of Speech, Language, Hearing Research; Trends in Hearing*

Honors

2001 - 2002	Huckabay Teaching Fellowship, The University of Washington
2008	Lessons for Success, American Speech-Language-Hearing Foundation and NIDCD

C. Contributions to Science

The following contributions represent work completed as PI or a Co-investigator.

1. Understanding the progression of auditory development under complex listening conditions

I have characterized the progression of auditory development for under complex listening conditions from infancy to adulthood. These studies have emphasized developmental aspects of “informational masking”, which plays an important role in natural acoustic environments, such as when multiple competing sources of sound are active at the same time. These publications, which have included both speech and non-speech stimuli, highlight the presence of substantial child-adult differences in auditory performance that extend into adolescence.

a. **Leibold, L.J.**, & Neff, D.L. (2007). Effects of masker-spectral variability and masker fringes in children and adults. *Journal of the Acoustical Society of America*, ***121***(6), 3666-3676. **[PMCID: PMC17552718]**

b. Bonino, A.Y., **Leibold, L.J.**, & Buss, E. (2013). Release from perceptual masking for children and adults: benefit of a carrier phrase. *Ear and Hearing*, ***34***(1), 3-14. **[PMCID: PMC3529824]**

c. **Leibold, L.J.**, & Buss, E. (2016). Factors responsible for remote-frequency masking in children and adults. *Journal of the Acoustical Society of America, **140***(6)***,*** 4367-4377. **[PMCID: PMC5392082]**

d. Buss, E., **Leibold, L.J.,** Porter, H.L., & Grose, J.H. (2017). Speech recognition in one- and two-talker maskers in school-age children and adults: Development of perceptual masking and glimpsing. *Journal of the Acoustical Society of America*, ***141***(4), 2650-2660. **[PMCID: PMC53911283]**

2. Effects of hearing loss on speech-in-speech perception

It is well documented that children with hearing loss experience greater speech perception challenges that peers with normal hearing when competing background sounds are present. These difficulties have historically been attributed to impairments in the peripheral encoding of sound, but I directed research implicating perceptual processing difficulties (e.g., selective attention to target speech in a competing masker) as a key contributor to the performance gap between children with hearing loss and children with normal hearing. This body of work has also provided evidence that children's speech recognition in a complex speech masker is associated with functional hearing abilities.

a. **Leibold, L.J.**, Hillock-Dunn A., Duncan, N., Roush, P.A. & Buss, E. (2013). Influence of hearing loss on children's identification of spondee words in a speech-shaped noise or a two-talker masker. *Ear and Hearing*, ***34***(5), 575-584. **[PMCID: PMC3686966]**

b. Hillock-Dunn, A., Buss, E., Duncan, N., Roush, P.A. & **Leibold, L.J.** (2014). Effects of nonlinear frequency compression on speech identification in children with hearing loss. *Ear and Hearing*, ***35***(3), 353-365. **[PMCID: PMC4301569]**

c. Hillock-Dunn, A., Taylor, C., Buss, E. & **Leibold, L.J.** (2015). Assessing speech perception in children with hearing loss: what conventional clinical tools may miss. *Ear and Hearing*, ***36***(2), e57-60. **[PMCID: PMC4336618]**

d. Corbin, N.E., Buss, E. & **Leibold, L.J.** (2017). Spatial release from masking in children: Effects of simulated unilateral hearing loss. *Ear and Hearing, **38***(2), 223-235. **[PMCID: PMC5321780]**

e. Assessing auditory behavior across the continuum from infancy to adulthood

Working with a collaborative team of basic and applied hearing researchers, I have developed feasible and scientifically sound methods and procedures for studying the auditory behavior of infants, preschoolers, school-age children, adolescents, and young adults. Rigorous and reliable testing procedures have been development and refined in our laboratory. These procedures have directly led to improvements in our ability to evaluate hearing in both clinical and laboratory settings. For example, we developed a two-interval, observer-based testing procedure as a means of obtaining unbiased estimates of threshold throughout infancy and the preschool years using an efficient adaptive paradigm. I served as the primary investigator or co-investigator for all of these studies.

a. **Leibold, L.J.**, & Werner, L.A. (2002). Relationship between intensity and reaction time in normal-hearing infants and adults. *Ear and Hearing*, ***23***(2), 92-97.

b. **Leibold, L.J.**, & Werner, L.A. (2006). Effect of masker-frequency variability on the detection performance of infants and adults. *Journal of the Acoustical Society of America*, ***119***(6), 3960-3970. **[PMCID: PMC16838539]**

c. Browning, J., Buss, E., & **Leibold, L.J.** (2014). Preliminary evaluation of a two-interval, two-alternative infant behavioral testing procedure. *The Journal of the Acoustical Society of America*, ***136***(3), EL236. **[PMCID: PMC4144168]**

d. Bonino, A.Y., & **Leibold, L.J.** (2017). Behavioral assessment of hearing in 2 to 4 year-old children: a two-interval, observer-based procedure using conditioned play-based responses. *Journal of Visualized Experiments, **119**,* 54788. **[PMCID: PMC5352283]**

3. Isolating acoustic cues that aid in the separation of target from background speech for children with normal hearing.

We have completed a series of experiments that have evaluated the extent to which children exploit acoustic differences between target and masker speech to facilitate separation of target from masker speech. The findings have revealed key differences between children and adults, and have provided the foundation for practical solutions that can be used to improve speech-in-speech recognition for children with hearing loss.

a. Baker, M., Buss, E., Jacks, A., Taylor, C., & **Leibold, L.J.** (2014). Children's perception of speech produced in a two-talker background. *Journal of Speech, Language, and Hearing Research*, ***57***(1), 327-337. **[PMCID: PMC4481168]**

b. Calandruccio, L., **Leibold, L.J.**, & Buss, E. (2016). Linguistic masking release in school-age children and adults. American Journal of Audiology, ***25***(1), 34-40. **[PMCID: PMC4832874]**

c. Buss, E., **Leibold, L.J.**, Porter, H.L., & Grose, J.H. (2017). Speech recognition in one- and two-talker maskers in school-age children and adults: Development of perceptual masking and glimpsing. *Journal of the Acoustical Society of America*, ***141***(4), 2650-2660. **[PMCID: PMC53911283]**

d. **Leibold, L.J.**, Buss, E., & Calandruccio, L. (2018). Developmental effects in masking release for speech-in-speech perception due to a target/masker sex mismatch. *Ear and Hearing*, 39(5), 935-945. **[PMCID: PMC6056341, Available on 2019/9/1]**

Complete List of Published Work in MyBibliography:
https://www.ncbi.nlm.nih.gov/sites/myncbi/lori.leibold.1/collections/54942192/public/

D. Research Support

Ongoing Research Support

5 P20 GM109023-05 Leibold (PD) 05/15/14-03/31/19
NIH-NIGMS
Center for Perception and Communication in Children (CPCC) - The goal of the CPCC, a COBRE at the Boys Town National Research Hospital in Omaha, Nebraska, is to expand the range of the current research program by providing a unique environment for the development of junior faculty who have an interest in understanding the consequences of childhood hearing loss for speech and language perception and processing, and ultimately describing performance of children with hearing loss in the real world.
Core A: Administration - The Administration Core will provide mechanisms for management of resources within the CPCC.
Role: Program Director

5 R01 DC011038-09 Leibold (PI) 07/01/16-06/30/21
NIH-NIDCD
Susceptibility To and Release From Masking in Infancy and Childhood
This administrative supplement provides support for supplemental informationist services provided by liaison librarians at UNC's Health Sciences Library. Each librarian is focused on one specific aim to enhance the ongoing project, which addresses the maturation of children's hearing across childhood.
Role: PI

5 R01 DC014460-04 Buss (PI) 04/01/15-03/31/20
NIH-NIDCD (Subaward w UNC)
Factors Influencing the Behavioral Assessment of Hearing During Infancy and Childhood
Basic and applied experiments are proposed to differentiate the factors responsible for immature auditory behavior, and to develop novel methods for the evaluation of particular functional hearing abilities.
Role: Subaward, Co-Investigator

Ongoing Research Support - continued

5 R01 DC015056-03 Leibold (PI) 08/10/16-07/31/21
NIH-NIDCD
A Test of Children's English/Spanish Speech Perception in Noise or Speech Maskers
The proposed work will develop an easy-to-administer clinical test of speech perception, allowing audiologists (regardless of their language proficiency) to appropriately evaluate Spanish- and English-speaking children in both noise and two-talker backgrounds.
Role: PI

5 U54 GM115458-03 Rizzo (PD) 09/01/16-06/30/19
NIH-NIGMS
Great Plains IDeA-CTR
Dr. Leibold, as Institutional Program Coordinator for Boys Town, will serve on the Steering Committee and help the IDeA-CTR meet its overall goals and milestones.
Role: Institutional Program Coordinator

Completed Research Support

1 F32 DC016771-01 Flaherty (PI) 01/25/18-01/24/19
NIH-NIDCD
The benefit derived from acoustic voice differences for speech-in-speech recognition in school-age children
The goal of this training program is to acquire knowledge, laboratory experience, and data in support of a future independent program of research that investigates how children take advantage of acoustic voice differences between target and masker speech to hear and understand speech.
Role: Sponsor (This F32 terminated early, 8/15/18)

No Grant # Leibold (PI) 07/01/16-02/28/17
Oticon
Effect of Combined Directionality and Noise Reduction Hearing Aid Signal Processing on Speech Recognition in Spatially Separated Noise or Speech
The overall goal of this project is to evaluate the influence of a fully adaptive directionality hearing aid algorithm on masked speech perception for children with bilateral, sensory/neural hearing loss.
Role: Principal Investigator

R01 DC011038-05S1 Leibold (PI) 03/01/14-02/29/16
NLM-NIDCD
Susceptibility To and Release From Masking in Infancy and Childhood
This administrative supplement provides support for supplemental informationist services provided by liaison librarians at UNC's Health Sciences Library. Each librarian is focused on one specific aim to enhance the ongoing project, which addresses the maturation of children's hearing across childhood.
Role: PI

Clinical Research Grant Hillock-Dunn (PI) 06/01/14-08/31/16
American Speech-Language-Hearing Foundation
Speech Identification in Children Using Frequency-Compression Hearing Aids
This project evaluates the influence of both balanced and ear-specific nonlinear frequency compression hearing aid settings on binaural speech perception benefit in children with asymmetric hearing loss.
Role: Consultant

F32 DC014209-01 Porter (PI) 09/01/14-08/31/16
NIH-NIDCD
Mechanisms of Temporal Processing Maturation
The goal of this training program is to acquire knowledge, laboratory experience, and data in support of a future independent program in the behavioral and electrophysiological assessment of temporal processing in children.
Role: Co-Sponsor

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Lewis, Dawna E.

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Senior Research Associate

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Univ. of Virginia, Charlottesville, VA	B.S.	05/1980	Speech Pathology & Audiology
Univ. of Tennessee, Knoxville, TN	M.A.	06/1982	Audiology
Univ. of Nebraska, Lincoln, NE	Ph.D.	05/2005	Human Sciences, with emphasis in Communication Disorders

A. Personal Statement

My focus as an audiologist and researcher has been on understanding and improving speech perception in individuals with hearing loss. The goal of Dr. McCreery's research program is to develop clinical interventions to optimize real-world speech understanding for children with hearing loss. Toward that goal, the proposed research will lead to a comprehensive model that reflects the influences of executive function and language on speech recognition in noise for children with hearing loss. For this project, I will bring expertise in audiology, hearing aids, and speech perception in children and adults with normal hearing and hearing loss. Prior obtaining my PhD, I worked for 23 years as a clinical and research audiologist at BTNRH. My work on Dr. Pat Stelmachowicz's NIH-supported grants focused on remediation of hearing loss in children, particularly related to hearing-aid signal processing and optimizing amplification for infants and young children. I continued to collaborate on Dr. Stelmachowicz's grants until their completion. My own NIH-supported research has focused on speech understanding in children with normal hearing and children with hearing loss. Recent work has examined the impact of mild bilateral and unilateral hearing loss on children's speech understanding in complex listening environments by manipulating acoustic and visual characteristics of target and masker stimuli. I also currently serve as the Clinical Research Coordinator for a multi-site clinical trial of a Spanish/English speech perception test for children (Co-PIs: Lori Leibold, PhD and Emily Buss, PhD).

1. **Lewis, D.** & Carrell, T.C. (2007). The effect of amplitude modulation on intelligibility of time-varying sinusoidal speech in children and adults. *Percept. Psychophys.* ***69***(7), 1140-1151.
2. Choi, S., Lotto, A.J., **Lewis, D.**, Hoover, B., & Stelmachowicz, P.G. (2008). Attentional modulation of word recognition by children in a dual-task paradigm. *J. Speech Lang. Hear. Res.* ***51***, 1042-1054. **[PMCID: PMC2585316]**
3. Valente, D.L., Plevinsky, H., Franco, J., Heinrichs, E. & **Lewis, D**. (2012). Experimental investigation of the effects of the acoustical conditions in a simulated classroom on speech recognition and learning in children. *J. Acoust. Soc. Am*. ***131***(1), 232-246. **[PMCID: PMC3283898]**
4. **Lewis, D.**, Kopun, J., McCreery, R., Brennan, M., Nishi, K., Cordrey, E., Stelmachowicz, P., & Moeller, M.P. (2017). Effect of context and hearing loss on time-gated word recognition in children. *Ear. Hear*. **38**, e180-e192. **[PMCID: PMC5405001]**

B. Positions and Honors

Positions and Employment

1982-2005	Research Assistant and Clinical Audiologist, Boys Town Nat'l Research Hospital, Omaha, NE
1984-2002	Asst. Instructor, Dept. Human Communication, Creighton Univ. School of Medicine, Omaha, NE
2001-2003	Clinical Supervisor, Audiology, Barkley Memorial Speech & Hearing Clinic, Univ. Nebraska-Lincoln
2005-2009	Senior Research Associate, Boys Town National Research Hospital, Omaha, NE
2009-2014	Adjunct Asst. Professor, Special Ed. & Communication Disorders, Univ. Nebraska-Lincoln, NE
2009-2018	Director, Listening & Learning Laboratory, Boys Town National Research Hospital, Omaha, NE
2018-present	Senior Research Associate, Boys Town National Research Hospital, Omaha, NE

Other Experience and Professional Memberships

1987-2012	ASHA Program Committee (Amplification, 1987, 1992, 2001; Aural Rehab., 1994; Audiology Assessment, 1995, 1996; Hearing Aids, 1997; Educational Management of Children with Hearing Loss, 2002; Infant Hearing: Screening and Assessment, 2012)
1991-1995	ANSI Accredited Standards Committee, SG/WG81 Assistive Listening Devices
1992-2000	ASHA Special Interest Division 9 Steering Committee
1993-1997	Editorial Consultant, *Lang Sp Hearing Serv Schools*
1995-1997	ASHA Board of Division Coordinators
1995-1997	Coordinator, ASHA Special Interest Division 9 Steering Committee
1996-2000	Joint Committee of ASHA/Council on Education of the Deaf
1996-1997	EAA Task Force on Recommendations for Professional Practices in Educational Audiology
1997-2003	EAA Research and Creative Endeavors Committee
1998-1999	ASHA Ad Hoc Committee on FM Systems
1998-1999	Chair, Joint Committee of ASHA/Council on Education of the Deaf
1998-2000	Associate Editor, *Lang Sp Hearing Serv Schools*
1999-2003	Chair, EAA Research and Creative Endeavors Committee
2001-2003	Editorial Consultant, *Lang Sp Hearing Serv Schools*
2001-	Editorial Board, *Seminars in Hearing*
2013-	BTNRH Institutional Review Board
2005-2015	AAA Task Force on Guidelines for Remote Microphone Hearing Assistance Technology (HAT)
2008-2010	Better Hearing Institute Pediatric Advisory Council
2009-	Phonak Pediatric Advisory Board
2009-2011	ABA Pediatric Audiology Specialty Certification Committee (subject matter expert)
2012-2016	ASHA Publications Board
2013	AAA Program Committee: Research and Clinical Posters
2014-2016	EAA Research Grants and Scholarships Committee
2015-2016	Associate Editor, *Am J. Sp. Lang. Path.*
2017	Editorial Board Member, *Lang Sp Hearing Serv Schools*
2018-2020	Editor, *Lang Sp Hearing Serv Schools*

Multiple **Ad Hoc Reviewer (current and past):** Am. J. Audiol.; Am. J. Sp. Lang. Path.; Build. Acoust., *Ear Hear.; J. Sp. Lang. Hear. Res.; Int. J. Audiol.; J. Acoust. Soc. Am.; J. Educ. Ped. Rehab. Audiol.; J. Exp. Child Psychol.; Lang. Sp. Hear. Serv. Schools; Trends in Amp.; J Applied Psycholing.*

Multiple **Member:** Am. Speech-Language-Hear. Assoc., Am. Auditory Soc., Am. Acad. of Audiol., Educ. Audiol. Assoc., Neb. Speech-Language-Hearing Assoc., Acoust. Soc. Am., Int. Soc. Audiol.

Multiple **Guest Associate Editor:** *Lang. Sp. Hear. Serv. Schools, Am J. Sp. Lang. Path*.

Honors

1994 **Editor's Award**, *Am. J. Audiol.*: **Lewis, D.E.** (1994). Assistive devices for classroom listening. *Am. J. Audiol.* ***3***, 58-69; **Lewis, D.E.** (1994). Assistive devices for classroom listening: FM systems. *Am. J. Audiol.* ***3***, 70-83.

2002 **Editor's Award**, *Ear Hear.*: Stelmachowicz, P.G., Pittman, A.L., Hoover, B.M., & **Lewis, D.E.** (2002). Aided perception of /s/ and /z/ by hearing-impaired children. *Ear Hear.* ***23***(4), 316-324.

2006 Folsom Distinguished Dissertation Award, University of Nebraska-Lincoln

2007 **Editor's Award**, *Ear Hear.*: Moeller, M.P., Hoover, B., Putman, C., Arbataitis, K. Bohnenkamp, G. Peterson, B., Wood, S., **Lewis, D.,** Pittman, A., & Stelmachowicz, P.G. (2007). Vocalizations of Infants with Hearing Loss Compared to Infants with Normal Hearing: Part I – Phonetic Development. Ear and Hearing, 28(5), 605-627.

Moeller, M.P., Hoover, B., Putman, C., Arbataitis, K., Bohnenkamp, G., Peterson, B., **Lewis, D.,** Estee, S., Pittman, A., & Stelmachowicz, P., (2007). Vocalizations of Infants with and without Hearing Loss: Part II – Transition to Words. Ear and Hearing, 28(5), 628-642

2008 Cheryl DeConde Johnson Award for Outstanding Achievement in Educational and Pediatric Audiology

C. Contribution to Science

1. Impact of high-frequency audibility in children and adults with normal-hearing or hearing loss.

Historically, the bandwidth of hearing aids has been narrower than that of the speech signal, resulting in reduced audibility for high-frequency speech sounds. While this reduced audibility may have a limited effect in adults with acquired hearing loss, the impact on children who are acquiring speech and language skills is significant. Our work in this area revealed that children require greater access to high frequencies for understanding important aspects of speech and language, including plurality and possession. A significant translational outcome from this line of research has been a change in hearing-aid signal processing to improve access to high frequencies, particularly for hearing aids designed for pediatric populations.

a. Stelmachowicz, P., Pittman, A., Hoover, B. & **Lewis, D.** (2001). Effect of stimulus bandwidth on the perception of /s/ in normal- and hearing-impaired children and adults. *J. Acoust. Soc. Am.* ***110***(4), 2183-2190.

b. Stelmachowicz, P., Pittman, A., Hoover, B. & **Lewis, D.** (2002). Aided perception of /s/ and /z/ by hearing-impaired children. *Ear Hear.* ***23***(4), 316-324.

c. Stelmachowicz, P.G., **Lewis, D.**, Choi, S. & Hoover, B.M. (2007). Effect of stimulus bandwidth on auditory skills in normal-hearing and hearing-impaired children. *Ear Hear.* ***28***(4), 483-494. **[PMCID: PMC2396880]**

d. Stelmachowicz, P.G., Nishi, K., Choi, S., **Lewis, D.**, Hoover, B., Dierking, D. & Lotto, A.J. (2008). Effects of stimulus bandwidth on the imitation of English fricatives by normal-hearing children. *J. Speech Lang. Hear. Res.* ***51***(5), 1369-1380. **[PMCID: PMC2630769]**

2. Effects of amplification on speech understanding in adults and children with hearing loss.

Amplification options for individuals with hearing loss have expanded, particularly with the advent of digital signal processing. However, research has demonstrated that amplification needs for children differ from the needs of adults, for a variety of reasons (e.g., speech/language/cognitive development, physical size, audibility needs). This work focused on examining the effects of signal-processing algorithms and amplification technologies used with children across a variety of speech inputs and acoustic conditions with the goal of optimizing amplification for children with hearing loss. As part of our work in this area, I collaborated in the development of the Situational Hearing Aid Response Profile (SHARP) computer program. This program is designed to quantify the audibility of speech in a variety of unamplified and amplified listening conditions, taking into account factors that vary with age, transducer and type of amplification. The program was updated in 2014, incorporating current signal-processing strategies in hearing aids. It is available to professionals for clinical and research applications (http://audres.org/rc/sharp/). A significant translational outcome from this line of research has been an understanding of ways in which amplification technologies may have different effects for developing children than would be found for adults with late-onset hearing loss.

a. Brennan, M.A., McCreery, R., Kopun, J., Hoover, B., Alexander, J., **Lewis, D.** & Stelmachowicz, P.G. (2014). Paired comparisons of nonlinear frequency compression, extended bandwidth, and restricted bandwidth hearing aid processing for children and adults with hearing loss. *J. Am. Acad. Audiol. **25***(10)*,* 983-998. **[PMCID: PMC4269381]**

b. Kimlinger, C., McCreery, R., & **Lewis, D.** (2015). High-frequency audibility: the effects of audiometric configuration, stimulus type and device. *J. Am. Acad. Audiol. **26***(2), 128-137. **[PMCID: PMC4397964]**

c. Brennan, M., McCreery, R., Kopun, J., **Lewis, D.**, Alexander, J., & Stelmachowicz, P. (2016). Masking release in children and adults with hearing loss when using amplification. *J. Sp. Lang. Hear. Res. **59***(1), 110-121. **[PMCID: PMC4867924]**

d. Brennan, M., **Lewis, D.,** McCreery, R., Kopun, J., & Alexander, J. (2017). Listening effort and speech recognition with frequency compression amplification for children and adults with hearing loss. *J. Am. Acad. Audiol., **28***(9), 823-827 **[PMCID: PMC5634744]**

3. Speech perception in noise and reverberation of children with normal hearing and children with hearing loss.

Examining the effects of noise and reverberation on children who are developing speech-perception abilities is important for understanding how they will be able to communicate in complex listening environments. Our work in this area examined speech understanding for a variety of speech stimuli and amplification technologies, and in acoustic conditions that are representative of those found in realistic environments, such as classrooms. This work contributes essential information about the effects of acoustics on varying aspects of speech perception that are important for real-world understanding.

a. Stelmachowicz, P.G., **Lewis, D.**, Hoover, B., Nishi, K., McCreery, R. & Woods, W. (2010). Effects of digital noise reduction on speech perception for children with hearing loss. *Ear Hear. **31***(3), 345-355. **[PMCID: PMC2864336]**

b. **Lewis, D.**, Hoover, B., Choi, S. & Stelmachowicz, P. (2010). Relationship between speech perception in noise and phonological awareness skills for children with normal hearing. *Ear Hear*. ***31***(6), 761-768. **[PMCID: PMC3358133]**

c. Nishi, K., **Lewis, D.**, Hoover, B.M. & Stelmachowicz, P.G. (2010). Children's recognition of American English consonants in noise. *J. Acoust. Soc. Am. **127***(5), 3177-3188. **[PMCID: PMC2882671]**

d. Wroblewski, M., **Lewis, D.**, Valente, D. & Stelmachowicz, P. (2012). Effects of reverberation on speech recognition in stationary and modulated noise by school-aged children and young adults. *Ear Hear. **33***(6), 731-744. **[PMCID: PMC3474865]**

4. Speech understanding in complex listening environments in children with normal hearing and children with minimal/mild bilateral or unilateral hearing loss.

