OMB Number: 4040-0001
Expiration Date: 06/30/2011

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: GRANT11164037

b. Agency Routing Identifier:

2. DATE SUBMITTED:

Applicant Identifier:

5. APPLICANT INFORMATION

*** Organizational DUNS:** 041544081

* Legal Name: University of Illinois Urbana-Champaign
Department: OSPRA
Division:
* Street1: 1901 S. First Street, Suite A
Street2:
* City: Champaign
County / Parish: Champaign
* State: IL: Illinois
Province:
* Country: USA: UNITED STATES
* ZIP / Postal Code: 61820-7406

Person to be contacted on matters involving this application

Prefix:
* First Name: Linda
Middle Name:
* Last Name: Learned
Suffix:
* Phone Number: 217-333-2187
Fax Number: 217-239-6830
Email: GCOAward@uillinois.edu

6. * EMPLOYER IDENTIFICATION *(EIN) or (TIN):* 1376000511A6

7. * TYPE OF APPLICANT: H: Public/State Controlled 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:
Aural Confusions of Consonants and Vowels in Children with Reading Disabilities

12. PROPOSED PROJECT:
* Start Date: 04/01/2013
* Ending Date: 03/31/2015

*** 13. CONGRESSIONAL DISTRICT OF APPLICANT**
IL-015

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix: Prof.
* First Name: Cynthia
Middle Name: J.
* Last Name: Johnson
Suffix:
Position/Title: Associate Professor
* Organization Name: University of Illinois Urbana-Champaign
Department: Speech & Hearing
Division:
* Street1: 901 S. Sixth
Street2:
* City: Champaign
County / Parish: Champaign
* State: IL: Illinois
Province:
* Country: USA: UNITED STATES
* ZIP / Postal Code: 61820-7406
* Phone Number: 217-244-2540
Fax Number:
* Email: cjj@illinois.edu

15. ESTIMATED PROJECT FUNDING

a. Total Federal Funds Requested	409,606.00
b. Total Non-Federal Funds	0.00
c. Total Federal & Non-Federal Funds	409,606.00
d. Estimated Program Income	0.00

16. * IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

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 penalities. (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

Add Attachment | Delete Attachment | View Attachment

19. Authorized Representative

Prefix: * First Name: Walter Middle Name: K.

* Last Name: Knorr Suffix:

* Position/Title: Comptroller

* Organization: University of Illinois Urbana-Champaign

Department: OSPRA Division:

* Street1: 1901 S. First Street, Suite A

Street2:

* City: Champaign County / Parish: Champaign

* State: IL: Illinois Province:

* Country: USA: UNITED STATES * ZIP / Postal Code: 61820-7406

* Phone Number: 217-333-2187 Fax Number: 217-239-6830

* Email: GCOAward@uillinois.edu

* Signature of Authorized Representative	* Date Signed
Julia McCabe	06/18/2012

20. Pre-application Add Attachment | Delete Attachment | View Attachment

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

OMB Number: 4040-0010
Expiration Date: 08/31/2011

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: University of Illinois Urbana-Champaign

DUNS Number: 0415440810000

* Street1: 506 S. Wright Street

Street2:

* City: Urbana

County: Champaign

* State: IL: Illinois

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 61801-3620

* Project/ Performance Site Congressional District: IL-015

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:

DUNS Number:

* Street1:

Street2:

* City:

County:

* State:

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code:

* Project/ Performance Site Congressional District:

Additional Location(s)

Add Attachment | Delete Attachment | View Attachment

Tracking Number:GRANT11164159

Funding Opportunity Number:PA-11-261 Received Date:2012-06-18T10:57:59-04:00

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

If no, is the IRB review Pending? ☒ Yes ☐ No

IRB Approval Date:

Human Subject Assurance Number: 00008584

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 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 of the United States or partnerships with international collaborators? ☐ Yes ☒ No

6.a. If yes, identify countries:

6.b. Optional Explanation:

7. * Project Summary/Abstract 1234-Summary.pdf Add Attachment | Delete Attachment | View Attachment

8. * Project Narrative 1235-Narrative.pdf Add Attachment | Delete Attachment | View Attachment

9. Bibliography & References Cited 1236-References.pdf Add Attachment | Delete Attachment | View Attachment

10. Facilities & Other Resources 1237-Facilities_Equipment.pdf Add Attachment | Delete Attachment | View Attachment

11. Equipment Add Attachment | Delete Attachment | View Attachment

12. Other Attachments Add Attachments | Delete Attachments | View Attachments ☐

It is well established that children with Reading Disabilities (RD) have poor phonemic awareness (PA) and that PA is highly correlated with reading success. The proposed study investigates whether a child's reading problems are more fundamental than PA, arising from poor auditory perception of speech sounds (phones), which we call phonetic perception (PP). The study has two aims: (1) to investigate abilities less linguistic and central than PA in children with RD, that may underlie PA and RD, namely more sensory and peripheral abilities of children with RD to aurally perceive speech sounds; and (2) to carefully map individual differences in perceptual confusions. To achieve these aims, we will systematically examine auditory perception of 24 English consonants (C) and 15 vowels (V) in nonsense syllables, to examine specific phonetic, perceptual confusions in children with a history of reading problems. The study addresses four hypotheses: (H1) Auditory perceptual deficits for speech sounds contribute to RD; (H2) Short-term auditory memory difficulties for speech sounds contribute to RD; (H3.) Processing of the auditory and visual streams is not well integrated in children with RD; and (H4) Reading disabilities are plastic, and thus will respond to training focused on a child's observed speech sound confusions. The proposed 2-year study includes three experiments, each with a cohort of 13 children, 8 to 12 years old, with documented histories of RD and 10 control children. Pairs of speech perception tasks will be tested in each experiment. In all experiments, the first task is a combination of two tasks that we explored in preliminary studies. The SCO task is an oddball task in which the child listens to three CV or VC nonsense syllables spoken by different professionally-recorded talkers, and picks the oddball syllable that differs by only one C or V. The NSCM task is an imitation task, where the child hears only one syllable at a time. This task is used to generate matrices of target sounds and the child's confusions. Our preliminary studies suggest that while children with RD do not experience severe consonant and vowel confusions, their confusions are significantly worse than controls' and affect many sounds. Cumulatively, this increased level of confusion could well result in considerable difficulty when learning to reading. Furthermore, patterns of confusion are often child-specific (idiosyncratic), and thus would require identification on an individual basis, for effective intervention. If we find that school children with RD have PP problems, our study could point the way to why and how RD develops and potentially a way to increase the effectiveness of training, by concentrating on the underlying source of problems in PA and reading.

Project Narrative

The proposed study explores whether poor sensory (phonetic) perception for speech underlies poor phonemic awareness and reading disability (RD). The study measures how well 8 to 12 year old children with RD can perceive all English consonants and vowels in nonsense syllables, in a series of experiments that increase the auditory memory load, add print to the auditory signal, and provide training for phonetic perception. Preliminary work suggests that although children with RD do not experience severe confusions, they do experience moderate confusions for many sounds, significantly more often than good readers. Cumulatively, this increased level of syllable confusions could result in considerable difficulty with reading.

Facilities and Equipment

Beckman Laboratory, UIUC: *Speech Lab:* This room in Beckman contains office space for 5 graduate students. This is where speech testing is done on student subjects for psychophysical tests. The room contains computers for the students (one computer per desk), equipment for stimulus generation and computation, software for presentation of stimuli, network, earphones, etc. A BW printer is available in the room. Each student has a laptop computer along with a desktop, for general purpose computing, with Matlab networked via the central facilities at Beckman. *Computers:* All of our computers are networked together using a Linux network. Wideband Internet services are provided by the Beckman Institute at no extra charge. The speech lab runs a local subnet so that laptops may be easily connected into the backbone without going through central services, Support personnel for maintenance of computers is available, however the PI does his own computer support.

Office: Office space is provided for the PI and the graduate students at Beckman. Phone service and computer services are provided. Prof. Allen's office is across from the Speech Lab.

Office: Office space is provided for PI Johnson and her graduate students in the Speech and Hearing Science Bldg.

Child Language Lab: Prof. Johnson has a three-room lab suite in the Speech and Hearing Science Building. The lab contains a computer that research assistants can use, statistical analysis software, earphones, video and audio recording equipment, and data storage cabinets and shelves. Additionally, there are two rooms set up for data collection with school-age subjects. Prof. Johnson also has a second five-room lab suite at The Children's Research Center (CRC) building on campus. That suite has a large office space for Prof. Johnson, an office for research assistants, a large data collection room set up like a classroom (for running small groups of research subjects), a small waiting room for the families of research participants, and a data analysis room. The CRC suite is only 2 blocks from the Speech-Language Clinic, run by the Dept. of Speech and Hearing Science.

Speech-Language Clinic: The Speech-Language Clinic offers complete diagnostic, intervention, and consultation services to a few hundred children and adults annually, and aids in clinical investigations conducted by faculty of the Dept. of Speech and Hearing Science. This resource would be available to the proposed project for subject recruitment and data collection. The clinic is located in the Research Park section of the University, and occupies the north half of a recently constructed building shared with Chesterbrook Academy (a preschool day-care program). The clinic has a number of clinical/research spaces for data collection, which are equipped with state-of-the-art video and audio recording technology. There also is a waiting room for families, a home living area (with a combined kitchen-living room), rooms for working with young children, and a large playroom equipped for multisensory stimulation. Office space is available for researchers and their assistants.

Department of Speech and Hearing Science, UIUC: The Department is housed in its own building, the Speech and Hearing Science Building, which was designed specifically for the discipline. The Speech and Hearing Science Building was completed in 1977 and includes many of the classroom, office, clinic, and laboratory spaces that are utilized by the program. Most laboratory space is located in the Speech and Hearing Science Building, but two large additional spaces outside of the building have also been assigned to the Department. Laboratory spaces include the Evoked Potential Laboratory, the Auditory Perception and Neuroscience Laboratory, the Auditory Neural Coding and Auditory Plasticity Laboratory, the Language Development Laboratory, the Child Language and Literacy Laboratory, the Discourse Analysis Laboratory, the Child Language Laboratory, the Speech Anatomy Laboratory, the Swallowing Research Laboratories, the Visual Processes Laboratory, the Auditory-Visual Perception Laboratory, the Signed Languages Laboratory, the Data Analysis Laboratory, the Multicultural Studies and Child Language and Traumatic Brain Injury Laboratory, the Medical Imaging Research Laboratory, and the Stuttering Research Data Acquisition Laboratory. The Department also houses an Audiology Clinic and a Speech-Language Pathology Clinic.

Audiology Clinic: The Audiology Clinic has two double-walled commercially produced sound-treated booths. The booths house two clinical diagnostic audiometers (GSI 16 and AC 40), CD players, supraaural and insert earphones, bone conduction transducers, talkback systems and participant response devices, and two real ear hearing aid test units (FP40D). The clinic has two acoustic immittance devices (an AE 206 screener and a Zodiac 901), and two additional hearing aid test units, a Frye Fonix 6500 and a Frye FP40D. Also in the clinic are two computers with a HI-PRO box and cables and NOAH and cables, an ultrasonic cleaner device, and otoscopes and ear canal examination and cerumen management supplies. An Earmold Room contains a video otoscope, earmold materials, earplugs, a drill and buffer, a third immittance screener (American 85 AR impedance screener), and hearing aid repair materials. An Assistive Listening Devices room contains a VCR, assorted assistive listening devices (for television and telephone, alerting devices), computers, and a NOAH with cables.

