PROGRAM PLAN
A. BACKGROUND

A.1. Vision & Goals of Program. Whether in spoken, signed, or written form, communication is fundamental to the human experience. There are many ways communication can break down: as a consequence of hearing loss, as a result of developmental disorders such as autism, dyslexia (also commonly referred to as reading disability), or developmental language disorder (DLD), or as a function of acquired disorders such as aphasia or traumatic brain injury (TBI). Taken together, these disorders have an enormous societal impact, affecting millions of adults and children (Baio et al., 2014; Beitchman et al., 1986; Frost et al., 2013; Habib & Giraud, 2013; National Institute on Deafness and Other Communication Disorders, 2015), at a cost of over $500 billion annually (Ruben, 2000). Many of the most exciting developments in research on communication disorders have come about due to a more sophisticated understanding of the neural structures and functions that underlie disordered communication, and this progress is only possible because of the advent of neuroimaging techniques. For instance, new research in reading disorder (Hoeft, McCandliss, et al., 2011), autism (Bosl et al., 2018; Eigsti et al., 2016), and aphasia (Crinion & Leff, 2007) seeks to predict an individual's response to treatment from functional activation patterns or on the basis of structural variation in the brain. Auditory brainstem responses (ABRs) have been in wide-scale clinical use for nearly 30 years as an objective measure of newborn hearing (Hood, 1998) and spurred by recent, transformative discoveries in animal models of noise exposure, the field is experiencing an upsurge of interest in ABRs and their potential to detect the earliest, pre-clinical stages of noise-induced hearing loss (Liberman & Kujawa, 2017; Mehraei et al., 2016; Skoe & Tufts, 2018). Neuromodulation techniques (tDCS, TMS) are being investigated as adjuvant therapies that modulate treatment outcomes for people with aphasia (Richardson et al., 2015). While significant progress has been made in understanding the underlying mechanisms that affect communication in these various conditions, and in developing assessment and treatment strategies, progress is slower than it could be because of significant gaps in training of new **communication scientists.** The current training plan seeks to fill these gaps by providing targeted training in the cognitive neuroscience of communication disorders, more meaningful connections between trainees and the clinical populations they study, and by preparing this generation of trainees with the necessary set of professional tools to conduct and disseminate impactful research.

One gap in training is that scholars rarely have the opportunity to conduct *independent trainee-led research* using imaging methods because of the expense of using these methods, and the extended learning curve in acquiring imaging skills. This is true even in our own programs, where faculty have substantial strengths in typical and atypical language (studying populations with aphasia, apraxia, autism, cochlear implants, reading disorder, SLI/DLD, and neurotoxic exposures) as well as expertise in a host of cognitive neuroscience techniques (fNIRS, ABR, EEG/ERP, MRI, TMS, tDCS).

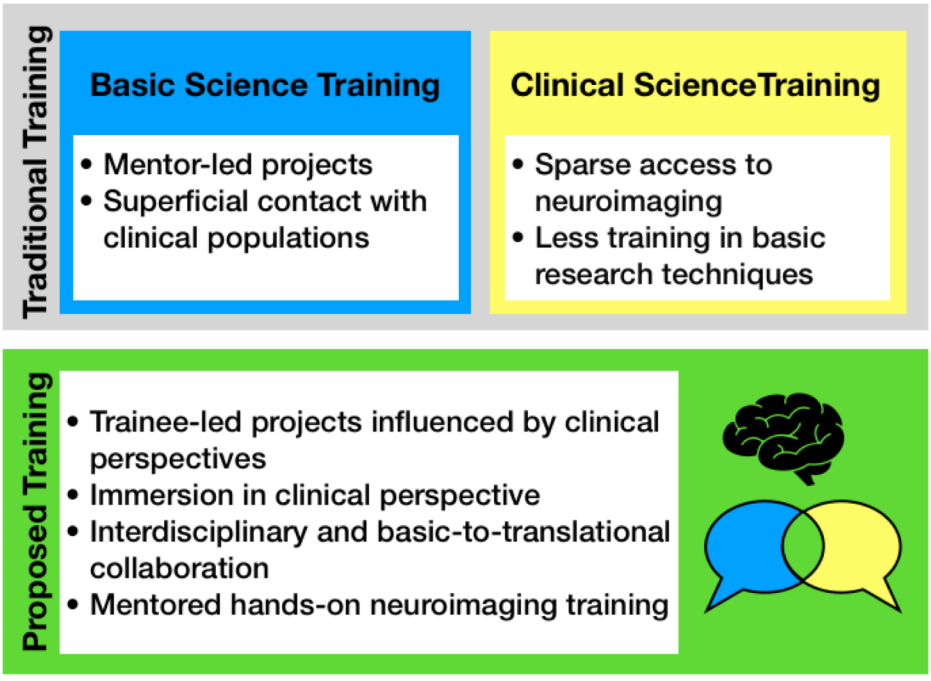

Figure 1. Value-added nature of proposed training program

Scholars who receive training in cognitive neuroscience rarely have contact, access or training with clinical populations. Further, **scholars training to work with clinical populations generally gain little expertise with the cognitive neuroscience tools and methods of the proposed training program**. This disconnect between methodological vs. clinical experience presents a cultural barrier to progress. The need for increased pathways to translational research is a common theme at NIH, where the Biomedical Research Workforce Working Group (2012) recommended that pre- and postdoctoral training programs enhance translational content in order to accelerate translation and to prepare trainees for a variety of careers. Training individuals to develop

clinical applications from clinical research is obviously essential; but equal or possibly greater acceleration can be achieved by training mixed teams of basic scientists and clinical researchers to work at the basic-clinical and cognitive-biological interface. By co-training clinical and basic scientists in the same program, we would be preparing them to see translation as 'normal', integral to the research process, and informative about models of development and change, and to typical processes of language acquisition and language processing.

The current training program, *Training in the Cognitive Neuroscience of Communication,* seeks to redress this imbalance by providing unique, targeted coursework and mentored research experiences to predoctoral and postdoctoral trainees at the University of Connecticut (UConn) and its affiliated centers. Through institutional support to our trainees, we can provide full access to imaging methodologies (MRI, ERP, fNIRS, TMS), enabling trainees to conduct mentored projects using imaging methods. The next generation of scientists working towards better treatment strategies and towards better understanding of the fundamental processes underlying human communication will need to be armed with this special set of tools to investigate typical communication and communication disorders, and will need to master a comprehensive knowledge base that is both broad and deep. The aim is to put trainees (and faculty) in direct contact with practitioners, paving the way for research that integrates practitioners and basic scientists, and accelerating the research-to-treatment feedback cycle. Rather than training translational specialists, we seek to inculcate a translational and collaborative orientation in trainees (**Figure 1**).

			Methodological Expertise				
Faculty	Program	Clinical population	EEG/ERP	MRI	Eyetracking	Other	Research foci
Skoe	SLHS	bilingualism, hearing impairment	✓	(✓)			Neuroplasticity of the auditory system
Theodore		DLD		✓			Perceptual learning and phonetic variability in language acquisition
Myers	SLHS/ PAC	aphasia	(✓)	✓	✓	TMS	Cognitive neuroscience of speech perception
Aslin	PAC	bilingualism	✓	✓	✓	fNIRS	Language acquisition, statistical learning and spoken word recognition
Hancock		reading disorder	✓	✓		TMS/tDCS, MRS, MEG	Language and auditory processing
Hoeft		reading disorder		✓		genetics, TMS, DWI, MRS	Neurobiological mechanisms of the acquisition of reading skills
Magnuson		DLD	✓	✓	✓	computational	Neurobiology of language understanding and acquisitino
Rueckl		reading disorder		✓		computational	Reading acquisition, individual differences
Eigsti	CLIN	autism, Deafness		✓	✓	genetics	Language plasticity, neural circuitry of language
Fein		autism		✓			Neuropsychology, long-term outcomes, early detection and diagnosis, parent intervention
Landi	DEV	Specific reading comprehension disorder, autism	✓	✓	(✓)	genetics	Cognitive neuroscience of reading disorder

Figure 2. Research foci, methodologies, and primary clinical foci of participating faculty. Additional areas of expertise are listed in the text.

Our **interdisciplinary team** is uniquely positioned to help trainees arrive at a deepe understanding of communication disorders, and to make progress in developing treatment and assessment strategies for these disorders[1]. As shown in **Data Table 2** and detailed in **§B.2 (see also Figure 2),** this team includes faculty from the Clinical division of Psychological Sciences (CLIN): **Inge-Marie Eigsti** (MPD), and **Deborah Fein**; from the

[1] Throughout, we use **bold** to highlight the mentors included in our core team, and *italics* to highlight the many local members of the research community who will have a role in the training program.