The work under this topic represents the most recent activities in my research program. This work examines auditory and audiovisual speech understanding of children with normal hearing and children with MBHL or UHL with the aim of better understanding of the factors that affect performance in complex listening environments. Our work has shown that, while children with MBHL and UHL may perform similarly to children with normal hearing on simple speech-perception tasks (that typically do not predict performance in real-world listening conditions), they differ in their ability to comprehend speech in acoustic conditions similar to those in which they typically learn, namely classrooms. My research addresses this problem through rigorously controlled studies that will provide data that will translate to realistic listening environments.

a. **Lewis, D.**, Manninen, C., Valente, D.L., & Smith, N. (2014). Children's understanding of instructions presented in noise and reverberation. *Am. J. Audiol.* ***23***(3), 236-336. **[PMCID: PMC4154970]**

b. **Lewis, D.**, Valente, D.L. & Spalding, J.L. (2015). Effect of minimal/mild hearing loss on children's speech understanding in a simulated classroom. *Ear Hear.* ***36***(1), 136-144. **[PMCID: PMC4272681]**

c. **Lewis, D.**, Schmid, K., O'Leary, S., Spalding, J., Heinrichs-Graham, E., & High, R. (2016). Effects of noise on speech recognition and listening effort in children with normal hearing and children with mild bilateral or unilateral hearing loss. *J. Speech Lang. Hear. Res*. ***59***(5), 1218-1232. **[PMDIC: PMC5345560]**

d. **Lewis, D.**, Smith, N., Spalding, J. & Valente, D.L. (2018). Looking behavior and audiovisual speech understanding in children with normal hearing and children with mild bilateral or unilateral hearing Loss. *Ear Hear.* ***39***(4), 783-794. **[PMCID: PMC6003828]**

List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/dawna.lewis.1/bibliography/40492039/public/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support

None to report.

Completed Research Support

5 R01 DC004300-15 Jesteadt (PI) 12/01/09-11/30/15 ***(no-cost ext.)***
NIH-NIDCD
Optimizing Amplification for Infants and Young Children
The overall goal of this project is to explore ways in which to enhance auditory access and auditory experiences in young children with hearing loss.
Role: Co-Investigator

5 P20 GM109023-05 Leibold (PD/PI) 05/15/14-03/31/19
NIH-NIGMS
Center for Perception and Communication in Children (CPCC) - The goal of the CPCC, a COBRE at the Boys Town National Research Hospital in Omaha, Nebraska, is to expand the range of the current research program by providing a unique environment for the development of junior faculty who have an interest in understanding the consequences of childhood hearing loss for speech and language perception and processing, and ultimately describing performance of children with hearing loss in the real world.

Project 1: The Impact of Mild Hearing Loss on Auditory Perception in Complex Environments - The overall goal of the proposed research is to improve communication access in complex listening environments for children with minimal/mild hearing loss (CMMHL).
Role: Project Lead, Project 1

Project 2: The Impact of Hearing Loss on Speech Communication by Spanish-English Bilinguals - The overarching goal of the proposed research is to provide much-needed evidence for the impact of hearing loss on speech communication in children whose dominant language is Spanish (SL2).
Role: Co- Investigator, Project 2

Project 3: Perception and Production of Audiovisual Speech in Children with Hearing Loss - In noisy situations, talkers adapt the way they speak to be more intelligible. Similarly, listeners adapt their processing strategies by increasing their reliance on visual information on the talker's face to compensate for the degraded auditory information. The goal of this research program is to understand the process of reciprocal adaptation in speech production and perception between mothers and their preschool children.
Role: Co-Investigator, Project 3

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES**.

NAME: Walker, Elizabeth A.

eRA COMMONS USER NAME (agency login): [redacted]

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING:

INSTITUTION AND LOCATION	DEGREE (*if applicable*)	Completion Date MM/YYYY	FIELD OF STUDY
University of Iowa, Iowa City, IA	B.A.	05/1999	Psychology, Speech & Hearing Sci.
University of Minnesota, Minneapolis, MN	M.A.	05/2002	Communication Disorders
University of Iowa, Iowa City, IA	Ph.D.	05/2010	Speech and Hearing Science

A. Personal Statement

My role in this project is co-investigator. The focus of the research proposal is to investigate the perceptual and cognitive skills that support speech recognition in noise. The participants will be children with hearing aids, who use spoken language to communication and have no additional disabilities. Specifically, we propose to assess variance in psychoacoustic abilities, based on the hypothesis that inconsistent auditory access leads to deficits in spectral resolution and perceptual weighting of speech. We also propose to evaluate executive function skills to examine individual differences in speech recognition in noise. Given my past clinical and research experiences, I am exceptionally well-qualified to serve as a co-investigator on this project. The expertise needed to carry out the proposed aims of this research started when I obtained dual certification as a speech-language pathologist and audiologist. I have worked with children with hearing loss over the past 15 years, first as a research associate in the Devault Otologic Research Laboratory at Indiana University. In this capacity, I worked under Drs. David Pisoni and Karen Kirk in their investigating neuropsychological mechanisms that influence listening and language outcomes in children with cochlear implants. More recently, I have served as a co-investigator on the following NIH-funded projects: The University of Iowa Cochlear Implant Research Center P50 grant, Outcomes of Children with Hearing Loss (OCHL), Outcomes of School-Age Children who are Hard of Hearing, and Complex Listening in School-Age Children who are Hard of Hearing. I have been actively involved in data collection, subject recruitment, data analysis, interpretation, dissemination and continuing reviews for all grants. I am currently the PI on a grant funded through the American Speech-Language-Hearing Foundation, which examines associations between language development and procedural learning in children with cochlear implants. I am also the PI on an NIDCD R21 that investigates the underlying auditory and cognitive mechanisms of listening effort in children who are hard of hearing. I have an extensive network for participant recruitment, through my contacts with state Early Hearing Detection and Intervention programs and audiologists located in Iowa, Minnesota, and Illinois. I have over 30 peer-reviewed manuscript publications related to pediatric hearing loss. My median Relative Citation Ratio is 4.61, indicating that my manuscripts have had a high impact within the context of my research field. For the proposed project, I contribute expertise in the areas of pediatric hearing loss and cognitive-linguistic development. In summary, my past endeavors have provided me with a unique perspective on the intersection of language, hearing, and cognition that will contribute to the stated research plan and objectives and support my role as co-investigator on this project.

B. Positions and Honors

Positions and Employment

1997-1999 Research Assistant, University of Iowa, Department of Psychology, Principal Investigators: Jodie Plumert and Grazyna Kochanska

2002-2004 Clinical Research Associate, Devault Otologic Research Laboratory, Indiana University School of Medicine, Principal Investigator: Richard T. Miyamoto

2003-2004 Audiology Clinical Fellowship, Riley Hospital, Indianapolis, IN

2006-2010	Research Associate, Children's Cochlear Implant Project, University of Iowa, Principal Investigator: Bruce J. Gantz
2008-2010	Research Associate, University of Iowa, Department of Communication Sciences and Disorders, Principal Investigators: J. Bruce Tomblin and Mary Pat Moeller
2010-2017	Investigator, Children's Cochlear Implant Project, University of Iowa, Principal Investigator: Bruce J. Gantz
2010-	Investigator, University of Iowa, Department of Communication Sciences and Disorders, Principal Investigators: J. Bruce Tomblin and Mary Pat Moeller
2011	Adjunct Faculty, Department of Communication Sciences and Disorders, Augustana College, Rock Island, IL
2015-	Assistant Professor, Department of Communication Sciences and Disorders, University of Iowa

Other Experience and Professional Memberships

2004- American Speech-Language-Hearing Association

Topic Committee Member, American Speech-Language-Hearing Association Annual Meeting, 2012-present

Topic Chair, Intervention/Rehabilitation for Infants and Children with Hearing Loss, Tinnitus or Balance Disorder, American Speech-Language-Hearing Association Annual Meeting, 2016-2017

Topic Chair, Listening, Language, and Speech in Children who are Deaf and Hearing of Hearing, American Speech-Language-Hearing Association Annual Meeting, 2018-2019

2008- Board member, AG Bell of Iowa

Public Relations Director, 2013-present

2012- American Auditory Society

2013- American Cochlear Implant Alliance

2018 Guest Editor, Language, Speech, Hearing Services in Schools

2018 Reviewer, American Speech-Language-Hearing Foundation

Ad-hoc Reviewer: Pediatrics; Ear and Hearing; Journal of Speech, Language, and Hearing Research; American Journal of Audiology; American Journal of Speech-Language Pathology; International Journal of Audiology; Journal of Communication Disorders; Language, Speech, and Hearing Services in Schools; Journal of Educational Audiology; Otology and Neurotology; Applied Cognitive Psychology

Honors

1999	Robert G. Robinson Audiology Scholarship, University of Minnesota
2000	Minnesota Speech and Hearing Foundation Scholarship
2000	American Speech-Language-Hearing Foundation Scholarship
2001	Outstanding Teaching Assistant Award, Mortar Board Honor Society
2004-2008	Presidential Graduate Research Fellowship, University of Iowa
2004	Editors' Award for Best Paper in the area of Hearing, *Journal of Speech, Language and Hearing Research*
2006	New Century Scholars Doctoral Scholarship, American Speech-Language-Hearing Foundation
2007, 2009	Symposium for Research on Child Language Disorders Student Travel Award
2013	Editors' Award for Best Paper, *American Journal of Audiology*
2016	Old Gold Fellowship, University of Iowa
2016	Special Recognition, *Ear and Hearing* Supplement 1 (2015), "The Outcomes of Children with Hearing Loss Study," American Auditory Society
2017	Editor's Picks, Best Features 2017: The Hearing Review
2018	American Speech-Language-Hearing Foundation Clinical Practice Research Institute

C. Contributions to Science

1. **The role of lexical characteristics on speech perception skills in children and adults who are deaf or hard of hearing.** These publications showed that children and adults with hearing loss appear to be less sensitive to word frequency, neighborhood density, and phonological structure compared to age-matched peers with typical hearing. In children who use hearing aids, strong vocabulary skills support speech perception.
   a. **Collison (Walker), E.A.**, Munson, B. & Carney, A.E. (2004). Relations among linguistic and cognitive skills and spoken word recognition in adults with cochlear implants. *Journal of Speech, Language, and Hearing Research, 47*, 496-508. [Public Access Compliance – N/A, accepted prior to 4/7/08]
   b. Klein, K.E., **Walker, E.A.**, Kirby, B., & McCreery, R.W. (2017). Vocabulary facilitates speech perception in children with hearing aids. *Journal of Speech, Language, and Hearing Research*, 60, 2281-2296. [PMCID: PMC5829804]

2. **Underlying mechanisms that support speech and language development in children with cochlear implants**. My work in the area of cochlear implants has focused on declarative and procedural learning in children who are congenitally deaf. Using a dynamic declarative learning paradigm, I showed that declarative learning skills and lexical acquisition are strongly associated with extant vocabulary size for children with cochlear implants. Children with cochlear implants perform similarly to their vocabulary-matched peers with typical hearing in terms of fast mapping, word extension and word retention, and are delayed with respect to these variables compared to their same-age peers with typical hearing. Age at implantation does not appear to play a significant role in declarative or procedural learning for children implanted before 4 years of age. In addition, I made major contributions to manuscripts associated with the University of Iowa Cochlear Implant NIH P50 grants, focusing on the influence of age at implantation on language outcomes and functional outcomes of children with cochlear implants.
   a. **Walker, E.A.** & McGregor, K.K. (2012). Word learning processes in children with cochlear implants. *Journal of Speech, Language, and Hearing Research. 56,* 375-387. [PMCID: PMC3578980]
   b. Dunn C.C., **Walker, E.**, Oleson, J., Kenworthy, M., Van Voorst, T., Tomblin, J.B, Ji, H., Kirk, K., McMurray, B., Hansen, M., & Gantz, B. (2013). Longitudinal speech perception and language performance in pediatric cochlear implant users: the effect of age at implantation. *Ear and Hearing,* 35, 148-160. [PMCID: PMC3944377]
   c. Pimperton, H. & **Walker E.A.** (2018). Word learning in children with cochlear implants: Examining performance relative to hearing peers and relations with age at implantation. *Ear and Hearing,* 39, 980-991. [PMCID: PMC6105547]
   d. Klein, K.E., **Walker, E.A.**, Tomblin, J.B. (2018). Nonverbal visual sequential learning in children with cochlear implants: Preliminary findings. *Ear and Hearing,* Epub ahead of print. [PMCID: PMC6139094; available 2019-09-15]

3. **Understanding and improving access to audiologic services for children with hearing loss.** The focus of my current research involves examination of variations in auditory access for children who are hard of hearing. I have published manuscripts related to timeliness in service provision for children who are hard of hearing. One paper found that over a third of our sample who were later-identified with hearing loss received early intervention services for reasons other than hearing loss, and the average age at hearing loss confirmation for these children was 12 months after they started intervention. This finding supports the need for hearing screenings as part of the evaluation process for Part C services in IDEA, regardless of whether or not hearing loss is the primary reason for referral. I have also explored variations in auditory input based on the amount of daily hearing aid use by children. These studies showed that children with milder degrees of hearing loss, younger children, and mothers with lower education levels were less likely to wear hearing aids on a consistent basis, compared to children with more severe hearing loss, older children, and mothers with higher education levels. These studies have drawn attention to the individual differences in amplification usage among children with hearing loss, which has implications for service provision in this population.
   a. **Walker, E.A.**, Holte, L., Spratford, M., Oleson, J., Welhaven, A., & Harrison, M. (2013). Timeliness of service delivery for children with later-identified mild to severe hearing loss. *American Journal of Audiology, 23,* 116-128. [PMCID: PMC3950303]

b. **Walker, E.A.**, Spratford, M., Moeller, M.P., Oleson, J., Ou, H., Roush, P. & Jacobs, S. (2013). Predictors of hearing aid use time in children with mild-to-severe hearing loss. *Language, Speech, and Hearing Services in Schools, 44,* 73-88. [PMCID: PMC3543484]

c. **Walker, E.A.**, McCreery, R.W., Spratford, M., Oleson, J.J., Van Buren, J., Bentler, R.A., Roush, P. & Moeller, M.P. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear and Hearing, 36,* 38S-47S. [PMCID: PMC4704121]

d. **Walker, E.A.**, Spratford, M., Ambrose, S.E., Holte, L., & Oleson, J. (2017). Service delivery to children with mild hearing loss: Current practice patterns and parent perceptions. *American Journal of Audiology, 26,* 38-52. [PMCID: PMC5597083]

4. **Cumulative auditory-linguistic experience influences auditory, speech, and language outcomes in children who are hard of hearing.** These recent manuscripts have made a substantial contribution to research on children who are hard of hearing, a population that the National Institute on Deafness and Other Communication Disorders has recognized is underrepresented in the scientific literature. Our findings have helped inform theories about the extent to which early auditory experience (measured by aided audibility and hearing aid use) moderates the relationship between degree of hearing loss and functional outcomes.

a. **Walker E.A.**, Holte L., McCreery R.W., Spratford M., Page T., & Moeller M.P. (2015). The influence of hearing aid use on outcomes of children with mild hearing loss. *Journal of Speech, Language, and Hearing Research, 58*, 1611-1625. [PMCID: PMC4686313]

b. McCreery, R.W., **Walker, E.A.**, Spratford M., Oleson J., Bentler R., Holte L., & Roush P. (2015). Speech recognition and parent ratings from auditory development questionnaires in children who are hard of hearing. *Ear and Hearing, 36*, 60S-75S. [PMCID: PMC4703361]

c. **Walker, E.A.**, McCreery, R.W., Spratford, M., & Roush, P. (2016). Children with auditory neuropathy spectrum disorder fitted with hearing aids applying the American Academy of Audiology pediatric amplification guideline: Current practice and outcomes. *Journal of the American Academy of Audiology, 27,* 204-218. [PMCID: PMC4789798]

d. **Walker, E.A.**, Ambrose, S.E., Oleson, J., & Moeller, M.P. (2017). False belief development in children who are hard of hearing compared with peers with normal hearing. *Journal of Speech, Language, and Hearing Research, 60,* 3487-3506. [PMCID: PMC5962924]

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/myncbi/browse/collection/41574661/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support

1 R21 DC015832-01A1 Walker (PI) 07/01/17-06/30/20
NIH-NIDCD
Mechanisms of Listening Effort in School-Age Children Who are Hard of Hearing
This project will obtain critical information regarding the role of audibility and cognitive-linguistic skills on listening effort in children with mild-severe hearing loss, using dual-task procedures and self-report measures. The project also will provide important insight into the effectiveness of interventions concerned with mitigating hearing loss and its negative consequences. These data will form the foundation for evidence-based practice and policy for the clinical management of children with hearing loss.
Role: PI

5 R01 DC009560-10 Tomblin & Moeller (PIs) 08/01/13-07/31/19 (no-cost ext.)
NIH-NIDCD
Outcomes of School-Age Children who are Hard of Hearing
This project will obtain critical information regarding language and academic outcomes of school-age children with mild-to-severe hearing loss.
Role: Co-Investigator

Ongoing Research Support - continued

5 R01 DC013591-05 McCreery (PI) 12/01/13-11/30/19 (no-cost ext.)
NIH-NIDCD
Complex Listening Skills in School-Age Children who are Hard of Hearing
This project examines speech perception outcomes of school-age children with mild-to-severe hearing loss. The project also will provide important insight into the effectiveness of interventions concerned with cognitive skills and working memory.
Role: Co-Investigator

Clinical Research Grant Walker (PI) 12/01/16-11/30/18 (no-cost ext.)
American Speech-Language-Hearing Foundation
Investigating Links between Non-Linguistic Learning Processes and Grammar Skills in Children with Cochlear Implants
This project investigates whether non-verbal learning is associated with grammatical abilities in school-age children with CIs. This proposal seeks to determine whether lack of experience with sound, prior to CI receipt, leads to deficits in the development of domain-general sequential processing and learning.
Role: PI

Completed Research Support

Departmental Start-Up Grant Walker (PI) 07/01/15-06/30/17
University of Iowa
Research Initiation Funds
The purpose of this grant is to set up the PI's laboratory and fund preliminary studies needed to be competitive for extramural research support.
Role: PI

3 P50 DC00242-26A1 Gantz (PI) 02/15/12–01/31/17
NIH-NIDCD
Iowa Cochlear Implant Clinical Research Center Project VI - Developmental Studies of Children
The specific aims of this project are to examine the influence of prolonged cochlear implant experience on the speech and language development of children who receive cochlear implants.
Role: Co-Investigator in Developmental Studies Section

Interdisciplinary Research Grant Walker & Pimperton (PIs) 06/27/16-07/08/16
Obermann Center for Advanced Studies; Office of the Vice President for Research at the University of Iowa, the Avalon L. Obermann Endowment Fund, and the Laura Spelman Rockefeller Endowment Fund
The Influence of Age at Implantation on Sequential Learning Processes in Children with Cochlear Implants
The purpose of this grant is to support interdisciplinary collaboration.
Role: PI

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Oleson, Jacob J.

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Associate Professor

EDUCATION/TRAINING:

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Central College, Pella, IA	B.A.	1997	Mathematics
University of Missouri, Columbia, MO	M.A.	1999	Statistics
University of Missouri, Columbia, MO	Ph.D.	2002	Statistics

A. Personal Statement

As a Professor in the Department of Biostatistics, College of Public Health, University of Iowa and the Director of the Center for Public Health Statistics, I conduct both biostatistical methodologic research and collaborative clinical research. I have served as the lead biostatistician on several hard of hearing related and language development studies over the past decade (e.g., Memory and Word Learning, the University of Iowa cochlear implant project, OCHL, OSACHH, Complex Listening). In these projects I work closely with all team members on study design, statistical methods, analysis, and reporting of results. This experience includes longitudinal analysis, mixed effects models, factor analysis, and missing data analyses. The work in these collaborations also lead to methodologic work in biostatistics including PhD dissertations on functional data analysis and growth curves stemming from longitudinal data routinely collected in hearing impairment studies. My background in clustered and longitudinal data analysis including time series, growth trends, linear and nonlinear mixed models, and repeated measures will integrate well with the goals of the study. Below are four papers directly related to the work outlined in this proposal. I look forward to contributing to this grant as well as future collaborations and opportunities stemming from this grant.