OMB Number: 4040-0001
Expiration Date: 06/30/2011

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix:	Prof.
* First Name:	Cynthia
Middle Name:	J.
* Last Name:	Johnson
Suffix:	
Position/Title:	Associate Professor
Department:	Speech & Hearing
Organization Name:	University of Illinois Urbana-Champaign
Division:	
* Street1:	901 S. Sixth
Street2:	
* City:	Champaign
County/ Parish:	Champaign
* State:	IL: Illinois
Province:	
* Country:	USA: UNITED STATES
* Zip / Postal Code:	61820-7406
* Phone Number:	217-244-2540
Fax Number:	
* E-Mail:	cjj@illinois.edu
Credential, e.g., agency login:	CYNTHIA_JOHNSON
*** Project Role:**	PD/PI
Other Project Role Category:	
Degree Type:	PhD
Degree Year:	1979
***Attach Biographical Sketch**	1241-Johnson_CJ_Biosketch.pdf
Attach Current & Pending Support	

Add Attachment | Delete Attachment | View Attachment

PROFILE - Senior/Key Person 1

Prefix:	Prof.
* First Name:	Jont
Middle Name:	
* Last Name:	Allen
Suffix:	
Position/Title:	Associate Professor
Department:	
Organization Name:	University of Illinois Urbana-Champaign
Division:	
* Street1:	405 N. Mathews Ave
Street2:	
* City:	Urbana
County/ Parish:	Champaign
* State:	IL: Illinois
Province:	
* Country:	USA: UNITED STATES
* Zip / Postal Code:	61801-2325
* Phone Number:	217-244-9567
Fax Number:	
* E-Mail:	jontalle@illinois.edu
Credential, e.g., agency login:	JONT_ALLEN
*** Project Role:**	PD/PI
Other Project Role Category:	
Degree Type:	PhD
Degree Year:	1970
***Attach Biographical Sketch**	1242-Allen_Biosketch.pdf
Attach Current & Pending Support	

Add Attachment | Delete Attachment | View Attachment

BIOGRAPHICAL SKETCH

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

NAME	POSITION TITLE
Johnson, Cynthia Jane	Associate Professor of Speech and Hearing Science
eRA COMMONS USER NAME (credential, e.g., agency login) CYNTHIA_JOHNSON	

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)*	MM/YY	FIELD OF STUDY
University of Iowa	B.A.	05/73	Speech and Hearing Science
University of Iowa	M.A.	07/75	Speech Pathology
University of Minnesota	Ph.D.	06/79	Communication Disorders

Please refer to the application instructions in order to complete sections A, B, C, and D of the Biographical Sketch.

A. **Personal Statement**

The goal of the proposed research is to investigate the phonetic perception of children with reading disabilities, to explore whether poor sensory perception for speech underlies poor phonemic awareness and ultimately poor reading in such children. Our study is designed to measure how well children with reading disabilities in late elementary school can perceive consonants and vowels in nonsense syllables, compared to good readers, in a series of experiments that increase the auditory memory load, add printed syllables to the auditory stream, and provide training for phonetic perception.

I have the expertise and collaborative experience to conduct the proposed project and serve as a Co-PI with Dr. Allen. Indeed, Dr. Allen and I have been collaborating on preliminary studies for the proposed project for a number of years, and I was in charge of participant recruitment, diagnostic assessment, and data collection. I have background in both the clinical practice of speech-language pathology and research in the area of assessment and intervention for children's language and literacy-related disorders (including reading); and specifically phonological disorders. With regard to clinical intervention, I am a nationally clinically-certified speech-language pathologist, as well as a licensed speech-language pathologist in the state of Illinois. With regard to phonology, I was first hired as an assistant professor at Northwestern University for my expertise in phonology, having trained as a doctoral student in the speech perception laboratory of Dr. Charles Speaks; and the child phonology laboratory of Dr. Patricia Broen, at the University of Minnesota. At Northwestern and later at the University of Illinois (as an assistant and associate professor) I have taught clinically related coursework for many years in assessment and treatment of language and phonological disorders in children.

I have served on seven convention program committees for the American Speech-Language-Hearing Association (ASHA), for language assessment and treatment for school-age children, and assessment and treatment of speech sounds disorders. I am a Fellow of ASHA and have served as an Associate Editor (i.e., section editor) or Guest Associate Editor for each of ASHA's three major journals: handling manuscripts for phonological disorders for our flagship research journal, and for language in infancy and school age children, and spoken and written discourse and reading for our two clinical practice journals. I have belonged to a group of 50 to 60 child phonologists in the U.S. and internationally since early in my career, and have twice hosted their annual meeting. I have published research on phonological development and processing (in monolingual and bilingual children and adults) and assessment (of children with limited speech, hearing impairment, and reading disorders): in *Language, Speech, and Hearing Services in Schools; Applied Psychololinguistics; Studies in Linguistic Sciences; Journal of Communication Disorders; Clinical Linguistics and Phonetics*; and the *Proceedings of the 27th World Congress of the International Association of Logopedics and Phoniatrics*. I have published research on assessment or treatment of children's language and literacy disorders in the *Handbook of Research on Writing; Journal of Speech and Hearing Disorders; Applied Psycholinguistics; First Language; The Clinical Connection; Language, Speech, and Hearing Services in Schools; Journal of Communication Disorders*; and the *Proceedings of the Symposium on Research in Child Language Disorders*. Additionally, since 1992, I have presented 65 conference papers and seminars on speech, language, and literacy disorders at meetings of the American Speech-Language-Hearing Association, Symposium on Research in Child Language Disorders, International Child Phonology Conference, International Association of Logopedics and Phoniatrics, Society for Research in Child Development, and Illinois Speech-Language-Hearing Association (in Chicago). Of these, seven were presentations of our preliminary studies for the proposed project. Since 1988, I also have made 28 invited presentations or workshops to practicing speech-language pathologists and public schools.

I have leadership and collaborative experience with colleagues as the current PI and Project Director of the 5-year Project FOCAL (Focusing on Causality and Assessment to Train Leaders in Children's Communication Disabilities), a collaborative doctoral training grant between Speech and Hearing Science and Special Education, from the Office of Special Education Programs, in the U.S. Department of Education. I have worked with doctoral trainee appointments, postdoctoral fellows, training timelines, and budget, as director of this nationally funded, multiyear project. In addition to my collaboration with Dr. Allen for this project, I am engaged in another line of collaborative research on intervention for children's writing disorders, with Dr. Julie Hengst in Speech and Hearing Science. With Dr. Allen, I have collaborated for a number of years with The Reading Group, a local nonprofit center that tutors children with reading disabilities. Recently, I joined the steering committee of LEAP (Linking Educators and Parents), a local community action and study group of professors, school administrators, teachers, and parents serving children and adults with dyslexia. Lastly, I have honed leadership and collaboration by directing and serving on many graduate theses committees in speech and hearing science and special education. In addition, I have interacted with Dr. Allen as a member of two doctoral dissertation committees, one directed by him and one by me.

B. **Positions and Honors**

Positions and Employment

1979-81	Assistant Professor, Speech and Language Pathology Program, Dept. of Communicative Disorders, Northwestern University, Evanston, IL
1981-87	Assistant Professor, Dept. of Speech and Hearing Science, University of Illinois at Urbana-Champaign
1987-Present	Associate Professor, Dept. of Speech and Hearing Science, University of Illinois at Urbana-Champaign

Other Experience and Professional Memberships

1980-	Member, American Speech-Language-Hearing Association
1980-	Member, Society for Research in Child Development
1980-	Certificate of Clinical Competence, Speech-Language Pathology, American Speech-Language-Hearing Association
1984, 1998, 2000, 2003, 2004, 2006, 2009	Member, seven Program Committees, Annual Convention of the American Speech-Language-Hearing Association (subcommittees on Language Disorders-Learning Disabilities, Diagnostic Assessment of Developmental Language Disorders, Language and Learning in School-Age Children and Adolescents, and Speech Sound Disorders)
1987	Site Visit Team Member, National Institutes of Health, Denver Center for the Performing Arts

1988	Special Reviewer, RO1 Proposal, National Institutes of Health
1988, 1992	Organizer and Host, Annual Child Phonology Meeting (a national meeting of 50-60 child phonologists)
1989-	Licensed Speech-Language Pathologist, State of Illinois
1989-93	Editorial Consultant (functioned in a capacity similar to an associate editor, for language papers), *ASHA Monographs*
1994	Guest Associate Editor (for Phonological Disorders), *Journal of Speech and Hearing Research*
1997-2001	Key Faculty, *Training Leadership Personnel to Facilitate Communication Skills of Children and Youth with Disabilities*. Halle, James (PI), Preparation of Doctoral Leadership Personnel Grant, U.S. Department of Education.
2001-2006	Key Faculty, *Project TALK: Training academic leaders with knowledge in communication* disabilities. Watkins, Ruth (PI), Preparation of Doctoral Leadership Personnel Grant, U.S. Department of Education.
1999-2002	Associate Editor (for Language in Infancy and School-Age Children), *American Journal of Speech Language Pathology* (comparable to a section editor)
2005-	Member, International Association for the Study of Child Language
2006-2008	Member, International Association of Logopedics and Phoniatrics
2007-2012	PI and Director, Project FOCAL: *Focusing on Causality and Assessment to Train Leaders in Children's Communication Disabilities for the 21st Century.* Preparation of Doctoral Leadership Personnel Grant, Office of Special Education Programs (OSEP), U.S. Department of Education.
2010-11	Associate Editor (for Spoken and Written Discourse and Reading), *Language Speech and Hearing Services in Schools* (comparable to a section editor)
2012	Member, Steering Committee, LEAP (Linking Educators and Parents), a local community action and study group serving children and adults with dyslexia.

Honors

1973	Phi Beta Kappa
1973	Undergraduate Honors Certificate of Achievement, University of Iowa
1983-2011	70 times appeared on the List of Teachers Rated as Excellent, including 14 times as an "Outstanding Teacher," University of Illinois at Urbana-Champaign
1995	Outstanding Staff Member, Panhellenic Council of the University of Illinois, for "constant devotion to teaching and advising"
2000	Excellence in Teaching Award, College of Applied Life Studies
2000	Honorable Mention, Campus Award for Excellence in Undergraduate Teaching
2003	Outstanding Graduate Mentor Award, College of Applied Life Studies
2003	Academic Excellence Award, Chi Omega
2004	Certificate of Recognition, Women in Math, Science and Engineering Living-Learning Community (nominated as an outstanding teacher, for undergraduate instruction)
2006	Fellow, American Speech-Language-Hearing Association
2009	"Bazerman, C. (Ed.). (2008). *Handbook of Research on Writing: History, Society, School, Individual, Text*. New York: Lawrence Erlbaum" was selected of one of two winners of the *2009 CCCC Outstanding Book Award* (Conference on College Composition and Communication, National Council of Teachers of English. Chapter 29 is: Hengst, J., & Johnson, C. J. "Writing and communication disorders across the life span" (pp. 471-484).
2011	College Award for Excellence in Undergraduate Teaching, College of Applied Health Sciences, University of Illinois at Urbana-Champaign
2011	Campus Award for Excellence in Undergraduate Teaching, University of Illinois at Urbana-Champaign

Selected Peer-reviewed Publications (Selected from 24 peer-reviewed publications)

Most relevant to the current application

1. Johnson, C. (1995). Expanding norms for narration. *Language, Speech, and Hearing Services in Schools, 26*, 326-341.
2. Johnson, C.J., Phatak, S., Steele, S.D., Lobdell, B., & Allen, J. (2007). Speech perception confusions in children with reading disabilities. *Proceedings of the 27th World Congress of the International Association of Logopedics and Phoniatrics*, Copenhagen, Denmark.
3. Ha, S., Johnson, C. J., & Kuehn, D. P. (2009). Characteristics of Korean phonology: Review, tutorial, and case studies of Korean children speaking English. *Journal of Communication Disorders, 42*, 163-179.
4. DeThorne, L. S., Johnson, C. J., Walder, L., & Mahurin-Smith, J. (2009). When "Simon Says" doesn't work: Alternatives to imitation for facilitating early speech development. *American Journal of Speech-Language Pathology, 18*, 133-145.
5. Lin, L., & Johnson, C.J. (2010). Phonological patterns in Mandarin-English bilingual children. *Clinical Linguistics and Phonetics, 24,* 369-386.