Perception, Action, and Cognition (PAC) division of Psychological Sciences: **Richard Aslin** (Research Professor, joint with Haskins Laboratories), **Fumiko Hoeft** (joining UConn in August, 2018), **Roeland Hancock**, **James Magnuson**, and **Jay Rueckl**; and from the Developmental (DEV) division: **Nicole Landi**. Finally, we include mentors from Speech, Language, Hearing Science (SLHS): **Rachel Theodore**, **Erika Skoe**, and **Emily Myers** (MPD; joint with PAC)**.** Our team's expertise encompasses a variety of clinical populations (hearing loss: **Skoe**, aphasia: **Myers**, DLD, language impairment: **Theodore, Landi, Magnuson**, reading disorder: **Hoeft, Landi, Rueckl, Magnuson, Hancock**, and autism: **Eigsti, Fein**). We also have expertise in a diversity of methods for studying these disorders (MRI: **Eigsti, Fein, Hancock, Hoeft, Landi, Myers, Rueckl, Theodore;** EEG: **Aslin**, **Hancock, Hoeft, Landi, Magnuson, Skoe;** TMS: **Hoeft**; fNIRS: **Aslin;** computational modeling: **Magnuson, Rueckl; and** eyetracking: **Aslin, Landi, Magnuson, Myers**). Finally, this team represents a spectrum of approaches to the study of communication, from scientists who conduct **fundamental research** to describe and model the cognitive and neural architectures that support communication (e.g.,Emberson et al., 2017; Hancock et al., 2017; Jasińska et al., 2016; Rueckl et al., 2015; Schuh et al., 2016; Skoe et al., 2016; Xie & Myers, 2018), to those who engage in **clinical applications of this knowledge** (e.g.,Collisson et al., 2015; Hoeft, Walter, et al., 2011; Kornilov et al., 2015; Landi et al., 2017; Mirman et al., 2011; Mozeiko et al., in press; Song et al., 2012).

Our training program is built on three premises. **First, true progress ameliorating communication disorders cannot be accomplished without a thorough understanding of the neurobiological mechanisms that underlie atypical as well as typical communication**. The next generation of scientists will need training in cognitive neuroscience to understand the architectures and mechanisms that support *typical* language, and will also need to understand how this system goes awry in *disordered* populations. By itself, this focus is not novel: coursework in neuroscience is included in many PhD programs in Psychology and Speech, Language, and Hearing Sciences. A key innovation of our proposal is its focus on providing trainees with both formal and hands-on experience with cutting-edge tools to answer questions about the neuroscience of communication: ERP, fNIRS, TMS/tDCS, and MRI. Trainees will apply these methods in mentored research projects using neuroimaging methods to investigate typical and atypical communication.

The second premise is that fundamental science and clinical science are both vital ingredients to research progress whether the scientist is asking questions about typical or atypical communication. In the same way that a mechanic fixing an engine needs to understand how the pieces of that engine fit and operate together, in order to understand why communication breaks down, trainees need to understand the cognitive and neurobiological architectures that support *typical* communication (Emberson et al., 2017; Kadam et al., 2016; Kutas & Federmeier, 2011; Myers & Blumstein, 2005; Myers et al., 2009; Myers & Theodore, 2017; Schuh et al., 2016; Skoe et al., 2016; Song et al., 2012; Xie & Myers, 2018). Conversely, scientists who are interested in typical communication architectures can learn much from *atypical* communication, just as the apprentice mechanic can learn about the functions of the carburetor by seeing how the car functions when that component malfunctions. For instance, as cognitive scientists first began to create models of typical language architecture in the 1950s and 60s, the patterns of deficits seen in the aphasia syndromes provided key insights (Dronkers et al., 2017), and the patterns of deficits in individuals with reading disabilities have been informative to researchers building models of typical reading (Myers et al., 2014; Wachinger et al., 2018; Yu et al., 2018). Our trainees will become familiar with psycholinguistic models of typical language and reading, as well as with speech, hearing, language, and reading disorders, giving them the basic foundation that future coursework and training can build on as they develop their specialty areas.

Third, researchers need to ask questions that have the highest likelihood of helping people who suffer from communication disorders. We propose that direct, structured interactions with children and adults with aphasia, reading disorder, autism, hearing impairment, and language impairment (and their family members) will help trainees to truly understand the every-day impact of these disorders on the real people that experience them. By bringing to life the complex social, cognitive, and societal factors implicated in communication impairments (Achenbach, 1990; Cicchetti, 1993), the proposed training will prepare these future scientists to confront and address the complexities of diagnosis and treatment in the real world (Mezzich & Salloum, 2008; Tanaka et al., 2011; Wilson et al., 2001). For instance, there has been a recent recognition that social (family support; Hilari & Northcott, 2006) and cognitive (memory, attention; Gravier et al., 2017) variables are as much predictors of treatment outcomes as the type of treatment itself. Further, mentorship from expert clinicians who work with these populations on a daily basis can help our trainees to identify gaps in the knowledge base supporting basic and applied research. The aim is not to turn basic scientists into clinicians, or to provide redundant clinical experience to those who are already pursuing a clinical degree. Rather, we suggest that to learn to ask the "right" questions about communication disorders -- the questions

that have the highest probability of leading ultimately to interventions for communication disorders -- the new communication scientist needs to be mindful of the end goal: making daily life better for people who experience communication disorders, and their families. We hope to pave the way for trainees to collaborate with translational scientists to achieve this goal. As we describe below, the expertise of trainees in the proposed program will be enhanced by a unique **Clinical Connections Proseminar developed specifically for this training program,** required both semesters of the first year, and revisited as relevant in the second year. This practicum is designed to introduce trainees to the research base on communication disorders, to allow them to interact with people who experience these conditions, and to open pathways to mentorship from expert clinical faculty members, which will be further customized for each trainee in the Clinical Connections portion (see **§B.3.a**) of his/her Individualized Development Plan (IDP).

Over the life of the grant, ten predoctoral and five postdoctoral scholars will each participate in a two-year training program on the *Cognitive Neuroscience of Communication***.** The Objectives of this program are to **capitalize on strengths in the neurobiology of speech, language, hearing, and reading in order to:**

1. Train communication scientists in the cognitive neuroscience of typical and atypical communication.
2. Equip trainees with knowledge of cutting-edge human neuroscience techniques (MRI, EEG, TMS/tDCS, EEG/ERP), with exceptional access to experts in these techniques as well as hands-on, mentored research projects employing these methods.
3. Bring the scientists closer to the clinical populations they study through structured, meaningful interactions with community stakeholders.
4. Position trainees for careers in research by supporting grant-writing skills and other professional development activities.

	Theodore	Skoe	Rueckl	Myers	Magnuson	Landi	Hoeft	Hancock	Fein	Eigsti
Aslin			A(1)		A, G(2*), C(3)	A(1)	A(1)			A(1)
Eigsti	A(1), C(1)	A(1), G*(1)	A(1)	A(1),G(1), C(1)	A(1), C(1)	A(1)			A(2), G(2*), C(17)	
Fein	A(1)	A(2)	A(1)	A(1)	A(1)	A(1)				
Hancock		C(1)	C(1)	C(1)		A(1), G(1)	A(3), C(8), G(2)			
Hoeft			A(2), C(2), G(1)	A(1)	A(1)	A(1), C(5)				
Landi	A(2), C(1)	G(1)	A(3), G(1*), C(3)	A(2), G(1*), C(2)	A(2)		*Co-mentorship of F31/F32 recipient			
Magnuson	A(2), G(4)	A(1)	A(3), G(4), C(3)	A(2), G(2), C(1)			co-participant in IGERT/NRT training grants (Magnuson, PI)			
Myers	A(2), G(5), C(5)	A(2), G(6), C(1)	A(3), G(2*)				co-participants in Haskins P01 award (Rueckl, PI)			
Rueckl	A(1)	A(1)					participants in both P01 and NSF IGERT or NRT			
Skoe	A(2), G(4), C(1)						co-participants in NIRS equipment grant (Aslin, PI)			

Figure 3. Collaborations between participating faculty. Key: A = funding application (number of funded grants); C = collaboration (number of publications), G = grad student (number of trainees). Three large-scale grant efforts involved many members of our team. Two NSF training awards (IGERT and NRT; blue) had participation from multiple mentors. A P01 award to Haskins laboratories (**Rueckl**, PI) involved four faculty (yellow; green=faculty who participated in both NSF training awards and the P01). *co-mentorship of F31 or F32 recipient

A.2 Relationship between proposed training program and current training activities

Trainees will benefit from UConn's thriving communication science community. Approximately 40 full-time tenure-track research faculty, housed across the Departments of Psychological Sciences, Linguistics, and Speech, Language, and Hearing Sciences, study some aspect of speech, language, or hearing. Members of this community interact regularly, attending colloquia in their home departments and in the interdisciplinary Cognitive Science program; students lead a weekly language science brown-bag series ("Talk Shop") that

draws 30-40 students, postdocs, and faculty, and an annual "Language Fest" conference with over 100 undergraduate and graduate students, postdocs, and faculty participating. Communication science researchers represent the largest group within the CT Institute for the Brain and Cognitive Sciences (IBACS), and IBACS provides important support for research and training via seed grant funding and infrastructure (support for shared labs focused on electrophysiology, neuroimaging, and murine research).