1. Walker EA, McCreery RW, Spratford M, **Oleson JJ**, VanBuren J, Bentler R, Roush P, & Moeller MP. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear and Hearing*, ***36***, Supplement 1, 38S-47S. **[PMCID: PMC4704121]**
2. Tomblin JB, **Oleson JJ**, Ambrose SE, Walker E, & Moeller MP. (2014). The influence of hearing aids on speech and language development in children with hearing loss. *Journal of the American Medical Association Otolaryngology-Head & Neck Surgery*, ***140***(5), 403-409. **[PMCID: PMC4066968]**
3. McCreery RW, Walker EA, Spratford M, Bentler R, Holte L, Roush P, **Oleson JJ**, VanBuren J, & Moeller MP. (2015). Longitudinal predictors of aided speech audibility in infants and children. *Ear and Hearing*, ***36***, Supplement 1, 24S-37S. [**PMCID: PMC4704126]**
4. McCreery R, Walker E, Spratford M, Kirby B, **Oleson JJ**, & Brennan M. (2016). Stability of audiometric thresholds for children with hearing aids applying the American Academy of Audiology pediatric amplification guideline: implications for safety. *Journal of the American Academy of Audiology*, ***27***(3), 252-263. **[PMCID: PMC4789775]**

B. Positions and Honors

Positions and Employment

2002-2004	Assistant Professor, Depart. of Mathematics and Statistics, Arizona State Univ., Tempe, AZ
2004-2012	Assistant Professor, Department of Biostatistics, University of Iowa, Iowa City, IA
2012-2018	Associate Professor, Department of Biostatistics, University of Iowa, Iowa City, IA
2014-present	Director, Center for Public Health Statistics, College of Public Health, University of Iowa, Iowa City, IA
2015-present	Director of Graduate Studies, Department of Biostatistics, University of Iowa, Iowa City, IA
2018-present	Professor, Department of Biostatistics, University of Iowa, Iowa City, IA

Other Positions and Professional Memberships

American Statistical Association
Institute of Mathematical Statistics
International Biometric Society (ENAR)
American Cochlear Implant Alliance

Honors

2008	Thank a Teacher Note of Appreciation, Center for Teaching
2009	One of the Best 2008 Audiology Literature: Cochlear Implants
2012	Faculty Teaching Award, College of Public Health
2012	Top Cited Paper Impact Factor for 2011 (Hybrid 10 Clinical Trial), Audiology & Neurotology
2013	2012 ASHA Editor's Award for the American Journal of Audiology, American Speech-Language-Hearing Association
2013	Thank a Teaching Note of Appreciation, Center for Teaching
2015	Elected to Delta Omega (Public Health Honor Society)

C. Contribution to Science

1. I am the lead biostatistician for the Cochlear Implant Research Center at the University of Iowa. The University of Iowa has been at the forefront of cochlear implant research for more than three decades. My role for this research center is to oversee research design, implementation, analysis, and interpretations. I work closely with all team members on the cochlear implant research studies. The sample sizes in many of these analyses are typically very small with multiple observations per subject. I use standard statistical methodology in these collaborations including t-tests, correlations, regressions, ANOVA, linear mixed models, generalized linear mixed models, and multiple imputations, as well as develop new techniques where the need arises. Modern cochlear implants preserve residual acoustic hearing during the implantation giving individuals with higher levels of pre-operative residual hearing the ability to be implanted with this remarkable device. This not only improves hearing of speech and language, but the ability to hear of music, and it leads to better cognitive processing ability as we have shown in our research.

a. Gfeller K, Turner C, **Oleson JJ**, Zhang X, Gantz B, Froman R, & Olszewski C. (2007). Accuracy of cochlear implant recipients on pitch perception, melody recognition, and speech reception in noise. *Ear and Hearing, **28***(3), 412-423.

b. Gantz BJ, Hansen MR, Turner CW, **Oleson JJ**, Reiss LA, & Parkinson AJ. (2009). Hybrid 10 clinical trials: preliminary results. *Audiology and Neurotology, **14***, Supplement 1, 32-38. **[PMCID: PMC3010181]**

c. Gfeller KG, **Oleson JJ**, Knutson JF, Breheny P, Driscoll V, & Olszewski C. (2008). Multivariate predictors of music perception and appraisal by adult cochlear implant users. *Journal of the American Academy of Audiology, **19***(2), 120-134. **[PMCID: PMC2677551]**

d. Woodson EA, Dempewolf RD, Gubbels SP, Porter AT, **Oleson JJ**, Hansen MR, & Gantz BJ. (2010). Long-term hearing preservation following microsurgical excision of vestibular schwannoma. *Otology and Neurotology, **31***(7), 1144-1152. **[PMCID: PMC3641783]**

2. I collaborate extensively with researchers in speech and language development. Again, I work closely with all research team members on study design, implementation, analysis, and reporting of results. It was recognized that research on children who are hard of hearing was lacking, and that a study comparing the various aspects of development of hard of hearing children with normal hearing children and children wearing cochlear implants was needed. This work has validated the effectiveness of newborn screening and how important it is to maintain timeliness in follow-ups. The work has also shed light on hearing aid fittings, consistency of hearing aid use, accuracy of parent reports of hearing aid use, risk and resilience in speech and language, and early literacy skills. The work is leading to a "best practice" guide for clinicians and service providers around the nation.

a. Spencer LJ & **Oleson JJ.** (2008). Early listening and speaking skills predict later reading proficiency in pediatric cochlear implant users. *Ear and Hearing, **29***(2), 270-280. **[PMCID: PMC3210570]**

b. Holte L, Walker E, **Oleson JJ**, Spratford M, Moeller MP, Roush P, Ou, H, & Tomblin JB. (2012). Factors influencing follow-up to newborn hearing screening for infants who are hard of hearing. *American Journal of Audiology, **21***(2), 163-174. **[PMCID: PMC3435452]**

c. Dunn CC, Walker EA, **Oleson JJ**, Kenworthy M, Van Voorst T, Tomblin JB, Ji H, Kirk KI, McMurray B, Hanson M, & Gantz BJ. (2014). Longitudinal speech perception and language performance in pediatric cochlear implant users: the effect of age at implantation. *Ear and Hearing, **35***(2), 148-160. **[PMCID: PMC3944377]**

d. Tomblin JB, **Oleson JJ**, Ambrose SE, Walker E, & Moeller MP. (2014). The influence of hearing aids on speech and language development in children with hearing loss. *Journal of the American Medical Association Otolaryngology-Head & Neck Surgery, **140***(5), 403-409. **[PMCID: PMC4066968]**

3. My work in Bayesian spatio-temporal models has primarily been geared towards sparse data, which include excessive zero values and mission data. The conditional auto-regression (CAR) models relate similar regions on a spatial scale. I showed how the CAR model is beneficial along with an autoregressive temporal function when the data are sparse, including zero counts. We illustrated the method using turkey hunting success rates per county in Missouri (Oleson and He, 2004). Additional work integrated spatio-temporal modeling into survey statistics and small area estimation to pool strength by considering spatial priors for categorical response data with data that were not missing at random. This work was extended to survey nonresponse with a multiple wave survey approach using a multinomial response outcome when follow-up surveys are sent multiple times to those who haven't responded. Furthermore, we developed an analysis framework when the sampling design differs from the study domains. In such cases, the same areal unit contains observations from multiple strata and many of those will have zero values, so we demonstrate an appropriate way to combine the stratified estimations, which typically contain zero counts. Bayesian spatio-temporal models are naturally suited for air quality modeling. The paper Oleson, Kumar, and Smith (2013) focuses on spatio-temporal models that relate Aerosol Optical Depth (AOD) with particulate matter (PM), and determining aspects of AOD related to health and what aspects are not directly related. This involves novel spatial-temporal modeling techniques due to the high dimensionality and the large amounts of missing data.

a. **Oleson JJ**, He CZ. (2004). Space-time modeling for the Missouri turkey hunting survey. *Environmental and Ecological Statistics, 11*, 85-101.
b. **Oleson JJ**, He CZ, Sun D, Sheriff S. (2007). Bayesian estimation in small areas when the sampling sub-domain differs from the study sub-domain. *Survey Methodology, 33*, 173-186.
c. **Oleson JJ**, Kumar N, & Smith BJ. (2013). Spatiotemporal modeling of irregularly spaced Aerosol Optical Depth data. *Environmental and Ecological Statistics, **20***(2), 297-314. **[PMCID: PMC3901316]**
d. Porter AT & **Oleson JJ**. (2014). A multivariate CAR model for mismatched lattices. *Spatial and Spatiotemporal Epidemiology, **11***, 79-88. **[PMID: 25457598; Public Access Compliance – N/A]**

4. My work in infectious diseases has centered around modeling and predicting the spread of infectious diseases over both space and time. The paper by Oleson and Wikle (2013) predicted an epidemic such as the spring 2015 outbreak of the avian flu in the poultry farms in the northwest corner of Iowa. The work dealt with sparse data and excessive zero counts using dimension reductions involving a two-step process of empirical orthogonal functions. In addition to this work, spatial SEIR models are promising in their ability to predict spread and control for interventions of various types. Traditional SEIR models assume a population averaged exponential decay function for the rate of change in the latent and infectious periods. In Porter and Oleson (2013), we showed how to relax the exponential decay function using a path-specific SEIR Bayesian hierarchical model that also has the ability to handle vaccinations and other intervention types. Then, Porter and Oleson (2014) extended the path specific work to include spatio-temporal structure. Brown, Oleson, and Porter (2015) created an empirically adjusted reproductive number that gives more realistic and time specific information on the reproductive number than was previously available. I am currently the PI of an R01 funded by the Fogarty International Center of NIH to study epidemic modeling for complex, multi-species disease processes, with special emphasis on Leishmania transmission in peri-urban Brazil.

a. **Oleson JJ** & Wikle CK. (2013). Predicting infectious disease outbreak risk via migratory waterfowl vectors. *Journal of Applied Statistics, 40*(3), 656-673. **[Public Access Compliance – N/A]**
b. Porter AT & **Oleson JJ**. (2013). A path-specific SEIR model for use with general latent and infectious distributions. *Biometrics, **69***(1), 101-108. **[PMCID: PMC3622117]**
c. Porter AT & **Oleson JJ**. (2016). A spatial epidemic model for disease spread over heterogeneous spatial support. *Statistics in Medicine, **35***(5), 721-733. **[PMID: 26365804; Public Access Compliance – N/A]**
d. Brown GD, **Oleson JJ**, & Porter AT. (2016). An empirically adjusted approach to reproductive number estimation for stochastic compartmental models: A case study of two Ebola outbreaks. *Biometrics*, ***72***(2), 335-343. **[PMID: 26574727; Public Access Compliance – N/A]**

5. I am currently the Director of the Center for Public Health Statistics (CPHS) and have been involved with CPHS activities for the past 11 years. During that time I produced the biennial Iowa Health Fact Book in 2005, 2007, and 2009 which is now a fully interactive website updated annually since 2015.. This book is used by public health practitioners and professionals throughout the state of Iowa to learn more about the public health status of various health aspects for their county. This work that is conducted in partner with the Iowa Department of Public Health is just one of many important activities that CPHS engages in with IDPH.

a. Iowa Health Fact Book 2005, 2007, 2009, 2015, 2016, 2017
b. Cancer Center Mapping

c. **Oleson JJ**, Breheny PJ, Pendergast JF, Ryan S, & Litchfield RE. (2008). Impact of travel distance on WISEWOMAN Intervention attendance for a rural population. *Preventive Medicine,* ***47***(5), 565-569. **[PMID: 18672000; Public Access Compliance – N/A]**

A full listing of my published work can be found at:
https://www.ncbi.nlm.nih.gov/sites/myncbi/jacob.oleson.1/bibliography/49843733/public/?sort=date&direction=ascending

D. Research Support
Ongoing Research Support

5 R01 DC011742-07 McGregor (PI) 07/02/17-06/30/22
NIH-NIDCD
The Dynamics of Word Learning in Children with Developmental Language Impairment
The long-term goal of this research program is to develop a full explanation of the vocabulary problems associated with developmental language impairment. Role: PI, Subaward

2 P50 DC000242-31A1 Gantz (PI) 09/09/85-11/30/22
NIH-NIDCD
Iowa Cochlear Implant Clinical Research Center Project VII
Grant funds allow researchers to continue to identify the factors that determine why some individuals benefit to a greater extent from the implant than others. In addition, researchers work to develop and evaluate new signal processing for speech perception and music appreciation and to study the expansion of selection criteria including adults with more hearing and to track the benefit of early implantation in infants. Role: Co-Investigator

No Contract #: IPA-VA Hansen (PI) 04/01/14-03/31/19
DOD (Oleson MOU)
Cochlear Implants
CDC RFA-DD14-001, Surveillance and Research of Muscular Dystrophies and Neuromuscular Disorders, Component A: Core (Existing MD Surveillance and Research Programs). Role: Contact PI

Contract #5889NB90 Oleson (PI 08/01/95-06/29/21
IDPH
IDPH FY18 Screening Data Management
Breast and Cervical Cancer Early Detection Program, Data and Entry Analysis; WISEWOMAN Enhanced Design, Data Entry and Analysis; Data Management subcontract. Subcontract studies design, data management, and analysis on this project. Role: Contact PI, subcontract

1 R21 DC015832-01A1 Walker (PI) 07/01/17-06/30/20
NIH-NIDCD
Mechanisms of Listening Effort in School Age Children Who are Hard of Hearing
Role: Co-Investigator

5 R25 HL131467-03 Zamba (PI) 02/15/16-01/31/19
NIH-NHLBI
Iowa Summer Institute for Research Education in Biostatistics
This project aims to introduce talented undergraduates to biostatistics and encourage them to enter graduate school in biostatistics and subsequently pursue careers in biostatistics. Role: Mentor

5 R01 TW010500-03 Oleson (PI) 07/20/16-06/30/21
FIC-NIAID
Epidemic Modeling Framework for Complex, Multi-Species Disease Processes and the Impact of Vertical and Vector Transmission: A Study of Leishmaniasis in Peri-Urban Brazil.
As there is limited understanding of how vertical transmission for any infection alters R0, this novel platform will have a broader impact on our understanding of vertical as well as horizontal transmission in many infectious diseases that are carried in multiple hosts and transferred both horizontally and vertically. In the case of leishmaniasis, this model will be used to guide the next stage of VL-control in Natal and serve as a guide for VL control measures globally. Role: PI

Ongoing Research Support - continued

1 U01 DD001223-01 Romitti (PI) 09/01/18-08/31/23
NIH-NCBDD
Iowa CBDRP: Component A BD-STEPS II Core
The purpose of this NOFO is to identify causes of certain major, structural birth defects using epidemiologic and genetic research methods and to provide information that could be translated into public health prevention messages. Component A. BD-STEPS II Core. To support the epidemiological and genetic research capabilities of the Centers for Birth Defects Research and Prevention (CBDRP) through the Birth Defects Study To Evaluate Pregnancy exposureS (BD-STEPS). BD-STEPS is a case/control study of genetic and environmental risk factors for birth defects that focuses on the key areas of: (1) maternal chronic diseases and their treatments; (2) infectious disease in pregnancy; and (3) medications.
Role: Co-Investigator

1 R01 DC015997-01A1 Wu (PI) 05/01/18-04/30/23
NICDC
Cost Effective Hearing Aid Delivery Models: Outcomes, Value, and Candidacy
The proposed project is relevant to public health because the knowledge gained from the project will directly facilitate accessible, affordable, and quality hearing healthcare and improve amplification intervention outcomes. The proposed study is relevant to the part of NIH/NIDCD's mission that pertains to facilitating better outcomes for human communication and improving the quality of life of Americans with hearing impairment.
Role: Co-Investigator

Completed Research

5 U01 DD001035-05 Romitti (PI) 09/01/13-08/31/18
NIH-NCBDD
IOWA CBDRP: Birth Defects Study to Evaluate Pregnancy Exposures
Role: Co-Investigator

5 R01 DC012082-03 Brown; Abbas (MPI) 08/01/12-07/31/16
NIH-NIDCD
Evoked Potentials and Music Perception: Effects of Hearing Loss and Training
Role: Biostatistician

5 R01 DC013591-05 McCreery (PI) 12/01/13-11/30/19 (no-cost ext.)
NIH-NIDCD (Subaward)
Complex Listening Skills in School-Age Hard of Hearing Children
The purpose of this research is to identify the factors that support speech recognition in realistic environments with a large group of children with mild to severe hearing loss in the school years.
Role: Biostatistician

5 R01 DC009560-10 Tomblin (PI); Moeller (PI) 08/01/13-07/31/19 (no-cost ext.)
NIH-NIDCD
Outcomes of School Aged Children who are Hard of Hearing
This is a competitive renewal application, which proposes to continue work related to the Outcomes of Children with Hearing Loss.
Role: Co-Investigator

5 R01 DC015056-03 Leibold & Buss (MPI) 08/10/16-07/31/21
NIH-NIDCD (Subaward)
A Test of Children's English/Spanish Speech Perception in Noise or Speech Maskers
The goal of this project is to develop, refine and evaluate a pediatric speech perception test for use with English-speaking, Spanish-speaking and bilingual children.
Role: Co-Investigator, Subaward

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Davidson, Lisa

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Research Associate Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
East Tennessee State University	BS	05/1985	Communication Disorders
Washington University, St. Louis, Missouri	MS	05/1987	Speech & Hearing Sciences
Washington University, St. Louis, Missouri	PHD	12/2003	Speech &Hearing Sciences

A. Personal Statement

The primary goal of the current proposal is to develop a comprehensive model of speech recognition in noise for school-age children with hearing loss. The proposed studies will examine the combined effects of perceptual skills, linguistic knowledge and executive function skills on speech recognition in noise for children with hearing loss who wear hearing aids (HAs). I will serve as a consultant related to the design, analyses, and interpretation of the study. These goals align with the primary focus of my research experience related to examining the perceptual, cognitive, and audiological factors influencing speech and language outcomes in children with cochlear implants (CIs) and hearing aids (HAs). My current and past research projects have utilized a multidisciplinary approach to understand the perceptual, cognitive and linguistic mechanisms that facilitate spoken language development in children with sensory devices. My experience as a pediatric, clinical and research audiologist motivates me to address key clinical questions with evidence based research. I am currently a Research Associate Professor in the Department of Otolaryngology at Washington University School of Medicine and serve as Director of Audiological Outcomes at the Central Institute for the Deaf Oral School in St. Louis, Missouri. I am the Principal Investigator on a currently funded R01 project that examines the effects of early acoustic hearing on the speech and language development of children with bilateral cochlear implants (BCIs) or bimodal devices (CI+HA). Specifically, we seek to determine critical aided HA threshold levels and duration of HA use that should be applied before proceeding to bilateral CIs. My completed K23 NIDCD research project allowed me to examine receptive vocabulary level using an information-processing model including perception, processing speed, learning, and memory. These studies were integral in determining the interactive role of audibility and word learning on receptive vocabulary level for children with cochlear implants. We received intramural funding from the McDonnell Neuroscience Foundation to examine the effects of auditory deprivation on verbal and visual-spatial working memory, receptive language and higher order reasoning in children with cochlear implants and age-matched peers with normal hearing sensitivity. We continue to use a multidisciplinary approach to understand the mechanisms underlying the benefits of various sensory devices.

B. Positions and Honors

<u>Positions and Employment</u>

1987 -	Educational and Clinical Audiologist, Central Institute for Deaf, St. Louis, MO
1991 - 1996	Lecturer in Audiology, Washington University, St. Louis, MO
1996 - 2004	Assistant Professor in Audiology, Washington University, St. Louis, MO
2003 - 2015	Coordinator of Pediatric Audiology, Central Institute for the Deaf, St. Louis, MO
2005 - 2015	Research Assistant Professor, Department of Otolaryngology / Program in Audiology and Communication Sciences, Washington University School of Medicine, St. Louis, MO

2015 - Research Associate Professor, Department of Otolaryngology / Program in Audiology and Communication Sciences, Washington University School of Medicine, St. Louis, MO

2015 - Director of Audiology Outcomes, Central Institute for the Deaf, St. Louis, MO

Other Experience and Professional Memberships

1987 - Member, American Speech Language and Hearing Association

1998 - Member, Member, American Academy of Audiology

2000 - Member, American Auditory Society

2013 Member of Knowledge Implementation in Pediatric Audiology (KIPA) Group

2017 - Member of Editorial Board ASHA Journals

Honors

1987 Antoinette Frances Dames Academic Award, Washington University

2004 Advancing Academic Research Careers Award, American Speech Language Hearing Association Language Hearing

2006 American Journal of Audiology Editors Award, American Speech Language Hearing Association

2008 Lessons for Success Research Conference, American Speech Language Hearing Association

2012 Margo Skinner Research Award, Missouri Academy of Audiology

C. Contributions to Science

1. As a clinician-scientist, my goal is to conduct research that will: i) provide audiologists with the best hearing-device-fitting guidelines (based on rigorous scientific studies), and ii) enable educators of the deaf to combine device technology and intervention strategies that will optimize the spoken language abilities for children who are deaf and hard of hearing. While working as the primary pediatric audiologist at CID, I had my first opportunities to work on test development and data collection thanks to two NIDCD-funded R01 research grants under the direction of Dr. Ann Geers: the first compared the effects of sensory device (hearing, tactile, cochlear-implant) on speech perception, speech production and language outcomes in deaf children (DC00443), and the second compared the effects of rehabilitation methodologies on the benefits children received from cochlear implants (DC03100). During the first study, I worked alongside researchers, educators of the deaf and clinical audiologists to examine how different sensory devices processed speech and how we could capitalize on this information for effective habilitation strategies for young children. This work resulted in the development and subsequent publication of the Speech Perception Instructional Curriculum and Evaluation (SPICE) auditory training program. This program continues to be used worldwide by audiologists, educators of the deaf and speech-language pathologists. The second research project involved evaluating the speech perception, speech production and language abilities of 181 children with CIs from various educational programs across the United States and Canada. For this project, I developed a loudness-scaling test to assess a child’s perceived loudness growth over a 30-dB range of increasing intensity, using a multi-talker speech stimulus delivered to the cochlear implant. This loudness-growth measure, in addition to CI-processor parameters (many under the control of the fitting audiologist), were examined for their relation to a child’s speech perception ability. These studies detailed the contribution of device characteristics and programming strategies to speech perception abilities for children with severe-to-profound hearing loss.
   a. Geers A, Brenner C, **Davidson L.** (2003). Factors associated with development of speech perception skills in children implanted by age five. Ear Hear. 24(1 Suppl):24S-35S.
   b. **Davidson LS**, Brenner C, Geers AE. (2000). Predicting speech perception benefit from loudness growth measures and other map characteristics of the nucleus 22 implant. Ann Otol Rhinol Laryngol Suppl. 185:56-8.
   c. Moog J, Biedenstein J, **Davidson L.** (1995). Speech Perception Instructional Curriculum and Evaluation (SPICE). St. Louis, Missouri: Central Institute for the Deaf.

d. Moog J, Biedenstein J, **Davidson L**, Brenner C. (1994). Instruction for developing speech perception skills. In A.Geers and J. Moog, Eds. "Effectiveness of Cochlear Implants and Tactile Aids for Deaf Children: The Sensory Aids Study at Central Institute for the Deaf." [Print]. Volta Review, Vol. 96, No.5.