Additional publications of importance to the field (in chronological order)

1. Schober-Peterson, D., & Johnson, C. (1991). Non-dialogue speech during preschool interactions. *Journal of Child Language, 18*, 153-170.
2. Weiss, A., & Johnson, C. (1993). Relationships between narrative and syntactic competencies in school-aged, hearing impaired children. *Applied Psycholinguistics, 14*, 35-59.
3. Schober-Peterson, D. & Johnson, C. (1993). The performance of 8- to 10-year-olds on measures of conversational skillfulness. *First Language, 13*, 249-269.
4. Miskiel, L. W., Carney, A., Johnson, C., & Carney, E. (1994). An analysis of the *Phonetic Level Evaluation*: Age and task factors. *Language Speech and Hearing Services in Schools, 25*, 165-173.
5. Griffiths, S., & Johnson, C. (1995). Effects of training on fricative identification in toddlers. *Applied Psycholinguistics, 16*, 443-462.
6. Sutter, J., & Johnson, C. (1995). Advanced verb form production in story retelling. *Journal of Speech and Hearing Research, 38*, 1067-1080.
7. Kuo, S., Cheng, C., Bilger, R., & Johnson, C. (2001). Perceptual distance of initial consonants between Southern Min and Cantonese. *Studies in Linguistic Sciences, 30* (2), 102-131.
8. Marinellie, S., & Johnson, C. (2002). Definitional skill in school-age children with specific language impairment. *Journal of Communication Disorders, 35*, pp. 241-259.
9. Marinellie, S., & Johnson, C. (2003). Adjective definitions and the influence of word frequency. *Journal of Speech-Language-Hearing Research, 46*(5), 1061-1076.
10. Hengst, J., & Johnson, C. (2008). Writing and communication disorders across the life span. In C. Bazerman (Ed.), *Handbook of Research on Writing: History, Society, School, Individual, Text* (pp. 471-484). New York, NY: Lawrence Erlbaum. (Note: not peer-reviewed, but relevant to the proposed study.)

Ongoing Doctoral Training Grant Support

H325D070061 Johnson, Cynthia (PI) 8/14/07-8/15/12
This grant is called, Project FOCAL: *Focusing on Causality and Assessment to Train Leaders in Children's Communication Disabilities for the 21st Century*. It is a Preparation of Doctoral Leadership Personnel Grant, from the Office of Special Education Programs (OSEP), U.S. Department of Education. The overall goal is to train six doctoral students and four postdoctoral fellows as scientists and future professors with expertise in investigating and assessing the underlying causes of children's language, language-related (e.g., literacy), and learning disorders. In addition to mentoring graduate students' research, my role as PI is to make trainee appointments, co-mentor all doctoral and postdoctoral trainees, co-teach a biweekly Transdisciplinary Seminar, write several annual reports for OSEP, ensure that trainees make progress with educational and research timelines, and manage a large multi-year budget.
Role: PI and Project Director

BIOGRAPHICAL SKETCH

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

NAME	POSITION TITLE
Allen, Jont B.	Associate Professor, ECE

eRA COMMONS USER NAME
JONT_ALLEN

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

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
University of Illinois, Urbana, IL	B.S.	1966	Electrical Engineering
The University of Pennsylvania, Philadelphia, PA	M.S.	1968	Electrical Engineering
The University of Pennsylvania, Philadelphia, PA	Ph.D.	1970	Electrical Engineering

A. Personal Statement

During his 32 year AT\&T Bell Labs career (after 1998, AT&T Labs) Prof. Allen specialized in nonlinear and cochlear auditory speech processing, and speech perception. While at AT&T Allen wrote many journal articles on hearing, cochlear modeling, signal processing, and speech perception, especially on Harvey Fletcher's articulation index. Allen is know as an expert on Harvey Fletcher, the Bell Labs pioneer who in 1921 invented the first audiometer, and then was the first to measures human hearing thresholds; invented the Articulation index (AI), an important objective measure of human speech recognition; and developed the first model of loudness and the Fletcher-Munson curves.

In 1982-1987 Allen he had primary responsibility with the development of the first commercial multiband compression hearing aid, later sold as the ReSound hearing aid. During this 5 years he was working closely with clinical audiologists, and many others, involved in speech and hearing science, including several hearing aid manufactures (Starkey, Phonak, Etymotic), who have funded Allen's work. He wrote the first DSP code and developed the first fitting system, based on loudness in $\frac{1}{2}$ octave bands (LGOB) which was used by ReSound as their preferred fitting system for many years. He was also responsible for the first analog compression circuits used in the primary product, that was produced by AT&T for ReSound, at the Allentown PA production line.

From 1998-2003, while at AT&T Labs, a spin off from Bell Labs, he worked on Loudness and human phoneme (consonant) perception, which is a problem closely related to AI theory. In Aug. of 2003 he join the ECE faculty, University of IL, UIUC. Allen is investigating cochlear modeling, noninvasive diagnostic testing of cochlear function (such as DPOAE) and power reflectance measurements in the ear canal (to characterize middle ear function), auditory psychophysics, speech processing for hearing aid applications (noise reduction and multiband compression), speech and music coding (bit-rate reduction) and speech perception (models of loudness and masking) and aspects of acoustics. With only minor exceptions, all the the commercial DPOAE systems were born out of CubeDis, an open-source system Allen created in 1987. He is most actively working on the theory and practice of human speech recognition, with the goal of improving automatic speech recognition robustness in the presences of noise and filtering.

From 2003-present, Allen has a number of students active in various projects on speech perception and signal processing with hearing applications: http://hear.beckman.illinois.edu/wiki/Main/ResearchGroup

In the last 5 years Allen and his students have collected several large databases of speech perception data as a result of various types of modifications. This work is well documented in the publications from 2005-2012. This work also includes measurements on 46 hearing impaired ears from $\approx$ 26 subjects.

From 2005-present Allen has been working on reading disabilities in young children. This work has been in collaboration with Prof. Cynthia Johnson of the UIUC Speech and Hearing Department. This work is related to work on hearing impaired subjects.

Allen has successfully developed several complex and innovative research programs, first at Bell Labs in 1995 (cochlear modeling), followed by the development of the Bell Labs multiband compression hearing aid (1985-88) (Now labeled as GN-ReSound), followed by his speech perception research at UIUC in 2003 with his group of highly productive students. This research has provided many deep insights into difficult, significant and challenging problems of speech perception. Specifically Allen and his students have identified the basic features of many plosive and fricative speech sounds. This has allowed them to manipulate the perception of the sound with surgical precision.

He is well-versed in cochlear modeling, auditory neurophysiology, speech perception, speech processing, psychophysics, audiology as well as musical acoustics, acoustics, impedance and reflectance, analog and digital signal processing, and **clinical audiology**.

Allen has more than 20 US patents on hearing aids and signal processing.

He teaches courses in analog and digital signal processing, mathematical physics, speech processing, electroacoustics, transducer design, digital signal processing and **clinical audiology**. His special love is speech perception, which brings together many of these fields in the most interesting, as well as important, way. Allen has been a visiting scientist in the Departments of Otolaryngology of Columbia University, City university of New York, and University of Calgary.

Positions and Employment

1987 + Adjunct Associate Research Scientist, Dept. of Otolaryngology, Columbia University
1990 Osher Fellow, Exploratorium Museum, San Francisco
1994 Visiting Scientist and Distinguished Lecturer, Dept. of Otolaryngology, Univ. of Calgary
1970-1987 Member of Technical Staff, AT&T Bell Laboratories, Murray Hill, NJ
1987-1996 Distinguished Member of Technical Staff, AT&T Bell Laboratories, Murray Hill, NJ
1996-2002 Technology Leader, AT&T Labs Research, Florham Park, NJ
2003-present Associate Professor, ECE, University of Illinois, Urbana, IL
2003-present Affiliate Associate Professor, Speech and Hearing Science, UIUC, Urbana, IL

Other Experience and Professional Memberships

1978 Publicity Chairman, IEEE Int. Conf. Acoustics, Speech and Signal Processing
1979-85 IEEE ASSP DSP Technical Committee (Vice Chairperson for 2 years)
1980-83 Editor of the IEEE Transactions on ASSP
1982 Administrative Board IEEE ASSP
1983-85 Chairman of the Publication Board of the ASSP Society
1987 Executive Council of the ASA
1987-96 Member of ReSound (Hearing Aid Company) Scientific Advisory Board
1988 General Chairman ICASSP, New York
1991 International Distinguished Lecturer for the Signal Processing Society
1997-00 Member of SoundID Scientific Advisory Board
2000 General Chairman IEEE Workshop on Audio, Mohonk, NY
2003-present Acoustical Soc. Am.: -Publication Board; -History committee; -Books+

Honors

1981 Fellow, Acoustical Society of America (ASA)
1985 Fellow, IEEE
1986 IEEE ASSP Meritorious Service Award
1991 International Distinguished Lecturer for the Signal Processing Society
2000 IEEE 3rd Millennium Medal for Outstanding Achievements and Contributions

B. Selected peer-reviewed publications (1977-2012)

Recent publications (2009+): *http://hear.beckman.illinois.edu/wiki/Main/Publications*

1. Riya Singh and Jont Allen. Sources of stop consonant errors in low-noise environments. J. Acoust. Soc. Am., apr, 3051-3068, 2012.
2. Yoon, Y., Allen, J.B. and Gooler, D. Relationship between Consonant Recognition in Noise and Hearing Threshold. J. of Speech, Language and Hearing Research, doi: 10.1044/1092-4388(2011/10-0239), Apr 2012.
3. Kapoor, Abhinauv and Allen, Jont B. Perceptual Effects of Plosive Feature Modification. J. Acoust. Soc. Am., 131, 478-491, 2012.
4. Allen, Trevino, Han. Speech perception in impaired ears. Invited for the AG Bell Research Symposium, Scottsdale AZ. Jul 1 2012
5. Jont B. Allen and Woojae Han. Sources of decoding errors of the perceptual cues, in normal and hearing impaired ears. ISAAR, 2011.
6. Feipeng Li and Jont B. Allen. Manipulation of Consonants in Natural Speech. IEEE Trans. Audio, Speech and Language processing, March 496-504, 2011.
7. F. Li, A. Menon, and J. B. Allen. A psychoacoustic method to find the perceptual cues of stop consonants in natural speech. J. Acoust. Soc. Am., apr, 2599-2610, 2010.
8. Parent, Pierre and Allen, Jont. Wave model of the human tympanic membrane. Hearing Research, 263:152–167, 2010.
9. RH Withnell, PS Jeng, Kelly Waldvogel, Kari Morgenstein, and Jont B. Allen. An in-situ calibration for hearing thresholds. J. Acoust. Soc. Am., 125(3), 1605-11, March (2009).
10. S. A. Phatak, Y. Yoon, D. M. Gooler, and J. B. Allen. Consonant loss profiles for hearing impaired listeners. J. Acoust. Soc. Am., 126(5), pp 2683-2694, Nov. 2009.
11. A. Trevino, T.P. Coleman, and J. Allen. A Dynamical Point Process Model of Auditory Nerve Spiking in Response to Complex Sounds. Journal of Computational Neuroscience, 2009.
12. Feipeng Li and Jont B. Allen. Additivity law of frequency integration for consonant identification in white noise. J. Acoust. Soc. Am. 126(1) pp 347-353, Aug 2009.
13. Feipeng Li and Jont Allen. Speech perception and cochlear signal processing. IEEE Signal Processing Magazine, 26(4), pp73-77 July 2009.
14. Phatak, S., Lovitt, Andrew and Allen, Jont B. Consonant confusions in white noise. J. Acoust. Soc. Am., 124(2) Aug, 1220-1233, 2008.
15. Marion S. Regnier and Jont B. Allen. A method to identify noise-robust perceptual features: application for consonant /t/. J. Acoust. Soc. Am., 123(5):2801--2814, 2008.
16. PS Jeng, Jont Allen, JA Miller, and Harry Levitt. Wideband power reflectance and power transmittance as tools for assessing middle-ear function. Perspectives on Hearing and Hearing Disorders in Childhood. ASHA journal, 18(2):44–57, 2008.
17. Allen, Jont B. Nonlinear Cochlear Signal Processing and Masking in speech perception. Springer Handbook on speech processing and speech communication. Editors: Benesty, Jacob and Sondhi, Mohan, 1-36, Chap. 3, Springer, 2008.
18. S. Phatak, Andrew Lovitt, and Jont B. Allen. Consonant confusions in white noise. J. Acoust. Soc. Am., 124(2):1220--33, 2008.
19. PS Jeng, Jont Allen, JA Miller, and Harry Levitt., "Wideband power reflectance and power transmittance as tools for assessing middle-ear function," Perspectives on Hearing and Hearing Disorders in Childhood, 18(2):44-57, 2008. ASHA journal (http://journals.asha.org/perspectives/terms.dtl).

