

Application for Federal Education Assistance (ED 424)



U.S. Department of Education

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Applicant Information

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2. Applicant's D-U-N-S Number

6. Novice Applicant [X] Yes [] No

3. Applicant's T-I-N

7. Is the applicant delinquent on any Federal debt? [] Yes [X] No (If "Yes," attach an explanation.)

4. Catalog of Federal Domestic Assistance #: 84.

8. Type of Applicant (Enter appropriate letter in the box.) [] G []

Title:

- A - State B - Local C - Special District D - Indian Tribe E - Individual F - Independent School District G - Public College or University H - Private, Non-profit College or University I - Non-profit Organization J - Private, Profit-Making Organization

5. Project Director: Stephanie Nagle

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9. State Application Identifier

Application Information

10. Type of Submission:

-PreApplication -Application [] Construction [] Non-Construction [X] Non-Construction

13. Are any research activities involving human subjects planned at any time during the proposed project period? [X] Yes (Go to 13a.) [] No (Go to item 14.)

11. Is application subject to review by Executive Order 12372 process? [] Yes (Date made available to the Executive Order 12372 process for review): / / [] No (If "No," check appropriate box below.) [] Program is not covered by E.O. 12372. [] Program has not been selected by State for review.

13a. Are all the research activities proposed designated to be exempt from the regulations? [] Yes (Provide Exemption(s) #): [X] No (Provide Assurance #):

12. Proposed Project Dates: 8 / 31 / 2009 8 / 31 / 2010 Start Date: End Date:

14. Descriptive Title of Applicant's Project: An Investigation of Training-Induced Auditory Plasticity and Behavioral Change in Teenagers with Auditory Processing Deficits

Estimated Funding

15a. Federal \$ 42,658 .00 b. Applicant \$.00 c. State \$.00 d. Local \$.00 e. Other \$.00 f. Program Income \$.00 g. TOTAL \$ 42,658 .00

Authorized Representative Information

16. To the best of my knowledge and belief, all data in this preapplication/application are true and correct. The document has been duly authorized by the governing body of the applicant and the applicant will comply with the attached assurances if the assistance is awarded.

a. Authorized Representative (Please type or print name clearly.) Stephanie Nagle b. Title: Principal Investigator and doctoral student

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e. Signature of Authorized Representative

Date: / /

Project Abstract

Title: An Investigation of Training-Induced Auditory Plasticity and Behavioral Change in Teenagers with Auditory Processing Deficits

Sponsor: University of Connecticut

Principal Investigator: Frank Musiek, PhD., Director of Auditory Research, Communication Sciences, University of Connecticut

Project Coordinator: Stephanie Nagle, BA, Doctoral Student, Communication Sciences, University of Connecticut

Project Description:

For over fifty years, researchers have consistently documented deficits in the processing of sound by the central nervous system. Brain injury, neurodegenerative disease, neuromaturational delay, neuromorphological abnormalities, or age-related changes are some causes of deficits in auditory processing in the central nervous system. Specific populations notably affected by auditory processing deficits include the elderly; individuals with head injury, stroke, and patients with multiple sclerosis; and school age children.

Evolving research on auditory processing has identified common specific deficits in fundamental auditory processes, which are believed to underlie the critical communication issues associated with auditory processing disorders. These communication deficits include difficulty:

- understanding speech in the presence of background noise
- locating a sound source in space
- understanding rapid or accented speech, and
- perceiving changes in intonation that indicate humor or sarcasm.

The above communication issues can lead to academic and work-related difficulties, and can also have social and emotional effects.

Auditory training in some form is often recommended for children who display deficits in central auditory processing. Overall, the goal of auditory training is to enact lasting changes in how the brain is organized. These changes in the brain will manifest behaviorally as improved

auditory processing skills. While neuroscience and animal studies have demonstrated that auditory training **can** lead to changes in the brain organization and improved auditory behavior, few studies have examined this specifically in individuals with central auditory processing disorders. Additionally, recent studies that have examined brain re-organization and auditory processing have largely utilized measures that are not typically used in clinical practice. As a result, findings and recommendations from those studies are difficult to implement clinically.

Expert opinion and research from closely related fields suggest the use of individualized auditory training intervention that addresses each patient's specific auditory deficits. In typical clinical practice as well as the school systems, auditory training for children is often given in the form of a CD-ROM that trains multiple auditory processes, as well as more global cognitive functions. However, no published research exists that compares computer-based auditory training to in-person, formal, deficit-specific auditory training. Thus, the most common auditory training intervention used with school aged children may be considerably less effective than other treatment options. One population of school age children, teenagers between 13-19 years of age, will serve as the sample for this project. Teenagers are the ideal sample because they still have increased capacity for brain reorganization compared to adults, and the auditory structures of the central auditory nervous system typically reach maturity around age 12-13 years.

The proposed research will provide a comparison of the effects of deficit-specific training exercises and more global, computer-based training exercises on auditory processing skills in teenagers. Brain reorganization and changes in auditory processing abilities will be assessed using common clinical measures before and after training. Results from this study will improve treatment recommendations and practices, as well as communication outcomes, for this population.

Project Goals:

- 1). Design a valid and methodologically sound research study to compare the effects of a global, computer-based auditory training program and an in-person, deficit-specific training program on brain reorganization and auditory processing.
- 2). Identify a sample of at least 45 participants from local audiology clinics and offices.
- 3). Collect data and perform auditory training.
- 4). Analyze and evaluate data.
- 5). Disseminate information through a publication, posters, and presentations at national conferences and meetings.