The boundaries between existing graduate training programs are already fairly porous. Graduate students are often co-advised; students take courses in other departments, and there are already multiple graduate student and faculty research collaborations (see **Figure 3**). UConn's vibrant interdisciplinary training culture was jump-started by a 2008 NIH American Recovery & Reinvestment Act (ARRA) P30 award, which led to the hire of MPD **Myers** as well as *Marie Coppola*, and was further stimulated by the receipt of a 2012 NSF IGERT grant (**Magnuson**, PI) on the topic of *Neurobiology of Language.* This training program included foundational, cross-disciplinary coursework in genetic, neurobiological, cognitive, and computational approaches to the study of language. Although the program no longer receives NSF funding (it is in a final year of no-cost extension), the Neurobiology of Language program continues to thrive as a graduate certificate program (and sponsors the annual Language Fest). In 2017, members of our community, again led by **Magnuson**, secured an NSF Research Traineeship (NRT) grant on *The Science of Learning and the Art of Communication,* broadening the focus of training efforts beyond language sciences. MPDs **Eigsti** and **Myers** are key personnel on the NRT, and **Skoe** and **Landi** are mentors of NRT scholars; these grants are captured in **Data Table 3**. The Neurobiology of Language and NRT programs offer a scaffolding on which the current T32 proposal builds. For instance, one of the elective courses in the proposed training program, Cognitive Neuroscience of Language Across the Lifespan, is a foundational requirement from the Neurobiology of Language certificate program. Professional development activities, outlined in **§B.3.b**, from the NRT will also serve our trainees; and we expect that our trainees will capitalize on the collaborative culture that characterizes the Neurobiology of Language and NRT programs.

Nonetheless, the goals of these two training programs differ substantially from the proposed T32, which includes specific "value-added" components. For example, the Neurobiology of Language graduate certificate program is entirely coursework-based. Students who pursue this curriculum receive no funding to help them extend coursework to the lab. In the proposed training program, coursework is designed to fit flexibly into current graduate programs without extending time-to-degree; students will develop individualized development plans (IDPs; see **Appendix** for blank IDP) that include customized curricular plans and tailored clinical experiences to provide them with the skills and knowledge base to support a mentored, individual research project. The goals of the NRT, as mentioned previously, overlap to some extent with goals of this training program: in both, we recognize that positioning trainees for successful research careers requires training in grant writing, research ethics, data stewardship, and science communication.

However, the research emphasis of the NRT (*science of learning*) is rather different than the focus of this T32 (*typical and atypical communication*). The proposed T32 training grant builds on the momentum and infrastructure of these earlier training efforts, but allows us to turn our focus to training goals that are unique to the current proposal, namely **methodological training in neuroimaging techniques**, and **contact with people from clinical populations** and other stakeholders (clinicians, family members).

At UConn, there is an existing T32-funded training program (T32-MH074387), "*Training in Social Processes of HIV/AIDS,*" awarded to the Dept. of Psychological Sciences (Kalichmann, PI). None of the faculty on the current proposal have any connection to the existing T32, and there is *no* programmatic overlap. Beyond UConn, there are two current NIDCD-supported T32 programs that are similar to current proposal (U S. California's *Training in Hearing and Communication Neuroscience* and San Diego State's *Neurocognitive Approaches to Communication Disorders*. The three programs are superficially similar in the aim to inform clinically-oriented researchers with deeper understanding of the component processes in communication. However, our program is unique in its targeted focus on human *cognitive neuroscience methods*, particularly providing training and access to neuroimaging.

In summary, the current proposal is designed to add value to standard training in Communication Sciences and Cognitive Neuroscience at UConn, via a number of elements that are unique to the current proposal. The keystone of the proposal is the *Clinical Connections Proseminar*, which will broaden our trainees' perspectives, helping them to become more mindful of the concerns, symptoms, and experiences of individuals with communication disorders. In contrast to the typical graduate student or postdoc, our trainees will develop and carry out a mentored, *trainee-led* research project using MRI, EEG, TMS/tDCS, fNIRS, or other neuroimaging tools. Beyond these experiences, that go above and beyond "business as usual" training, our predoctoral and postdoctoral trainees will complete a *Professional Development* seminar, the *Research*

Design Studio, and trainee-organized "J-term" workshops, completing a package of training elements that are not typical within our PhD programs nor typical of the pre- or postdoctoral experience at UConn (or most institutions).

A.3. Participating Degree Programs

Our trainees are drawn from four graduate training programs. Two are focused on clinical populations; **CLIN** trainees earn Clinical Psychology degrees that prepare them for clinical science and practice, and **SLHS** trainees are in pursuit of a research degree, but may also have clinical degrees (or be pursuing such degrees) as speech-language pathologists or audiologists. In our other two programs (**DEV**, **PAC**), many students and faculty conduct research with clinical populations, but without necessarily having training with or exposure to these populations. Postdoctoral trainees will likewise arrive with expertise in either fundamental science or clinically-oriented science. Our program is designed to meet the needs of trainees from diverse backgrounds, by connecting them with mentors and skills that run the gamut from clinically-applied to basic science.

Research Training Activities of Participating Programs. The four participating programs (**SLHS**, **DEV**, **PAC**, and **CLIN**) are highly active in training PhD students and postdoctoral fellows. As shown in **Data Table 1**, the programs encompass 42 faculty (of whom 22 are actively studying language and 22 study clinical populations and disorders; there is partial overlap across these lists). Our 11 mentors currently advise an average of three predoctoral trainees each (**Data Table 1**: 28 total, 26 of whom would have been eligible as trainees for this proposal), and are currently mentoring four postdoctoral fellows. These mentors serve also as secondary advisors to multiple additional students. In total, our team has mentored 38 predoctoral and 23 postdoctoral trainees in the past 10 years with between 80% (predoctoral) and 94% (postdoctoral) continuing in research-active careers (19% have gone into primarily clinical careers).

A.4. Participating Faculty Members

Several important foci unite the 11 faculty participating in this T32. **First**, each mentor is engaged in research on the neurobiology of communication, with expertise in a range of imaging modalities and levels of the communication system: hearing (Skoe & Tufts, 2018), phonology (Myers & Theodore, 2017), lexical access (Magnuson et al., 2007), semantics (Landi & Perfetti, 2007; Rueckl et al., 2015), reading (Landi et al., 2010; Rueckl & Raveh, 1999; Skoe et al., 2017). **Second**, each mentor's research has direct or indirect impacts on clinical application, serving an ultimate goal of developing better clinical and educational interventions for communication disorders (e.g.,Mozeiko et al., in press; Mozeiko et al., 2015; Orinstein et al., 2014; Skoe & Tufts, 2018). **Third**, our research aims at a comprehensive, multi-level (i.e., gene to brain to behavior) understanding of communication disorders; it is the potential of such integrative approaches to refine theories of cognition and language that led us to pursue various cognitive neuroscience methods (e.g., Hoeft et al., 2014; Jasińska et al., 2016; Kornilov et al., 2015; Landi et al., 2013). **Finally,** team members use the patterns of strengths and weaknesses that characterize neurological and neurodevelopmental disorders to guide theory (e.g., Del Tufo & Myers, 2014; Hancock et al., 2017; Hoeft, Walter, et al., 2011; Kadam et al., 2016; Myers & Blumstein, 2005; Pugh et al., 2014).

A.4.a. Mentorship. Data Table 5A documents that mentors have substantial experience mentoring PhD students. Each tends to admit a new student every 1-2 years, and these trainees have been highly productive. The 66 predoctoral trainees in **5A** (including current trainees) have generated a total of 170 publications to date, of which 97 are first-authored by the predoctoral student (**Data Table 5A**, representative trainees shown for some mentors with many trainees). This represents an average of 2.6 papers per trainee, including an average of 1.5 first-author publications per trainee. These means include 12 trainees currently in the program. Considering only trainees who completed the PhD, the productivity rate is 5.5 per trainee. Similarly, **Data Table 5B** summarizes the productivity of our 18 current and past postdoctoral trainees, who generated a total of 81 publications, an average of 4.5 publications each, including 50 first-author publications. These means include two new postdocs. *Both predoctoral and postdoctoral trainees are highly representative of our likely eligible applicant pool.*

All of our mentors have mentoring experience (at the undergraduate, graduate, and/or postdoctoral levels); in the aggregate, this team has been exceptionally effective in training independent scientists, with a total of 42 predoctoral graduating with PhDs and 14 postdoctoral fellows passing through training over the past 10 years (in addition to 28 predoctoral and 4 postdoctoral scientists *currently* in training) -- an average of five PhD students and three postdoctoral fellows each. **Clearly, this team has an exceptionally strong record of graduating trainees who are themselves independent scientists**.