2. I subsequently continued my research in device optimization by serving as a co-PI on Dr. Margo Skinner's grant, "Strategies to Optimize Benefit with a Cochlear Implant (NIDCD; R01 DC000581). Studies from this project resulted in publications that highlighted the relevance of device programming techniques and clinician selection of device parameters for pediatric speech perception performance.

   a. Holstad BA, Sonneveldt VG, Fears BT, **Davidson LS**, Aaron RJ, Richter M, Matusofsky M, Brenner CA, Strube MJ, Skinner MW. (2009). Relation of electrically evoked compound action potential thresholds to behavioral T- and C-levels in children with cochlear implants. Ear Hear. 30(1):115-27. [PMID: 19125034; Public Access Compliance – N/A]

   b. **Davidson LS**, Skinner MW, Holstad BA, Fears BT, Richter MK, Matusofsky M, Brenner C, Holden T, Birath A, Kettel JL, Scollie S. (2009). The effect of instantaneous input dynamic range setting on the speech perception of children with the nucleus 24 implant. Ear Hear. 30(3):340-9. [PMID: 19322085; Public Access Compliance – N/A]

3. Providing optimal audibility via sensory devices is a critical component for eventual spoken language outcomes for children with hearing loss. While working everyday as a pediatric audiologist, I realized that recommendations for CI candidacy for children lacked rigorous scientific evidence. I felt compelled to address clinical CI-recommendation questions in a carefully-designed study and embarked on my Ph.D. dissertation. Specifically, I aimed to provide information that would help determine whether a child should continue using Digital Signal Processing (DSP) hearing aids with Wide Dynamic Range Compression (WDRC) or be recommended for a CI. The dissertation resulted in two publications; one provided empirical guidelines for CI candidacy, the other provided evidence for the effectiveness of HA technology for speech perception in everyday listening environments. I continued my work examining the effects of device audibility on spoken language skills of children with HAs and CIs with a K23 training grant (DC0029503-Davidson, PI). The overall goal of this project was to develop an understanding of how perceptual and cognitive abilities interact to determine relative benefits of sensory devices for children with moderate to profound sensorineural hearing loss. My colleagues and I published a paper that examined the interactive role of audibility and word learning on receptive vocabulary level for children with cochlear implants.

   a. **Davidson LS**, Geers AE, Nicholas JG. (2014). The effects of audibility and novel word learning ability on vocabulary level in children with cochlear implants. Cochlear Implants Int. 15(4):211-21. [PMCID: PMC3938995]

   b. **Davidson LS**, Skinner MW. (2006). Audibility and speech perception of children using wide dynamic range compression hearing AIDS. Am J Audiol. 15(2):141-53.

   c. **Davidson LS.** (2006). Effects of stimulus level on the speech perception abilities of children using cochlear implants or digital hearing aids. Ear Hear. 27(5):493-507.

4. As CI candidacy guidelines expand to include children with greater degrees of residual hearing, the use of bimodal devices (CI+HA) are becoming more prevalent. Studies have documented that speech cues are not transmitted equally well with acoustic (HAs) and electric (CIs) hearing devices. Suprasegmental features are acoustic features that are generally reflected in the speech signal's time-intensity envelope and fundamental frequency information, and their perception requires accurate encoding of low-frequency and/or temporal information. Due to the restricted spectral resolution of current CI systems, listening via CI(s) only (electrical hearing only) limits a user's ability to perceive these suprasegmental features. In contrast to suprasegmental perception, the perception of speech segments or phonemes is roughly opposite. Children with CIs typically perform better on tests of segmental perception (e.g., word and sentence recognition) than children with severe to profound losses with hearing aids. Literature from infants with normal hearing sensitivity has shown that these suprasegmental cues are critical to early vocabulary development. Thus, we are developing speech and language tests that examine the unique

contributions of acoustic and electrical hearing on spoken language outcomes in children with hearing loss. We have published studies that have used segmental and suprasegmental tasks, developed in our laboratory, to examine how to optimize bimodal devices and better understand variability in spoken language outcomes.

a. **Davidson LS**, Geers AE, Hale S, Sommers M, Brenner C, Spehar B. The effects of early auditory deprivation on working memory and reasoning abilities in verbal and visuospatial domains for pediatric cochlear implant recipients. Ear Hear. (In Press).

b. Nickerson A, **Davidson L**, Uchanski RM. Pre-implant hearing aid fittings and aided audibility for pediatric cochlear implant recipients. J Am Acad Audiol. (In Press).

c. Wenrich, KA, **Davidson LS**, Uchanski, RM. (2017). Segmental and suprasegmental perception in children using hearing aids. J Am Acad Audiol. 28(10):901-12. DOI: 10.3766/jaaa. [PMCID: PMC5726292]

d. **Davidson LS**, Firszt JB, Brenner C, Cadieux JH. (2015). Evaluation of hearing aid frequency response fittings in pediatric and young adult bimodal recipients. J Am Acad Audiol. 26(4):393-407. [PMCID: PMC4423567]

D. Research Support

Ongoing Research Support

5 R01 DC012778-05 Davidson (PI) 08/01/13-07/31/19 (no-cost ext.)
NIH-NIDCD
The Effects of Early Acoustic Hearing for Pediatric Cochlear Implant Recipients
This study attempts to establish levels and durations of acoustic stimulation that are most beneficial for language outcomes in young cochlear implant recipients. These studies will eventually guide clinicians in making informed recommendations regarding early bimodal (HA/CI) use and the timing of potential bilateral cochlear implantation for pediatric CI recipients.
Role: PI

Completed Research Support

None to report in the previous 3 years.

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 1

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ❍ Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2019 **End Date*:** 06-30-2020 **Budget Period: 1**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Ryan	W.	McCreery	Ph.D	PD/PI	189,600.00	3.6	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Research Audiologist	9.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]				[redacted]		[redacted]
					[redacted]		[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 1

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ○ Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2019 **End Date*:** 06-30-2020 **Budget Period:** 1

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	Funds Requested ($)*
Total funds requested for all equipment listed in the attached file	
Total Equipment	[redacted]

Additional Equipment: File Name:

D. Travel		**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)		[redacted]
[redacted]		
	[redacted]	[redacted]

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	[redacted]

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 1

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ○ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2019 **End Date*:** 06-30-2020 **Budget Period:** 1

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
[redacted]	[redacted]
[redacted]	
[redacted]	[redacted]
[redacted]	
[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	**514,759.00**

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		Total Indirect Costs	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification*	File Name: BudJust_RWM_R01resbm_16dec.pdf (Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 2

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ○ Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period:** 2

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Ryan	W.	McCreery	Ph.D	PD/PI		3.6	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Research Audiologist	9.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]
						[redacted]	[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 2

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ❍ Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period:** 2

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file	
Total Equipment	[redacted]

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs	**Funds Requested ($)***
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	[redacted]

RESEARCH & RELATED Budget {C-E} (Funds Requested)

Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 2

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period:** 2

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
[redacted]	[redacted]
[redacted]	
[redacted]	[redacted]
[redacted]	
[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification* File Name:
BudJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 3

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ❍ Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period:** 3

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Ryan	W.	McCreery	Ph.D	PD/PI		3.6	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Research Audiologist	9.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]

[redacted] [redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 3

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ○ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period:** 3

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file	
Total Equipment	[redacted]

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs	**Funds Requested ($)***
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	[redacted]

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 3

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period:** 3

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
[redacted]	[redacted]
	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification*	File Name: BudJust_RWM_R01resbm_16dec.pdf (Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 4

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ❍ Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 4

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Ryan	W.	McCreery	Ph.D	PD/PI		3.6	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Research Audiologist	9.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]
						[redacted]	[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 4

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 4

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	Funds Requested ($)*
Total funds requested for all equipment listed in the attached file	
Total Equipment	[redacted]

Additional Equipment: File Name:

D. Travel	Funds Requested ($)*
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
2. Foreign Travel Costs	
Total Travel Cost	[redacted]

E. Participant/Trainee Support Costs	Funds Requested ($)*
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 4

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ❍ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 4

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
[redacted]	
[redacted]	[redacted]
[redacted]	
[redacted]	[redacted]
[redacted]	
[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification* File Name:
BudJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

Tracking Number: GRANT12761949 Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 5

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ❍ Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** **5**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Ryan	W.	McCreery	Ph.D	PD/PI		3.6	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Research Audiologist	9.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]
					[redacted]		[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 5

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ● Project ❍ Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** 5

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file	
Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs		**Funds Requested ($)***
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other:		
Number of Participants/Trainees	**Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 5

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ● Project ○ Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** 5

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	[redacted]
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Subject reimbursement/travel	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification*	File Name: BudJust_RWM_R01resbm_16dec.pdf (Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

BUDGET JUSTIFICATION

FATHER FLANAGAN'S BOYS' HOME DOING BUSINESS AS BOYS TOWN
BOYS TOWN NATIONAL RESEARCH HOSPITAL

A. Senior/Key Person

Ryan W. McCreery, Ph.D., Principal Investigator, (effort = 3.6 CY months). Dr. McCreery is the Director of Research and the Director of the Audibility, Perception, and Cognition Laboratory at BTNRH. Dr. McCreery will be responsible for the overall administration of the project. Specific responsibilities include experimental design, data collection and analyses, overall management and prioritizing of specific experiments, interpretation of data, manuscript preparation, and budget management.

Adam Bosen, Ph.D., Co-Investigator, (effort = 1.2 CY months). Dr. Bosen is the Director of the Auditory Perceptual Encoding Laboratory at BTNRH. Dr. Bosen has developed open-source software that will be used the proposed spectral resolution and perceptual weighting experiments. Dr. Bosen will also provide expertise related to psychophysics and measurements.

Monita Chatterjee, Ph.D., Co-Investigator, (effort = 1.2 CY months). Dr. Chatterjee is the Director of the Auditory Prostheses and Perception Laboratory at BTNRH. Dr. Chatterjee will provide expertise in psychophysical methods for the studies, as well as support in statistical analysis, interpretation of data and manuscript preparation.

Lori Leibold, Ph.D., Co-Investigator, (effort = 1.2 CY months). Dr. Leibold is the Director of the Human Auditory Development Laboratory at BTNRH. Dr. Leibold will provide expertise in experimental design related to speech recognition in noise for children with hearing loss and informational masking in children, as well as support in manuscript preparation.

Dawna Lewis, Ph.D., Co-Investigator, (effort = 3 CY months). Dr. Lewis is a Research Associate at BTNRH who has collaborated with Dr. McCreery on his research for the last 8 years. Dr. Lewis has considerable experience in experimental design and data collection with children with hearing loss. Dr. Lewis will assist with recruitment of subjects, manuscript preparation, and statistical analysis.

B. Other Personnel

Meredith Spratford, Au.D., Research Audiologist, (effort = 9 CY months). Dr. Spratford has considerable experience in all aspects of pediatric audiology and has worked in Dr. McCreery's lab for the last 6 years. Dr. Spratford will be trained in all experimental procedures and will be responsible for hearing-related, standardized speech and language assessment, and data collection. Dr. Spratford also will supervise the research assistant and assist with subject consent, retention, scheduling, payment, family contacts and selected family and teacher surveys or interviews.

TBN, Research Assistant, (effort = 12 CY months). A full-time research assistant will help with subject recruitment, subject scheduling, administering informed consent, recordkeeping, administering assessments, literature searches, data checking, and various clerical duties as needed.

D. Equipment Description – Not applicable.

E. Travel ([redacted]

Travel funds are requested for one trip per year for the PI to present at a scientific meeting.

F. Participant/Trainee Support Costs – Not applicable.

G. Other Direct Costs

1. Materials and Supplies [redacted]

Funds in the amount [redacted] are requested for research supply costs including replacement of computers across Years 1-4 (1/year), media support staff, office supplies, calibration and maintenance contracts for lab equipment, and printing costs for research posters, brochures, and other advertising.

2. Publication Costs – Not applicable.

3. Consultant Services

Other Significant Contributor

Lisa Davidson, Ph.D., Consultant (effort = zero person months). [redacted]year for a two-day consultant visit per year with Dr. Davidson for Years 1-4. This includes airfare [redacted] per diem [redacted]for hotel and meals, and consultant fee of [redacted]day for 2 days). Dr. Davidson is an Associate Professor in Otolaryngology at Washington University in St. Louis School of Medicine and the Director of Audiology Outcomes at the Central Institute for the Deaf. Dr. Davidson has an active research program in perception for children who wear hearing aids and cochlear implants. She has extensive experience recruiting large cohorts of children with hearing loss from around the United States for several multi-center research studies. Dr. Davidson has agreed to serve as a consultant on this project to assist with aspects related to subject recruitment, experimental design, statistical analysis, and manuscript preparation.

4. ADP/Computer Services – Not applicable.

5. Subawards/Consortium/Contractual Costs [redacted]

Proposed Budget Period: 07/01/2019 - 06/30/2024

Approximately [redacted]Total Costs. [redacted]direct costs; [redacted] F&A costs)

Consortium with the University of Iowa (UIA), Iowa City, Iowa.

Calculations are based on [redacted]F&A rate for UIA. { X } Domestic { } Foreign

Senior/Key Person:

Beth Walker, Ph.D., Co-Investigator (effort = 1.4 CY months [9 calendar months]; 0.30 summer months [1 calendar month]). Dr. Walker is an Assistant Professor in the Department of Communication Sciences and Disorders at the University of Iowa. Dr. Walker has been a research collaborator with Dr. McCreery for the last 8 years. Dr. Walker will be responsible for administrating the data collection that will occur at the University of Iowa. Dr. Walker will also assist with all aspects of the proposed studies including experimental design, data collection and analyses, interpretation of data, manuscript preparation, and budget management at the University of Iowa.

Jake Oleson, Ph.D., Co-Investigator (effort = 1.2 CY months). Dr. Oleson is an Associate Professor in the Department of Biostatistics at the University of Iowa. Dr. Oleson has served as a statistician and research collaborator with Dr. McCreery's laboratory for the past 5 years. Dr. Oleson will provide support in statistical design, power analyses, data analysis, manuscript preparation, and preparing data and statistical code for public sharing.

Other Personnel:

Meggie Dallapiazza, Au.D., Audiologist (effort = 6 CY months). Dr. Dallapiazza is an experienced pediatric audiologist who has worked in Dr. Walker's lab for the past 2 years. Dr. Dallapiazza will be trained in all experimental procedures and will be responsible for hearing-related, standardized speech and language assessment, and data collection. Dr. Dallapiazza also will assist with subject consent, retention, scheduling, payment, family contacts and selected family and teacher surveys or interviews.

Wendy Fick, Research Associate (effort = 6 CY months). Ms. Fick is a Research Associate at the University of Iowa. Ms. Fick has served as a project coordinator for Drs. McCreery and Walker in the current grant cycle. Ms. Fick manages the data sharing across the two research sites, including quality control for data entry and management of the research database. Ms. Fick also assists with scheduling subjects, coordination of IRB and protocol changes across sites, and other support functions as needed.

6. Equipment or Facility Rental/User Fees – Not applicable.

7. Alterations and Renovations – Not applicable.

8. Other [redacted]/year)

Subject Costs: (Total: [redacted]/year):

Subject compensation for children recruited at Boys Town will be [redacted]/hour plus an additional travel stipend for participants traveling more than 20 miles to the laboratory. The travel stipend is especially necessary for children with hearing loss because of the need to expand our geographical recruitment areas. Travel stipends cover the cost of round-trip flights for the research participant and one parent or guardian or mileage if the participant lives within driving distance. For participants who travel more than 60 miles for research on concurrent days, we also pay for a hotel [redacted] We approximate [redacted] of participant data collection over the course of this project with additional funds [redacted] for travel stipends based on estimates from the last grant cycle.

RESEARCH & RELATED BUDGET - Cumulative Budget

	Totals ($)	
Section A, Senior/Key Person		[redacted]
[redacted]		[redacted]
[redacted]	[redacted]	
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
1. Domestic	[redacted]	
2. Foreign	0.00	
Section E, Participant/Trainee Support Costs		0.00
1. Tuition/Fees/Health Insurance	0.00	
2. Stipends	0.00	
3. Travel	0.00	
4. Subsistence	0.00	
5. Other	0.00	
6. Number of Participants/Trainees	0	
Section F, Other Direct Costs		[redacted]
1. Materials and Supplies	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
Section G, Direct Costs (A thru F)		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 1

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2019 **End Date*:** 06-30-2020 **Budget Period:** 1

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Elizabeth		Walker	Ph.D	Co-Investigator	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: **Total Senior/Key Person** [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Audiologist	6.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]
					[redacted]		[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

Tracking Number: GRANT12761949
Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 1

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ○ Project ● Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2019 **End Date*:** 06-30-2020 **Budget Period:** 1

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file	
Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs	**Funds Requested ($)***
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 1

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2019 **End Date*:** 06-30-2020 **Budget Period:** 1

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Subject Payments	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		Total Indirect Costs	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification* File Name:
ConsortiumJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 2

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ○ Project ● Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period: 2**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Elizabeth		Walker	Ph.D	Co-Investigator		1.4	0.0	0.3	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Audiologist	6.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]
					[redacted]		[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 2

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period:** 2

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	Funds Requested ($)*
Total funds requested for all equipment listed in the attached file	
Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel

D. Travel	Funds Requested ($)*
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	1,854.00
2. Foreign Travel Costs	
Total Travel Cost	[redacted]

E. Participant/Trainee Support Costs

E. Participant/Trainee Support Costs	Funds Requested ($)*
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

Tracking Number: GRANT12761949 Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 2

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2020 **End Date*:** 06-30-2021 **Budget Period:** 2

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Subject Payments	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	[redacted]	[redacted]	[redacted]
		Total Indirect Costs	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification* File Name:
ConsortiumJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 3

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ❍ Project ● Subaward/Consortium
Enter name of Organization: [redacted]

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period: 3**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Elizabeth		Walker	Ph.D	Co-Investigator		1.4	0.0	0.3	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Audiologist	6.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]

[redacted] [redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 3

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period:** 3

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file	
Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs	**Funds Requested ($)***
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 3

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2021 **End Date*:** 06-30-2022 **Budget Period:** 3

F. Other Direct Costs	Funds Requested ($)*
1. Materials and Supplies	[redacted]
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Subject Payments	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	Funds Requested ($)*
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)*
1 . MTDC	[redacted]	[redacted]	[redacted]
		Total Indirect Costs	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	Funds Requested ($)*
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	Funds Requested ($)*

K. Total Costs and Fee	Funds Requested ($)*
	[redacted]

L. Budget Justification* File Name:
ConsortiumJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 4

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 4

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Elizabeth		Walker	Ph.D	Co-Investigator		1.4	0.0	0.3	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] [redacted] [redacted] [redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Audiologist	6.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]

[redacted] [redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 4

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 4

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	**Funds Requested ($)***
Total funds requested for all equipment listed in the attached file	
Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs	**Funds Requested ($)***
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 4

ORGANIZATIONAL DUNS*: [redacted]
Budget Type*: ❍ Project ● Subaward/Consortium
Organization: [redacted]

Start Date*: 07-01-2022 **End Date*:** 06-30-2023 **Budget Period:** 4

F. Other Direct Costs	**Funds Requested ($)***
1. Materials and Supplies	[redacted]
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8 . Subject Payments	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	54.5	155,153.00	[redacted]
		[redacted]	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification* File Name:
ConsortiumJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION A & B, Budget Period 5

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Enter name of Organization: [redacted]

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** **5**

A. Senior/Key Person

	Prefix	First Name*	Middle Name	Last Name*	Suffix	Project Role*	Base Salary ($)	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits ($)*	Funds Requested ($)*
1 .		Elizabeth		Walker	Ph.D	Co-Investigator		1.4	0.0	0.3	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]													
[redacted]				[redacted]							[redacted]		[redacted]

B. Other Personnel

Number of Personnel*	Project Role*	Calendar Months	Academic Months	Summer Months	Requested Salary ($)*	Fringe Benefits*	Funds Requested ($)*
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Audiologist	6.0	0.0	0.0	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]	[redacted]
					[redacted]		[redacted]

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, Budget Period 5

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** 5

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	Funds Requested ($)*
Total funds requested for all equipment listed in the attached file	
Total Equipment	**0.00**

Additional Equipment: File Name:

D. Travel	**Funds Requested ($)***
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	[redacted]
[redacted]	
[redacted]	[redacted]

E. Participant/Trainee Support Costs	**Funds Requested ($)***
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees **Total Participant Trainee Support Costs**	**0.00**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

Tracking Number: GRANT12761949

Funding Opportunity Number: PA-18-484 . Received Date: 2018-12-17T11:44:23.000-05:00

RESEARCH & RELATED BUDGET - SECTIONS F-K, Budget Period 5

ORGANIZATIONAL DUNS*: [redacted]

Budget Type*: ❍ Project ● Subaward/Consortium

Organization: [redacted]

Start Date*: 07-01-2023 **End Date*:** 06-30-2024 **Budget Period:** 5

F. Other Direct Costs		**Funds Requested ($)***
1. Materials and Supplies		[redacted]
2. Publication Costs		
3. Consultant Services		
4. ADP/Computer Services		
5. Subawards/Consortium/Contractual Costs		
6. Equipment or Facility Rental/User Fees		
7. Alterations and Renovations		
8 . Subject Payments		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
	[redacted]	[redacted]

G. Direct Costs	**Funds Requested ($)***
Total Direct Costs (A thru F)	[redacted]

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	**Funds Requested ($)***
1 . MTDC	54.5	159,768.00	[redacted]
		[redacted]	[redacted]

Cognizant Federal Agency DHHS, [redacted]
(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)***
Total Direct and Indirect Institutional Costs (G + H)	[redacted]

J. Fee	**Funds Requested ($)***

K. Total Costs and Fee	**Funds Requested ($)***
	[redacted]

L. Budget Justification* File Name:
ConsortiumJust_RWM_R01resbm_16dec.pdf
(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

CONSORTIUM JUSTIFICATION

Proposed Budget Period: 07/01/2019 - 06/30/2024

Approximately [redacted] Total Costs. [redacted] direct costs; [redacted] F&A costs)

Consortium with the University of Iowa (UIA), Iowa City, Iowa.

Calculations are based on [redacted] F&A rate for UIA. { X } Domestic { } Foreign

A. Senior/Key Person

Beth Walker, Ph.D., Co-Investigator (effort = 1.4 CY months [9 calendar months]; 0.30 summer months [1 calendar month]). Dr. Walker is an Assistant Professor in the Department of Communication Sciences and Disorders at the University of Iowa. Dr. Walker has been a research collaborator with Dr. McCreery for the last 8 years. Dr. Walker will be responsible for administrating the data collection that will occur at the University of Iowa. Dr. Walker will also assist with all aspects of the proposed studies including experimental design, data collection and analyses, interpretation of data, manuscript preparation, and budget management at the University of Iowa.