Project Activities:

- 1). Complete a review of the literature on central auditory test measures and training procedures, and collect pilot data to identify optimum study design.
- 2). Identify and recruit subjects through flyers, and contacts with local audiologists and speech pathologists.
- 3). Conduct initial auditory testing, including behavioral measures and electrophysiological measures of auditory processing. Conduct auditory training, using a commercially available CD-ROM training program that is age-appropriate for teenagers, and an in-person, formal training paradigm. Conduct post-training testing, duplicating all the measures used initially.
- 4). Analyze electrophysiological waveforms and results from behavioral tests. Conduct statistical analyses on data. Compare results obtained with previously published results.
- 5). Disseminate results and implications through presentation at national and local meetings, and publication in a scholarly journal.

An Investigation of Training-Induced Auditory Plasticity and Behavioral Change in Teenagers with Auditory Processing Deficits

A. IMPORTANCE

1. The issue to be addressed is of significance.

Central auditory deficits **have** a detrimental and damaging effect on learning for school age children. According to information from the National Institute of Health in 2005 (NIH, 2005), children with auditory processing deficits may exhibit:

Comment [SCN1]: Maybe stronger word

- Poor listening skills;
- Confusion of syllables;
- Problems with vocabulary, reading, and spelling; and
- Difficulty with language comprehension.

All of the above deficits can lead to poor academic performance, grade failure, and the necessity of special education services for these children. Additionally, children with auditory processing deficits typically have considerable difficulty understanding speech in the presence of background noise (Bellis, 2002; Chermak & Musiek, 2007), which is a typical communication setting in both academic and social situations. As a result, children with auditory processing disorders may experience social difficulty in addition to the academic issues listed above. In fact, the National Center for Learning Disabilities notes that inefficient processing of speech or language information can lead to “frustration, low self esteem, and social withdrawal,” (NCLD, 2008).

Although prevalence of central auditory deficits is difficult to ascertain, experts estimate that approximately 7% of school age children may be affected (Chermak & Musiek, 1997; Bamiou, Musiek & Luxon, 2001). Using this estimate, for the State of Connecticut, 36,148

students currently enrolled in public school may have auditory processing disorders (Connecticut State Data Center, 2008), and could benefit from improved treatment procedures. A serious paucity of data exists on treatment for auditory processing deficits, and “additional research is needed to demonstrate the effectiveness and efficacy of central auditory processing disorder treatment approaches...using both auditory and behavioral outcome measures, and electrophysiologic outcome measures,” (2009 Clinical Practice Guidelines on Auditory Processing Disorders, American Academy of Audiology Task Force, in revision, unpublished).

2. The project is based on previous research findings related to the problem or issue.

Past literature has examined the neurophysiology that underlies brain reorganization, and in turn behavioral change, as a result of auditory training (see Chermak, Bellis, & Musiek, 2007 for a review). Key points of this research include:

- Systematic stimulation or training of the auditory system leads to fundamental changes in representation of auditory stimuli in the brain;
- Changes on electrophysiological measures accompany changes in behavior (such as improved performance on a task); and
- Auditory training can lead to improvements on the specifically trained task as well as on related but un-trained tasks.

The above research has positive implications for the ability of audiologists and speech-language pathologists to enact change in brain organization and facilitate remediation of auditory deficits. The application of this research has led to the establishment of recommendations for maximizing effectiveness of auditory training programs, which include:

- Use of varying age- and language-appropriate tasks
- Presentation of tasks in a systematic manner such that difficulty progresses over time

- Careful monitoring and feedback regarding patient progress; and
- Intensive practice of tasks over a number of training sessions, for at least ½ hour per session.

These principles have been incorporated in the deficit-specific temporal training program designed for this project (see **Appendix C**). Additionally, the second form of auditory training used in this study, the computer-based Earobics program (**Appendix D**), has the first three principles built into its design, and will be administered in this project in an intensive manner, over the same number of sessions as the first auditory training program (see **Appendix C** for a copy of the training schedule).

Multiple studies have shown electrophysiological measures to be valid outcome measures for tracking training-induced changes in the brain in the auditory processing deficit population (Jirsa, 2008; Kraus, et al., 1995). Behavioral tests that assess central auditory function have also been shown to reflect training-induced changes (see Bellis, Chermak & Musiek, 2007 for a review) and may provide an indication of skill generalization and real-world benefit associated with the training. In addition, a recent article (Chermak, 2002) indicated that the behavioral and electrophysiological tests used in this study are among the most common used clinically to diagnose deficits of auditory processing. This finding is noteworthy because of the many studies that utilize measures, especially electrophysiological measures, which are not typically used in clinical settings and so have little clinical relevance.

3. A significant number of individuals will benefit from the results of this project.

Using the 7% prevalence mentioned previously, almost 4 million school-age children in America may be affected by deficits in auditory processing. Of that group, just over 1 million students are teenagers (aged 13 - 19), the population that will be examined in this study (enrollment data from National Center for Education Statistics, 2008). Moreover, professionals

with direct involvement in auditory processing deficits will benefit from efficacy data on specific treatments. These professionals include approximately one thousand audiologists involved in diagnosis and treatment of auditory processing disorders in teenagers and any speech language pathologists who treat teenagers with auditory processing deficits.

Additionally, treatment that successfully remediates the auditory deficit benefits school systems and taxpayers monetarily. If treatment is provided that corrects the deficit and brings auditory skills into the normal range, special education services and assistive technology may no longer be required by the student. As an example, a wireless FM system, which is a device frequently used in classrooms by students with auditory processing deficits in order to reduce background noise, typically costs over \$1000 per student.