20. Parent, P. and Allen, J. B. Wave model of cat tympanic membrane. J. Acoust. Soc. Am., 122(2), p. 918-931, 2007.
21. Phatak, S. A. and Allen, J. B. Consonant and vowel confusions in speech-weighted noise. J. Acoust. Soc. Am., 121(4), p. 2312-2326. (2007)
22. J.B. Allen. Articulation and Intelligibility. Morgan and Claypool, 3401 Buckskin Trail, LaPorte, CO 80535, Peer reviewed monograph, ISBN: 1598290088, 2005.
23. J.B. Allen. How do humans process and recognize speech? IEEE Transactions on Speech and Audio, 2, 567-577, 1994.
24. Allen, J.B., Psychoacoustics. In J.G. Webster, editor, Wiley Encyclopedia of Electrical and Electronics Engineering, volume 17, pages 422-437. John Wiley & Sons, Inc, New York, NY (1999).
25. J. B. Allen. DeRecruitment by multiband compression in hearing aids. In B. Kollmeier, editor,Psychoacoustics, speech, and hearing aids, pages 141-152. World Scientific Press,Singapore, (1996).
26. J.B. Allen and M.M. Sondhi. Cochlear macromechanics: Time-domain solutions. J. Acoust. Soc. Am., 66, 120-132, 1979.
27. J.B. Allen and L.R. Rabiner. A unified approach to short-time Fourier analysis, synthesis. Proc. IEEE, 65, 1558--1564,1977.

C. Research Support.
Submitted Research Support
NA

Ongoing Research Support
Research in Motion Research grant gift account (3 years) 2010-2013
Phonak Research grant gift account
SBIR - N00014-11-C-0456. "Novel Methods to Monitor Health Status and Clinical Laboratory Data: Portable Acquisition, Assessment, and Reporting of Middle Ear Function and Hearing" September 9, 2011 thru March 15, 2013.
STTR - N00014-11-C-0498. "Insert ear-probe assembly for high-quality otoacoustic-emission (OAE) measurements in adults" September 22, 2011 thru March 15, 2013.

Completed Research Support
R21DC009277-01A1 May 30, 2008 NIDCD (year 3)
SBIR Mimosa Acoustics 2010 Phase I
STTR Mimosa Acoustics and University of IL 2010 Phase I
NIH/NIDCD A Wide-band Reflectance - DPOAE (WR-DP) Screener

PHS 398 Cover Page Supplement

OMB Number: 0925-0001

1. Project Director / Principal Investigator (PD/PI)

Prefix: Prof.
* First Name: Cynthia
Middle Name: J.
* Last Name: Johnson
Suffix:

2. Human Subjects

Clinical Trial? ☒ No ☐ Yes

* Agency-Defined Phase III Clinical Trial? ☐ No ☐ Yes

3. Applicant Organization Contact

Person to be contacted on matters involving this application

Prefix:
* First Name: Linda
Middle Name:
* Last Name: Learned
Suffix:

* Phone Number: 217-333-2187
Fax Number: 217-239-6830
Email: GCOAward@uillinois.edu

* Title: Co-Interim Director

* Street1: 1901 S. First Street, Suite A
Street2:
* City: Champaign
County/Parish: Champaign
* State: IL: Illinois
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 61820-7406

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4. Human Embryonic Stem Cells

* Does the proposed project involve human embryonic stem cells? ☒ No ☐ Yes

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://stemcells.nih.gov/research/registry/. Or, if a specific stem cell line cannot be referenced at this time, please check the box indicating that one from the registry will be used:

Cell Line(s): ☐ Specific stem cell line cannot be referenced at this time. One from the registry will be used.

Tracking Number:GRANT11164159 Funding Opportunity Number:PA-11-261 Received Date:2012-06-18T10:57:59-04:00

PHS 398 Modular Budget

OMB Number: 0925-0001

Budget Period: 1

Delete Period

Start Date: 04/01/2013 End Date: 03/31/2014

A. Direct Costs

	Funds Requested ($)
Direct Cost less Consortium F&A	125,000.00
Consortium F&A	
Total Direct Costs	125,000.00

B. Indirect Costs

	Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
1.	F & A (MTDC)	58.60	102,686.00	60,174.00
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number): ONR, Linda Shipp, (703)696-8559

Indirect Cost Rate Agreement Date: 03/01/2012

Total Indirect Costs: 60,174.00

C. Total Direct and Indirect Costs (A + B)

Funds Requested ($): 185,174.00

Budget Period: 2

Start Date: 04/01/2014 End Date: 03/31/2015

A. Direct Costs

	Funds Requested ($)
Direct Cost less Consortium F&A	150,000.00
Consortium F&A	
Total Direct Costs	150,000.00

B. Indirect Costs

	Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
1.	F & A (MTDC)	58.60	127,017.00	74,432.00
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number): ONR, Linda Shipp, (703)696-8559

Indirect Cost Rate Agreement Date: 03/01/2012

Total Indirect Costs: 74,432.00

C. Total Direct and Indirect Costs (A + B)

Funds Requested ($): 224,432.00

Tracking Number:GRANT11164159 Funding Opportunity Number:PA-11-261 Received Date:2012-06-18T10:57:59-04:00

PHS 398 Modular Budget

Cumulative Budget Information

1. Total Costs, Entire Project Period

Section A, Total Direct Cost less Consortium F&A for Entire Project Period	$	275,000.00
Section A, Total Consortium F&A for Entire Project Period	$	
Section A, Total Direct Costs for Entire Project Period	$	275,000.00
Section B, Total Indirect Costs for Entire Project Period	$	134,606.00
Section C, Total Direct and Indirect Costs (A+B) for Entire Project Period	$	409,606.00

2. Budget Justifications

Personnel Justification	1243-Budget_Justification.pdf	Add Attachment	Delete Attachment	View Attachment
Consortium Justification		Add Attachment	Delete Attachment	View Attachment
Additional Narrative Justification	1244-Additional_Budget_Justifi	Add Attachment	Delete Attachment	View Attachment

Budget Justification

Personnel Budget Justification

Senior Personnel:
Cynthia Johnson-PI (1.4 academic months 15% buyout): Co-PI Johnson will be responsible for overall conduct of the research program, including supervision of all subject recruitment, all data collection, lab procedures, and data analysis.
Jont Allen-PI (1.0 summer month): Co-PI Allen will be responsible for overall conduct of the research program as well, including management of the computer programming required to present the stimuli and take the data, data analysis, and management of the speech database.

Other Personnel:
GRA-TBA (5.5 calendar months) As a part of the requirements for an advanced degree in the Dept. of Speech and Hearing Science, this GRA will work closely with Professor Johnson and will be responsible for recruiting subjects, subject scheduling, data collection, supervision of 20 hourly undergraduate student employees who also will assist in data collection, and assisting in data preparation and analysis.
GRA-TBA (3.85 calendar months) As a part of the requirements for an advanced degree in the Dept. of Electrical and Computer Engineering, this GRA will work closely with Professor Allen and will be responsible for writing special purpose scripts in Matlab, to present stimuli, take data, manage the speech database, and analyze the data.
Student Hourly: Twenty students over the two years, 7 in year 1 and 13 in year 2 2 hrs/wk for 50 weeks $10/ hour. These undergraduate students will help run the child subjects in the data collection sessions for 24 subjects in Year 1 and 45 subjects in Year 2.

Fringe Benefit:
- the Fringe Benefit rate of 42.97% is assessed on salary for all Academic Salaries
- the Fringe Benefit rate of 6.25% is assessed on salary for all GRADs
- the Fringe Benefit rate of 7.79% is assessed on salary for all Students

Tuition remission: This is assessed on all Graduate Research Assistant salaries at a rate of 62%.

Additional Budget Justification

We have requested one extra module for Year 2. With a budget maximum of $275,000, it is not possible to have equal modules for both years. Therefore, the budget for Year 2 includes an extra module ($25,000), primarily to cover the increase in subjects.

OMB Number: 0925-0001

PHS 398 Research Plan

1. Application Type:

From SF 424 (R&R) Cover Page. The response provided on that page, regarding the type of application being submitted, is repeated for your reference, as you attach the appropriate sections of the Research Plan.

*Type of Application:

☒ New ☐ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

2. Research Plan Attachments:

Please attach applicable sections of the research plan, below.

1. Introduction to Application (for RESUBMISSION or REVISION only)		Add Attachment	Delete Attachment	View Attachment
2. Specific Aims	1239-Specific_Aims.pdf	Add Attachment	Delete Attachment	View Attachment
3. *Research Strategy	1240-ResearchStrategy.pdf	Add Attachment	Delete Attachment	View Attachment
4. Inclusion Enrollment Report		Add Attachment	Delete Attachment	View Attachment
5. Progress Report Publication List		Add Attachment	Delete Attachment	View Attachment

Human Subjects Sections

6. Protection of Human Subjects	1245-HumanSubjects.pdf	Add Attachment	Delete Attachment	View Attachment
7. Inclusion of Women and Minorities	1246-Inclusion_of_Women_and_	Add Attachment	Delete Attachment	View Attachment
8. Targeted/Planned Enrollment Table	1247-Target_Enrollment.pdf	Add Attachment	Delete Attachment	View Attachment
9. Inclusion of Children	1248-Inclusion_of_Children.p	Add Attachment	Delete Attachment	View Attachment

Other Research Plan Sections

10. Vertebrate Animals		Add Attachment	Delete Attachment	View Attachment
11. Select Agent Research		Add Attachment	Delete Attachment	View Attachment
12. Multiple PD/PI Leadership Plan	1249-Leadership_Plan.pdf	Add Attachment	Delete Attachment	View Attachment
13. Consortium/Contractual Arrangements		Add Attachment	Delete Attachment	View Attachment
14. Letters of Support		Add Attachment	Delete Attachment	View Attachment
15. Resource Sharing Plan(s)		Add Attachment	Delete Attachment	View Attachment

16. Appendix — Add Attachments | Remove Attachments | View Attachments

Specific Aims

In 1997 Congress requested that NICHD create a National Reading Panel to provide guidance on how to approach reading instruction and difficulties in school children, following extensive review of the literature, public hearings, and expert consultation (NICHD/NRP, 2000a). One conclusive finding was the high correlation between phonemic awareness (PA) and reading (cf. Schuele and Boudreau, 2008). Less clear is the nature of this interaction, namely, what does the correlation measure? Does poor phonemic awareness cause poor reading or vice versa (Goswami, 2010)? What is needed is a clear understanding of: why children with reading disability (RD) have poor PA scores, what PA measures, and what can be done to rectify the situation.