Mentorship Training for Junior Faculty. The team includes three early-stage faculty members, who by necessity have a limited track record of funding and solo mentorship. These junior faculty are vital members of the team by virtue of their neuroimaging expertise and their central role in multiple collaborations. For instance,

mentor **Hancock,** who just completed his first year as a faculty member, has an extensive history of research using ERP and MRI (Myers et al., 2014; Rueckl et al., 2015; Xiaoxia et al., 2016; Yamagata et al., 2016), a strong record of collaboration and co-mentorship with **Hoeft**, and as Associate Director of the BIRC and instructor of the *MRI Methods* course, he serves as the lynchpin of student training on MRI and multimodal imaging. Although he has not yet admitted graduate students, he has excelled in training graduate "IBRAIN fellows" (see **§B.6**) in an intensive methods-focused seminar that has received outstanding evaluations. He has an emerging training and funding record (serving as PI for three subcontracts and with an R01 application currently under review). **Skoe** and **Theodore** were appointed in 2013 and 2011 respectively; their first students are expected to graduate in 2018 and 2019. **Skoe** has extensive expertise in ABR techniques for assessing fine-grained neural responses to auditory stimuli (over 50 publications on the topic), and her *Auditory Electrophysiology* course is a prime example of how imaging can be applied to research and clinical assessment. **Theodore** is PI of an R21 award to study phonological processing in DLD using fMRI; she is the incoming Director of the *Neurobiology of Language* program at UConn, and engages in significant undergraduate mentoring, having developed and directed the *Research-Intensive Summer Experience* (RISE) program, pairing undergraduate students with research labs. **Skoe** and **Theodore** are both known in the community as excellent mentors, whose students compete successfully for internal and external awards, and frequently serve as associate mentors. For instance, **Skoe**, with **Eigsti**, is co-mentor on an F31 NRSA application, and **Theodore** and **Skoe** have served as associate mentors for most of **Myers**' trainees. One of **Theodore**'s PhD students was selected as the 2018-19 Acoustical Society of America Stetson Fellow in Phonetics and Speech Science. In sum, the junior members of the team add significant expertise in mentoring and research.

Training in Mentoring. Rather than assuming that our already-strong junior faculty have been sufficiently trained in 'mentorship', we will work with them to design opportunities to strengthen and enhance their mentoring skills. In our experience so far, engaging in such conversations serves to strengthen the mentoring skills of the more senior faculty as much as the junior ones. In order to support these junior faculty in continuing to develop their mentorship skills, we will invite junior faculty to choose one or more "Mentorship Mentors" from our core faculty, the Steering Committee, or our External Advisory Board. We will especially encourage junior faculty to select a mentor outside their home program to provide some breadth of perspective. This mentor will advise junior faculty on navigating challenges such as tracking trainee progress, supporting a trainee's gradual transition to independence, dealing with lab conflicts, etc. Similarly, when postdocs choose to work with a mentor who has limited postdoc mentoring experience, the Steering Committee will invite a seasoned senior mentor to provide guidance to that pair. Further, as is standard in our program, more senior members of the team will serve on thesis and other committees for each trainee, ensuring that a seasoned mentor will support all trainees. Finally, each month, we will schedule a "Mentoring Lunch" for *all* mentors to discuss the specific challenges that they have faced *vis a vis* mentorship, and share solutions for how they have navigated troubled waters.

A.4.b. Training Grant and other Support Available to Participating Faculty. In addition to extensive collaboration, and stimulated in part by those very collaborations, the research environment at UConn is *strongly supported by external funding*. As seen in **Data Table 4**, the mentors and MPDs currently have some 47 active grants, including 22 from NIH and 5 from NSF, with total annual direct costs of $4.9M (an average of $382K per mentor). One mentor (**Skoe**) does not have current federal support, but has a pending NSF CAREER application and a pending NSF MPD award with **Myers;** similarly, **Hancock** has an R01 currently under review (and is subcontract PI on three grants). Additional research support is available to trainees through seed funds from multiple sources described in **§ Institutional Environment and Commitment to Training**.

A.4.c. Research scope. Funded projects are focused on *topics directly related to communication science, either from a typical or a clinical perspective*, including: speech sound processing and the neural and electrophysiological correlates of pitch perception; phonetic category structure and category learning; the neural bases (including neurochemistry) of literacy; reading disorder treatment; statistical learning and the neural bases of probabilistic computations; computational modeling of spoken word recognition and language development; the neural basis of the perception, integration and imitation of speech; bilingualism; subclinical hearing loss; and genetic and neural bases of autism spectrum disorder; see **Figure 2, Data Table 4**. This abundant funding will provide individual faculty with flexibility in supervising trainees who are developing novel research studies that *build* on currently-funded projects, incorporating course-based training and hands-on lab and clinical experiences. Funded projects also incorporate a diverse array of methodological tools; see **Figure 2**. Trainees will be supported by existing infrastructure and expertise of well-equipped and developed labs.

A.4.d. Research collaborations. Coherence comes from a long history of collaborative research and training partnerships among mentors and a shared interest in communication and language disorders. This group, together with other members of the larger research community, is characterized by a highly collegial atmosphere. Faculty have successfully undertaken several major collaborative projects, outlined in **§A.2**.

In addition to training grants, the team's research is supported by multiple collaborative R-level grants. **Eigsti** and **Fein** have an R01 that bring together clinicians and basic scientists to investigate long-term outcomes and the neural bases of communication deficits in autism. **Hancock** and **Hoeft** have three shared R01s. One is on learning to read in the context of foreign language immersion; the second, on the neurochemistry of reading, also involves **Landi**. **Magnuson** and **Rueckl** have an NSF award on computational approaches to human spoken word recognition. **Aslin**'s appointment as Research Professor in PAC began in 2017; he has a recently-renewed R01 on statistical learning and an fNIRS R21 that will engage members of the team, as well as a McDonnell grant on which **Rueckl** is a co-PI**.** He is also submitting a revised NIH Scientific Instrumentation Grant on May 31, 2018 to obtain funding for a second fNIRS machine to be used by **Magnuson, Landi, Hoeft,** and **Eigsti. Eigsti** and **Theodore** are collaborating on a project (see Hogstrom et al. 2018), as are **Eigsti** and **Myers** (Castelluccio et al., 2016). *Spaulding* and **Myers** are consultants on **Theodore**'s R21 grant, and **Theodore** and **Myers** have produced five co-authored publications. In addition, **Theodore** collaborates extensively with **Skoe** (one co-authored paper and an intramural grant; multiple co-mentoring of trainees). **Skoe** co-mentored a trainee with **Magnuson** and **Myers**, and also co-directs a shared EEG lab with **Magnuson, Landi** and *Sprouse*. **Magnuson** and **Landi** have co-advised 2 trainees and have 4 co-authored publications. Even before joining the UConn faculty, **Hoeft** has established an extensive network of collaboration with other members of this team, including shared grants and co-authored papers with **Hancock** (her former trainee), **Landi**, and **Rueckl**, on the cognitive neuroscience of reading disorder. As this brief (and incomplete) summary makes clear, most members of this team have worked together for 10 or more years, and some for more than 25. It is this rich matrix (see **Figure 3**) of scientific and personal relationships that undergirds the current proposal.

B. PROGRAM PLAN

B.1. Program Administration

B.1.a. MPD Leadership. Eigsti and **Myers** will serve as MPDs of the award. They have the necessary background, skills, and expertise to lead this training program. Their combination of distinct, yet complementary research backgrounds and disciplinary affiliations enhances the training program. **Eigsti** holds dual PhDs in Clinical Psychology and Cognitive Psychology, and is a licensed clinical psychologist; as such, she is well-positioned to bridge potential divides in training needs between clinical scientists and fundamental scientists. **Myers** holds dual appointments in Speech, Language, and Hearing Sciences and Psychological Sciences (PAC division), and will facilitate our trainees' access to clinical populations with communication disorders and to expert clinicians in SLHS. **Eigsti** is the Interim Scientific Director of the Brain Imaging Research Center (BIRC), and oversees the MRI, EEG/ERP, TMS, and eyetracking equipment housed there. Both **Eigsti** and **Myers** have a significant history of successful mentorship for their career stages, both have supervised NRSA (F31/F32) recipients, and both have attracted funding at the federal level (see **Data Table 4**). **Myers** has increased the culture of grantsmanship among our trainees, and teaches a seminar in professional development and grant-writing that has led to several successful bids for fellowship funding. **Eigsti** and **Myers** will each devote 8% effort per year through cost-sharing agreements with UConn. The details of the MPD collaboration are outlined in the **Multiple PD/PI Leadership Plan**. In brief, **Myers** has significant expertise in cognitive neuroscience, particularly MRI, and will take primary responsibility for ensuring that trainees receive excellent methodological training. **Eigsti**, a clinically-trained psychologist (also with significant neuroimaging