Families of teenagers with auditory processing disorders may benefit as well. Family members of children with improvements in auditory processing will experience concurrent improvements in ease of communication and ability to successfully communicate with their child. Also, the teenagers enrolled in the study will directly benefit from the therapy they receive in this project.

4. The project addresses the issue in an adequate manner

Auditory training in some form is often recommended for children who display deficits in central auditory processing. Overall, the goal of auditory training is to enact lasting changes in how the brain is organized. These changes in the brain will manifest behaviorally as improved auditory processing skills. However, treatment efficacy data for auditory processing deficits is scarce in comparison to diagnostic test sensitivity data. While some treatment data on individual auditory training therapies and computer based training are available, most populations studied include a heterogenous sample (e.g., children with varied learning disabilities, dyslexic children)

that does not focus specifically on children with auditory processing deficits. As a result, audiologists and other professionals may be unable to make appropriate and effective treatment decisions that are based on research findings. Selecting outcome measures that are commonly used by professionals who diagnose auditory processing deficits makes research-based efficacy data highly relevant to clinical populations. In addition, training procedures can then be implemented and progress monitored with tools already available. This project will:

- Obtain data pre- and post-training in order to measure training induced changes in auditory processing;
 - Utilize electrophysiologic measures to obtain information about initial brain organization, as well as any training-induced changes in brain organization that may occur;
 - Use behavioral measures to measure initial skill levels in different areas of auditory processing, and to measure difficulties understanding speech in a noisy background;
- Compare two auditory training techniques in order to determine efficacy for each;and
- Use auditory processing measures used commonly in clinical settings so that results will have high clinical applicability.

B. IMPACT

1). The project will make significant contributions to our current knowledge of the topic.

Although some previous studies have shown both computer-based programs as well as deficit-specific interventions to have a positive effect when compared to control groups that received no treatment at all (see Thibodeau, 2007, for a review), no previous literature has been published to compare the two treatments to each other. Additionally, multiple panels of experts

(American Academy of Audiology Task Force, 2008; ASHA Working Group, 2005) have noted that research is “needed in the area of treatment efficacy to enhance the selection of deficit-specific remediation approaches and to guide recommendations,” (ASHA Working Group, 2005). Also, as the field of communication disorders seeks to integrate the model of evidence-based practice, research findings that translate easily and directly into clinical practice have considerable value.

Teri Bellis, Chair of the Department of Communication Disorders at the University of South Dakota and author of *Assessment and management of central auditory processing disorders in the educational setting: From science to practice*, notes that, “this study will provide much needed evidence of treatment efficacy in the area of auditory processing, an area which has been sadly neglected. To date, treatment recommendations have largely been based on expert opinion, case studies, and retrospective data description, and that must change,” (see **Appendix E** for letter of support).

Findings from this study may also have implications for neurophysiology. Although past literature has identified theoretical principles for auditory training schedules based on neurophysiology, specific data detailing required length of training in order to enact change within the brain is not available. If results from this project can clearly delineate changes in brain organization and behavior within the time frame established for the training program, information may be extrapolated about the time course of neurophysiological change of the auditory system.

In short, this study will:

- Provide much-needed efficacy data on multiple training techniques for auditory processing deficits;

- Compare results of two training techniques to each other in order to determine if one is superior;
- Guide future clinical recommendations for remediation of auditory processing deficits; and
- Contribute to the field of auditory neurophysiology by providing information about the time course necessary for training to enact changes in brain organization.

2). *Appropriateness of methods used for dissemination of project findings to target audiences*

At the conclusion of the project, the dissertation will be written and defended to faculty who are current researchers in the fields of speech-language pathology and audiology. Findings will also be presented at annual meetings of the American Academy of Audiology, which had an attendance of approximately 7,500 audiologists in 2008, and the American Speech-Language Hearing Association, which had an attendance of over 13,000 speech language pathologists and audiologists in 2007. The project will be written up for publication and submitted to national refereed journals (see **Table 1** for specific journals). Findings will be posted on the website of the Educational Audiology Association, in order to reach audiologists who specifically work with school-age children.

Further, findings will be disseminated on the Internet via the website www.neuroaudiology.com, which is owned and operated by the laboratory where the project will be conducted. Additionally, results will be disseminated via email to all members of the Pathways group, a group founded by Dr. Frank Musiek to share information and interest in the area of auditory processing disorders. The Pathways email list has approximately 1000 members. Findings will also be shared at the meetings of the Pathways group, which convenes twice a year, at the two national conferences mentioned above.

Project Goals and Objectives	Activities	Timeline	Personnel
<p>1. Design and implement a valid and methodologically sound research study to compare the effects of two different interventions on brain reorganization and auditory processing.</p> <p>a) Identify what is known about effects of treatments on brain reorganization and auditory processing.</p> <p>b) Develop initial methodology and research questions.</p> <p>c) Perform pilot work.</p> <p>d) Revise methodology and research questions.</p> <p>e) Obtain permission to conduct study.</p>	<ul style="list-style-type: none"> ▪ Review literature on types of auditory training, auditory training efficacy, brain reorganization, auditory processing. ▪ Integrate research on auditory training, and measures of brain reorganization and auditory processing to develop research questions. ▪ Assess efficiency and validity of available outcome measures. Select outcome measures supported by research-based evidence. ▪ Solicit feedback from advisors, committee, and experts in auditory processing. ▪ Evaluate length of testing and training paradigms, feasibility of paradigm, validity of research questions, and ability of outcome measures to answer research questions. ▪ Review pilot data and experience running pilot participants to revise methodology and research questions. ▪ Write research prospectus and seek approval from advisor and committee. ▪ Request IRB approval if experiment is not already covered under an existing IRB. 	<p>Pre-grant</p> <p>Pre-grant</p> <p>Pre-grant</p> <p>Pre-grant</p> <p>Pre-grant</p>	<p>Nagle</p> <p>Nagle</p> <p>Nagle</p> <p>Nagle</p> <p>Nagle</p>