Jake Oleson, Ph.D., Co-Investigator (effort = 1.2 CY months). Dr. Oleson is an Associate Professor in the Department of Biostatistics at the University of Iowa. Dr. Oleson has served as a statistician and research collaborator with Dr. McCreery's laboratory for the past 5 years. Dr. Oleson will provide support in statistical design, power analyses, data analysis, manuscript preparation, and preparing data and statistical code for public sharing.

B. Other Personnel

Meggie Dallapiazza, Au.D., Audiologist (effort = 6 CY months). Dr. Dallapiazza is an experienced pediatric audiologist who has worked in Dr. Walker's lab for the past 2 years. Dr. Dallapiazza will be trained in all grant procedures and will be responsible for hearing-related, standardized speech and language assessment, and data collection. Dr. Dallapiazza also will assist with subject consent, retention, scheduling, payment, family contacts and selected family and teacher surveys or interviews.

Wendy Fick, Research Associate (effort = 6 CY months). Ms. Fick is a Research Associate at the University of Iowa. Ms. Fick has served as a project coordinator for Drs. McCreery and Walker in the current grant cycle. Ms. Fick manages the data sharing across the two research sites, including quality control for data entry and management of the research database. Ms. Fick also assists with scheduling subjects, coordination of IRB and protocol changes across sites, and other support functions as needed.

C. Equipment Description – Not applicable.

D. Travel [redacted]

Funds are requested for PI to attend one conference trip per year at [redacted], increased by an additional [redacted] for each subsequent year.

E. Participant/Trainee Support Costs – Not applicable.

F. Other Direct Costs

1. Materials & Supplies

[redacted]

Funds are requested [redacted] in Years 1-5 for project and research related supplies at levels appropriate to the effort of data collection. Behavioral data collection supplies [redacted] include commercial test forms, specific test scoring software, record keeping, data management supplies and other associated testing/research supplies. Funds [redacted] are requested in Year 1 only for two laptops to be used for administration of tasks and data entry throughout the project.

2. Publication Costs – Not applicable.

3. Consultant Services – Not applicable.

4. ADP/Computer Services - Not applicable.

5. Subawards/Consortium/Contractual Costs – Not applicable.

6. Equipment or Facility Rental/User Fees – Not applicable.

7. Alterations and Renovations - Not applicable.

8. Other

Subject Costs: (Total:[redacted]

Subject Payment Costs: ([redacted]

Funds [redacted] are requested annually for research subject payments at a rate of [redacted] per CHL subject (two, two-hour sessions) and [redacted] per CNH subject (one, two-hour session). Iowa will test 15 CHL and 15 CNH subjects each year of the project. This study will recruit subjects from the entire state of Iowa and neighboring states of Illinois, Minnesota and Missouri, which will require participants to travel (mileage) to Iowa City for testing.

Subject Travel Costs:

[redacted]

Therefore, funds [redacted] are requested annually for research subject cost, escalated by an additional [redacted] for each subsequent year. These costs include mileage reimbursement, parking pass and meal voucher (CHL subjects only). The current UI rate for mileage is [redacted] per mile. Average number of miles per subject will be 228.4 miles. Each subject will require a [redacted] parking pass. CHL subjects will also receive a [redacted] meal voucher. The cost per CHL subject will be [redacted] X 15 subjects per year equals [redacted] total. The cost per CNY subject will be [redacted] X 15 subjects per year equals [redacted] (for a grand total of [redacted] subject costs).

Networking Fees: [redacted]

Funds [redacted] are requested annually for networking fees to the Department of Public Health, a mandatory cost related to the effort level of statistician, Dr. Jacob Oleson, escalated by an additional [redacted] for each subsequent year.

RESEARCH & RELATED BUDGET - Cumulative Budget

	Totals ($)	
Section A, Senior/Key Person		[redacted]
[redacted]		[redacted]
[redacted]	[redacted]	
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]		[redacted]
1. Tuition/Fees/Health Insurance	0.00	
2. Stipends	0.00	
3. Travel	0.00	
4. Subsistence	0.00	
5. Other	0.00	
6. Number of Participants/Trainees	0	
Section F, Other Direct Costs		[redacted]
1. Materials and Supplies	[redacted]	
2. Publication Costs	0.00	
3. Consultant Services	0.00	
4. ADP/Computer Services	0.00	
5. Subawards/Consortium/Contractual Costs	0.00	
6. Equipment or Facility Rental/User Fees	0.00	
7. Alterations and Renovations	0.00	
8. Other 1	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	
Section G, Direct Costs (A thru F)		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]
[redacted]		[redacted]

Total Direct Costs less Consortium F&A

NIH policy (NOT-OD-05-004) allows applicants to exclude consortium/contractual F&A costs when determining if an application falls at or beneath any applicable direct cost limit. When a direct cost limit is specified in an FOA, the following table can be used to determine if your application falls within that limit.

Category	Budget Period 1	Budget Period 2	Budget Period 3	Budget Period 4	Budget Period 5	TOTALS
[redacted]						

Tracking Number: GRANT12761949 Funding Opportunity Number: PA-18-484. Received Date: 2018-12-17T11:44:23.000-05:00

PHS 398 Cover Page Supplement

OMB Number: 0925-0001

Expiration Date: 03/31/2020

1. Vertebrate Animals Section

Are vertebrate animals euthanized? ● Yes ○ No

If "Yes" to euthanasia

Is the method consistent with American Veterinary Medical Association (AVMA) guidelines?

● Yes ○ No

If "No" to AVMA guidelines, describe method and provide scientific justification

2. *Program Income Section

*Is program income anticipated during the periods for which the grant support is requested?

○ Yes ● No

If you checked "yes" above (indicating that program income is anticipated), then use the format below to reflect the amount and source(s). Otherwise, leave this section blank.

*Budget Period	*Anticipated Amount ($)	*Source(s)

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3. Human Embryonic Stem Cells Section

*Does the proposed project involve human embryonic stem cells? ❍ Yes ● No

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: http://grants.nih.gov/stem_cells/registry/current.htm. Or, if a specific stem cell line cannot be referenced at this time, check the box indicating that one from the registry will be used:

❑ Specific stem cell line cannot be referenced at this time. One from the registry will be used.

Cell Line(s) (Example: 0004):

4. Inventions and Patents Section (Renewal applications)

*Inventions and Patents: ❍ Yes ● No

If the answer is "Yes" then please answer the following:

*Previously Reported: ❍ Yes ❍ No

5. Change of Investigator/Change of Institution Section

❑ Change of Project Director/Principal Investigator

Name of former Project Director/Principal Investigator

Prefix:

*First Name:

Middle Name:

*Last Name:

Suffix:

❑ Change of Grantee Institution

*Name of former institution:

PHS 398 Research Plan

OMB Number: 0925-0001
Expiration Date: 03/31/2020

Introduction	
1. Introduction to Application (for Resubmission and Revision applications)	2_Introduction_RWM_R01resbm_12dec18.pdf
Research Plan Section	
2. Specific Aims	2a_SpecificAims_RWM_R01_11dec18.pdf
3. Research Strategy*	2b_ResStrategy_RWM_R01resbm_12dec18.pdf
4. Progress Report Publication List	ProgRptPubsList_12dec18.pdf
Other Research Plan Section	
5. Vertebrate Animals	
6. Select Agent Research	
7. Multiple PD/PI Leadership Plan	
8. Consortium/Contractual Arrangements	ConsortiumArrangement_RWM_R01resbm_16dec.pdf
9. Letters of Support	LtrsSupport_RWM_R01resbm.pdf
10. Resource Sharing Plan(s)	9_ResourceSharing_RWM_R01resbm_07dec18.pdf
11. Authentication of Key Biological and/or Chemical Resources	
Appendix	
12. Appendix	

INTRODUCTION

We appreciated the constructive comments on our original submission, which were helpful in improving the application. We thank the reviewers of the original application for their excellent scores for our team of investigators (mean = 1.3), innovation (mean = 2), and the scientific environment (mean = 1). Reviewers provided helpful comments to improve the significance and approach. The feedback from reviewers (*italicized)* has been incorporated into the revised application as specified below. The revisions to the research strategy were extensive, so we did not mark the text to indicate where changes were made in the interest of readability.

Significance: *Reviewers noted that hypotheses regarding the effects of language, working memory, and selective attention on speech perception in noise for children with hearing loss were not clearly differentiated.* We clarified the hypotheses in each experiment to differentiate the role of each of these factors on different speech recognition in noise. Our core scientific premises that the developmental effects of selective attention and working memory on speech recognition in noise in children with normal hearing are further complicated by deficits in audibility and language related to hearing loss have been strengthened. Additional preliminary data were added to support the more clearly specified hypotheses.

- *Reviewers suggested that the theoretical framework did not acknowledge potential bidirectional relationships between predictors and outcomes or caveats if the theoretical model is not confirmed.* The theoretical framework and statistical analyses have been modified to acknowledge and test for bidirectional relationships between constructs and caveats have been further developed to acknowledge alternative findings.

Investigators: *Reviewer 2 suggested that the roles of each member of the research team was not justified.* The specific roles of the team members have been clarified in the budget justification.

General Approach: *All three reviewers noted that the longitudinal experiments were not sufficiently justified.* These experiments provide evidence for the relationships among selective attention, working memory, language and speech recognition in noise because they directly measure any changes in these constructs over time. This justification has been clarified in the revised application.

- *Reviewer 1 requested further scientific justification for the age range of the study.* Our ambitious research plan covers a wide age range in order to characterize multiple perceptual processes that mature during childhood and adolescence. The justification for the age range has been revised in the general approach.
- *Reviewer 1 requested justification for the inclusion of participants with a broad range of degree of hearing loss.* The range was selected to reflect the entire range of degrees of hearing loss in children who are clinically fitted with hearing aids (better-ear average 20-80 dB HL).
- *Reviewers 2 and 3 commented that the effects of audibility were not considered.* We added and clarified specific hypotheses about the immediate and cumulative effects of audibility across experiments.

Aim 1 Approach: *Reviewers 1 and 2 raised questions about the extent to which effects of attention and memory on psychophysical tasks were related to specific relationships hypothesized in the application or more general task difficulty.* We added an experiment (new Exp. 1b) to test the effect of inter-stimulus interval on task performance to address this question. Supporting preliminary data also have been added.

- *Reviewer 2 suggested that the temporal resolution experiment was not well-integrated and requested additional clarification of the spectral resolution task.* We removed the temporal resolution experiment from Aim 1 and included a new experiment to test the relationship between spectral resolution and selective attention.

Aim 2 Approach: *Reviewers 1 and 3 commented that there was no consideration of the potential confounding of spectral resolution and perceptual weights with stimulus level for children with hearing loss.* We will analyze the effects of stimulus levels related to spectral resolution (Aim 1) and band importance (Aim 2).

- *Reviewer 2 indicated that the link between band importance and speech perception in noise was not directly measured. An independent measure of sentence recognition in noise was added to Aim 2 experiments to address this concern.*
- *Reviewer 3 commented that band-importance experiments did not consider potential interactions between frequency bands.* An interaction term has been added to the model in Aim 2 to address this.

Aim 3 Approach: *Reviewer 1 noted that the preliminary data for Aim 3 were not compelling.* New preliminary data based on the measures of selective attention proposed in the application are now included.

We hope that the changes noted above and in the revised application will be satisfactory to the reviewers.

SPECIFIC AIMS

Approximately 3% of school-age children in the United States have permanent bilateral hearing loss (Mehra et al. 2009). Children with mild-to-severe hearing loss (CHL) are often identified and fitted with hearing aids within the first few months of life. Despite early identification and provision of amplification, speech recognition in noise for school-age CHL remains substantially poorer than it is for children with normal hearing (CNH; McCreery et al. 2015a). Background noise is ubiquitous, so poor speech recognition in noise has cascading negative consequences for social, behavioral, and academic functioning for CHL. Our research in the previous cycle focused on the effects of restoration of speech audibility with hearing aids on speech recognition in noise (e.g. McCreery et al. 2016; McCreery et al. 2017). Our findings showed that relative to CNH, CHL have deficits in speech recognition in noise even after audibility is improved with hearing aids. Poor speech recognition in noise for CHL highlights critical shortcomings of current models for the prescription of amplification for CHL and a major gap in our understanding of the mechanisms that restrict speech recognition in noise for this group.

Adults with normal hearing rely on selective attention (Shinn-Cunningham, 2017) and working memory (Rönnberg et al. 2013) to understand speech in noise. Selective attention is used to focus on the features of the auditory signal of interest while inhibiting attention to irrelevant sounds. Working memory is used to temporarily store and process incoming sensory information. Emerging data from CNH (McCreery et al. 2017) support our hypothesis that selective attention and working memory are associated with better speech recognition in noise, but these effects have not been studied in CHL who use hearing aids. We hypothesize that speech recognition in noise deficits in CHL are related to the development of selective attention and working memory (like CNH), but that these deficits are compounded by hearing-loss related deficits in audibility and language. We hypothesize that selective attention will predict performance in auditory tasks that require attention to features of the auditory signal (spectral resolution), inhibition of irrelevant information (perceptual weighting for speech and informational masking), and segregation of target and masker signals (informational masking). We also hypothesize that working memory will affect tasks that require temporary storage and processing of information. Finally, we hypothesize that language ability will predict performance when the stimulus or the masker is speech (perceptual weighting and informational masking). We will examine these effects for CHL and CNH.

Aim 1: Examine the effects of selective attention, working memory, and spectral resolution on speech recognition in noise. The ability to resolve spectral changes in auditory signals predicts speech recognition in noise for CNH (Kirby et al. 2016). However, spectral resolution also has been related to cognitive abilities in both CNH and CHL (Kirby et al. 2018). The extent to which cognitive mechanisms affect spectral resolution and speech recognition in noise remains unresolved. To separately quantify spectral resolution and cognitive factors in CNH and CHL, the influence of selective attention, working memory, and spectral resolution on speech recognition in noise will be measured. We predict that spectral resolution and speech recognition in noise are related directly and via mediating factors of selective attention and working memory.

Aim 2: Characterize the effects of selective attention and language on perceptual weighting for speech in noise. Perceptual weights for speech represent the importance of specific frequency bands to speech recognition in noise. Weights for the same frequency band vary among CNH, but little is known about what contributes to this variability. Whether individual differences in weighting predict speech recognition in noise is also unclear. We predict that the variability in weights reflects differences in selective attention to bands where speech is most important based on the child's language skills. We will test the hypothesis that children with stronger selective attention and language skills have weights concentrated in the mid-frequencies. This pattern of weights will be associated with stronger speech recognition in noise, reflecting more mature selective listening. Band importance for CHL is predicted to be mediated by the audibility of each band, providing a potential mechanism to optimize individual weighting functions with amplification.

Aim 3: Evaluate selective attention as a predictor of speech recognition in speech maskers. Background noise is often comprised of competing talkers, which is more challenging for children than adults (Corbin et al. 2016). We hypothesize that 1) the ability to selectively attend to the target talker and inhibit irrelevant speech is crucial for speech recognition in speech maskers and 2) the relationship between selective attention and speech recognition in speech maskers is mediated by language and working memory abilities. We predict that CHL with better speech audibility will show better performance in speech maskers than peers with poorer audibility due to the immediate effects of audibility on access to the signal and the long-term effects of audibility on language.

Impact: Data generated by this proposal will provide a foundation for novel developmental models of speech recognition for CNH and greater opportunity for the individualization of hearing aid prescription in noise for CHL.

RESEARCH STRATEGY

A. SIGNIFICANCE

Approximately 2.3 million (3%) of school-age children in the United States have permanent, bilateral hearing loss (Mehra et al. 2009). Most children with hearing loss (CHL) use hearing aids (HAs) to improve speech audibility in order to support communication, social, and academic development. The implementation of universal newborn hearing screening and early intervention for CHL has lowered the average age of HA fitting in the US from over 2 years (Moeller 2000) to less than 7 months (Holte et al. 2012). Previous studies of developmental outcomes in CHL have focused on the timing of amplification and/or early intervention (Yoshinaga-Itano et al. 1998; Moeller, 2000; Ching et al. 2013). Lowering the age of intervention has allowed some CHL who wear HAs to close the gap in language outcomes with children who have normal hearing (CNH; Tomblin et al. 2014; Tomblin et al. 2015). Nonetheless, CHL continue to have greater difficulty understanding speech in noise than peers with NH (Blamey et al. 2001; Davidson & Skinner, 2006). Even CHL with strong speech recognition in quiet demonstrate substantial deficits in noise compared to CNH (**Fig. 1**).

Difficulties with listening in noise cannot be overstated because children must communicate, learn, and socialize in listening environments with high levels of background noise (Crukley et al. 2011; Nelson & Soli, 2000). The pervasiveness of noise in children's everyday listening situations means that deficits in speech recognition in noise have cascading, long-term negative consequences, affecting academic, behavioral, and social functioning (Shield & Dockrell, 2008). Adults with normal hearing rely on executive function skills, including selective attention (Shinn-Cunningham, 2017; Sussman, 2017) and working memory (Rönnberg et al. 2007), to understand speech in noise. <u>Selective attention</u> is the ability to attend to relevant information and ignore distracting information (D'Angiulli et al. 2008). The inability to inhibit attention to off-frequency masking has been related to deficits in speech recognition in noise in young CNH (Youngdahl et al. 2018), but the developmental time course in older CNH and CHL remains unclear. <u>Working memory</u> is the ability to temporarily store and process representations of sensory inputs (Baddeley, 2002). A better understanding of the role of selective attention and working memory on speech recognition in noise may help to explain why CHL have persistent deficits in speech in noise even after audibility has been improved with HAs. Our previous research has focused on the effects of restoring audibility with HAs on speech recognition and language abilities. The continuation of this work will expand our theoretical model to include selective attention and working memory. Our experimental design includes cross-sectional and longitudinal experiments to allow us to separate immediate and long-term effects of developmental and auditory contributors to speech recognition in noise. This research is scientifically important because it will enhance our understanding of the mechanisms that affect speech perception in noise for CNH and CHL. The proposed research is innovative in that heretofore unexamined variables will now be evaluated in relation to childhood hearing loss. The findings from this proposal are translational because the results will aid in the development of individualized amplification strategies for CHL that reflect differences in perceptual, cognitive, and linguistic abilities.

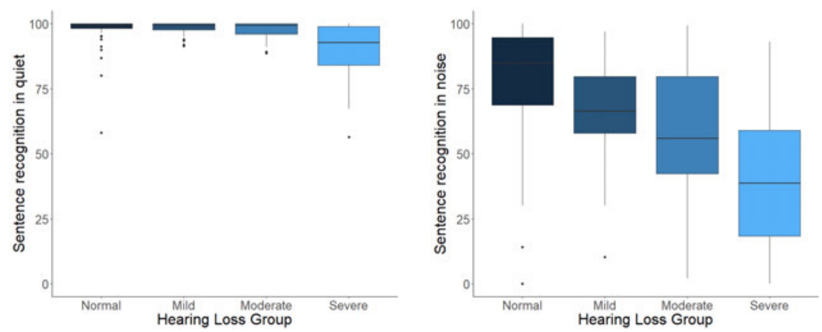

Fig. 1. Pilot data for CNH (n=80) and CHL (n=130) who wear HAs by increasing degree of hearing loss. Percent correct sentence recognition in quiet (left panel) and in noise (right panel, speech-shaped noise at a +6 dB SNR).

The aims and significance of the proposed research are based on the following scientific premises:

Scientific Premise 1: Restoration of audibility does not optimize speech recognition in noise for CHL.

Children's HAs are designed and fitted to make speech audible. The proportion of speech that is audible through a child's HA (aided audibility) can be quantified using the Speech Intelligibility Index (SII; ANSI S3.5-1997). The SII represents the proportion of the speech spectrum that is audible for a particular listening situation weighted by the importance of each frequency band. Audibility-based models predict that speech recognition increases as speech audibility increases and, thus, aim to maximize access to the speech signal based on the child's audiogram (Scollie et al. 2005; Ching et al. 2010). Most HA prescriptions for CHL optimize audibility for listening in quiet and assume the child is near the talker of interest. However, school-age children spend much of their time listening in background noise (Crukley et al. 2011; Nelson & Soli, 2000) and proximity to the talker of interest is variable and inconsistent (Ching et al. 2009). Real-world background noise often includes speech of non-target talkers and speech from electronic media (Ambrose et al. 2014). Fitting HAs to optimize audibility for speech in quiet also increases audibility of competing noise in noisy environments. The focus of previous research on optimizing aided audibility in quiet has not resolved difficulties in speech perception in noise for CHL. Models of speech recognition that reflect cognitive and linguistic development of CHL could help to address limitations in previous research, as these factors affect children's speech recognition in noise. Research on cognitive and linguistic contributions to speech recognition in noise for CHL has been limited to date. Immaturity in the ability to listen selectively and greater susceptibility to maskers has been documented in infants with normal hearing (Bargones & Werner, 1994) and young school-age CNH (Leibold & Buss, 2016). For CHL who have not developed the ability to listen selectively, providing broadband audibility through a HA will increase masking effects and reduce speech recognition in noise (Nittrouer & Lowenstein, 2015). Expanding on audibility-based models of speech recognition, we will examine the effects of selective attention, working memory, and language on perceptual abilities that are important for speech recognition in noise. Evaluating these factors represents a unique and significant step towards our understanding and eventual interventions related to optimizing speech perception in noise for CHL.

Scientific Premise 2: Speech recognition in noise depends on the listener's selective attention, working memory, and linguistic knowledge.

To understand speech in noise, the listener must be able to hear and attend to the relevant acoustic cues within the speech signal and process those cues by relying on a combination of cognitive and linguistic skills (Mattys et al. 2012). Previous studies investigating links between speech perception and cognitive abilities have focused specifically on the role of verbal working memory on speech recognition in degraded listening conditions. Adults' reliance on verbal working memory to understand speech and communicate in background noise (Surprenant, 2007; Füllgrabe et al. 2015; Wingfield & Tun, 2007) led to the development of the Ease of Language Understanding (ELU) model (Rönnberg et al. 2013). The ELU model predicts that stronger working memory allows the listener to more efficiently store and process phonological information during speech recognition. Predictions consistent with the ELU model have been documented in adults with hearing loss who wear HAs (Akeroyd, 2008; Miller et al. 2017) and in children (Geers, Brenner & Davidson, 2003) and adults with cochlear implants (Moberly et al. 2017). The predictions of the ELU have been extended to preschool (Lalonde & Holt, 2014) and school-age CNH (McCreery et al. 2017b) and CHL who wear HAs (McCreery et al. 2015b; Klein et al. 2017), confirming the importance of working memory during speech recognition in noise.