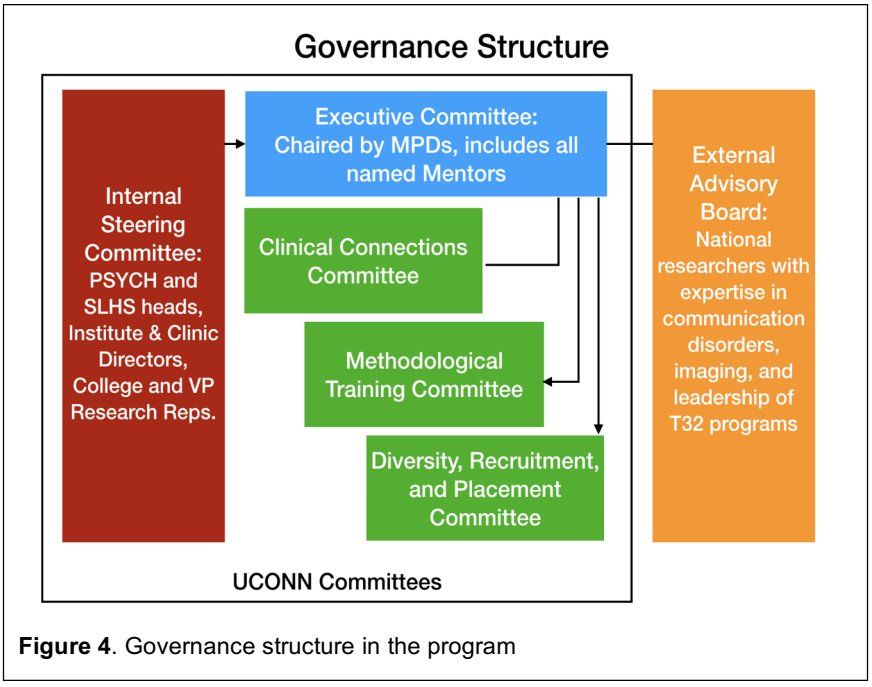

Figure 4. Governance structure in the program

expertise), will assume primary responsibility for the clinical and applied components of the current project. Their history of collaboration in project governance, manuscript authorship, and mentoring of graduate students, is a testament to their ability to share governance. The MPDs will alternate yearly as chairs of the **Executive Committee**, with **Eigsti** serving first. The Governance of the project is depicted in **Figure 4**, and detailed below.

B.1.b Executive Committee. The MPDs will be supported by the Executive Committee (ExCom). The ExCom will consist of the named mentors listed in this proposal (**Aslin, Fein, Hancock, Hoeft, Landi, Magnuson, Rueckl, Skoe, Theodore**) as well as the MPDs (**Eigsti** & **Myers**). This committee will be responsible for the final selection of the predoctoral and postdoctoral trainees and the administration of the program. The ExCom will meet at least three times per semester to ensure that formal coursework is available to trainees, to provide feedback on second-year research project proposals and postdoctoral research plans (**§B.3.c**), to review students' Individualized Development Plans (IDPs; **§B.3.a.**), to identify professional development opportunities for trainees, and to connect trainees with appropriate mentors. Several subcommittees will administer specific components of training, including the Clinical Connections Committee, Methodological Training Committee, and the Diversity, Recruitment, and Placement Committee.

B.1.b1. Clinical Connections Committee (**Eigsti**, **Fein**, **Hoeft**, **Theodore**, *McMahon, Barton*). The Clinical Connections Committee will oversee the Clinical Connections Practicum (jointly led by **Myers** & **Eigsti**), facilitating access to community stakeholders for various disorders. This committee will also review the Clinical Connections portion of trainees' IDPs, which trainees will submit at the beginning of their second semester of training. The Directors of the relevant UConn clinics (*Dr. Barton*, Director of the Psychological Services Clinic, and *Dr. McMahon*, Director of the Speech and Hearing Clinic) have agreed to sit on this committee; see Letter of Support, LoS). Three mentors on this committee also have clinical degrees: **Eigsti** and **Fein** are licensed clinical psychologists, and **Hoeft** holds an MD; as such they can offer perspective on the clinician-scientist career path. The Clinical Connections Committee will facilitate trainees' access to clients/patients affected by communication disorders, their families, and to clinicians with special expertise in these disorders.

B.1.b2. Methodological Training Committee (**Hoeft, Myers, Aslin, Fein, Hancock, Skoe, Landi**). The Methodological Training Committee is responsible for methods training, with special emphasis on neuroimaging methods. This training will be supported by elective coursework in auditory electrophysiology (**Skoe**), EEG/ERP (**Landi**, **Magnuson**, *Sprouse*), fNIRS (**Aslin**), and MRI (**Hancock, Myers, Hoeft**). **Hoeft** will chair this committee in her role as incoming Scientific Director of the Brain Imaging Resource Center (BIRC), and together with BIRC Associate Director **Hancock**, will ensure that trainees have access to BIRC resources, including MRI, in-scanner EEG, TMS and tDCS equipment. This committee will review the Methodological Training portion of IDPs, ensuring that trainees are making appropriate progress in methods training, including coursework, external workshops, and mentorship from members of the team. Program Support funds provided by the university will allow us to invite methods experts to conduct specialized workshops on (for instance) multivariate MRI and network analyses, infant neuroimaging techniques, simultaneous TMS/EEG techniques. These opportunities will be available first to our trainees, then to the larger community as space allows.

B.1.b3. Committee on Diversity in Recruitment and Placement (**Eigsti**, **Myers**, **Magnuson**, TBA). This committee will be responsible for enhancing the diversity of our applicant pool, for coordinating recruitment efforts in order to draw an exemplary set of trainee applicants, and for mentoring trainees into postdoctoral positions and research positions (academic, industry) as they transition from the program. MPD **Eigsti** currently serves on the University Diversity Council, established in 2016 to help the University to become a leader in diversity and inclusion in higher education. The Council's mandate is, among other tasks, to increase recruitment and retention of URGs (underrepresented groups) amongst students and faculty, monitoring progress on this goal through analysis and assessment. As a Council member, **Eigsti** has access to program-related data and measurement tools, and to strategies that T32 PIs and mentors can utilize to enhance diversity within our program. All team members who have been part of NSF-sponsored training programs have been part of successful efforts to increase diversity in our graduate training programs. When IGERT began, participating PhD programs had 11% students from URGs; that figure is now 16%, due largely to diversity efforts that led to ~30% of IGERT trainees coming from URGs (12/40, including 8/28 fellows). We will extend practices established within IGERT and NRT awards that promote successful recruiting and retention of diverse trainees. See **§C. Recruitment Plan to Enhance Diversity** for further details.

In addition, we will partner with the UConn Women in Math, Science and Engineering (WiMSE) program for undergraduates, and invite WiMSE students to work as apprentice researchers for trainee-led projects. Recruiting efforts for women will include outreach to organizations such as the Association for Women in

Science, the Association for Women in Computing, and on-campus Psi Chi and honors organizations serving undergraduate women in STEM nationally, and contacts with service and education groups within prominent professional societies, such as Women in Neuroscience and Women in Cognitive Science.

B.1.c. Internal Steering Committee. (Eigsti, **Myers**, *Altmann, Shoulson, Barton, McMahon*, *Coppola, Naigles, Snyder).* We benefit from the support and guidance of many programs and offices at UConn. To take advantage of the abundant resources available on campus, an Internal Steering Committee will advise the ExCom, and will be composed of the leaders of these entities. Among these are the Institute for Brain and Cognitive Science (IBACS; see *Dr. Altmann's* LoS). IBACS promotes and supports the interdisciplinary science of the mind and its realization in biological and artificial systems. Two on-campus clinics, the Psychological Services Clinic, headed by *Dr. Marianne Barton*, and the Speech and Hearing Clinic, headed by *Dr. Nancy McMahon*, serve children and adults with communication and other neurodevelopmental disorders and are the cornerstones of our clinical degree programs in Clinical Psychology, Speech-Language Pathology, and Audiology (see LoS from *Drs. Barton* and *McMahon*). UConn's Vice Provost for Interdisciplinary Affairs, Dr. Shoulson, will serve on this Committee and provide guidance on UConn-wide initiatives and strategic planning. Finally, there are many faculty members at UConn who are likely participants in this training program, but are not part of the core team of mentors (see **Other Significant Contributors**, below). To represent the interests of this group of faculty, and to establish continuity with the NRT award and Neurobiology of Language certificate program, we propose to add *Drs. Letitia Naigles* (expert in longitudinal research), *Marie Coppola* (sign language expert), and *William Snyder* (language acquisition) to this committee. Notably, both *Naigles* and *Coppola* have served on Diversity and Recruitment Committees for the IGERT and NRT programs, so they will have unique insights into the challenges associated with recruiting, supporting, and retaining a diverse set of trainees. *Naigles* is also incoming director of the Cognitive Science Program, and leads the UConn KIDS research participant recruitment consortium. *Snyder* is a faculty member in Linguistics who directs the curriculum committees for the certificate in Neurobiology of Language and the NRT, and can help ensure that curricular offerings from those programs continue to be available to our trainees.