Project Goals and Objectives	Activities	Timeline	Personnel
<p>2. Identify a sample of participants from local audiology clinics and offices.</p> <p>a) Identify and recruit eligible teenage participants with auditory processing deficits.</p>	<ul style="list-style-type: none"> ▪ Communicate with local audiology clinics and practitioners that diagnose auditory processing disorders in teenagers. Disclose eligibility criteria and request permission from these facilities to contact eligible parents and teenagers through postal mail, email, or telephone. ▪ Contact teenagers and parents with information about the study, including possible benefits as well as time commitment required. ▪ Recruit sample of at least 15 for each treatment group (global computer-based, formal deficit-specific, and control) 	Fall '09	Nagle
<p>3. Collect data and conduct auditory training.</p> <p>a) Collect pre-training behavioral and electrophysiological data.</p> <p>b) Conduct auditory training intervention to experimental groups.</p>	<ul style="list-style-type: none"> ▪ Identify parameters and protocols to be used for test sessions. ▪ Administer behavioral test battery, randomizing test order and maintaining vigilance for fatigue, boredom or inattention of subject. ▪ Perform electrophysiological measure. ▪ Code data in accordance with confidentiality requirements. ▪ Randomly assign participants to experimental training groups. ▪ Identify possible game-playing reward system for formal training tasks to maintain motivation of participant. ▪ Use formal temporal training tasks and techniques to train experimental group 1. Use commercially available computer-based CD-ROM to train group 2. Use academic learning CD-ROM to train the control group. Train all groups on same training schedule (see Appendix C). 	<p>Fall '09- Spring '10</p> <p>Fall '09- Spring '10</p>	<p>Nagle</p> <p>Nagle</p>

Project Goals and Objectives	Activities	Timeline	Personnel
c) Collect post-training behavioral and electrophysiological data	<ul style="list-style-type: none"> ▪ Re-administer behavioral test battery, randomizing test order and maintaining vigilance for fatigue, boredom or inattention of subject. Perform electrophysiological measure again. ▪ Code data in accordance with confidentiality requirements. 	Fall '09- Spring '10	Nagle
4. Analyze and evaluate data.			
a) Score behavioral tests.	<ul style="list-style-type: none"> ▪ Score tests in accordance with published guidelines and established clinical practice. 	Summer '10	Nagle
b) Analyze electrophysiological data.	<ul style="list-style-type: none"> ▪ Mark peaks on electrophysiological waveforms. Record amplitude and latency measurements ▪ Submit waveforms to jury of at least 2 other scientists familiar with electrophysiological procedures for verification of peak-picking. 	Summer '10	Nagle, Electrophys. Scientists
c) Perform statistical analyses of data.	<ul style="list-style-type: none"> ▪ Use statistical software package to perform quantitative analyses of data, focusing on group differences between pre- and post- test measures. 	Summer '10	Nagle
d) Evaluate relationship of current data to previous literature.	<ul style="list-style-type: none"> ▪ Integrate findings from current data with results in previously published literature. Hypothesize about possible explanations of current findings. 	Summer '10	Nagle
5. Disseminate information through a publication, posters, and presentations at national conferences and meetings.			
a) Write dissertation.	<ul style="list-style-type: none"> ▪ Write dissertation in accordance with University of Connecticut guidelines. 	Fall '09 – Summer '10	Nagle
b) Defend dissertation.	<ul style="list-style-type: none"> ▪ Present and defend findings to advisory committee. 	Fall '10 (Post-grant)	Nagle, Musiek, Advisory Committee

Project Goals and Objectives	Activities	Timeline	Personnel
c) Disseminate findings.	<ul style="list-style-type: none"> ▪ Share results of study with audiologists involved in auditory processing nationwide via Pathways email list. ▪ Submit to peer-reviewed professional journals in audiology for publication, such as International Journal of Audiology, Journal of the American Academy of Audiology, Journal of the Acoustical Society of America, Journal of Speech, Language, and Hearing Research. ▪ Submit findings to local and national conferences, such as American Academy of Audiology (AAA), American Speech, Hearing and Language Association (ASHA), and American Auditory Society (AAS). 	Fall '10 (Post-grant)	Nagle

3). *The findings of the project are replicable.*

Table 1 sequences each goal, objective, and activity necessary to replicate this project. Additionally, more specific details about goals, objectives and activities can be found in the narrative of the Technical Soundness section. Details of the deficit-specific auditory training plan can be found in **Appendix C**, and information about the commercially available computer program Earobics can be found in **Appendix D**. Additionally, the email address of the project coordinator will be listed with any dissemination of the findings, which will allow for resolution of any questions about methodology. Researchers and clinicians alike will have sufficient information to easily replicate this project.

C. TECHNICAL SOUNDNESS

1). *The design of the project is high quality.*

Table 1 delineates the goals and objectives, activities, timeline, and personnel involved in the project in detail. Additional information included in this section will expand on information presented in **Table 1**.