Our proposed work has **two aims: (1) to investigate abilities less linguistic and central than PA in children with RD, that may underlie PA and RD, namely more sensory and peripheral abilities of children with RD to aurally perceive speech sounds; and (2) to carefully map individual differences in perceptual confusions.** Recent theorists have provided evidence of auditory processing difficulties in RD and argued that it is essentially an auditory (or phonological) disorder (Dawes and Bishop, 2009; Goswami, 2010; Rosen, 2003; Snowling, 2000, 2001; Tallal, 1980; Vandewalle et al., 2012; Ziegler and Goswami, 2005; see also Merzenich et al., 1996; Tallal et al., 1996; and Ziegler et al., 2005, for a similar argument for children with Specific Language Impairment). Perceptual confusion is suggestive of children with hearing loss or deaf children who receive cochlear implants. Namely, if there are early hearing related problems in RD (perhaps due middle ear pathology that goes undetected but eventually resolves), the child might be unable to discern critical features in the speech signal even in late elementary school. If so, speech perception training for the child's particular observed confusions could lead to improved assessment and intervention for RD.

This basic exploratory study will evaluate four intertwined hypotheses related to reading disabilities. **H1 *Consonant (C) and vowel (V) perception***: *Auditory perceptual deficits for speech sounds contribute to RD.* If true, children with RD do not spontaneously perceive certain speech sound distinctions, similar to participants who use hearing aids and claim to hear the amplified speech but cannot understand it. Alternatively, if children with RD perceive all Cs and Vs as good readers do, we may assume that sensory aspects of the auditory system do not contribute to reading problems. **H2 *Short-term auditory memory***: *Short-term auditory memory difficulties for speech sounds contribute to RD.* If both H1 and H2 are true, children with RD would eventually reach cognitive overload when asked to perceive sounds they tend to confuse, in increasingly longer strings of nonsense syllables. Their error rate should increase as a function of the number of the sounds in the syllable sequence. Alternately, given no memory disorder, children with RD should perform like good readers in repeating back long sequences of nonsense syllables. Note, in our reasoning, H2 is contingent on H1. (We have **Preliminary Data** consistent with both H1 and H2.) **H3**. ***Integration of visual and auditory streams****: Processing of the auditory and visual streams is not well integrated in children with RD*. Here we ask if auditory information is used well by children with RD for decoding and reading fluency with novel print. Participants will view a printed random string of four nonsense syllables (decoding) while listening to an auditory version that differs by only one speech sound, and detect the point of mismatch. Then participants will read the printed sequence aloud (reading fluency). We predict that children with RD will have difficulty detecting mismatches and will produce read-aloud errors for sounds they confused on the H1 task. **H4 *Auditory plasticity****: Reading disabilities are plastic, and thus will respond to training focused on a child's observed speech sound confusions.* We will test this hypothesis with extensive listening training, with feedback, concentrating on specific Cs and Vs in whole nonsense syllables that a child had difficulty perceiving for H1. Unlike the *FastForWord* program (Merzenich et al., 1996; Scientific Learning Corporation, 1998; Tallal et al., 1996), our training will involve only unmodified syllables from the natural speech of multiple talkers and thus remain closer to real-life listening experience. If the plasticity hypothesis is true, children with RD should learn to accurately perceive the difficult syllables, leading to a measurable improvement in their global skill set for print decoding, reading comprehension, and reading fluency. Such plasticity has previously been observed for phonemic awareness (Ehri et al., 2001).

In combination, these four hypotheses are designed to test a hierarchical model of auditory speech perception in children with RD and assess the nature of each child's disability. If improper phonetic perception (in the more peripheral auditory system) contributes to RD (H1 true), we should see abnormal performance on all the tasks (perhaps due to early diminished auditory exposure from middle ear fluid and undetected hearing loss, as suggested by patterns seen in our Preliminary Data). Having detected a child's specific misperceived phones, we can potentially retrain those, possibly resulting in dramatic and permanent gains in speech perception and reading (H4 true). If on the other hand the child with RD has a more central, cognitive disorder, errors will appear in the later tests (only H2 and H3 true), but phonetic perception will be normal (H1 false).

Research Strategy

(a) Significance

Reading disability (RD) in children represents a seriously limiting intellectual disorder, causing children difficulty in learning, frequently across their lifespan. While estimates of the degree and severity of RD vary, at least 15% of children have RDs (IRA, 1998; NICHD/NRP, 2000a). Reading is necessary for success in school, thus is critical for success in life. Schuele & Boudreau (2008) argue that phonemic awareness (PA), including segmentation and blending, is vital for learning to read, but does not occur naturally, without training. If current PA training were generally successful, RD would be resolved early instead of presenting a lifelong challenge. The reasons why children with RD have such poor PA have yet to be determined, but to our knowledge, the sensory abilities of children with RD, to discriminate and identify the full speech-sound repertoire of English consonants (Cs) and vowels (Vs), have yet to be examined. Some recent work on a small number of speech contrasts in French and Dutch speaking children with Specific Language Impairment—a disorder resembling RD—is suggestive (Ziegler et al., 2005; Vandewalle et al., 2012).

A major barrier to progress in the field is that normal speech perception is a complex, poorly understood process, with many potential barriers. Speech is spontaneously learned with very little direct feedback on success. Children first learn to understand speech from their parents (caretakers) when learning to talk, and only then, how to read. We propose that RD problems start early, prior to actual reading instruction, and are fundamentally related to the auditory perception of speech sounds (phones), which we will denote as *phonetic perception* **(PP)**, but others have labeled *phonology* (i.e., receptive rather than expressive phonology; e.g., Dawes and Bishop, 2009; Mody et al., 1997; Snowling, 2001; Studdert-Kennedy and Mody, 1995; Vandewalle et al., 2012). Early auditory difficulties (e.g., from otitis media with effusion) is known to limit the speech learning process (Klein, 1984; Ptok, 2005; Paden, Novak & Beiter, 1987; Mody et al., 1999; Rosenfeld et al., 2011). When this happens, the child and parents may never be aware of any hearing loss. Although our study focuses on residual speech-sound confusions in older elementary school children with RD, the possibility that they once experienced early undetected hearing loss is supported by possible correlations in their pathologies, supported by our **Preliminary Studies** and by Co-PI Allen's published work on CV confusions in the hearing impaired (Phatak et al, 2009; Allen 2012, 2011).

The present study will improve scientific knowledge and clinical practice by exploring new methods of evaluating PP. In most children, learning to read can be efficient and automatic, yet highly error prone in the child with RD. If we find that school children with RD have phonetic perception problems, our study could point the way to why, and how, RD develops, and suggest an onset at a very early age (before kindergarten reading instruction). Our study has the potential to change clinical concepts and interventions by providing child-dependent measures of deficiencies in PP. These measures should allow us to increase the effectiveness of training, by concentrating on the underlying source of PA and reading.

Another barrier to progress is that RD studies often use average performance measures, thus masking key individual differences. For clinical application, individual performance is crucial (as in the fitting of glasses, hearing aids, or cochlear implants). In the field of speech-language pathology (SLP), it is well established practice to map the profile of speech production errors of the individual child with an articulation-phonological disorder. By mapping *perceptual* error profiles in the same way, for the individual child with RD, we may be able to discern the range of perceptual errors and error rates that can be found in the RD population. While improving scientific knowledge, this should also advance clinical practice by enhancing the diagnosis of (a) RD, (b) assessment for intervention and ultimately, (c) individual intervention outcomes.

(b) Innovation

Our study is innovative in five ways: *First*, we pair the PI's expertise in their respective fields. Cross-disciplinary research is a important advantage when investigating such complex problems. A licensed and certified SLP, the area of Co-PI Johnson's research expertise is in phonological (DeThorne et al., 2009; Ha et al., 2009; Lin & Johnson, 2010), language (Marinellie & Johnson, 2002, 2003; Lyons et al., 2010), and literacy development and disorders in children (Frame et al., 2008; Yang & Johnson, 2009; Johnson et al., 2011a). The area of Co-PI Allen's expertise is in auditory and cochlear speech processing (Allen, 2008), middle ear disease (Allen et al., 2005), speech perception in the normal hearing (Li et al., 2010; Singh & Allen, 2012), speech hearing loss (Allen & Li, 2009; Phatak et al., 2009) and RD.

Second, we seek to shift current research paradigms by choosing the broader term, *reading disability*, rather than the more narrow term, *dyslexia*, to accommodate the possibility that children with reading problems have co-morbid and perhaps undocumented problems with spoken language (e.g., speech perception or lexical or grammatical difficulties; cf. Catts, 1993; Catts & Kamhi, 2005; Catts et al., 2002; Flax et al., 2003), attention (King et al., 2003; Loo et al, 2004; Shaywitz & Shaywitz, 1994; Willcutt & Pennington, 2000;), and importantly, PP. A related argument is in Dawes & Bishop, 2009, pp. 443-444.

Third, child RD experts fully appreciate *phonemic* awareness (PA; Ehri et al., 2001; Stahl & Murray, 1994; Wagner & Torgesen, 1987) and understand its relevance to reading (Catts & Kamhi, 2005; IRA, 1998; NICHD/NRP, 2000b; Rvachew et al., 2003;). Yet RD experts do not either have a well defined working hypothesis of how PA operates during reading, or even an agreed upon measure of PA. Measures of PA vary widely, from simple syllable-level awareness tasks to complex, phoneme-level manipulation tasks (Schuele & Boudreau, 2008).

Theorizing about PA's relation to RD has been limited because the speech science community has not fully understood the nature of consonant perception (i.e., PP). Prior to 2005, the basic perceptual units (acoustic features) of consonants had not been identified (Allen, 1994; Allen et al., 2005; Blumstein & Stevens, 1980; Liberman, 1996; Shannon et al., 1995).

Co-PI Allen's recent investigations on phonetic features (Phatak and Allen, 2007; Phatak et al., 2008; Li et al., 2010) have naturally led us to the hypothesis that basic perception of phones (PP) has gone astray in the child with RD, and underlies poor PA. Allen's studies have identified the acoustic features used by normally hearing adults to identify hundreds of tokens of CV syllables and demonstrated that consonants are identified by normal hearing ears with zero error, even given large amounts of noise (Singh & Allen, 2012). This newly acquired understanding of consonant feature decoding opens a door for innovative RD research. Our *Preliminary Studies* have been designed to further test this hypothesis, on possible interesting parallels between the hearing impaired and the RD populations (Phatak et al., 2009). If our instinct regarding this parallel is correct, it could pave the way to a new level of understanding of RD ears.

Fourth, to measure PP, which we theorize occurs earlier in the auditory processing stream than PA, we break from the methodological approaches traditionally used in the PA literature, namely, we ask children only to judge and imitate whole nonsense syllables. Unlike the PA literature, our tasks never require the child to parse and recognize the *phoneme* as a linguistic unit of real words, an ability that Ziegler and Goswami's Grain Size Theory of reading acquisition and dyslexia (2005; also Goswami, 2010) argues is learned *from* successful reading rather than serving as its foundation.

Lastly, though addressing C and V perception, our work represents a shift away from the algorithm used by Tallal (1980), Tallal et al. (1996) and Merzenich et al. (1996), which yields substantially modified tokens of speech to train children with RD to better hear consonant distinctions. We use only naturally produced tokens by multiple talkers, to retain a better match between our experimental tasks and spontaneous speech. This should improve: (a) accuracy in diagnosing a child's perceptual difficulties in conversational speech, (b) translation of our method to typical settings in which reading specialists work, and (c) generalization of a child's learning to natural situations. We focus on precise controls. Based on the results of Allen et al. from 2005 to 2012, we suggest that isolated consonants and vowels are the source of PP, not CV transitions.