B.1.d. External Advisory Board. The proposal will be strengthened by the guidance of an **External Advisory Board**, consisting of scientists with expertise in relevant methods and populations. Final membership on this panel is TBD, but will include Dr. Tracy Love of San Diego State who serves in a significant role on a "West Coast partner" T32-funded training program (see LoS from Dr. Love); Dr. Laurie Cutting of Vanderbilt, an expert on developmental brain-behavior relations with a particular emphasis on reading disabilities, reading comprehension and executive function; Dr. Adriana di Martino of NYU/Langone Medical Center, whose expertise centers on functional connectivity in ASD and ADHD and who has pioneered the establishment of a large pediatric imaging database; Dr. Charles Nelson of Harvard, whose wide-ranging expertise encompasses EEG, MRI, genetics, international adoptees, and autism, and who is PI of a T32 proposal on neurodevelopmental disorders; Dr. Allan Reiss of Stanford, with expertise in fNIRS and developmental neuroimaging; and Dr. Victor Ferreira of U. of California, San Diego, who studies language, speech production, and bilingualism using psycholinguistic methods and is a mentor in Dr. Love's T32.

The Advisory Board will: provide guidance on program structure, career placement, science, and long-term planning. Board Members are also willing to refer promising applicants to our program (see, e.g., LoS from Love), and may provide a ready-made network of potential postdoctoral fellowship mentors for our newly-trained PhDs. The board will convene twice yearly via conference calls, and panel members will be invited to a Capstone Conference in 2020-2021, to showcase trainee research and collaborative projects and to permit detailed in-person discussion of program challenges and opportunities. Additional in-person visits by panel members will be scheduled as their availability permits. In addition, the project will organize a yearly satellite meeting, coordinated with the Society for the Neurobiology of Language meeting (for which mentor **Magnuson** is Society Treasurer, and which is attended by many Panel members). UConn Program Support funds will support trainee attendance at this meeting, to strengthen the important networking aspect of this meeting. UConn has committed to providing funding to cover travel expenses and an honorarium for on-site visits by panel members.

B.2. Program Faculty

Inge-Marie Eigsti, PhD (MPD, CLIN) studies how constraints imposed by core neurocognitive processes impact social communication abilities. Her research utilizes multiple converging approaches – behavioral paradigms, functional brain imaging, animal modeling and behavioral genetics – to study autism spectrum disorder (ASD) and to uncover the mechanisms that funnel developmental along atypical developmental pathways. Domain-general cognitive processes such as working memory, cognitive control, and implicit

learning influence language and communication; measuring these core domain-general processes enables us to tie communication abilities to brain functioning and genetic profiles. Her research on perception-action coupling in ASD (with a focus on co-speech gesture) was recognized by a Research Scholar fellowship from the Fulbright Foundation. **Eigsti** also leads a multi-disciplinary team in a study utilizing whole exome sequencing in a deeply-phenotyped ASD sample. The current primary focus in **Eigsti**'s lab is on the neural underpinnings of long-term outcomes in ASD, particularly focusing on individuals with ASD who have lost their ASD diagnosis, a so-called "optimal outcome." This NIH-funded collaboration with **Fein**, described in several NYT features (Carey, Jan 17, 2013; Padawer, Aug 3, 2014), generated strong public interest. It has had a broad clinical impact on families and the public at large, and has raised fundamental questions about the long-held assumption that ASD is a life-long condition, and about the mechanisms underlying long-term outcomes. The paper that first reported on optimal outcomes in ASD (Fein et al., 2013) was described as a 'landmark' by the journal editor. In 20 additional papers, the group has described how "optimal outcomes" individuals are behaviorally indistinguishable from their typically developing peers. The recent five-year renewal of the project uses fMRI to probe functional connectivity networks underlying compensation. Postdoctoral and doctoral trainees are central to every aspect of research in the lab, including study planning and development, implementation, recruitment, data collection, analysis, and interpretation, and presenting study findings at conferences and in peer-reviewed outlets; most lab publications are student-first-authored. Her lab has a "vertical team" structure, where postdocs help to mentor doctoral students, who mentor less advanced students; most graduate students mentor undergraduate assistants.

Emily Myers, PhD (MPD, SLHS and PAC) addresses the neural and behavioral mechanisms which enable listeners to map the speech signal onto meaning. In this program of study, she uses neuroimaging techniques, principally fMRI, to investigate how the brain responds to acoustic variation within and between categories and behavioral methods to probe the mechanisms which allow for parsing the speech stream into meaningful categories (Earle & Myers, 2015; Xie & Myers, 2018). Lately, research in her lab has explored the stability and flexibility of phonetic category sensitivities in the face of native language variability and non-native learning, including the contributions of sleep and interference to phonetic category learning, and the neural systems which support optimal speech sound learning. The discovery of the boundary conditions on language plasticity (the factors that enhance and hinder adaptation to speech stimuli) are particularly informative in motivating treatment programs for individuals with acquired and developmental language disorders. To this end, her lab also investigates breakdowns in speech processing in individuals with acquired language disorders (aphasia) and adults with a history of language disorder (Earle et al., 2018). This work is primarily supported by an R01 from the NIDCD and an NSF CAREER award. **Myers** has a strong record of predoctoral and postdoctoral training, including mentoring those trainees to federal awards. For instance, **Myers'** trainee Sayako Earle won a F31 in 2016 (co-mentored by **Rueckl** & **Landi)**, her current postdoctoral trainee, Chris Heffner, won an NSF SPRF award, and a current predoctoral trainee (co-mentored by **Magnuson**), Sahil Luthra, is a 2018-21 NSF GRFP recipient. Her recent graduates are in tenure-track positions at R1 or R2 institutions (3), or in research positions in academia and industry (3). Trainees in **Myers** lab will acquire skills in structural and functional MRI, speech acoustics, eyetracking and psychophysics, and will learn to apply these skills in order to better understand neural plasticity for speech sound processing.

Richard Aslin, PhD (PAC) has a primary appointment at Haskins Laboratories and a secondary appointment in Psychological Sciences at UConn. His areas of research include studies of language processing and statistical learning in adults, children, and infants. He uses behavioral (eye-tracking) and neuroimaging (EEG, fMRI, fNIRS) methods to study how infants learn the meaning of spoken words, how adults access spoken words from the mental lexicon as the speech signal unfolds in real-time, and how the structure of artificial grammars is acquired in the lab based on complex distributional properties of the input. Some of these artificial grammar studies employ visual-motor tasks to mimic the structural properties of linguistic input but in a non-linguistic domain. **Aslin** is also using a variety of multivariate analysis techniques to conduct decoding studies of speech stimuli from EEG and fNIRS signals. Trainees will have widespread opportunities to participate in all of these research projects, including access to a state-of-the-art fNIRS machine at Haskins Laboratories that is able to gather up to 142 channels from the whole brain of adults or 80 channels from infants. In the past decade, **Aslin** has mentored 10 PhD students supported by T32 predoctoral grants, 2 PhD students supported by NSF individual graduate fellowships, and 3 postdoctoral students supported by individual NRSA grants from NIH.

Deborah Fein, PhD (CLIN) investigates language and other cognitive functions in young children with ASD and in children who have lost their ASD diagnosis. One line of research concerns the predictive value of early language emergence in toddlers with ASD for their outcomes at age 4 and age 8 and specific

communication features that indicate risk for ASD in the second year of life; this is funded by two active grants from NICHD. A second line of research is a detailed investigation of language in children and adolescents who have moved off the autism spectrum and have average or better scores on standardized language tests, that is, the "optimal outcomes" cohort. Analysis of their pragmatic language (e.g., narrative production and conversation) reveals that although differences are subtle, some of these individuals show mild, persistent deficits in constructing narratives, and in impulsive conversational style. Analysis of neural activation during a language processing task showed specific bilateral areas in which compensatory hyper-activation appears to be present (Eigsti et al., 2016). This research is supported by an NIMH grant to **Eigsti** and **Fein** (MPDs) with collaboration from *Naigles* and *Barton* (co-Is). A third line of research involves developing material to use to teach parents how to provide language stimulation and language teaching for their newly diagnosed children with ASD. This work, which was supported by an NIMH R34, involves collaboration and co-mentoring with *Barton*. Trainees choose to participate in any or all of these projects, which all involve clinical assessment for ASD, and which can also involve training in structural and functional MRI and advanced statistical techniques for RCT's.