The following main elements of the project are expanded upon in detail below:

- Design of the study
- Identification and selection of the sample
- Data collection
- Auditory training programs
- Analysis of data

Design of the study

A randomized experimental design will be used in this study to answer the question, **“Can global, as well as deficit-based, auditory training programs induce changes in brain**

organization, and subsequently, behavior; and is the global auditory training program as effective as the deficit-specific program?" The study will utilize both between group (Treatment group) and within group (Pre/Post scores) factors to answer this question. Treatment groups and dependent variables will be discussed in subsequent sections.

Identification and selection of the sample

Teenagers will be the population of interest for this project. Teenagers are the ideal population for this study because:

- Younger brains have an increased capacity to change and reorganize;
- The electrophysiological measure used does not reach full maturity until age 12; and
- Teenagers stand to benefit significantly in both social and academic situations from resolution of communication difficulties resulting from deficits in auditory processing.

Participants will be identified from local audiology clinics, including CREC-Soundbridge, a non-profit, state-funded facility that provides audiological services to approximately 1/3 of towns and school districts in Connecticut. CREC-Soundbridge (alone) follows approximately 175 school age children with central auditory processing disorders, the majority of whom are teenagers (see **Appendix E** for letter of support from CREC-Soundbridge director). Eligible teenagers and their parents will be recruited with permission of the referring facility and/or clinician. Teenagers will be considered eligible if they have normal peripheral hearing, a diagnosis of auditory processing disorder, and their treatment history excludes the treatments used in this study. A final sample of at least 45 will be selected from the initial subject pool, and then randomly assigned to one of three treatment groups (see auditory training section below for further detail on groups).

Auditory training programs

Three training programs will be used for the project. The first is a commercially available global, computer-based auditory training program, *Earobics*® (1997) which targets multiple auditory deficits using a variety of speech and non-speech stimuli (see **Appendix D**).

The second training program was developed by project personnel for this project based upon expert recommendations for maximum effectiveness of auditory training. It was specifically developed to remediate deficits in temporal auditory processing, and details for that training program can be found in **Appendix C**.

The third training program will be *Basic English Fitness* (2005), a commercially available, computer based program for teaching language arts skills (see **Appendix F**). As any intensive training program may increase ability to attend and focus, this non-auditory training program will be used as a control program. The inclusion of a control program was considered important as well as it was considered unethical to omit or delay all treatment in 1/3 of the study sample. Children with auditory deficits often have concurrent deficits in spelling and language arts therefore this training program will provide an intervention unrelated to the study outcomes of interest (Chermak & Musiek, 1997; Bellis, 2003).

The training schedule will be consistent across groups, and will involve 45 minute training sessions which occur 3 times per week, for 6 consecutive weeks; this schedule is used in order to assure adequate intensity of training (see **Appendix C** for details of the training schedule).

Data collection

Data will be collected from each subject before and after training. Dependent variables of the study for which data will be collected include:

- Amplitude and latency of the auditory middle latency response (MLR), an electrophysiological measure; and
- Scores from behavioral tests of auditory processing:
 - Frequency patterns
 - Competing sentences
 - Gaps-in-Noise test
 - Dichotic Digits
 - Speech in noise tests.

Additional data regarding past history of treatment, age at diagnosis, assistive listening technology, and subjective complaints will be collected as well. Additional information on the instruments is available in Appendix H.

Analysis of data

Data will be analyzed using SPSS. Repeated measure ANOVAs will be used, with treatment group as the between subjects factor, and pre/post scores as the within subjects factor. Post-hoc tests will determine which treatment, if any, was more effective for each outcome measure. MANOVAs will also be used to determine if there is a main effect of treatment on all outcome measures, on outcome measures that specifically assess temporal processing, or on behavioral compared to electrophysiological outcome measures.

2). *The project ensures that the participants of the project will not be discriminated against based on race, color, nationality, gender, age, handicapping condition.*

CREC-Soundbridge, the main facility where participants will be recruited, provides services solely to children with auditory disabilities, including hearing loss and auditory processing deficits. Soundbridge is partially funded by the State of Connecticut, and its services

Comment [SCN2]: I think I would start with the place you are using and how your recruitment strategy will ensure diversity...what is typical makeup of the facility etc. Can you state what % of their current population is minority maybe- or at least for this class make that up?- will you try to recruit equal numbers of males and females- even though most kids with issues are male- so will you oversample females to make up for it?

are contracted through varied towns and school districts, including both urban and rural settings. As a result, Soundbridge is able to provide services to all eligible children regardless of race, national origin, gender, or ability to pay.

All project personnel are members of the American Academy of Audiology (AAA), and as such are bound by the Academy's Code of Ethics, which states, audiologists "shall not discriminate in the provision of services to individuals on the basis of sex, race, religion, national origin, sexual orientation, or general health," (AAA Code of Ethics, available at <http://www.audiology.org/publications/documents/ethics/>).

Participants of this study will be limited to teenagers. Teenagers are the ideal population for this study because: younger brains have an increased capacity to change and reorganize; and the electrophysiological measure used does not reach full maturity until age 12. Males and females will be equally represented in the sample, and every effort will be made to recruit an ethnically diverse sample.

3). The methods and procedures used to implement the design, including instrumentation and data analysis are sound.

The methods and procedures used to implement the design are listed in **Table 1**. All methods, procedures, instrumentation, and data analysis are based on current literature, published clinical guidelines, expert opinion, previously published research, and professional standards and practices. All methods and procedures will be reviewed by the advisory committee before implementation, and their guidance will continue throughout execution of the study to assure soundness of methodology.