Although verbal working memory is important for sequencing phonological information in speech, mechanisms involving selective attention are also known to support speech recognition in noise. The ability to segregate a target talker from a speech background depends on the listener's selective attention in adults with normal hearing (Fritz et al. 2007) and adults with hearing loss (Kidd et al. 2002). Adults with normal hearing use spectral features of the auditory signal to segregate various sound sources that arrive at the ear as a mixture (Carlyon, 2004). Developmental immaturity of selective attention and working memory skills in CNH may be compounded by immediate and cumulative effects of reduced audibility in CHL. In CHL, domain general tests of selective attention will be needed to disambiguate the effects of developmental and sensory factors. To date, the effects of the development of selective attention on speech recognition in noise have not been studied in CHL, but an emerging literature in CNH (Leibold & Buss, 2016; Youngdahl et al. 2018) supports our hypothesis that deficits in selective attention is crucial for understanding speech in noise.

Our approach (**Fig. 2**) examines three pathways by which selective attention, working memory, and language abilities are likely to enhance speech recognition in noise for CNH and CHL. We hypothesize that selective attention will predict performance in auditory tasks that require (1) attention to relevant features of the signal (spectral resolution), (2) inhibition of irrelevant information (perceptual weighting and informational masking), and (3) segregation of target and masker signals (informational masking). Working memory is expected to affect all auditory tasks that require temporary storage and processing of information. We expect that the child's language ability will predict performance only in tasks where the stimulus or the masker is speech (perceptual weighting and informational masking). In **Aim 1**, we will examine the effects of selective attention,

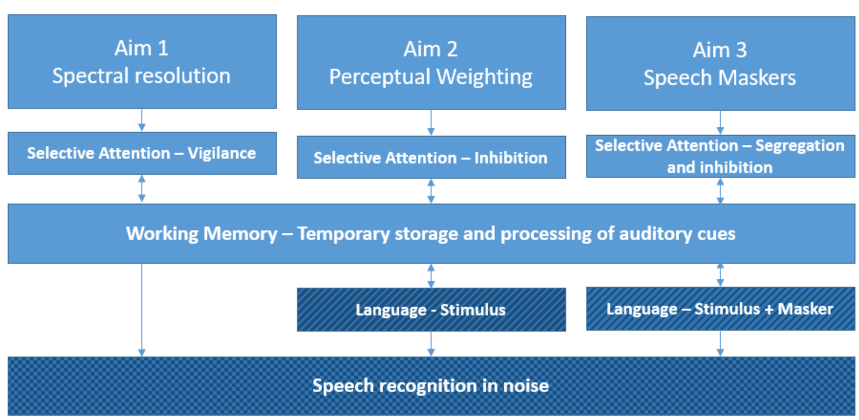

Fig. 2. Our theoretical model describes how selective attention, working memory, and language affect speech recognition in noise. The dark blue rectangles represent factors where audibility will mediate effects in CHL.

working memory, and spectral resolution on speech recognition in noise for CNH and CHL. Spectral resolution, selective attention, and working memory are inter-related. This complexity makes it difficult to determine whether there is a direct relationship between spectral resolution and speech recognition in noise in children or if spectral resolution is related to children's speech recognition in noise through cognitive mechanisms, such as working memory and selective attention. Both spectral resolution and speech recognition in noise have been associated with individual differences in cognitive abilities in children (Kirby et al. 2018). We predict that selective attention and working memory affect the ability to attend to and process spectral cues. In **Aim 2**, the effects of selective attention, working memory, and language abilities on perceptual weights for speech will be examined for individual CNH and CHL. A key assumption of current audibility-based models is that the band-importance weights are uniform across listeners. Based on our pilot data and previous research (Nittrouer & Lowenstein, 2015), we predict that individual differences in selective attention, working memory, and language abilities are related to differences in perceptual weighting for speech. Individualized weighting functions may be useful in determining the extent to which children listen selectively to frequency bands that have the highest importance weights for speech when listening in noise. The development of individualized weighting functions could form the basis for more precise hearing-aid prescriptions for children. In **Aim 3**, we will examine the influences of selective attention, working memory, and language abilities on speech recognition in noise when the masker is speech. Segregating the target signal from the masker is challenging when the two signals are comprised of speech. We predict that selective attention represents the ability to attend to the target talker and inhibit the masker talker, but that these abilities are also is mediated by a child's working memory and language abilities. Overall, our work will add to the understanding of the mechanisms that support speech recognition in noise for children and expand on current audibility-based models to better account for individual differences in speech recognition in noise for CNH and CHL. The inclusion of cognitive and linguistic factors in models that influence the development of amplification strategies for CHL represents a paradigm shift from our current models based on the child's audiogram.

B. INNOVATION

The proposed research is innovative in scientific theory, methods, and the potential for developing individualized clinical interventions. The dominant methodological paradigm for researching developmental outcomes of CHL who wear HAs has focused on the timing of intervention and the restoration of audibility for speech. In contrast, our approach is innovative because it incorporates higher-level skills—selective attention, working memory, and language abilities—as additional predictors of speech recognition in noise. We will use a combination of cross-sectional and longitudinal experiments to address mechanistic questions about the factors that contribute to persistent speech-recognition deficits in noise for CHL. These efforts will lead to a more refined theoretical model of speech recognition and its development in CHL. Moreover, extant research has focused on omnibus measures of speech recognition, cognition, and language compared to CNH. Comparisons between CNH and CHL are important because minimizing differences between CHL and CNH should be our long-term objective. However, studies that focus on group differences cannot reveal mechanisms that contribute to individual deficits and variability in speech recognition in noise. Our approach is innovative because we will document individual differences within groups of CNH and CHL and, in the case of Aim 2, determine each child's unique perceptual weighting for speech. Current methods of fitting HAs are based on restoring audibility in quiet using average perceptual weighting functions from groups of adult listeners. Our approach is innovative because we will determine the contributions of selective attention, working memory, and language to speech recognition abilities for different types of noise, including speech maskers. A clearer understanding of mechanisms that contribute to speech recognition in noise will allow us to develop novel individualized hearing-aid fitting methods designed to optimize speech recognition in noise. This work will support future scientific and clinical approaches to improve developmental outcomes for CHL and will address a key strategic area of the National Institute for Deafness and Communication Disorders to describe development of speech perception for CHL and develop individualized treatments for people with hearing loss in alignment with NIH Precision Medicine initiatives.

C. APPROACH

Progress Report: [12/01/2013 to 12/01/2018]

In the previous funding period we have published 28 peer-reviewed manuscripts, a book chapter, and a book related to our research to date. We have three additional manuscripts under review. We have had 42 presentations at national or international scientific conferences. We have collected data from 465 subjects in the current funding period, including data from over 200 CHL. Our scientific progress during the previous funding cycle can be summarized across three main areas:

Effects of aided audibility and hearing-aid use on speech recognition and language outcomes in CHL. Our research focused on the influence of aided audibility and HA use as predictors of outcomes in CHL. We found that nearly half of CHL do not have HAs that provide optimal speech audibility (McCreery et al. 2015a; McCreery et al. 2017a). Daily HA use varies among CHL (Walker et al. 2015). Variations in aided audibility and HA use have a cumulative effect on speech recognition in quiet (McCreery et al. 2015b; McCreery et al. 2017a), language development (Tomblin et al. 2015), and morphosyntactic skills (Koehlinger et al. 2015). We applied longitudinal methods to examine the effects of changes in ear canal acoustics and hearing thresholds on aided audibility over time (McCreery et al. 2016), as well as extending this model to children with auditory neuropathy spectrum disorder (Walker et al. 2016). This research has been theoretically innovative for modelling the effects of HAs on developmental outcomes as variable and dependent on the amount of aided audibility and HA use, rather than invariant and related to the timing of intervention or time since HA fitting.

Language abilities and working memory support speech recognition in CHL. In a series of experiments, we demonstrated a relationship between vocabulary and working memory abilities and speech recognition in CHL from 2 to 9 years of age and across a wide range of speech recognition tasks (McCreery et al. 2015b; Lewis et al. 2017; McCreery et al. 2017). We found larger benefits for vocabulary size for speech recognition in noise when the stimuli were later-acquired rather than early-acquired words, which could explain inconsistencies in previous literature (Klein et al. 2017). Further, we demonstrated that the effects of speech audibility on gated sentence recognition are mediated by the child's language abilities (Lewis et al. 2017).

Interactions between speech perception and HA signal processing for CHL. HA signal processing algorithms are developed based on assumptions about the listening needs and behavior of adults with hearing loss, leaving aside questions about the effects of signal processing on perception for CHL. We found that time constants for amplitude compression affected the release from forward masking (Brennan et al. 2015) and modulated masking release (Brennan et al. 2016), which are important skills for understanding speech in noise. We also found interactions between spectral resolution and frequency-lowering signal processing benefit in CHL, where better spectral resolution predicted speech recognition in noise for CHL when listening to frequency-lowered speech (Kirby et al. 2017). This area of research is crucial for the development of optimal clinical prescriptions of HA signal processing for CHL.

Our progress in these areas using large samples of CHL has been informative. However, deficits in speech recognition in noise for CHL are persistent, even after audibility is restored with hearing aids. This key finding led us to adopt a mechanistic focus in our continuation of the current work that will allow us to establish linkages between perceptual, linguistic, and cognitive factors on speech recognition in noise.

General Methods. Methods that are common across all three aims are summarized below:

Participants. The proposed experiments will include CNH and CHL, matched for age, sex, and maternal education level. Children will be 6-12 years-old at the time of enrollment. This age range was selected to allow us to characterize shifts in perceptual weighting functions and selective attention known to emerge around 6 years of age (McCreery et al. 2017b), as well as the time course for understanding speech with speech maskers that persists into adolescence (Corbin et al. 2016). A group of adults with normal hearing (ANH) between 19-40 years of age will be recruited for a subset of experiments in Aim 2 to provide a mature comparison group and support replication comparisons to previous research. CHL and CNH will participate in experiments under several Aims whenever possible. CNH and ANH will have pure-tone averages (PTA; average threshold at 0.5, 1, and 2 kHz) less than 20 dB HL in both ears with no history of neurodevelopmental, communication or sensory disorders. All CHL will have better-ear PTA between 20 dB and 80 dB HL (sensorineural, conductive or mixed), reflecting the range of hearing losses where HAs are clinically provided to CHL. Children with cochlear implants or unilateral hearing loss will be excluded due to the likelihood of different effects in these groups. All participants will speak English as their primary language. No effect of sex is expected, but we will recruit equal numbers of male and female participants and analyze listener sex as a variable. Socioeconomic status will be collected based on parent's self-reported education level.

Study design and power analyses. We will use linear mixed models with random intercepts for each subject to account for the correlation between repeated observations within subjects across conditions or over time. Each model may also include random slopes to account for individual variability across time, different variance parameters per level to account for heterogeneity, or different correlations between levels. Model selection criteria (e.g., Akaike or Bayesian Information Criteria) will be used to determine the best fitting covariance pattern to each model. Models will be organized within a path-analytic framework where variables serve as predictors, mediators of predictors, outcomes, or control variables. We will use empirical methods (model selection) and rational methods (scientific knowledge) for variable reduction prior to hypothesis testing to minimize collinearity between predictor variables. When possible, 1,000 datasets were simulated based on anticipated effect sizes from our previous research or the literature to estimate the statistical power and sample size specified for each experiment (Lu et al. 2008). Power analyses for each experiment assume α=0.05 to achieve 80% power computed as the percentage of the 1,000 datasets that rejected the null hypothesis.

Language measures. The Peabody Picture Vocabulary Test-IV (PPVT-IV; Dunn & Dunn, 2007) will be used to measure receptive vocabulary. The Vocabulary subtest of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) will be used to measure expressive vocabulary. These measures were selected because they are predictive of speech recognition in noise and sensitive to differences between CNH and CHL (McCreery et al. 2015b; Walker et al., in press). Receptive and expressive scores will be combined as a Z-score to represent language ability for each subject in statistical analyses.

Selective attention, working memory, and nonverbal cognition. Tests from the Psychology Experiment Building Language (PEBL; Mueller & Piper, 2014) will be used to assess skills related to selective attention. Selective attention will be measured using tasks that assess inhibition of attention (Eriksen Flanker) and attention switching (Switcher task). Subtests of the Automated Working Memory Assessment (AWMA; Alloway et al. 2008) related to verbal short-term storage (Nonword Recall), verbal working memory (Listening Recall), visuo-spatial short-term storage (Block Recall) and visuo-spatial working memory (Odd One Out) will be completed. With the exception of verbal working memory, measures were selected to be nonverbal, visually presented, with minimal language demands to help minimize the effects of audibility and language. The WASI Matrix Reasoning subtest will be administered to establish that nonverbal cognitive abilities are within normal limits (within 1.5 standard deviations from the normative mean for each subject's age). As with language measures, Z-scores will be generated for each subject to represent constructs if individual measures are highly correlated.

Audiometry. Behavioral thresholds at octaves from 0.25 – 8 kHz will be measured at each visit for all participants. Speech recognition in quiet will be measured for average (65 dB SPL) conversational levels in sound field using monosyllabic words selected from the Child Lexical Database (Storkel & Hoover, 2010). Speech recognition in quiet will be used as a baseline for comparison to speech recognition in noise across experiments, as well as ensuring that participants can recognize speech in quiet. Participants with less than 25% word recognition in quiet at 65 dB SPL will be excluded. For all speech-recognition tasks, CHL will be tested with their HAs in sound field at 0 degree azimuth. Parents of CNH and CHL will complete a hearing-history questionnaire. For CHL, the questionnaire will assess age milestones related to the onset and confirmation of hearing loss, and age at HA fitting and amount of daily HA use. Data logging, an automatic system in the HA, will measure average daily HA use. Use of remote-microphone systems at school and at home will be indexed.

Aided audibility and electroacoustic analysis. Electroacoustic analysis of HA characteristics will be measured at each visit to determine aided audibility (SII) average (65 dB SPL) speech. The proximity of the fitting to Desired Sensation Level (Scollie et al. 2005) prescriptive targets (dB root-mean-square [RMS] error) will be documented. All testing with HAs will be completed at the child's use settings. HA features (noise reduction, directional microphones, and frequency lowering) will be documented.

Scientific rigor and reproducibility. Our research team has considerable experience and expertise in the proposed experimental measures and methods both with CNH and CHL. The measures of cognition and language that were selected for each experiment have high test-retest reliability based on published data from children in the age range of the proposed experiments. Speech recognition for all experiments will be video recorded, and a subset of responses will be scored by an additional blinded examiner to quantify reliability. Transparency and reproducibility will be enhanced by using publicly available, open-source experimental software (PEBL and BTNRH custom software) and statistical analyses (R programming language; R Core Team, 2016). Source code for experiments and statistical analyses is either freely available or will be made freely available through the Boys Town Github repository (https://github.com/BoysTownorg). Experimental design and statistical analyses will be pre-registered prior to the beginning of data collection. Raw data (compliant with applicable privacy regulations) from each experiment will be made freely available once each experiment has been completed. Pre-registrations and data will be available on the Open Science Framework website for BTNRH (https://osf.io/institutions/bt/).

Aim 1: Examine the effects of selective attention, working memory, and spectral resolution on speech recognition in noise.

Background and rationale. The ability to understand speech in background noise depends on a listener's ability to encode and use spectral cues (Fu et al. 1998). Adults use spectrotemporal cues to segregate speech from noise (Carlyon, 2004). Numerous studies have shown that spectral resolution positively predicts speech recognition in quiet and in noise, including work with adults with HAs or cochlear implants (Henry et al. 2005; Won et al. 2007; Davies-Venn et al. 2015). In CNH, spectral resolution (Kirby et al. 2015) improves from the early school-age years through adolescence. Even temporary conductive hearing loss related to otitis media has been shown to have lasting effects on modulation detection in children (Benoit et al. 2018), but the effects of permanent hearing loss have not been extensively studied. Our work with CNH (Kirby et al. 2015) and CHL (Kirby et al. 2018) suggests that spectral resolution is related to working memory, which confounds our ability to interpret individual differences in spectral resolution in CNH and CHL independently from cognitive abilities. Our goal in Aim 1 experiments is to disambiguate the sensory and cognitive factors that affect spectral resolution in CNH and CHL. We predict that spectral resolution in children is dependent on the listener's selective attention and working memory skills because the listener must attend to features of the stimulus (selective attention) and temporarily maintain the representations of that stimulus for analysis (working memory). If confirmed, these results would support a novel mechanism in which selective attention and working memory support speech recognition in noise by enhancing processing of spectral cues. A longitudinal experiment will be used to characterize how spectral resolution changes over time and interacts with sensory and cognitive factors.

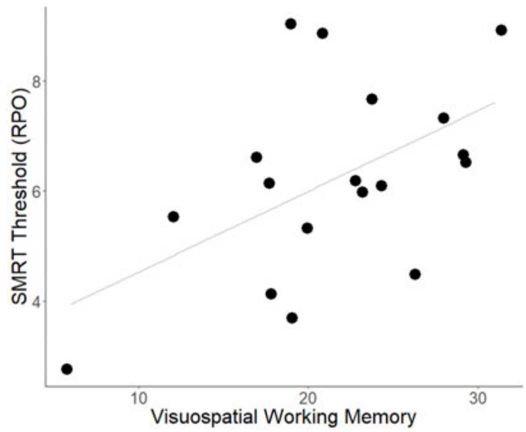

Fig. 3. Spectro-temporal modulation ripple task (SMRT) thresholds as a function of visuospatial working memory. The partial correlation between SMRT threshold and visuospatial working memory after controlling for age is r = .42 (p=0.04).

Preliminary data. Broadband spectro-temporal modulation detection was measured in 18 CHL (6-12 years of age) using an adaptive task (Aronoff & Landsberger, 2013). Spectro-temporal modulation includes changes in both spectral and temporal cues. CHL with higher visuospatial working memory could detect more ripples per octave (RPO) than CHL with poorer visuospatial working memory ability (**Fig. 3**) after controlling for age. However, the combined spectrotemporal modulation task does not allow us to separate contributions of spectral resolution from temporal cues. Additionally, the use of a broadband carrier signal without a level rove may have allowed listeners to rely on loudness cues rather than spectral cues. Experiments in Aim 1 will address these limitations using narrowband carriers and roving of level across trials to minimize the influence of loudness perception.

Exp 1a: Selective attention, working memory, and spectral resolution as predictors of speech recognition in noise.

This experiment tests the hypothesis that spectral resolution has direct effects on speech recognition and mediated effects from selective attention and working memory. Specification of direct and mediated effects will allow better characterization of auditory and cognitive contributions to spectral resolution in children. We predict that children with better selective attention and working memory will have better spectral resolution compared to peers with poorer skills in these domains.

Participants. Eighty CNH and 80 CHL will be sufficient to detect effect sizes of Cohen's d > 0.2 for group comparisons and will allow us to detect r > 0.3 for a three-predictor linear mixed model based on simulation.

Methods. Spectral-ripple discrimination will be measured under headphones at 20 dB sensation level (SL) using an adaptive, three-alternative, forced choice task (3AFC). Two octave-wide carrier signals will be used (a low-frequency (500 Hz) and high-frequency (2000 Hz) band) to capture frequency-dependent differences in spectral resolution for children with sloping hearing losses. Two ripple densities (1 and 2 ripples/octave) will be measured for each carrier condition. Selective attention and working memory (verbal and visuospatial) will be measured for each subject. Speech recognition in noise will be measured in sound field at 65 dB SPL for Pediatric AZ-Bio sentences (Spahr et al. 2014) using a one-up, one-down adaptive procedure (Levitt, 1971) to identify the SNR needed for 50% keyword recognition (SNR50). The masking noise will be speech-shaped noise matched to the spectrum of the AZ-Bio corpus.

Data analyses and expected outcomes. Linear mixed models with a random intercept for each subject will be used to assess the effects of hearing status (CNH vs CHL), selective attention, working memory, and spectral resolution on speech recognition in noise. A path model then will be used to determine whether the effects of spectral resolution on speech recognition in noise (SNR50) are direct and/or mediated by selective attention and working memory. For CHL, better-ear aided audibility (SII with HAs) will be included as a covariate. We predict that selective attention and working memory will predict spectral resolution in CHL and CNH. Working memory will mediate the relationship between spectral resolution and speech recognition in noise due to the role of working memory in storage and processing of both speech and non-speech stimuli (Kirby et al. 2015). Evidence for direct and mediated relationships between spectral resolution and speech recognition in noise will enhance our understanding of the effects of sensory and cognitive factors on spectral resolution in children.

Pitfalls and potential solutions. If our hypothesis predicting both direct and mediated effects between spectral resolution and speech recognition in noise are not supported, the information generated will still provide useful information about the effects of spectral resolution on speech recognition in noise. Additionally, CHL who have the greatest degrees of hearing loss may not be able to complete the task at 20 dB SL due to loudness intolerance. In those cases, the task will be performed at a lower SL. The effect of absolute level (dB SPL) will also be analyzed to reflect the potential variation in presentation levels for the same 20 dB SL across participants.

Exp 1b: The effect of inter-stimulus interval (ISI) on spectral resolution in children.

To analyze task-related cognitive factors that influence spectral resolution, we will modify the ISI to increase demands on working memory and selective attention. We predict that the strength of the relationship between selective attention, working memory, and spectral resolution will increase as the ISI increases.

Participants. The same subjects who participated in Exp 1a will participate in this experiment.

Methods. Spectral ripple depth discrimination will be measured under headphones as in Exp 1a. This experiment will include three ISI conditions for the 3AFC task: 0.4 seconds, 1.2 seconds, and 3 seconds. Measures of selective attention and working memory will be the same as in Exp 1a.

Preliminary data. Spectral ripple depth discrimination was measured using a 3AFC task with ISIs of 0.4, 1.2, and 3 seconds for a group of ten CNH between 6 and 12 years of age. The order of ISI conditions was randomized across participants. Spectral ripple depth discrimination improved with age ($r = 0.34$, $p = 0.02$). CNH with higher working memory abilities had better spectral resolution ($r = 0.45$, $p < 0.01$). The association of age and working memory with spectral resolution increased as the ISI increased, supporting our prediction that task-based factors influence performance on spectral resolution tasks.