Roeland Hancock, PhD (PAC) investigates individual differences in the neurobiology of language processing in both typical and atypical (e.g. reading disorder) samples with a focus on (1) distinguishing genetic and environmental susceptibilities in functional language circuits using genetically-informed neuroimaging study design; and (2) using magnetic resonance spectroscopy (MRS) to investigate the role of local neural excitability in regulating neural oscillations underlying sensory and language processing. His research approach primarily uses functional techniques (e.g. fMRI and EEG) and MRS, and genetically-informed neuroimaging designs to address these questions. Examples of work relevant to this proposal include (1) investigating the role of neural excitability in reading, including reading disorder, using MRS, fMRI, and EEG (with *Pugh*/**Hoeft**, **Landi**, and *Chen*); (2) model-based prediction and perturbation of speech and auditory perception using MRS, EEG and TMS (with *Chen* and *Large*); (3) intergenerational transmission of complex behavioral and brain phenotypes in reading and language (with **Hoeft**). Trainees will gain experience in fMRI, EEG, MRS, TMS and other neuroimaging techniques, and working with large scale genetically-informed neuroimaging datasets (e.g. Human Connectome Project).

Fumiko Hoeft, M.D./PhD (PAC) investigates the neurobiological mechanisms underlying individual differences in brain maturational processes, literacy acquisition (and atypical processes such as reading disorder), and how they interact. She is also interested in identifying how biology (genes) and environment influence neurodevelopment. Her lab employs a variety of neuroimaging techniques (e.g. fMRI, T1 aMRI, DWI, MRS, NIRS, EEG/MEG, TMS/tDCS), analytical approaches (e.g. machine learning, graph theory), designs (e.g. intergenerational neuroimaging, imaging genetics, human natural cross-fostering), and perturbation techniques (e.g. neuromodulation using TMS/tDCS, perturbation of English literacy acquisition through foreign language/literacy learning, and atypical populations such as reading disorder). She has over 100 peer-reviewed papers in the areas of literacy acquisition, neurodevelopmental and genetic disorders including reading disorder and autism, neuroimaging methods and other cognitive processes. **Hoeft** has a strong record of mentoring: (1) She has mentored over 40 doctoral students, serving as primary thesis advisor for 12; (2) She runs a 50-member laboratory that hosts two Clinical Psychology Practica in pediatric neuropsychology for Tier 3 Research/Doctoral universities and (3) She is Executive Director of a Multi-University Precision Learning Center (UCSF, UCLA, UC Berkeley, UC Davis, UC Merced, UC Irvine and Stanford), where the primary focus is on: (a) interdisciplinary training of graduate and postdoctoral students and faculty across clinical and cognitive neurosciences, education, linguistics and policy, (b) multi-site research, (c) outreach and (d) services. Her students have been accepted to graduate schools and as faculty in the areas of education, cognitive neuroscience and computational methods at universities such as Harvard, Stanford, Caltech, UC Berkeley, UConn, Boston College as well as internationally.

Nicole Landi, PhD (DEV) uses a lifespan approach focusing on the acquisition and development of reading and language skill in children and adults with typical development, or language or reading impairments. She utilizes multiple cognitive neuroscience methodologies, including fMRI, ERP and imaging genetics. Atypical reading and language development can be traced to genetic factors, environmental factors and gene by environment interactions; **Landi** uses a comparative approach to identify common and distinct causal mechanisms, studying groups for whom language impairment has a genetic basis (reading disorder, DLD), groups for whom impairment is due to environmental factors (e.g., in utero toxin exposure), and groups for whom language impairment is secondary to a primary disorder such as autism. Relevant examples of **Landi's** recent work include (a) investigations of the neural noise hypothesis for reading disorder using MRS and EEG (collaboration with *Pugh*/**Hoeft/Hancock/**trainee Perdue; (b) investigations of structural MRI and

genetic variation in children with reading disorder (collaboration with Dr. Elena Grigorenko, Baylor college of Medicine/Fumiko **Hoeft**/trainee Perdue; (c) examinations of the neural and genetic bases of DLD in a rural Russian population with high prevalence (collaboration with **Magnuson**/Grigorenko/former trainee Kornilov); (d) studies of audio visual integration of speech in children with autism spectrum disorder (ASD) using eye tracking and event related potentials ERPs (collaboration with Dr. Julia Irwin at Haskins /trainee Ryherd), and (e) exploration of the behavioral neural mechanisms that contribute to specific reading comprehension impairment in adolescents (collaboration with Dr. Van Dyke at Haskins/trainee Ryherd). **Landi**'s current and former graduate trainees are involved in many of these projects. Trainee Perdue (2nd year) recently received an NSF-GRFP for a proposal that examines relations between brain structure (using diffusion weighted imaging) and choline (a neurometabolite linked to white matter microstructure development) in reading disorder. Perdue is also centrally involved in (b), along with former trainee Kornilov, with a recent publication that links an *SETBP1* mutation to brain function and reading skill. Ryherd (4th year) has been involved in (d) and (e), and both of these projects have led to publications on which Ryherd is a coauthor. In particular, Ryherd has been foundational in the development of a new technique that uses eye-fixations and events in a combined eye tracking/fMRI paradigm to explore word-by-word integration during naturalistic text reading in adolescents with S-RCD.

James Magnuson, PhD (PAC) has 3 interrelated research programs. The first is his long-standing basic research program on the time course of information integration in language processing, from speech perception and word recognition to sentence processing. This research was funded by an NIDCD R01 and an NSF CAREER award, and uses temporally-sensitive measures such as eye tracking and EEG/ERP and computational modeling to infer the fine-grained temporal workings of mechanisms supporting language processing. This work has also led to connections with aphasia (Mirman et al., 2011), language development throughout the lifespan (Magnuson & Nusbaum, 2007; Magnuson et al., 2003; Mirman et al., 2008), and reading disability (Magnuson et al., 2011). The second research program builds on the first to examine cognitive and genetic bases for DLD. Along with **Rueckl**, *Spaulding*, and others, he examines how subtle differences in attentional and learning may fundamentally change the way children with DLD sample linguistically relevant information from the world around them (Collisson et al., 2015). Along with **Landi** and others, he is using EEG/ERP data to derive sensitive endophenotypes for DLD using genome wide association studies (GWAS) and other techniques in collaboration with Dr. Grigorenko (Baylor), and colleagues at JAX Genomic Medicine at UConn. Computational modeling has been an essential tool in these research programs, but is now a primary research focus. A team including **Rueckl**, a postdoc, and 3 PhD students has developed the first large-vocabulary model of human speech recognition that operates on real speech, with a first report to be presented at Neurobiology of Language in August (You et al., 2018, August). **Magnuson** has mentored several PhD students (4 graduated, 4 current) and postdocs (2 former, 1 current). His former trainees are now faculty (3), postdocs (2), or working in data science (1). His leadership of IGERT and NSF training programs has also significantly impacted the training of 40+ PhD students at UConn in 6 PhD programs.

Jay Rueckl, PhD (PAC) investigates the neurocomputational mechanisms of word reading. The primary goal of his work is to develop a theory of word reading that (i) explains how the organization of the reading system develops from the interaction of a universal neurocognitive mechanism and a linguistic environment that is structured differently depending on the properties of the language and its writing system, and (ii) supports the development of both educational and individualized remedial practices. **Rueckl** investigates reading at both the millisecond time scale at which individual words are read, and at the longer time scale at which the organization of the reading system evolves as a consequence of learning. To do this, he employs three primary methodologies: behavioral experiments using both simple cognitive tasks (e.g., lexical decision, naming aloud) and learning paradigms (e.g. the artificial lexicon method); fMRI studies exploring the neural correlates of the processes engaged in these tasks; and simulation modeling, using a connectionist model to develop an explicit computational theory of the mechanisms involved in reading and reading acquisition. His work explores the influence of orthographic, phonological, and morphological information in word reading; the role of memory processes in reading, and variation in the organization of reading both within and across linguistic communities. In NIH-funded collaborations, **Rueckl** applies his emerging theoretical framework to a variety of translational domains, including (a) learning and consolidation in typically developing and dyslexic adolescents, and (b) the behavioral and biological differences between reading impaired children who do or do not respond to treatment, and (c) the acquisition of word-decoding skills. Trainees will have the opportunity to participate in any of these projects and to receive training in all of these methods.