4). The anticipated outcomes are reasonable.

Comment [SCN3]: Repeat of information you've already presented?

Auditory training has been shown to be an effective method of enacting changes in auditory behavior (Tremblay, Kraus, Carrell & McGee, 1997; Musiek, Baran & Shinn, 2004; Kraus et al, 1995; Tallal et al., 1996; Hayes et al., 2003; Russo et al., 2005). These changes are thought to be due to underlying neural changes in brain organization (Chermak, Bellis & Musiek, 2007). The measures used in this study are effective tools for measuring these changes. In addition, previous studies (Kraus, 2002; Tremblay & Kraus, 2002) have shown that auditory training administered over as short a period as one week can result in behavioral and neural change. Outcomes of this study are expected to:

- provide information about neural and behavioral change that occurs as a result of different types of auditory training interventions
- provide information about advantages of global versus deficit-specific auditory training programs.

D. PLAN OF OPERATION (2.5)

1). The management will ensure proper and efficient administration of the project.

Please see **Table 1** and the above ‘Technical Soundness’ narrative section for details on timeline, personnel, and activities of the project. The advisory committee and all members of the project team will meet monthly to evaluate progress of the project.

2). The goals and objectives of the project are clearly stated.

Refer to **Table 1** for statement of project goals and objectives.

3). The quality of the activities proposed to accomplish the goals and objectives are sound.

The proposed activities for this project are detailed in **Table 1**, the ‘Technical Soundness’ narrative, and appendices. The data collection, auditory training, and analysis activities are

sound, and will provide two different types of data, electrophysiological and behavioral, to support the same outcomes.

4). The proposed timeliness for accomplishing those activities are adequate.

See **Table 1** for project timelines. The one year design for this project is adequate for careful and appropriate execution of the proposed activities. Literature review, approval from the Institutional Review Board, pilot work, and revision of methodology will all be carried out prior to the start of the grant in order to increase time dedicated to the activities of data collection and auditory training.

5). The plans to use the resources and personnel to accomplish the goals and objectives are effective.

The project coordinator, Stephanie Nagle, will undertake design and implementation of the project as her dissertation study (see **Table 1** for goals, objectives, and activities). As such, this project will be the focus of her full time study over the period of one year. The principal investigator and advisory committee will oversee the project and provide guidance and consultation as needed. See **Appendix B** and the 'Personnel' section of the narrative for further documentation of the expertise of the committee.

One state-funded audiological facility that serves exclusively school-aged children, CREC-Soundbridge has already committed to participation in this study (see **Appendix E** for letter of support). With the commitment of this facility, and anticipated participation from additional facilities and audiologists, access to an appropriate number of participants (at least 45) is expected. Half of the expenses to travel to and from the laboratory for testing and training (average distance = approximately 20 miles) will be reimbursed for parents, and a \$30 bookstore gift certificate will be provided to each teenager who successfully completes a training program.

E. EVALUATION (1.25)

1. The methods of evaluation are appropriate and produce objective and quantifiable data.

See **Table 2** for evaluation plan and methods.

Table 2.

<u>Project Goals</u>	<u>Project Implementation</u>	<u>Evaluation Criteria</u>	<u>Personnel & Timeline</u>
1. Design and implement a valid and methodologically sound research study to compare the effects of two different interventions on brain reorganization and auditory processing.	<ul style="list-style-type: none"> • Literature Review conducted. • Pilot study developed and completed. • Revision of methodology based on pilot work and committee feedback. • Dissertation proposal written. • IRB paperwork submitted. 	<ul style="list-style-type: none"> • Literature review completed. • Pilot data obtained and analyzed. • Final methodology presented to committee. • Dissertation proposal approved. • IRB approval obtained. 	Pre-grant (Nagle) Pre-grant (Nagle, advisory committee) Pre-grant (Nagle)
2. Identify a sample of participants from local audiology clinics and offices.	<ul style="list-style-type: none"> • Identify and approach local facilities. • Recruit at least 45 participants. 	<ul style="list-style-type: none"> • Permission for recruiting obtained from facilities. • Consent and assent obtained from all participants and/or parents. 	Fall '09 (Nagle)
3. Collect data and conduct auditory training.	<ul style="list-style-type: none"> • Collect data pre-training for all groups. • Implement training programs. • Collect data post-training for all groups. 	<ul style="list-style-type: none"> • Completion of all pre-tests by all participants. • Completion of training program by at least 45 participants. • Completion of all post-tests by all remaining participants. 	Fall '09 - Spring '10 (Nagle)
4. Analyze and evaluate data.	<ul style="list-style-type: none"> • Score all tests and input data into SPSS. • Review analyses. 	<ul style="list-style-type: none"> • Data analyzed using repeated-measures methods. • Changes in dependent variables documented. 	Summer '10 (Nagle)
5. Disseminate information through a publication, posters, and presentations at national	<ul style="list-style-type: none"> • Dissertation written. 	<ul style="list-style-type: none"> • Dissertation defended successfully. • Link is functional and 	Post grant

conferences and meetings.	<ul style="list-style-type: none"> • Results posted on lab website. • Article written for professional journals. • Conference proposals submitted. 	<p>information easily accessible on the site.</p> <ul style="list-style-type: none"> • Article submitted. • Proposals accepted. 	
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F. QUALITY OF KEY PERSONNEL (2.5)

Vitae of project personnel are included in **Appendix B**.