(c) Approach

Preliminary Studies: In two earlier studies (Johnson et al., 2007a,b,c,d; 2010a,b; 2011b,c), we reasoned that children's perceptual difficulties might be more fundamental than poor PA or poor auditory to visual phonic to phone mapping, arising from acoustic-phonetic properties of speech sounds, rather than their linguistic properties (in meaningful words). Consequently, we systematically measured confusions of a full array of English nonsense syllables, to examine specific phonetic perceptual confusions in children with a history of RD.

Participants: In collaboration with The Reading Group, a local nonprofit reading tutoring center, we compared two groups of children: 11 children with *reading disabilities* (RD) and 6 *reading controls* (RC), age 8-11 years. The RDs attended weekly reading lessons at the center. All participants were administered an assessment battery of reading, speech, language, phonological awareness, nonverbal cognition and hearing, by speech-language pathologists (SLPs).

Methods: We measured speech perception in two studies, with 17=11RD+6RC and 15 participants, respectively; with 10 hour-long sessions per study. In the first study, we presented a *Syllable Confusion Oddball* (**SCO**) task: a speech discrimination task to determine which of 24 consonants (Cs) and 15 vowels (Vs) caused confusion errors for a child. The child listened over headphones, via a computer, at a comfortable listening level, to random sequences of three nonsense CV or VC syllables *spoken by three different talkers* drawn from a set of 20 professionally recorded talkers (Linguistic Data Consortium database LDC2005S22 "Articulation Index Corpus," University of Pennsylvania; Fousek et al., 2004). For example, the child would hear [dɑ] (Voice 1) – [dɑ] (Voice 2) – [fɑ] (Voice 3), in which two of the three stimuli were the same CV, but the 3rd stimulus differed, in this example, in /f/. The child's task was to indicate the odd syllable. The child could request a trial be repeated, but received no performance feedback. The computer program randomly selected the syllable triads and the three talkers, thus the number of trials varied across sounds (mean $\mu = 41$).

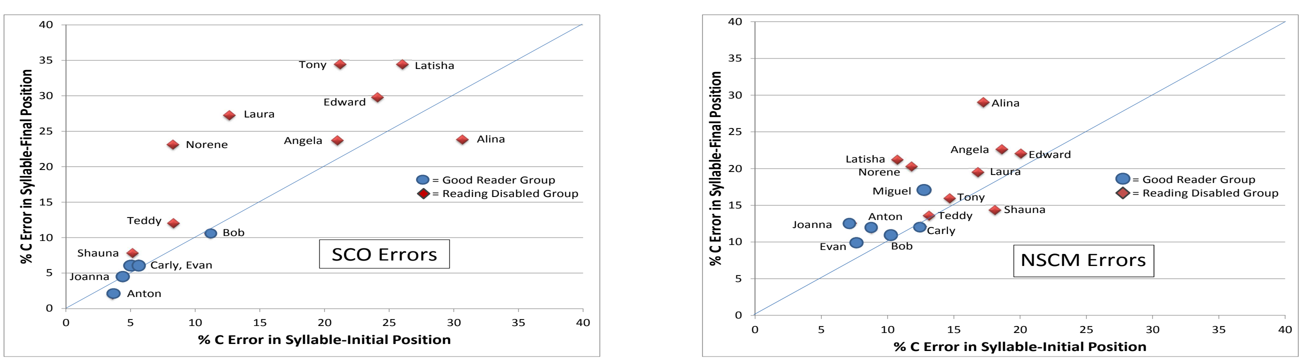

Figure 1: Percent of consonant error in syllable-initial and syllable-final position for the Reading Disabled (RD; red diamonds) and Control groups (RC; blue circles) on the SCO (left) and NSCM (right) tasks. Three participants were excluded from the left panel, due to too few trials and two subjects who did not return for the NSCM task were removed.

In the second study, we presented a *Nonsense Syllable Confusion Matrix* (**NSCM**) task: a C,V speech identification task, designed to discern each participant's idiosyncratic confusions. With NSCM we presented one syllable at a time and the child repeated it back. Responses were entered into the laptop computer by one examiner and transcribed phonetically (in the International Phonetic Alphabet) by a second. Because of random presentation, the number of trials varied ($\mu = 69$).

Results: For the SCO task, RCs (mean $\mu = 93\%$ correct, SD $\sigma = 3\%$) perceived speech sounds significantly better than children with RD ($\mu = 81\%$ correct, $\sigma = 10\%$), $t\ (14.9) = 4.09$, $p = .001$. All individuals in the RD group performed well above chance (chance being 33% on the SCO task). All individuals had some sounds for which the perceptual accuracy was 80% or higher, indicating that both groups could perform the task: Five of the six RCs perceived 100% of the 24 Cs and 15 Vs correctly. The sixth RC perceived 92% of Cs and 100% of Vs correctly; three children with RD performed similarly. Four RDs perceived 58 to 88% of Cs correctly, and from 27 to 100% of Vs. Four children with RD perceived only 13 to 35% of Cs correctly, and only 0 to 40% of Vs. Thus, the RC group had low error for nearly all sounds, whereas the RD group ranged from low error, to substantial difficulty, with many sounds. With respect to Cs, 88% of the 17 RD and RC participants perceived /s, h, n, r/ accurately; only the four lowest performing children in the RD group had difficulty with these four sounds (and with /w/). This suggests that RD difficulty with these five sounds might provide a quick screen.

For the NSCM task, the RC group ($\mu = 87\%$ correct, $\sigma = 1\%$) perceived speech sounds significantly better than the RD group ($\mu = 80\%$ correct, $\sigma = 7\%$), $t\ (9.68) = 3.55$, $p = .006$). Effect size was determined via arcsine transformed values on the average group scores. Cohen's *d* was 1.96, indicating a large effect. As with the SCO task, all participants had some sounds for which accuracy was ≥90%, demonstrating that they could do the task. Ranges for the number of accurate sounds went from RD: 6-14 to RC: 12-18 for consonants and RD: 2-8 to RC: 8-10 for vowels. The best consonant perception in RD and RC children was for /d, k, w, j/ (≤6% error): RCs additionally perceived /t, s, ʃ, h/ with a similar low error. Low error was seen for the vowels /i, u/ for both RD and RC children. RCs additionally perceived /e, o, aɪ, aʊ, ɔɪ, ɝ/ with low error. These results are summarized in Fig. 1 which compares percent error for Cs in syllable initial (CV) and final (VC) position for the two tasks. RCs show substantially fewer errors than RDs on both tasks, with only a small overlap. RCs show little influence for syllable position, whereas a number of children with RD make more perceptual errors in syllable-final (VC) position.

From the assessment battery, three reading measures from the WRMT-R significantly correlated with performance on the SCO task: Average percentile rank (PR) for reading fluency correlated highly and significantly with SCO performance ($r = .73$, $p < .001$), as did average PR for word attack ($r = .67$, $p < .01$). Average PR for reading comprehension on the GORT-4 also correlated significantly, but more weakly, with SCO performance ($r = .55$, $p < .05$). One oral language measure, PR for Recalling Sentences on the CELF-4, also correlated significantly, but only weakly, with SCO performance ($r = .53$, p< .05).

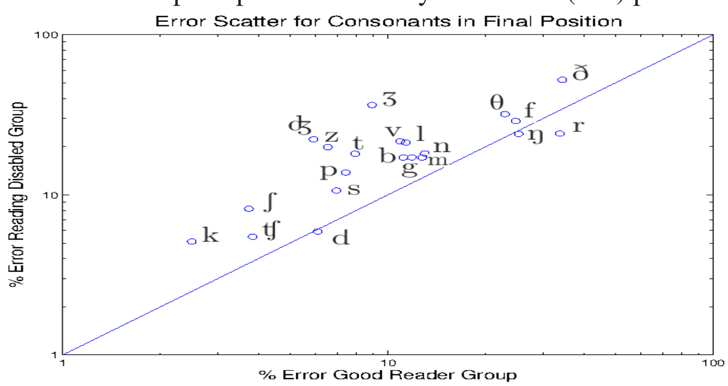

Figure 2: NSCM task final C error [log-%], RD vs. RC groups.

Figure 2 compares the RD vs. RC log-error on the NSCM VC task. Here the RD group has substantially greater error for most final Cs. Next, consonant confusion matrices were generated for each child. As shown in Fig. 3, RDs showed nearly twice as many confusions as RCs. Only severe errors (≥ 20%) are shown. Most confusions were for fricatives and affricates. The degree of confusions may be ordered as place, voicing, and finally manner being the least. Five confusion were shared by the groups, however the RDs had twice the final consonant error (15 confusions) as the RCs (7), including some confusions of nasals and plosives. This indicates more quantitative than qualitative group differences. Similar errors were evident in syllable-initial position, except that only fricatives and affricates were affected.

Conclusions: Children with RD have poor PP that relates to all aspects of reading, including fluency, decoding, and even comprehension. All children with RD perceived some sounds well, indicating that they could do the SCO task, and that poor performance on certain sounds was not due to a general auditory memory problem, but rather to selective difficulties with PP for certain Cs and Vs. Particular C confusions on the NSCM task were primarily for fricatives and affricates, with children in the RD group showing many more idiosyncratic confusion than the controls. Thus, our preliminary studies suggest that although children with RD do not experience extreme PP difficulty (i.e., they are well above chance on most sounds), they are significantly and measurably worse than the controls. *Cumulatively*, this increased *level* of confusions could well result in considerable difficulty when learning to reading. Patterns of confusion are child-specific (idiosyncratic), and thus would require identification on an individual basis, for effective intervention.

Feasibility of the Proposed Project: In our preliminary collaboration with The Reading Group center over more than a three-year span, we were successful in recruiting and running 17 participants. That collaboration continues, allowing the recruiting of participants for the proposed study. Children regularly attended our experimental sessions (generally twice a week), completing 23 sessions for both studies in 3 or 4 months. Having regularly-scheduled lessons at The Reading Group center (held immediately following experimental sessions) boosted attendance in our preliminary studies and allowed us to document the children's success in their concurrent reading intervention program. Consequently we have included funding for each participant's reading lessons at The Reading Group center in our proposed budget. Furthermore, the methods we have developed have been shown to be feasible. Children enjoy the experimental sessions, including snacks, short play breaks and a modest remuneration per session (all having IRB approval). The SCO and NSCM tasks appear to be a feasible way to define and measure PP, because overall performance was well above chance for all participants. Nor did performance

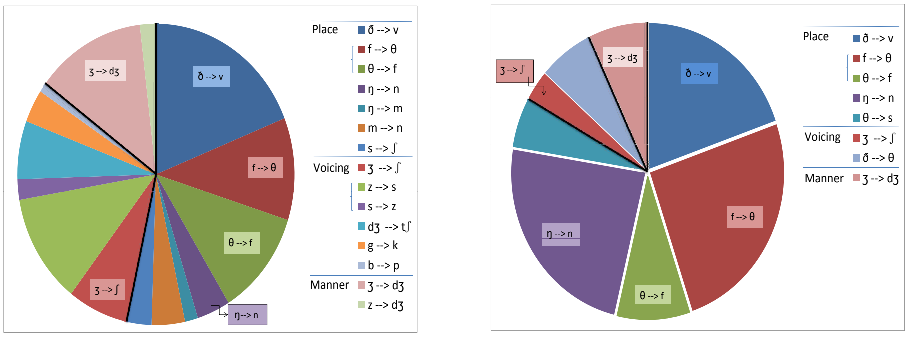

Figure 3: Distribution of sever C confusions in VCs, occurring $\geq$ 20% of the time for any child, for the RD group (left) and RC group (right). The RD group had 74% more $\geq$20% confusions in VCs ($N = 222$ judgments by 2 examiners for 9 children) than the RC group (N = 127 for 6 children).

appear to decline due to boredom or fatigue, as all RDs had target sounds with $<$ 20% error in both tasks.