Data analyses and expected outcomes. Linear mixed models with a random intercept for each subject will be used to assess the effects of hearing status, ISI, selective attention, and working memory on spectral ripple depth discrimination. We predict that CNH will have better spectral resolution than CHL. We predict that children with better selective attention will have fewer attentional lapses and less threshold variability in their adaptive tracks compared to peers with poorer selective attention. Children with better working memory will have more stable estimates of spectral resolution as the ISI increases than children with poorer working memory, consistent with our hypothesis that spectral resolution in children is influenced by task-dependent cognitive factors. This finding would provide evidence for the relationship between cognitive factors and spectral resolution in children and potentially lead to the development of spectral resolution task that minimize the influence of differences in cognition.

Pitfalls and potential solutions. If manipulation of the ISI does not affect spectral resolution or the relationships between selective attention and working memory are weak, the data would provide evidence that this method of measuring spectral resolution in children is not impacted by differences in cognitive abilities and could provide a tool for future research. Further, pilot testing suggested younger children may adopt a strategy of treating each interval as a present-absent judgement, rather than comparing across intervals. If this occurs, the effect of working memory on spectral resolution will be weak for the long ISI condition, providing evidence for this alternative strategy and the basis for a novel task to measure spectral resolution in children.

Exp 1c: Longitudinal effects of selective attention, working memory, and spectral resolution on speech recognition in noise for CHL.

This experiment uses a longitudinal design to determine the extent to which changes in selective attention, working memory, and spectral resolution affect speech recognition in noise over 24 months. We predict that the development of selective attention and working memory over time will lead to improvements in spectral resolution and speech recognition in noise for CNH and CHL.

Participants. The 80 CHL and 80 CNH who participated in Exp 1a and 1b will participate in Exp 1c.

Methods. Estimates of spectral resolution, selective attention, working memory, and speech recognition from Exps 1a and 1b will serve as a baseline. Measures will be repeated 12 and 24 months post-baseline visit.

Data analyses and expected outcomes. A linear mixed model with baseline selective attention, working memory, and spectral resolution as predictors of speech recognition in noise at will be contrasted with a linear mixed model with only selective attention and working memory as predictors of speech recognition in noise at 12 months and 24 months. Random slopes will be used to allow for different patterns of growth across children over time. We expect that baseline selective attention, working memory, and spectral resolution will predict later speech recognition in noise, but that baseline spectral resolution will not directly predict later speech recognition in noise. This pattern would suggest that changes in selective attention and working memory affect spectral resolution in children over time, providing additional evidence for the influence of cognitive abilities on spectral resolution tasks in children.

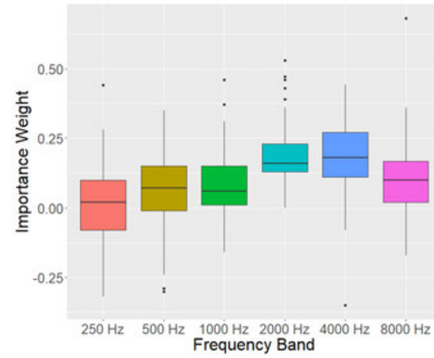

Fig. 4. Individual band-importance weights for consonant-vowel-consonant non-word stimuli for children with normal hearing (n=96).

Pitfalls and potential solutions. First, it is possible that the relationships between cognitive factors and spectral resolution are bidirectional. For example, poor spectral resolution may inhibit the development of speech recognition in noise. Our statistical modelling approach allows us to evaluate this possibility. An alternative outcome where both models are equally predictive would confirm a bidirectional relationship between these factors. Second, hearing thresholds of the CHL may shift over time (McCreery et al. 2015a). Changes in thresholds will affect audibility and may alter spectral resolution. Each child's unaided SII will be included as a co-predictor to account for changes in hearing over time.

Aim 2: Characterize the effects of selective attention and language on perceptual weighting for speech in noise.

Background and rationale. Shifts in selective attention to acoustic cues occur between 4-6 years of age in CNH (Nittrouer, 2006) and CHL (Nittrouer & Lowenstein, 2015). Differences in attention to vowel formant and amplitude cues for a phoneme-recognition task are observed between CNH and CHL and between older and younger CNH. As children develop, their attention to specific acoustic cues shifts from a broadband approach to a frequency-specific approach that reflects the child's use of frequency-specific acoustic cues. Perceptual importance weighting experiments have been used to estimate the relative importance of frequency bands for speech recognition for adults with normal hearing, but have not been used to assess individual weighting strategies for speech recognition in noise for CNH or CHL. Individual band-importance weights could reflect the ways in which listeners selectively attend to and process different frequency bands during speech recognition in noise, but this assumption has not been assessed. Current audibility-based models that form the basis of HA prescriptions assume that band-importance weights are uniform across listeners (SII; ANSI S3.5-1997, R2007). This assumption may hold for adults with normal hearing, but our pilot data show that speech weighting strategies for CNH are variable and that variability is related to age, reflecting a lack of uniformity in importance across listeners for the same stimuli (**Fig. 4**).

Children's perceptual weights are difficult to measure because they require a large number of trials (Mlot, Buss, & Hall, 2010; McCreery & Stelmachowicz, 2011). This has limited our ability to assess individual variability in children's band-importance and answer fundamental questions about the manner in which linguistic context and listeners' cognitive and linguistic skills affect individual band-importance weights. An individual pattern of band-importance that is distributed evenly across frequencies may reflect a lack of selective attention to specific bands that are important for speech recognition, which could lead to greater susceptibility to broadband maskers (Leibold & Buss, 2016). We predict that CNH and CHL with greater band importance in mid-frequencies (similar to adults using linguistic context) will have better speech recognition in noise compared to peers with weights more broadly distributed across frequency. We have developed a method of estimating band importance that can be completed by children in less than 30 minutes. This method will allow us to estimate individual band-importance weights for multiple stimulus types. A longitudinal experiment will allow us to characterize the extent to which individual importance weights shift over time within a child and how growth in language and cognitive abilities affect weighting shifts.

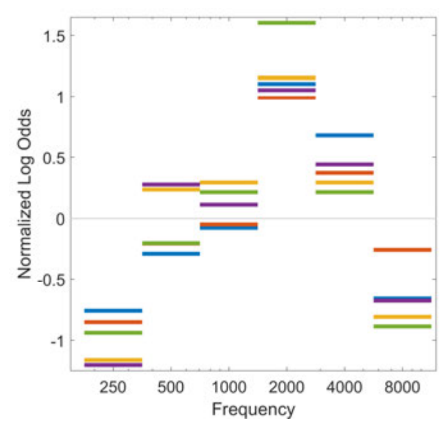

Fig. 5 Individual band-importance weights for five children with normal hearing for phono-tactically balanced monosyllabic words. Each colored line represents a different listener. Green/Yellow bars are 10 year-olds, and Red/Blue/Purple bars are 6-7 year-olds.

Preliminary data. Individual band-importance weights were derived from consonant-vowel-consonant (CVC) non-word recognition data from 96 CNH from a previous study (McCreery & Stelmachowicz, 2011). In **Fig. 4**, the range of individual perceptual weights as a function of frequency are shown. Children with better language ability had larger perceptual weight for 2 kHz (r = 0.41, p < 0.001). This pattern is consistent with reduced reliance on high-frequency acoustic cues for children with better language ability. However, the band-filtering method used in our previous work was difficult for children because it required four hours of data collection per subject. Additionally, the effects of selective attention were likely to have been confounded by the length of the task and age of the subjects. Our novel approach to measuring band-importance for children yields repeatable weights and has been used in studies with adults with cochlear implants (Bosen & Chatterjee, 2016). **Figure 5** shows preliminary data for this approach from five CNH. The ordering of bands at 2 kHz and 4 kHz matches predictions that older children (green and yellow bars) have larger weights at 2 kHz and lower weights at 4 kHz than younger children (red, purple, and blue bars).

Exp 2a: Effects of selective attention on perceptual weights for CNH and ANH for non-words and words.

This experiment will test the hypothesis that CNH with stronger selective attention will have band-importance weights that peak at 2 kHz, reflecting a selective listening approach that is less susceptible to masking. Weighting is predicted to be more evenly distributed across bands for non-words, reflecting the listener's reliance on acoustic cues when lexical cues are minimized. Higher 2 kHz weights are expected to be associated with better speech recognition in noise after controlling for language and working memory abilities.

Participants. Eighty CNH and 25 ANH will be sufficient to model differences in perceptual weights > d = 0.10 and predictors for a three-predictor model with effect sizes > r = 0.30.

Methods. Selective attention and language will be measured for CNH. Weights will be measured under Sennheiser SD-25 headphones in one ear, selected at random. Band importance will be estimated using a method described in Bosen and Chatterjee (2016). Participants will listen to and repeat filtered CVC non-words (McCreery & Stelmachowicz et al. 2011) and CVC words (Klein et al. 2017). Each word will be filtered to include a subset of octave bands with center frequencies ranging from 250 Hz to 8 kHz with cutoff frequencies equally spaced on a log scale. For each word, a combination of these bands will be selected for inclusion, and the rest will be removed. Each participant will start with 40 words that include all 6 bands, to obtain a baseline speech recognition score. Next, they will complete 6 blocks of 50 words each (300 words total), filtered to contain 3 of 6 bands. Choosing 3 out of 6 bands produces 20 possible combinations, so each combination will be used 15 times, with a different word each time. The importance of each band will be estimated with logistic regression. The percentage of words correctly identified will be regressed against the presence or absence of each band in the words (e.g., Doherty & Lutfi, 1995). This estimates the main effect of each band's presence, averaged across its interactions with all other bands, on the odds of the participant correctly identifying words. Each participant's band importance will be normalized to a mean importance of zero by subtracting the mean log odds across all bands from each band. This normalization removes the effect of their performance in the baseline condition, which is likely to differ between CNH and ANH. The normalization does not affect the relative position of bands for individual listeners, which allows us to compare weights across participants. Sentence recognition in noise will be measured using the same approach as Aim 1 experiments.

Data analyses and expected outcomes. Average band importance weights for ANH will be compared to weighting functions for non-words and words from previous studies with adults to validate the weights obtained from the novel method. For CNH, selective attention will be used to predict octave-band importance weights using linear mixed models. Compared to children with poorer scores, children with stronger selective attention will have larger band importance for 1 kHz and 2 kHz bands and lower importance for 4 kHz and 8 kHz bands. Children with larger weights at 1 and 2 kHz will be predicted to have better sentence recognition in noise, reflecting the benefits of selective listening for speech in noise. This pattern of results would support our hypothesis that individual weighting functions of CNH reflect differences in selective attention.

Pitfalls and potential solutions. Although our preliminary data suggest that CNH will be able to complete the task, there is a potential for an attentional confound if children who have more limited selective attention skills are less likely to complete the tasks than peers with stronger selective attention skills. The pattern of missing data from the task and variability within blocks of trials will be associated with selective attention to ensure that the sample is not biased towards inclusion of only children with the strongest selective attention skills.

Exp 2b: Perceptual weights for CHL for non-words and words.

As in CNH, we predict that band importance in CHL will be influenced by selective attention after controlling for differences in language. Band importance in CHL will also be affected by the audibility of specific frequency bands. This experiment will test the hypothesis that CHL with stronger selective attention will have importance weights similar to CNH for the same stimulus type. Individual band importance will also be used to predict sentence recognition in noise on a separate task as in Exp 2a.

Participants. Eighty CHL will be sufficient to model differences in perceptual weights > *d* = 0.15 and examine the effects of a three-predictor linear mixed model for band-importance weights.

Methods. Selective attention, working memory, language, and band importance will be measured as in Exp 2a. For CHL, however, band importance weights will be measured in each ear at 65 dB SPL using a hearing-aid simulator (Brennan et al. 2015) that provides hearing-aid signal processing under headphones. This approach allows for precise accounting of the level of the signal in each band, as differences in signal level are known to affect importance weights for speech (Calandruccio, Doherty, & Buss, 2016). Individual band importance will be measured for CVC non-words and CVC words.

Data analyses and expected outcomes. As with CNH, a linear mixed model will be used to assess the effects of selective attention on octave-band importance for CHL. CHL who have better selective attention are predicted to have higher band importance for 1 kHz and 2 kHz bands and at 4 kHz and 8 kHz bands, after controlling for differences in language and working memory. We predict that bands with limited audibility or poor spectral resolution are unlikely to contribute importance to a child's speech perception. We expect that children with symmetrical hearing thresholds will have symmetrical band importance weights between ears. For children with asymmetrical hearing thresholds, we predict that the similarity in band importance between ears will be related to selective attention, working memory and language skills and any remaining variance in importance will be attributable to differences in sensation level or spectral resolution. Based on previous research, we will include the average stimulus level in each band as a predictor of weighting in the model to control for signal level effects across subjects and frequency bands (Calandruccio, Doherty, & Buss, 2016).

Pitfalls and potential solutions. Because CHL will have band importance measured in both ears, data collection will increase compared to Exp 2a. If pilot data indicates that band importance is correlated between ears, the child's better-ear will be used in Exp 2b.

Exp 2c: Longitudinal changes in perceptual weighting functions for CNH and CHL.

Audibility-based models of speech recognition assume that children's perceptual weighting functions are stable over time, even as selective attention improves. However, previous evidence suggests that children's use of frequency-specific acoustic cues changes over time (Nittrouer, 2006). This experiment will test the hypothesis that changes in band importance over time are related to improvements in selective attention.

Participants. Fifty CNH and 80 CHL who participated in either Exp 2a or 2b will allow for us to detect changes in importance weights over time > d = 0.10 using linear mixed models with three predictors.

Methods. Band importance for CVC words, selective attention and language will be measured as in Exp 2a and 2b for CNH and CHL. Measurements will be completed at baseline and then 12 and 24 months after baseline. For CHL, sensation level and aided audibility also will be measured.

Data analyses and expected outcomes. A linear mixed model with selective attention as a predictor of change in band importance will be completed for CNH. We predict that CNH who have growth in selective attention will experience shifts in band importance from 4 kHz or 8 kHz bands to 1 kHz or 2 kHz bands over time, reflecting improvements in selective listening in noise, after controlling for language abilities. For CHL, a linear mixed model with selective attention, sensation level, and aided audibility will be used to predict band importance over time. CHL with growth in selective attention will have shifts in band importance similar to the shifts observed in CNH. CHL with positive changes in aided sensation level will have positive shifts in band importance, suggesting that audibility contributes to individual band importance in CHL.

Pitfalls and potential solutions. Band weights may be stable over time, contradicting our expected outcomes. If weights in children are stable over time, it would support the current practice of using uniform band importance functions to model speech recognition for children regardless of their age and eliminate one potential source of variability in audibility-based predictions for speech recognition in noise for CNH and CHL.

Aim 3: Evaluate selective attention as a predictor of speech recognition in speech maskers.

Background and rationale. Children listen and learn in noisy environments (Crukley et al. 2011) that include other people talking (Ambrose et al. 2014). Audibility-based models of speech recognition only reflect the contributions of energetic masking, which occurs when the representations of the target signal and masker overlap in the auditory periphery. However, current models fail to account for the additional degradation in speech recognition that occurs for children when the masker has perceptual similarity to speech or uncertainty, such as the masking produced by competing talkers. Children show greater decrements in performance for maskers with both energetic and informational masking compared to adults (Wightman & Kistler, 2005; Hall et al. 2005; Leibold & Bonino, 2009). Children may not reach adult-levels of speech recognition in noise until adolescence (Corbin et al. 2016). Greater difficulty understanding speech with speech maskers may be related to an inability to selectively attend to the target or to segregate the target signal from the masker. Experiments with off-frequency maskers in children support this prediction (Leibold & Buss, 2016). However, the effects of individual differences in the ability to sustain and direct attention during a speech recognition task in the presence of both energetic and informational maskers have not been studied. The language abilities of the talker and the stimuli are also known to mediate the degree to which speech maskers interfere with speech recognition (Brouwer et al. 2012; Calandruccio et al. 2010). Our preliminary data show that selective attention is important for speech recognition in speech-like maskers. This suggests that children with greater ability to inhibit irrelevant information may have advantages when masking noise is comprised of other people talking. We predict that children with stronger selective attention will be less susceptible to informational masking than peers with poorer skills in these domains. The effects of selective attention on speech recognition in speech maskers may be mediated by language (Botting et al. 2017). However, the relationship between these factors and speech recognition in noise for CNH and CHL has not been explored.

Preliminary data. Sentence recognition in noise was measured for 43 CNH using Pediatric AZBio sentences in a masker comprised of two talkers reading a children's story. Children completed the PEBL Flanker and Switcher tasks as measures of selective attention and inhibition. Both measures were quantified as response times, which were converted to Z-scores for analysis. CNH with longer response times on Flanker and Switcher tasks (indicative of poorer selective attention) had higher SNR50 for the two-talker masker than peers with shorter response times on the Flanker and Switcher tasks (**Fig. 6**).

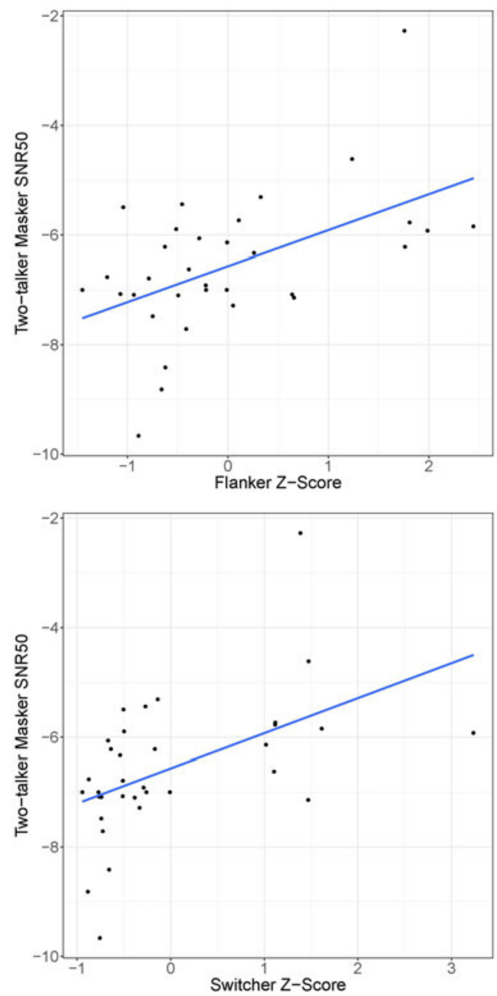

Fig. 6. The signal-to-noise ratio for 50% correct (SNR50) a two-talker masker as a function of the Flanker task (top panel, r = 0.52) and Switcher task (bottom panel; r = 0.51) for 40 CNH.

Exp 3a: The effects of selective attention on informational masking in CNH.

This experiment will test the hypothesis that CNH with better selective attention will have better speech recognition in noise with a two-talker masker than peers with poorer selective attention. Language and working memory will be modelled as mediating variables between selective attention and speech recognition in noise.

Participants. Eighty CNH will allow us to detect effect sizes > r = 0.2 between masking conditions.

Methods. Selective attention and language will be measured for each participant. Sentence recognition in noise will be measured in sound field with the target fixed at 65 dB SPL using the Pediatric AZ-Bio sentences in two masking conditions: unmodulated speech-shaped noise and a two-talker masker. The performance-intensity function for each participant will be estimated using an adaptive procedure with two interleaved tracks. The SNR50 for each masking condition will be estimated based on the average of the final six reversals in each track.

Data analyses and expected outcomes. The effects of selective attention on SNR50 for each masking condition will be assessed with a linear mixed model. The effects of selective attention, language, working memory, and masking condition will be modelled to test the hypothesis that children with stronger selective attention are less susceptible to speech-like maskers than peers with poorer skills in these domains. If selective attention is shown to affect word recognition, after controlling for the effects of cognitive-linguistic skills, our hypothesis that selective attention is necessary for speech-on-speech masking due to the ability to attend to the target and inhibit the masker talker would be supported. If vocabulary and working memory are found to mediate the association between selective attention and sentence recognition, the role of selective attention may be related to speech-on-speech masking through language ability or more general cognitive mechanisms.

Pitfalls and potential solutions. Our experience using adaptive tracking of SNR50 with CNH and CHL can lead to large deviations in the adaptive tracks, increasing test time and decreasing reliability. To minimize this variability, an adaptive procedure targeting SNR for 71% (SNR71) correct may be used instead of SNR50 if our initial results suggest that individual adaptive tracks or estimates of SNR50 are variable within subjects.

Exp 3b: Effects of selective attention on informational masking in CHL.

As in Exp 3a, this experiment will test the relationship between selective attention and speech recognition in noise for speech maskers for CHL. The same mediation analysis as Exp 3a will be included with an additional predictor of aided audibility based on recent data from our lab (Walker et al. in press).

Participants. Eighty CHL will allow us to detect effects > $r = 0.2$ between masking conditions and to use a three-predictor linear mixed model to assess the role of selective attention, language and audibility on SNR50.

Methods. The methods will mirror those used in Exp 3a with the following exceptions. For CHL, testing will be completed with their personal HAs in sound field with the target fixed at 65 dB SPL. Aided audibility for an average speech signal will be measured for each ear.

Data analyses and expected outcomes. A linear mixed model will be used to assess the effects of selective attention, language, working memory, masking condition, and aided audibility on SNR50. The same general pattern of relationship and mediation observed in CNH is expected in CHL. However, a path analysis will be used to assess whether the effect of aided audibility on sentence recognition in noise is direct and/or mediated by language abilities (Tomblin et al. 2015). CHL with higher aided audibility are also expected to have better sentence recognition in noise in both masker conditions.

Pitfalls and potential solutions. The path model may produce results that do not support our hypotheses. Alternative hypotheses include that the effects of selective attention and language are not specific to speech-on-speech masking conditions or that language is the primary predictive factor. In these cases, the experiment will nonetheless provide interesting evidence to update our model of speech recognition in CNH and CHL.

Exp 3c: The longitudinal effects of audibility, selective attention, and language on informational masking in CHL.

Exp 3b will allow us to estimate the association between audibility, selective attention, working memory and language ability on informational masking in CHL concurrently. However, longitudinal data would help to better understand the direction of the relationships between these predictors and sentence recognition in noise over time. Our hypothesis is that children with greater aided audibility at baseline will have increases in selective attention, and language that lead to improvements in sentence recognition over time. The effects of these factors are expected to be larger in the two-talker masker condition.

Participants. Eighty CHL who participated in Exp 3b.

Methods. The methods will be the same as Exp 3b, but measures will be repeated 12 and 24 months after the baseline visit.

Data analyses and expected outcomes. A linear mixed model will be used to quantify the effects of aided audibility, selective attention, and language ability on growth of sentence recognition in noise between baseline and 24 months after baseline. Children with higher aided audibility at baseline are expected to have greater gains in language ability compared to children with poorer aided audibility at baseline. In turn, we expect that children with gains in language will have improved recognition in the two-talker masker compared to baseline SNR50 for the two-talker masker. Older children may reach an asymptote in their ability to use language, so age will also be included in the analyses. Performance in the presence of speech-shaped noise is expected to be predicted by improvements in language. This pattern would support our prediction that selective attention and the ability to suppress irrelevant stimuli are important skills to minimize informational masking.