1. The project director is qualified.

Frank Musiek, Ph.D, Prinicpal Investigator: Dr. Musiek is a full professor and Director of Auditory Research at UConn. He has additional appointments as a Professor of Otolaryngology at the UConn Medical School, and as a Professor of Neurology at Dartmouth Medical School as well. His primary areas of research are neurophysiology of the auditory system, electrophysiology, and central auditory processing. He has over 300 major scientific presentations and 230 invited lectures and seminars, nationally and internationally. His publications include 140 refereed journal articles, 40 book chapters, and 8 books, 2 of which have won national awards. Recent honors include the Erskine Fellowship from the University of Canterbury in New Zealand, and the James Jerger Research Award, bestowed by the American Academy of Audiology for outstanding research contribution to the field of audiology.

Dr. Musiek has developed four of the most commonly used tests in central auditory assessment. He has previously served on multiple grants investigating central auditory processing in varied populations, including children who stutter and children with learning disabilities. He has recently developed an auditory training technique for use with children who have dichotic processing difficulties. Data is being collected on this technique at multiple audiology facilities across the country. Dr. Musiek has previously supervised 15 doctoral and post-doctoral students and 28 research fellows, and has been a recipient of over 20 internal and

external grants. Dr. Musiek is more than qualified to serve as Principal Investigator of this project.

2. The other key project personnel are qualified.

Stephanie Nagle, Project Coordinator: Stephanie is a dual degree student at UConn; she is seeking both a PhD in Hearing Science as well a clinical AuD. She has worked in the Neuroaudiology Laboratory at UConn under the direction of Dr. Musiek for over 4 years. Her research interests include: electrophysiology, anatomy and physiology of the auditory system, educational audiology, and central auditory processing. She has made 8 presentations at major national conferences, and won 2 national travel awards for submitted research proposals. She has also served as a consultant for Creare, Inc., a research and development company that is piloting new computer-based central auditory processing equipment for NASA and other agencies.

Stephanie has worked extensively with school aged children with auditory deficits at CREC-Soundbridge in Wethersfield, CT, as well as at Children's Hospital Boston. Her coursework and experience in statistics, central auditory processing disorders, and pediatric audiology qualify her for the role of project coordinator of this project.

Jane Baran, PhD, Advisor: Dr. Baran is a full professor and Chair of the Department of Communication Disorders at University of Massachusetts at Amherst. Her primary research interests include electrophysiology, anatomy and physiology of the central auditory nervous system, and central auditory processing. She has published over 25 peer-reviewed articles, and has presented at over 60 national and international scientific conventions. She is currently serving on a national panel for the Veterans Administration that is tasked with assessing central auditory deficits in veterans returning from active duty. Additionally, she is dually certified in

audiology as well as speech-language pathology, which will enable her to advise on both auditory and speech/language elements of the project.

Kathleen Cienkowski, PhD, Advisor: Dr. Cienkowski is an assistant professor at the University of Connecticut. Her specific research interests include auditory rehabilitation, auditory training, and assistive listening devices and amplification. She has published 10 refereed journal articles, and has made over 20 presentations at national conventions. Dr. Cienkowski will advise on issues related to the auditory training and rehabilitation aspect of the project.

3. The time commitment of personnel is reasonable.

The Project Coordinator will contribute the most time to this study, as it is her dissertation project. She will dedicate 20 hours per week to this project, for one full calendar year. The Principal Investigator will contribute .025 FTE to this project, and other advisors (Baran and Cienkowski) will contribute .015 FTE to the project. This will provide adequate time for the Project Coordinator, Principal Investigator and Advisors to meet bi-monthly to discuss project progress and give ongoing feedback.

4. The selection of personnel will be conducted without regard to race, color, national origin, gender, age, or handicapping condition.

The University of Connecticut deeply values diversity in the learning environment, and is committed “to achieving the full participation of people who differ by age, color, ethnicity, gender, national origin, race, religion, and sexual orientation, disability status, and socio-economic background (UConn DiversityWeb).” Currently, 16.1% of full time faculty at the University of Connecticut belong to ethnic or racial minorities, and 30% of full time faculty are women. Additionally, three out of four key personnel members of the current project are women, a population that has been traditionally underrepresented in academia. Further, all personnel

involved in this project have made it their life's work to provide service to individuals with auditory disabilities, an additional testament to the commitment of this project and personnel to equal service and equal access.

G. ADEQUACY OF RESOURCES

1. The resources allocated to the project are adequate.

This project will build on both the superior reputation of the audiology program at the University of Connecticut and the internationally renowned research of Dr. Frank Musiek and his Neuroaudiology Laboratory. The graduate program in audiology at the University of Connecticut has consistently been rated highest in New England by U.S. News and World Report. Both clinical and research training are combined throughout UConn's audiology program in order to produce well-rounded and knowledgeable clinicians and researchers.

The Neuroaudiology Laboratory at UConn was founded by Dr. Frank Musiek in 2002, and its mission statement asserts: "Our quest for knowledge concerning the central auditory system is driven by three main activities: clinical service, research activity, and education," (UConn Neuroaudiology Laboratory website). These tenets are illustrated by:

- The partnership between the Neuroaudiology Lab and the UConn Speech and Hearing Clinic, wherein lab members assist clinical audiologists with electrophysiological and behavioral assessment of complex cases of auditory processing deficiencies;
- The research output of the Neuroaudiology Lab over the past 5 years, which includes 81 invited lectures or major scientific paper presentations, as well as 23 peer-reviewed journal articles; and

- The Lectures in Auditory Disorder and Sciences seminar series, monthly student-led clinical Grand Rounds seminars, and summer symposia in auditory processing, all programs founded by Dr. Musiek.