Overall Strategy for the Proposed Project

Specifically designed tasks corresponding to each of the four hypotheses (H1-H4) are to be tested via a specific experiment, hierarchically organized to determine if poor PP contributes to memory and print difficulties. Each experiment includes RD and RC groups. Data sets for the two groups will be compared using repeated measures ANOVA and more general statistical tests, such as Fisher's exact test (Singh and Allen, 2012).

Methodology

Participants: Participants will be 39 children having documented RD and 30 RC children (good readers). All participants will be 8 to 12 years old, to ensure that they have had a number of years of reading instruction and have adult-like articulation, and to optimize the chances that they can do our experimental tasks.

Participants with documented histories of reading difficulties (RDs) will be recruited from The Reading Group center. Parents will be asked to fill out an extensive questionnaire about the child's physical, speech-language, and reading development; vision, hearing, and health; and educational history. Control children will be recruited from local schools and other community facilities, lab web site postings, and local newspaper announcements. Their parents should report no history of reading difficulties or any remedial services for reading. Control children will be paid $15 per session. For both the RD and control groups, two to three sessions will be devoted to a battery of standardized tests or protocols for hearing screening, nonverbal cognition (Matrices subtest, Kaufman Brief Intelligence Test-2), speech (Goldman-Fristoe Test of Articulation-2), language (Peabody Picture Vocabulary Test-4; Clinical Evaluation of Language Fundamentals-4; and a spontaneous language sample), phonological awareness (Comprehensive Test of Phonological Processing; and the Nonword Repetition Test, Dollaghan & Campbell,1998), and reading (Word Identification and Word Attack subtests, Woodcock Reading Mastery Tests-3; and the Gray Oral Reading Tests-5), administered by a graduate RA with an MA in SLP, under the supervision of Co-PI Johnson, a licensed and certified SLP. Most of these procedures are identical to our preliminary studies.

Data Collection: By providing funding for two lesson packs at The Reading Group center, we hope to secure regular, twice weekly attendance of children with RD at 1-hr experimental sessions (held in conjunction with the child's 1-hr reading lesson) and to thus document any progress in intervention. (We have been successful in this in the past at The Reading Group center.) Intervention plans and performance reports are provided by the child's reading teacher, at the end of each 10-session lesson pack. In our experience the nature and success of past and concurrent intervention is seldom documented in studies of children with RD. Thus we will collect current and past plans/reports for all participants with RD, to assist with data interpretation. All participants will be run at The Reading Group, or in our labs, in the Dept. of Speech and Hearing Science or the Beckman Institute, when appropriate.

In all tasks, the nonsense syllables will be drawn from the LDC database of 20 professionally recorded talkers as our preliminary studies (Fousek et al., 2004), and played from a laptop computer. The child will listen over headphones and wear a close talking microphone mounted on the head, to record responses. Participants will be assigned to one of three cohorts, on a rolling admission basis. Each cohort will consist of 13 participants with RD and 10 control children. Each cohort will participate in one experiment composed of two of the following tasks.

Combined SCO/NSCM tasks (H1: PP). The first task is a combined one and examines the nature of PP by measuring confusion between randomly presented CV or VC syllables. Data for each portion of the task will be collected on each trial: the SCO portion is similar to the one we used in our preliminary studies, only in the proposed project we have changed the number of comparison units in a trial from three to four, to set chance at 25%. In this task, the participant will listen to four syllables spoken by four different talkers. Three syllables will be the same and the forth will differ by one C or V, in either syllable initial or final position. The participant will use a touch-sensitive computer screen to indicate which of the CVs (1 to 4) is the "oddball." Sufficient trials will be presented to test all English Cs and Vs in both initial- and final-syllable position, with sufficient trials to be statistically significant at the α = 0.05 level, based on either ANOVA or Fisher's exact test.

To complete each trial, the participant will then repeat back the similar and dissimilar sounds. This portion is similar to the NSCM task used in our preliminary studies, but integrated into each SCO trial. The NSCM data will be used to form individual C and V confusion matrices. Immediately following the participant's SCO response, the computer software will turn on the head-mounted microphone and record the child's spoken responses. This is intended to provide accurate response time data. During the NSCM portion of a trial, the examiner will electronically record IPA symbols for Cs and Vs the participant spoke into the microphone. A second transcriber will also electronically enter transcription judgments. The SCO and NSCM tasks will help us to accomplish Aim 1, to measure the ability of children with RD to aurally perceive speech sounds, and Aim 2, to map out individual confusions for the two groups.

Memory task (H2: Short-term Auditory Memory). In this task, the duration of each of the SCO stimulus strings will be increased, to push the subject's phonetic memory limits. Thus, the SCO task will be replicated with CVCV and VCVC bisyllabic stimuli. Bisyllables will be created by combining individual syllables from our prerecorded database, with the constraint that the second syllable must contain both a different C and V than the first syllable. Statistically sufficient numbers of trials will be presented, to test all English Cs and Vs in syllable initial and final position, of both the first and second syllable of the bisyllables. (We have the option of testing triphones, i.e., CCVs, VCCs, and CVCs, as an alternative.)

Integration task (H3: Integration of Auditory and Visual Streams). In this task, participants will view a random printed string of four different nonsense syllables (all CVs or all VCs) on the computer screen while listening to an auditory version that differs in only one C or V. Here the task is to detect the point of mismatch between the auditory and visual signals and point to the corresponding letter or digraph in the visual display. Our hypothesis is that *the addition of the visual stream* will cause participants with RD to experience an *increased processing burden*, consequently their performance should decrease, whereas RC individuals should do well with the added visual input. Immediately after pointing, the participant will read the printed sequence aloud for recording. The examiner will have a matching copy of the print display on a second computer linked to the first and enter (in IPA symbols) or tag any errors made by the child, for later review.

Plasticity task (H4: Auditory Plasticity). In this task, participants will receive feedback when they make a perceptual or spoken error, to allow the participant to learn what she/he is doing wrong. Then we will compare the error rate pre- and post-feedback. The idea is to determine whether a simple training approach (i.e., merely providing feedback) will help a child improve her or his perceptual performance (indicating learning, i.e., demonstrating plasticity). It is important to demonstrate that training is possible, especially if we concentrate on the sounds for which the participant has the largest confusions.

In each of the four tasks, each child will be tested in 10-min blocks of approximately 20 to 30 trials, with four blocks per session and 5-min play breaks between blocks. Pacer items will be used to reward the child for each response (e.g., one bead on an abacus, one M&M, one penny, etc.). Pacer items allow the child to judge the remaining number of trials.

Experiments 1-3: The four tasks will be combined into three experiments as follows: **Expt. 1 (Cohort 1):** A combined (a) SCO/NSCM task for eight sessions will be followed by a (b) Plasticity task for eight more sessions. The only change between tasks will be the addition of feedback to the child about his or her response accuracy during the second task. Thus, this experiment tests whether training will improve a child's PP. **Expt. 2 (Cohort 2):** The combined (a) SCO/NSCM task will be followed by a (b) Memory task (eight sessions). The change between tasks will be in the total duration of the syllable string, i.e., in the Memory task, the four comparison slots in a string (trial) will be filled by bisyllables (i.e., CVCV or VCVC, with differing syllables in each bisyllabic nonsense word). Thus, this experiment tests whether poor PP in children with RD contributes to poor short-term auditory memory for speech. If children perceive some SCO sounds highly accurately, we will know that diminished perception of other SCO sounds is not simply due to a *general* short-term auditory-memory deficit. Thus, the apparent direction of causality will be that poor PP contributes to poor auditory memory, rather than vice versa. **Expt. 3 (Cohort 3):**The combined (a) SCO/NSCM task will be followed by a (b) Integration task (eight sessions). The change between tasks will be in the addition of print to the auditory signal and in the required response. In the Integration task, the child will be asked to detect the point of mismatch between the auditory stream and the print (rather than to detect an oddball syllable or imitate syllables, as for the SCO/NSCM task).

Data Analysis and Predictions

In all our tasks, even though participants are only asked to judge or imitate whole syllables, we will examine error rates for target Cs and Vs in our analyses. (During analysis, it is possible to separate out particular target Cs or Vs from the whole-syllable stimulus presentations, because the remaining parts of the comparison syllables are held constant, as in /fa fa ta fa/ or /ipəs ibəs ipəs ipəs/).

From the SCO portion of Expts. 1 through 3, we will determine each child's overall accuracy rate per target sound, as well as the slope of the child's accuracy per target across the eight sessions, including any plateaus or points of asymptote. We will prepare repertoires of speech sounds misperceived by each child ($\geq$ 10% error). These PP repertoires will be compared for the RD and RC groups. Eventually we aim to identify acoustic features in particular Cs and Vs that are misperceived by individual children with RD. From the NSCM portion of Expts. 1 through 3, we will prepare confusion matrices (CMs for target sound vs. responses). (If any child has consistent speech production errors for certain sounds on our assessment battery, trials for those sounds will be omitted from the NSCM analysis.). From these CMs, we will create logs of the proportion of total error represented by particular confusions (e.g., p $\rightarrow$ t), for each participant and group. We believe individual profiles are crucial for mapping the particular confusions experienced by a child with RD and for innovative planning of PP intervention.

A One-Between, Three-Within repeated measures ANOVA will be used to analyze PP accuracy (percent correct, with an arcsine transformation; a reaction-time measure is also possible), for the three cohorts combined. The Between variable will be Group (RD vs. RC) and the Within variables, task (SCO, NSCM), Speech Sound Type (C, V target) and Syllable

Position (initial, final). This will allow us to test the PP hypothesis (H1). We predict that the RD group will be less accurate than the RC group, and that consonants will be less accurate in syllable-final position. Similar ANOVAs will be used to compare accuracy across tasks in Expts. 1 and 2. In Expt. 1, Training (SCO or NSCM without or with training) will be a Within variable, to test the Plasticity hypothesis (H4). We predict that children with RD will improve their PP accuracy with training. In Expt. 2, Duration (short VC/VC syllabic strings in the SCO task or longer CVCV/VCVC bisyllabic strings) will be a Within variable, to test the Memory hypothesis (H2). We predict that PP will diminish with longer syllable strings for the RD group, but not for the RC group.

In Expt. 3, SCO performance will be used to determine which syllable initial and final C and V targets (24 and 15 targets, respectively) were Confused ($\geq$ 10% error) or Correctly Perceived by each participant, forming four sets of Cs and four sets of Vs. The dependent variable for the Integration task is the percent (proportion) of mismatches correctly detected. Following arcsine transformation, a repeated measures ANOVA will be used to examine PP. Here SCO Accuracy will be a Within variable (confused vs. correctly perceived sounds), allowing us to test Integration (H3). We predict that that the RD group will fail to detect sounds confused on the SCO task more often than those correctly perceived, and that the RD group will detect fewer mismatches than the RC group. Thus, this experiment will test whether poor PP contributes directly to reading difficulty. This analysis will be repeated for the read-aloud portion of the task. Again, we predict that children with RD will make errors that mirror their confusions on the SCO task. MANOVA will be used to compare error measures on the SCO and NSCM tasks to the clinical measures collected in our reading, speech, language, and cognitive assessment battery, for the RD and RC groups.