Pitfalls and potential solutions. Although we have taken care to select measures of selective attention that are valid across the age span of the study, our pilot data suggest that the effects of selective attention may decrease as children approach adolescence. If the same pattern of diminishing effects is observed in this study, alternative measures of selective attention from the PEBL battery will be considered, including having distinct measures of selective attention for younger and older children in the study.

FUTURE DIRECTIONS

The proposed research will generate knowledge across three key areas that will lead to a clearer understanding of the mechanisms that support speech recognition in noise for CNH and CHL. Defining the role of sensory and cognitive factors on spectral resolution in Aim 1 would lead to a clearer understanding of the mechanisms the support the development of spectral resolution. Knowledge about individual differences in band importance weighting for CHL from Aim 2 could lead to the development of individualized HA prescriptions for children based on their individual importance weighting, rather than the generic adult importance weighting used in current pediatric hearing prescriptions. The knowledge generated by experiments in Aim 3 will be useful in developing more targeted and individualized aural rehabilitation strategies for CHL by understanding the specific relationships between audibility, language ability, selective attention, and speech recognition in noise for speech-like maskers. Specific predictors with direct effects on speech recognition in noise would be candidate measures for future studies to develop interventions to improve speech recognition in noise for CHL.

Publications Reported for this Reporting Period

NIH Public Access Compliance	Citation
Complete	Ambrose SE, Walker EA, Unflat-Berry LM, Oleson JJ, Moeller MP. Quantity and Quality of Caregivers' Linguistic Input to 18-Month and 3-Year-Old Children Who Are Hard of Hearing. Ear Hear. 2015 Nov-Dec;36 Suppl 1:48S-59S. doi: 10.1097/AUD.0000000000000209. PubMed PMID: 26731158; PubMed Central PMCID: PMC4703365.
Complete	Brennan M, McCreery R, Kopun J, Lewis D, Alexander J, Stelmachowicz P. Masking Release in Children and Adults With Hearing Loss When Using Amplification. J Speech Lang Hear Res. 2016 Feb;59(1):110-21. doi: 10.1044/2015_JSLHR-H-14-0105. PubMed PMID: 26540194; PubMed Central PMCID: PMC4867924.
Complete	Brennan MA, McCreery RW, Jesteadt W. The influence of hearing-aid compression on forward-masked thresholds for adults with hearing loss. J Acoust Soc Am. 2015 Oct;138(4):2589-97. doi: 10.1121/1.4932028. PubMed PMID: 26520341; PubMed Central PMCID: PMC4627928.
Complete	Brennan MA, Lewis D, McCreery R, Kopun J, Alexander JM. Listening Effort and Speech Recognition with Frequency Compression Amplification for Children and Adults with Hearing Loss. J Am Acad Audiol. 2017 Oct;28(9):823-837. doi: 10.3766/jaaa.16158. PubMed PMID: 28972471; PubMed Central PMCID: PMC5634744.
Complete	Brennan MA, McCreery RW, Buss E, Jesteadt W. The Influence of Hearing Aid Gain on Gap-Detection Thresholds for Children and Adults With Hearing Loss. Ear Hear. 2018 Sep/Oct;39(5):969-979. doi: 10.1097/AUD.0000000000000558. PubMed PMID: 29489468; PubMed Central PMCID: PMC6105512.
PMC Journal In Process	Curran M, Walker EA, Roush P, Spratford M. Using Propensity-Score Matching to Address Clinical Questions: The Impact of Remote-microphone System on Language Outcomes in Children who are Hard of Hearing. Journal of speech, language, and hearing research : JSLHR. Forthcoming.
Complete	Kirby BJ, Browning JM, Brennan MA, Spratford M, McCreery RW. Spectro-temporal modulation detection in children. J Acoust Soc Am. 2015 Nov;138(5):EL465-8. doi: 10.1121/1.4935081. PubMed PMID: 26627815; PubMed Central PMCID: PMC4636496.
Complete	Kirby BJ, Kopun JG, Spratford M, Mollak CM, Brennan MA, McCreery RW. Listener Performance with a Novel Hearing Aid Frequency Lowering Technique. J Am Acad Audiol. 2017 Oct;28(9):810-822. doi: 10.3766/jaaa.16157. PubMed PMID: 28972470; PubMed Central PMCID: PMC5665573.

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Not applicable	McCreery RW, Walker EA. Pediatric Amplification: Enhancing Auditory Access. San Diego: Plural Publishing; 2017.

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Non-compliant **Dr. Walker just approved proofs on 12/12/18, not yet submitted to NIHMS.**	Walker EA, Curran M, Spratford M, Roush P. Remote Microphone Systems for Preschool-Age Children who are Hard of Hearing: Access and Utilization. International journal of audiology. Forthcoming.

PHS Human Subjects and Clinical Trials Information

OMB Number: 0925-0001 and 0925-0002

Expiration Date: 03/31/2020

Are Human Subjects Involved	● Yes	❍ No
Is the Project Exempt from Federal regulations?	❍ Yes	● No

Exemption Number ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8

Other Requested Information

Human Subject Studies

Study#	Study Title	Clinical Trial?
1	Complex listening skils in school-age children who are hard of hearing	No

Section 1 - Basic Information (Study 1)

OMB Number: 0925-0001 and 0925-0002

Expiration Date: 03/31/2020

1.1. Study Title *

Complex listening skils in school-age children who are hard of hearing

1.2. Is this study exempt from Federal Regulations * ❍ Yes ● No

1.3. Exemption Number ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8

1.4. Clinical Trial Questionnaire *

1.4.a. Does the study involve human participants? ● Yes ❍ No

1.4.b. Are the participants prospectively assigned to an intervention? ❍ Yes ● No

1.4.c. Is the study designed to evaluate the effect of the intervention on the participants? ❍ Yes ● No

1.4.d. Is the effect that will be evaluated a health-related biomedical or behavioral outcome? ● Yes ❍ No

1.5. Provide the ClinicalTrials.gov Identifier (e.g. NCT87654321) for this trial, if applicable

Section 2 - Study Population Characteristics (Study 1)

2.1. Conditions or Focus of Study

- Hearing Loss

2.2. Eligibility Criteria

Children and adults with normal hearing and children with permanent hearing loss

2.3. Age Limits	Min Age: 6 Years	Max Age: 40 Years
2.4. Inclusion of Women, Minorities, and Children	2_4_InclusionW_M_C_RWM_R01resbm_12Dec18.pdf	
2.5. Recruitment and Retention Plan	RecruitRetentionPlan_RWM_R01resbm.pdf	
2.6. Recruitment Status	Recruiting	
2.7. Study Timeline	2_7_Study_Timeline_RWM_R01resbm_07dec18.pdf	
2.8. Enrollment of First Subject	01/03/2018	Actual

INCLUSION OF WOMEN, MINORITIES, AND CHILDREN

Inclusion of Women and Minorities:

Inclusion of Women. Subject groups recruited for studies in this proposal will include equal numbers of males and females. Effects related to the sex of the participant are not anticipated, but will be analyzed for each experiment.

Inclusion of Minorities. The number of subjects shown in the Inclusion Enrollment Table reflects the ethnic/racial composition of the subjects enrolled in the current five year funding period who will be eligible to continue through the proposed five-year funding period. The percentages for individuals from minority backgrounds recruited from Nebraska and Iowa are comparable to the national estimates (according to Census information). The percentage of Hispanic populations is higher than national estimates for our area, but because the project subject sample is limited to English speaking homes, this difference will not necessarily be reflected in our recruitment numbers. As of the end of 2017, the racial distribution in the Omaha metropolitan area was 81.3% white, 11.6% Black or African American, 1.2% American Indian/Alaskan Native, 3.3% Asian, 0.1% Native Hawaiian/Pacific Islander, and 2.5% more than one race. The ethnic distribution was 12% Hispanic/Latino and 88% not Hispanic/Latino. The demographics for Des Moines and Iowa City, Iowa catchment areas are comparable to Omaha. Our Human Subjects Database currently has an approximately equal distribution of race and ethnicity compared to that of the Omaha metropolitan area. Income levels and high school graduation percentages are also comparable to the national population estimates.

[redacted] Hospital (BTNRH) has undertaken several initiatives to increase participation in research by individuals from under-represented populations. One successful approach for recruiting minority participants has been involvement in community-based health fairs through partnerships with local organizations. Over the past 3 years, the Coordinator of the BTNRH Human Subjects Core and research staff have participated in 45 events in under-represented communities. During these events, hearing screenings are conducted and community awareness education is provided. Individuals are given an opportunity to enroll in the recruitment database, indicating their willingness to be contacted for research studies. The Coordinator will continue to contact social organizations and churches in predominately Latino, African-American communities, and low-income communities to enlist their support in recruiting participants and/or scheduling community events for the purpose of recruitment. All of these approaches to ensuring and increasing minority participation in research occur on a continuous basis.

Inclusion of Children:

Children are the primary subject population for the proposed studies. Children will ranging in age from 6 to 12 years at enrollment. Children will be recruited from two groups: children with normal hearing and children with hearing loss who wear hearing aids. The inclusion of children is scientifically necessary to address questions about the development of speech recognition in noise.

RECRUITMENT AND RETENTION PLAN

The primary source of participant recruitment at [redacted] Hospital will be from the Human Subjects Core Database. Individuals whose names are listed in the database have previously expressed an interest in participating in research and have given us their written consent to include their names, addresses, phone numbers, email address, and limited clinical information (for example, their pure-tone audiograms) in the database. Children with hearing loss will be recruited from clinics at [redacted] l and the [redacted] Hospitals and Clinics. For experiments including adults with normal hearing, we will also recruit from local college campuses, which include the [redacted] ITT Technical Institute. Study information and online enrollment is also available on our laboratory website.

A summary of the study is provided at the initial recruitment contact for the prospective subject's review. At the initial visit, the investigator will verbally review the consent form with the potential subject and provide an opportunity for questions. Subjects will be enrolled in the study upon signing the consent form. Subjects will be paid hourly for their time and will also receive an additional travel stipend based on distance traveled from their home in order to help cover transportation costs. Hotel accommodations will also be offered for subjects traveling substantial distances and who agree to participate in consecutive days of research in the lab.

For each experiment, participants will be given frequent breaks to avoid fatigue. For experiments that will require multiple visits, participants will be given reminders for upcoming scheduled visits using their preferred contact (phone, email, etc.) to encourage attendance. Our laboratory has experience working with children with hearing loss and their families in our previous research studies. Children and their families may need to come for multiple visits to complete a single experiment. We collect satisfaction questionnaires that can be completed anonymously for all of our research participants. Our retention rate for children and their families in the previous cycle of the grant was over 90%.

STUDY TIMELINE

	Year 1	Year 2	Year 3	Year 4	Year 5
AIM 1					
Exp 1a					
Exp 1b					
Exp 1c					
AIM 2					
Exp 2a					
Exp 2b					
Exp 2c					
AIM 3					
Exp 3a					
Exp 3b					
Exp 3c					
	Data Collection	**Manuscripts**			

Inclusion Enrollment Reports

IER ID#	Enrollment Location Type	Enrollment Location
Study 1, IER 1	Domestic	Boys Town National Research Hospital and University of Iowa

Inclusion Enrollment Report 1

Using an Existing Dataset or Resource* : ❍ Yes ● No

Enrollment Location Type* : ● Domestic ❍ Foreign

Enrollment Country(ies): USA: UNITED STATES

Enrollment Location(s): Boys Town National Research Hospital and University of Iowa

Comments:

Planned

Racial Categories	Ethnic Categories				Total
	Not Hispanic or Latino		Hispanic or Latino		
	Female	Male	Female	Male	
American Indian/ Alaska Native	2	2	0	0	4
Asian	6	5	1	1	13
Native Hawaiian or Other Pacific Islander	0	0	0	0	0
Black or African American	19	19	3	3	44
White	136	132	18	18	304
More than One Race	4	4	1	1	10
Total	167	162	23	23	375

Cumulative (Actual)

Racial Categories	Ethnic Categories									Total
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	0	0	0	0	0	0	0	0	0	0
Asian	7	4	0	0	0	0	0	0	0	11
Native Hawaiian or Other Pacific Islander	0	0	0	0	0	0	0	0	0	0
Black or African American	10	17	0	0	0	0	0	1	0	28
White	278	288	0	7	3	0	2	3	0	581
More than One Race	13	16	0	0	2	0	0	0	0	31
Unknown or Not Reported	1	1	0	1	0	0	2	6	0	11
Total	309	326	0	8	5	0	4	10	0	662

Section 3 - Protection and Monitoring Plans (Study 1)

3.1. Protection of Human Subjects	3_1_ProtectionHumanSubj_RWM_R01resbm_12Dec18.pdf
3.2. Is this a multi-site study that will use the same protocol to conduct non-exempt human subjects research at more than one domestic site?	● Yes ❍ No ❍ N/A
If yes, describe the single IRB plan	SingleIRBPlan_RWM_R01resbm.pdf
3.3. Data and Safety Monitoring Plan	
3.4. Will a Data and Safety Monitoring Board be appointed for this study?	❍ Yes ● No
3.5. Overall structure of the study team	

PROTECTION OF HUMAN SUBJECTS

1. Risks to Subjects. Approximately 150 children with normal hearing and 200 children with hearing loss will participate in this project over the five-year period. The total number of subjects each experiment assumes that most children in both groups will participate in multiple studies during the cycle of the grant with approximately 10% attrition and an additional 20% subject recruitment per year for subjects who age out of the experiments during the grant. Children will be between the ages of 6 and 12 years of age at enrollment. Approximately half of the children will be recruited at BTNRH and the other half at the University of Iowa. Criteria for inclusion of children with normal hearing are: 1) normal hearing, 2) at least one hearing parent using spoken English in the home, 3) no evidence of disabilities. Criteria for inclusion of children with hearing loss in the current study are: 1) mild to severe, bilateral sensorineural hearing loss or permanent conductive hearing loss with better ear pure tone averages ranging from 20-80 dB HL, 2) no evidence or diagnosis of secondary disabilities, 3) at least one hearing parent using spoken English in the home. A group of 25 adults with normal hearing will be recruited for Exp 2a to provide a replication for previous research with adults using novel methods proposed in that experiment. The total testing hours for children and adults at each sampling age are described in the table below. We expect to recruit equal numbers of males and females.

Aim/Experiment	Total Subject Visits	Data Collection Hours	Male/ Female	Adult/Child	Hearing Status
Aim 1, Exp 1a	160	320 (2 hrs/subject)	equal	All children	80 with normal hearing (NH); 80 with hearing loss (HL)
Aim 1, Exp 1b	160	140 (2 hrs/subject)	equal	All children	Same as Exp 1b; separate visit
Aim 1, Exp 1c	80	320 (2 hrs/subject x 2 visits)	equal	All children	80 with HL from Exp 1a/1b
Aim 2, Exp 2a	105	210 (2 hrs/subject)	equal	80 children; 25 adults	NH
Aim 2, Exp 2b	80	240 (3 hrs/subject)	equal	All children	80 with HL
Aim 2, Exp 2c	130	390 (3 hrs/subject)	equal	All children	50 NH 80 with HL
Aim 3, Exp 3a	80	160 (2 hrs/subject)	equal	All children	80 NH
Aim 3, Exp 3b	80	160 (2 hrs/subject)	equal	All children	80 with HL
Aim 3, Exp 3c	80	160 (2 hrs/subject)	equal	All children	Same as Exp 3b
TOTALS:	**955**	**2,100 hours**			

The data to be collected in the proposed studies will be obtained specifically for research purposes, and is behavioral in nature. In the planned experiments, children will be tested using a combination of audiological tests, standardized procedures, interviews and child or parent-report questionnaires. Speech recognition testing will be audio recorded for later analysis. For the children with hearing loss, we also will collect routine clinical information concerning the audiogram, middle ear status, and amplification status, in addition to the measures of speech perception in noise and amplification use. For children using hearing aids, data logging capacities of their instruments will be checked annually as an objective measure of hearing aid use time.

We can foresee only minimal risk associated with these studies. There are no known psychological or physical risks, with the possible exception of discomfort from the small, flexible tube used during probe microphone electroacoustic hearing-aid measures. Adjustments will be made in the positioning of the tubing if discomfort is evident. As with any study involving human subjects, confidentiality of protected health information is crucial. Strict procedures for protecting subject confidentiality are in effect at both participating institutions due to their hospital affiliations. Subjects will not be identified by name in reports or publications. Electronic recordings will be listened to only by research staff and will be stored on password protected network folders accessible only to lab personnel approved by the Institutional Review Board.

2. Adequacy of Protection Against Risks. The Institutional Review Board [redacted] will review all recruitment materials. Individuals participating in current studies at [redacted] the University [redacted] will be asked to participate. At each study visit, subjects will complete the informed consent or assent process and any additional questions will be answered at that time. All subjects will be paid [redacted] for their time.

For all of experiments, auditory signals will be kept well below levels that could be at risk for hearing damage using both software and hardware safeguards. If a subject expresses discomfort during the placement of the soft, flexible tube used during hearing-aid probe microphone measures, the tube will be removed and reinserted. Confidentiality will be maintained by storing subject identifiers and data in password protected computer files accessible to the principle investigator and members of the research staff only. The proposed studies will be submitted to and approved by the Institutional Review Board [redacted] prior to beginning the project and will be subject to institutional annual review requirements.

3. Potential Benefits of the Proposed Research to the Subjects and Others. Parents of all enrolled participants will receive ongoing feedback regarding their children's progress in the study. All child participants will receive audiological, language and cognitive evaluations as part of the proposed experiments. In some cases, the information gathered on children with hearing loss will have relevance to their ongoing clinical and educational programs. With appropriate caregiver permissions, the research data will be shared with the child's clinical/educational teams. The benefit that may accrue to society from the proposed research is a better understanding of how mild to severe hearing loss affects child development and family functioning. The results are expected to support clinical amplification and intervention strategies for the children who participate.

4. Importance of the Knowledge to be Gained. The proposed research will enhance our understanding of the factors that support listening and learning in noise for children with hearing loss through the school-age years. The results will lead to targeted and individualized intervention approaches based on each child's precise needs. The importance of the knowledge to be gained is considerable, and the risks to subjects are minimal. Our longitudinal experiments will maximize the potential of the data set to address questions about the consequences of school-age vulnerabilities for social and academic development related to deficits in speech recognition in noise. These innovative analyses address a major gap in the literature on children with hearing loss by focusing on children who wear hearing aids. Overall, this work is expected to guide interventions promoting academic achievement and speech understanding in noise for children with hearing loss.

SINGLE INSTITUTIONAL REVIEW BOARD PLAN

The Institutional Review Board (IRB) at [redacted] will be recognized as the single IRB of record for the proposed study. The University of Iowa has agreed to recognize [redacted] as the single IRB of record. Although additional participating sites are not anticipated, any additional sites would be required to recognize the BTNRH IRB as the single IRB of record. The [redacted] IRBs are both participants in the Smart IRB consortium, which signifies that institutions have agreed to meet the same federal IRB requirements and regulations and facilitates institutional agreements regarding human subjects research.

The [redacted] University [redacted] have experience collaborating on multi-site projects and coordinating IRB reviews. Communication between the University [redacted] and [redacted] Research Hospital related to the single IRB of record will occur [redacted] at the University [redacted] Both have contacts with institutional officials that can help to facilitate communication between institutions. The University [redacted] has agreed to sign an inter-institutional agreement to recognize [redacted] the single IRB of record. The maintenance of records and communication plan will occur [redacted]

Section 4 - Protocol Synopsis (Study 1)

4.1. Brief Summary

4.2. Study Design

4.2.a. Narrative Study Description

4.2.b. Primary Purpose

4.2.c. Interventions

Type	Name	Description

4.2.d. Study Phase

Is this an NIH-defined Phase III Clinical Trial? ❍ Yes ❍ No

4.2.e. Intervention Model

4.2.f. Masking ❍ Yes ❍ No

❑ Participant ❑ Care Provider ❑ Investigator ❑ Outcomes Assessor

4.2.g. Allocation

4.3. Outcome Measures

Type	Name	Time Frame	Brief Description

4.4. Statistical Design and Power

4.5. Subject Participation Duration

4.6. Will the study use an FDA-regulated intervention? ❍ Yes ❍ No

4.6.a. If yes, describe the availability of Investigational Product (IP) and Investigational New Drug (IND)/ Investigational Device Exemption (IDE) status

4.7. Dissemination Plan

Delayed Onset Studies

Delayed Onset Study#	Study Title	Anticipated Clinical Trial?	Justification
The form does not have any delayed onset studies			

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CONSORTIUM/CONTRACTUAL ARRANGEMENTS

This project will function with consortium arrangements [redacted] The proposed Institutions (FFBH d/b/a BTNRH and UI) understand and agree to the following statement: *The appropriate programmatic and administrative personnel of each organization involved in this grant application are aware of the agency's consortium agreement policy and are prepared to establish the necessary inter-organizational agreement(s) consistent with that policy.*

[redacted] A biographical sketch, letter of support, and consortium justification are appended.

Proposed Budget Period: 07/01/2019 - 06/30/2024

[redacted]

Consortium with the University of Iowa (UIA), Iowa City, Iowa.

[redacted] { X } Domestic { } Foreign

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RESOURCE SHARING PLAN

Data Sharing:

The proposed research will include developmental data from approximately 200 children with mild to severe hearing loss and 150 normal hearing age mates. The final dataset will include behavioral data collected from standardized and experimental measures conducted with the subjects. These data will be made available to the public through the Open Science Framework (osf.io) page for the McCreery laboratory (**https://osf.io/3jpw6/**). For all data sets, the final data will be stripped of identifiers prior to public release for sharing. Thus, we will make the data and associated documentation available to users only under a data-sharing agreement that provides for: (1) a commitment to using the data only for research purposes and not to identify any individual participant; (2) a commitment to securing the data using appropriate computer technology; and (3) a commitment to destroying or returning the data after analyses are completed. Registered users will receive user support and publication lists.

Experimental and Statistical Software and Code Sharing:

The experimental software to be used in the proposed experiments will be made publicly available through the BTNRH GitHub repository (**https://github.com/BoysTownorg**). This will enable other scientists to access the software products of the proposed research and support replication. Similarly, software code for statistical analyses (using the R programming language) also will be made available with each publication of data via the BTNRH GitHub repository to support transparency and replication.