Additionally, the support of CREC-Soundbridge, a state-funded facility that exclusively diagnoses and treats children and teenagers with hearing loss and auditory processing issues, assures access to teenagers with auditory processing disorders (see letter of support, **Appendix E**). As Soundbridge supports approximately 175 school-aged children with auditory processing issues, and other local audiology facilities are expected to participate in subject recruitment, a sample of at least 45 teenagers with auditory processing deficits can be feasibly obtained for the project.

2. The facilities, equipment, and supplies to be used for the project are adequate.

Facilities at the Neuroaudiology Laboratory include a double-walled IAC sound treated booth, a GSI 61 audiometer, CD player and all commercially available behavioral testing materials. Multiple state-of-the-art electrophysiological averagers will be available for electrophysiological assessment and analysis. A laptop will be made available for administering and tracking the computer based training software programs. Multiple sound editing programs (Audacity, Cool Edit Pro) will be utilized for the generation and modification of training materials in the deficit-specific training program. All audiologic equipment has been calibrated to manufacturer specifications within 6 months.

The website www.neuroaudiology.com is owned and maintained by the Neuroaudiology Lab, and will be used for dissemination of results of the project. This website was established in August 2008, and has received 5,273 hits since that time. Additionally, the Pathways group,

which was established by Dr. Musiek in 2004, has an email list with over 1000 subscribed members that will also be used for dissemination of results.

H. BUDGET AND COST-EFFECTIVENESS

1. The budget to undertake the project is adequate to undertake project activities.

The details of the budget are delineated in **Table 3**. Participant support costs constitute a large fraction of the budget, and are needed to reimburse half of the costs incurred by parents in transportation to and from the Neuroaudiology Lab at UConn for their child's assessment and treatment sessions. Additionally, as the treatment is challenging and demands sustained attention, a \$30 gift certificate incentive for teenagers will help to assure maintained attention and dedication throughout the training period (which consists of 18 sessions over 6 weeks).

2. The costs are reasonable in relation to objectives of the project.

The total costs of the project are reasonable. All salaries are specified by institutional rules, and finances for the project will be monitored by UConn's Office of Sponsored Programs (OSP), which is subject to audit by the State. Approximately 17% of the total project cost will be contributed by personnel and facility; UConn will contribute \$8,551 to the project, and total cost to the grant is \$42,658. Budget guidelines from OSP are included in **Appendix G**.

Table 3.

<u>Budget Categories & Descriptions</u>	<u>Grant Costs</u>	<u>Project Contribution</u>
A. Personnel		
- <i>Stephanie Nagle – Project Coordinator</i> Full time Graduate Assistant III (1 FTE x \$22,013)	\$22,013	
- <i>Frank Musiek – Principal Investigator</i> Doctoral & Dissertation Advisor (.025 FTE x \$100,000) - contributed		\$2,500
- <i>Jane Baran – Advisory Committee</i> Advisor – Auditory Processing (.015 FTE x \$100,000)- contributed		\$1,500
- <i>Kathleen Cienkowski – Advisory Committee</i> Advisor – Auditory Training & Rehab (.015 FTE x \$60,000) - contributed		\$900
<i>Personnel Subtotal</i>	\$22,013	\$4,900
B. Fringe Benefits		
- <i>Nagle – Project Coordinator</i> (16.3% x \$22,013)	\$3,588	
- <i>Musiek – Principal Investigator</i> (61.6% x \$2,500)- contributed		\$1,540
- <i>Jane Baran – Advisory Committee</i> (61.6% x \$1,500) - contributed		\$924
- <i>Kathleen Cienkowski – Advisory Committee</i> (61.6% x \$900) - contributed		\$554
<i>Fringe Benefits Subtotal</i>	\$3,588	\$3,018
C. Travel		
- <i>Nagle</i> 1). American Speech-Language and Hearing Association Convention, November 18-20, 2010 Philadelphia, PA (Roundtrip airfare = \$350; 3 nights lodging = \$175/night; 3 days incidentals = \$50/day; registration = \$245)	\$1270	

Travel Subtotal	\$1270	
D. Materials		
- <i>Earobics Computer Software</i> (\$280)	\$280	
- <i>Basic English Fitness Computer Software</i> (\$180)	\$180	
Materials Subtotal	\$460	
E. Participant Support Costs		
- <i>Local travel to and from UConn facility</i> (.5 reimbursement x 40 miles (average) roundtrip x 20 sessions [18 training – 6 weeks, 3 sessions/week; 2 evaluations] x 45 participants)	\$10,530	
- <i>Teenager Incentives</i> (\$30 bookstore gift certificates x 45 participants)	\$1350	
Participant Support Subtotal	\$11,880	
F. Other		
- <i>Consultant Fees</i> Electrophysiological scientists (2 scientists x 3 hours x \$50 per hour)	\$300	
Other Subtotal	\$300	
DIRECT COSTS TOTAL	\$39,336	\$7,918
Indirect Costs		
- <i>UConn F & A Costs for Dissertation</i> <i>Training Grants – 8%</i>	\$3,147	\$633
TOTAL COSTS	\$42,483	\$8,551
TOTAL GRANT COSTS	\$42,658	
TOTAL PROJECT CONTRIBUTION	\$8,551	

Appendices

- A. References
- B. Vitae of project personnel
- C. Deficit specific training program information
(including training schedule)
- D. *Earobics* training program information
- E. Letters of support.
- F. *Basic Grammar* information
- G. OSP budget guidelines
- H. Instrumentation