For all children with RD, we will collect past and current intervention plans and final performance reports for lessons provided by The Reading Group center. We will review these for the top and bottom quartiles of each cohort, to assist in interpretation of performance on the experimental measures. We will determine number of years of reading and reading-related intervention, and examine teachers' estimates of the child's reading level at the beginning of each session block during the proposed study; the portion of intervention planned for word identification, word attack (reading decoding), reading fluency, reading comprehension, spelling or writing, phonemic awareness, and listening comprehension; and any progress made. These qualitative descriptions may lead to quantitative measures that can then be analyzed statistically.

Management Plan We estimate it will take 3 to 4 months, with twice weekly sessions, to collect data for each participant (total $\approx$ 19 sessions, depending on the child's ability to complete each session as scheduled). We anticipate running Expt. 1 (Cohort 1) and beginning Expt. 2 during the first year (due to yearly funding limits), and running Expts. 2 and 3 (Cohorts 2 and 3) simultaneously during the second year. Data processing will overlap with the sessions. Statistical analysis will be done as the data are collected, with the final analysis for the three cohorts done during the last 3-4 months of the second year. Regarding **Resource Sharing**, we will make our data available by posting them on the Internet within 2 years of publication. Table 1 provides **Benchmarks** and a **Timetable**.

Benchmarks for Success	**Year 1** (in quarters)				**Year 2** (in quarters)			
(C1 = Cohort/Experiment 1, etc.)	**Qt 1**	**Qt 2**	**Qt 3**	**Qt 4**	**Qt 1**	**Qt 2**	**Qt 3**	**Qt 4**
Software development	C1	C2,3	C2,3	C2,3				
Recruitment, Assessment Battery	C1	C1	C1	C2	C2,3	C2,3	C2,3	
Data Collection	C1	C1	C1	C1,2	C2,3	C2,3	C2,3	
Data Processing			C1	C1	C2,3	C2,3	C2,3	C2,3
Analysis				C1	C1		C2,3	C2,3
SCO/NSCM All Cohort Analysis								C1-3
Dissemination								C1-3

Table 1: Benchmarks for Success–Timetable.

Potential Problems and Alternative Strategies (see also **Feasibility**). Should we not recruit enough participants with RD from The Reading Group center, alternate possibilities are the University of Illinois Speech-Language Clinic, or our Office of School-University Research Relations (which assists in identifying schools and other community agencies willing to participate), and lab website postings or newspaper announcements. We will keep track of the balance of race/ethnicity, dialect, and family socioeconomic status through our intake questionnaire as we recruit each cohort, and do our best to match the RD and RC groups, and our three cohorts. Minorities tend to be over represented in RD children. We also will monitor children during longer tasks, to prevent children from becoming discouraged with the task. One alternative for design of the Memory task is to use a string of four triphones (CCV, VCC, CVC) rather than four bisyllables. Another potential problem is seasonal colds and allergies that might affect hearing. Our strategy is to reschedule sessions if a child shows acute symptoms, and re-screen hearing before sessions resume. Last is the possibility that participants may choose not to complete the entire experiment. In our design, all three experiments begin with the SCO/NSCM task. Therefore, as long as the child completes the first eight sessions, we will have usable data for some of our PP analyses.

Protection of Human Subjects

Risks to the subjects

Through Co-PI Allen's previous speech perception research, it has been established by the University of Illinois IRB committee that the risk to the subjects in this experiment is minimal. The most serious concern would be high levels of sound delivered over earphones. This possibility is easily avoided by hard-limiting the upper level. By its very nature, the upper levels of the laptop computers used in these experiments do not put out high levels of sound (max of 1 volt RMS). High levels of sound are not required for the experimental conditions, which are all presented in quiet. Furthermore, the sound level is monitored by a trained experimenter running each session.

Human subjects involvement and characteristics: The parameters of the human subject involvement is spelled out in some detail in the IRB forms. Specifically, all participation will be strictly voluntary and will follow written informed consent from children's parents/guardians and potential child subjects. Subjects and their families will be free to stop participating or withdraw at any time without penalty or prejudice to their relations with the University of Illinois or the Reading Group center. Participation will require approximately 19 sessions (3 assessment sessions, and two 8-block experimental sessions), each of which will be one hour in duration (broken into 10-min blocks of trials, with 5 min play breaks between blocks). The child's comfort with the experimental tasks will be monitored throughout a session.

The test signals will be played using the high quality earphones. Participants will be asked to adjust the level of signals that they hear over earphones so that it is at a "comfortable listening" level.

Potential risks: None are known.

Adequacy of protection against risks:

The upper levels of the sound are limited by the sound card in the laptop computer and by the type of earphones used. We instruct the subject that if they feel the sound is too loud, to stop the experiment and inform the person running the experiment. The same is true if the child becomes tired of the task.

Assessment batteries for reading, speech, language, hearing, and nonverbal cognition will be administered by clinically trained, speech-language pathologists, who hold Masters degrees in the field.

Recruitment and informed consent: Standard IRB procedures have been followed in Co-PI Allen's previous speech perception research and our preliminary studies for the proposed project, and will continue to be followed. The University of Illinois Beckman Institute and Dept. of Speech and Hearing Science and our collaborator, The Reading Group center, will be fully informed on the necessary approvals from the University IRB committee, as required. Written informed consent will be obtained from childrens parents/guardians and potential child subjects.

Protection against risk: The subjects are instructed to stop the experiment if they find the sounds too loud, and not to proceed. This is in the written instructions, and verbally explained to the subjects. All data collected (including original assessment data forms) will be identified only by an assigned name and subject number and kept in the locked laboratories of the PIs, in the Dept. of Speech and Hearing Science, and the Beckman Institute. The key linking the subject to her or his identification label will be destroyed at the end of the study.

Potential benefits of the proposed research to the subjects and others

There are several potential benefits: (a) results of the assessment battery may help the child's family understand the child's reading disability, (b) the experimental training condition may result in improved speech perception and possibly benefit the child's reading, (c) 20 concurrent reading lessons at The Reading Group will be funded by this research and may also result in reading improvement for the child, and (d) the control subjects will receive a small amount of remuneration ($10 per session, for 23 sessions).

Importance of the knowledge to be gained

If successful, it may be possible to help with reading intervention during the experiment, since we will be testing for this possibility. The knowledge gained from the study is intended to improve our understanding of aural sensory difficulties that may underlie poor phonemic awareness and, ultimately, reading disabilities.

Inclusion of Women and Minorities

The studies have a special and small population (children with reading disabilities). Because of the small size of the population, it is not always possible to strike an ethnic balance in the test population. It is well know that children with a reading disabilities have a more frequent representation in the low income, minority population. Thus we expect, and have already experienced, a larger than average minority population in our preliminary experiments.

There is no language requirement in these experiments, thus the subjects' first language or dialect does not impact their ability to participate.

Inclusion of women

By design, half of our subjects will be male, and half female.

Inclusion of minorities

No subject will be eliminated on the basis of race or ethnic group.

Targeted/Planned Enrollment

A total of 69 subjects will be required for this study.

Participants will be 39 children having a documented reading disorder, and 30 control children (good readers). All participants will be 8 to 12 years old, to ensure that they have had a number of years of reading instruction and have adult-like articulation, and to optimize the chances that they can do our experimental tasks.

The 39 participants with documented histories of reading difficulties (RDs) will be recruited from The Reading Group center. Parents will be asked to fill out an extensive questionnaire about the child's physical, speech-language, and reading development; vision, hearing, and health; and educational history.

The 30 control children will be recruited from local schools and other community facilities, lab web site postings, and local newspaper announcements. Their parents should report no history of reading difficulties or any remedial services for reading.

For both the RD and control groups, two to three sessions will be devoted to a battery of standardized tests or protocols for hearing screening, reading, speech, language, phonetic awareness and nonverbal intelligence.

co-PIs: Allen, Jont B. & Johnson, Cynthia

Targeted/Planned Enrollment Table

Study Title: Children with Reading Disabilities – years I/II, 8-12 years old

Total Planned Enrollment (I/II): 39

Ethnic Category	Females	Males	Total
Hispanic or Latino	0	0	0
Not Hispanic or Latino	20	19	39
Ethnic Category: Total of all subjects	20	19	39
Racial Categories	Females	Males	Total
American Indian/Alaska Native	0	0	0
Asian	0	0	0
Native Hawaiian or other Pacific Islander	0	0	0
Black or African American	10	10	20
White	10	9	19
Racial Categories: Total of All Subjects	20	19	39

Study Title: Normal Reading Control Children – years I/II, 8-12 years old

Total Planned Enrollment (I/II): 30

Ethnic Category	Females	Males	Total
Hispanic or Latino	2	2	4
Not Hispanic or Latino	13	13	26
Ethnic Category: Total of all subjects	15	15	30
Racial Categories	Females	Males	Total
American Indian/Alaska Native	0	0	0
Asian	0	0	0
Native Hawaiian or other Pacific Islander	0	0	0
Black or African American	5	5	10
White	10	10	20
Racial Categories: Total of All Subjects	15	15	30

Inclusion of Children

This research entirely about reading in children, thus by design, children necessarily comprise 100% of subject population.

Multiple PI Leadership Plan

This study has two co-PIs, Prof. Allen and Prof. Johnson.

We have been working together on preliminary research for the proposed study since 2005 (7 years), and there has never been any conflict. We know each other well enough that we are sure there will be no conflict in the future. The two PIs have one common goal: to create deep insight into reading disorders in children. Our working relationship is mutually supportive.

Prof. Johnson manages the data collection and processing for the experiment with the children, with the help of her Speech and Hearing Science graduate and undergraduate students. Consequently the major portion ($178,605) of the Total Direct Costs is allocated to her, primarily as support for a GRA and a group of undergraduate students who will assist in running the 39 subjects (23 sessions each).

Prof. Allen manages the programming of the computers, required to present the stimuli, and take and analyze the data; and does a major part, but not all, of the data analysis. Some of the finer statistical points of the analysis are performed by Prof. Johnson. The speech database is managed by Allen, as are the computer programs to collect and analyze the data. Consequently, $96,395 of the Total Direct Costs is allocated to him, primarily as support for a GRA to assist with computer programming.

Most of the time the PIs are attending to the graduate students involved in the project. Once a week we all meet to review the status of the project. These meetings are always professional and productive. It is in these weekly lab meetings that we reach consensus and make decisions on scientific direction for the project. Based on the last 7 years of closely working together, there is no sign of a need for a conflict management plan. This working relationship has always been very smooth and is a relationship built on trust and respect.

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PHS 398 Checklist

OMB Number: 0925-0001

1. Application Type:

From SF 424 (R&R) Cover Page. The responses provided on the R&R cover page are repeated here for your reference, as you answer the questions that are specific to the PHS398.

* Type of Application:

[X] New [ ] Resubmission [ ] Renewal [ ] Continuation [ ] Revision

Federal Identifier: GRANT11164037

2. Change of Investigator / Change of Institution Questions

[ ] Change of principal investigator / program director

Name of former principal investigator / program director:

Prefix:
* First Name:
Middle Name:
* Last Name:
Suffix:

[ ] Change of Grantee Institution

* Name of former institution:

3. Inventions and Patents (For renewal applications only)

* Inventions and Patents: Yes [ ] No [ ]

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

* Previously Reported: Yes [ ] No [ ]

Tracking Number:GRANT11164159 Funding Opportunity Number:PA-11-261 Received Date:2012-06-18T10:57:59-04:00

4. * Program Income

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)

5. * Disclosure Permission Statement

If this application does not result in an award, is the Government permitted to disclose the title of your proposed project, and the name, address, telephone number and e-mail address of the official signing for the applicant organization, to organizations that may be interested in contacting you for further information (e.g., possible collaborations, investment)?

☒ Yes ☐ No

Tracking Number:GRANT11164159 Funding Opportunity Number:PA-11-261 Received Date:2012-06-18T10:57:59-04:00