Erika Skoe, PhD (SLHS) studies the neural underpinnings of auditory perception across the lifespan. **Skoe** is interested in how the brain's ability to faithfully represent acoustic information influences language

development and cognitive flexibility. To examine neural encoding of auditory signals, **Skoe** adopts electrophysiological methods, principally auditory brainstem responses (ABRs) to complex sounds like speech and music. **Skoe** has applied this methodological approach to study diverse populations including musicians, bilinguals, noise-exposed populations, children from low socioeconomic backgrounds, and populations with reading impairment and ASD. Using ABRs, **Skoe's** research has helped establish the timeframes over which experience-dependent brainstem plasticity occurs in humans in response to enriched and deprived auditory environments; this work reshapes long-held notions about auditory system development. **Skoe's** current research delves deeper into the sources of individual differences in speech and non-linguistic auditory perception by studying how differences arise from (a) the neural precision with which speech sounds are encoded at multiple levels, from brainstem to cortex (with **Myers**), (b) age-related changes to the central nervous system (with **Myers** and **Magnuson**), (c) current and previous musical training, and (d) occupational and recreational noise exposure. As part of an collaboration with *Tufts*, *Njuki*, and medical faculty at the UConn Health Center (Parham), **Skoe** is undertaking a multiphase project of the early biological warning signs of noise-induced hearing loss in musicians and other at-risk populations. **Skoe**'s research also traces patterns of auditory brainstem development in language impairment (with **Theodore,** and a jointly-advised PhD student) and ASD (with **Fein,** *Naigles***,** and a jointly-advised PhD student), with an overarching goal of understanding the interplay between central auditory system development/function and language development. In addition, **Skoe** investigates the neural correlates of pitch perception using a multi-modal approach that combines high-density ABRs, computational modeling, and MRI (with **Hancock and Large**). Trainees will gain experience in ABRs and neuroimaging measures of auditory function and will collaborate in clinically-focused research.

Rachel Theodore, PhD (SLHS) examines how listeners map the speech signal onto individual consonants and vowels – the building blocks of larger linguistic units such as words and phrases. She also studies the factors that influence organization and retrieval of lexical items within memory. One crosscutting theme is the degree to which language comprehension is shaped by the input, both with respect to perceptual learning in end-state representations as well as plasticity underlying acquisition of speech sound categories in development. **Theodore's** current research, funded by an R21 from the NIDCD, examines phonetic category structure in individuals with and without DLD using fMRI neuroimaging and behavioral methods to compare phonetic category structure in children and adults with and without DLD with respect to (1) how phonetic category structure is represented in the brain and (2) how phonetic category structure is dynamically modified as a consequence of exposure to phonetic variation. The long-term goal of her research is to improve specification of the etiology of DLD, which can be used to develop more targeted rehabilitation protocols. **Theodore** is primary advisory to two PhD students who joined her lab in 2014 (and thus have not had time to complete the 5-year plan of study). Both students have been successful in securing extramural funding for their dissertation research: trainee Drouin has received the CAPCSD PhD fellowship, and trainee Monto has received the Stetson fellowship from the ASA. **Theodore** also co-mentored three doctoral graduates, all of whom are now working in research positions.

B.2.a. Other Significant Contributors

The eleven named core mentors named on this proposal are a small subset of the active researchers who study communication at UConn. We expect that this larger community will also nominate potential trainees for funding from our program (see **§Appointment of new faculty, removal of faculty, below)**

SLHS: Research conducted by faculty in the SLHS department includes work that is relevant to the treatment, assessment, and prevention of communication disorders including acquired language disorders (*Coelho, Mozeiko*), developmental language disorders (*Spaulding, Grela*), bilingual language development (*Garcia-Sierra*), and hearing impairment (*Cienkowski, Tufts, Friesen*). Many of these projects involve collaborative connections with the core T32 team. For instance, *Spaulding* collaborates with **Myers** (facilitated by former trainee Earle) in an imaging project investigating sleep consolidation in children and adolescents with DLD and is also a collaborator with **Theodore** on an fMRI study of phonetic category structure in DLD. *Mozeiko, Coelho* collaborate with **Myers** to study brain-based outcomes of rehabilitation in individuals with aphasia. **Skoe** and *Tufts* collaborate on a project that uses electrophysiology methods to examine the role of noise exposure on the auditory brainstem response to sound. **Skoe** also has a collaboration with *Garcia-Sierra* that examines the role of native language experience on neural processing of native and nonnative sound patterns using electrophysiology methods. *Grela* and *Cienkowski* co-direct the Leadership Education in Neurodevelopmental and Related Disabilities (LEND) program, an interdisciplinary training program that prepares graduate students in SLHS (MA and AuD clinical trainees and PhD research trainees) to assume leadership roles in the delivery of services to children with autism and other developmental disabilities. These collaborations among SLHS faculty are in addition to those among **Skoe**, **Myers**, and **Theodore** (all of which

involve student trainees) as described in **§A.4.d**.

PAC: The Perception-Action-Cognition division includes two PhD programs, Language & Cognition (LC) and Ecological Psychology (EP). Research in LC spans much of psycholinguistics, from speech perception (**Magnuson**, **Myers**), to morphology and spoken and written word recognition (**Magnuson**, *Pugh*, **Rueckl**, *Yee*), to sentence processing (*Altmann*, **Magnuson**, *Tabor*), semantics (*Altmann*, **Magnuson**, *Yee*) and linguistic and neural representation of simple and complex events (*Altmann*), complemented by computational modeling (*Altmann*, **Magnuson**, **Rueckl**, *Tabor*) and cognitive neuroscience tools (all members). **Hoeft**'s research spans neurobiology of reading development, from gene to brain to behavior. PAC research on atypical communication includes work on literacy and reading disorder (**Hoeft**, **Magnuson**, *Pugh*, **Rueckl**, *Tabor*), aphasia (**Magnuson**, **Myers**, *Yee*), and DLD (**Magnuson**). Research in EP focuses on perception and action, with particular emphasis on nonlinear dynamics. *Dixon* has collaborated with **Eigsti** and **Magnuson** to apply advanced mathematical methods from motor control to speech-gesture timing in ASD and eye movements. *Large* straddles both groups, applying advanced neuronal modeling and nonlinear dynamics to auditory perception and music cognition, with particular reliance on time-frequency analysis of EEG and fMRI. PAC faculty will be able to support training in cognition, psycholinguistics, cognitive neuroscience, a variety of communication disorders, and computational and mathematical tools.

CLIN: The central focus of the Clinical Division is on understanding, preventing, and treating a broad range of psychological disorders, with eight tenure-track faculty and two clinical faculty. *Barton*, **Eigsti** and **Fein** collaborate extensively in their research on autism spectrum disorders. In addition, CLIN faculty study disruptive behavior disorders (*Burke*), schizophrenia and brain stimulation techniques (*Chen*), health psychology (including weight management and psychoneuroimmunology (*Cruess, Gorin, and Park*), child and adolescent anxiety (*Treadwell*), and the impact of health disparities and community violence on mental health (*Milan, Williams*). *Chen* and **Fein** have collaborated on studies of ASD. CLIN faculty are central to the functioning of the Psychological Services Clinic (PSC), whose administrative personnel and structure will support *Clinical Connections* with patients and families, and provide space for these activities. Through the PSC, T32 trainees will have access to assessment observation (given the appropriate patient consent).

DEV: Research conducted by faculty in the Developmental division includes work that is relevant to typical and disordered language acquisition. *Naigles* is an expert in language development in typical preschool children and with ASD. *Naigles* is currently collaborating with **Skoe** on a project that uses auditory brainstem response (ABR; facilitated by a shared trainee, Lisa Tecoulesco) to investigate the relationship between stability in the ABR response and lexical development in children with ASD*. Coppola* studies language emergence and the relation between language and cognition in deaf individuals who vary in their experience with language. *Coppola* is currently collaborating with **Landi** to identify neural indices of prosodic processing (using ERP) that may be common across both signed and spoken languages. *Cuevas* examines how brain maturation and underlying brain-behavior associations contribute to early cognitive processes such as memory and imitation and collaborates on a project with **Landi** that examines neural mirroring during audiovisual speech and non-speech gestures in children with ASD. *Adam Sheya* investigates categorical and conceptual learning and relational reasoning in early childhood. With *Gerry Altman*, *Sheya* is currently using neuroimaging to investigate event representation in the hippocampus as a component of early spoken language comprehension.

Linguistics: UConn's department is internationally recognized as a leader in several areas of Linguistics. In addition to faculty with primarily theoretical research programs, three faculty in particular have been active in building the interdisciplinary research community at UConn. *Lillo-Martin* has conducted groundbreaking research on language acquisition and signed languages, and has also been an advocate for Deaf students, faculty and staff at UConn. She has collaborated with faculty in Psychology and SLHS in research and mentorship, including recent postdoc supervision with **Eigsti** (Hall). *Snyder*, a leading theoretician and empirical researcher of language acquisition, has been instrumental in other training grants (Co-PI of our IGERT and NRT grants), organizes our weekly interdisciplinary Talk Shop event, and has collaborated with multiple faculty in Psychology (*Coppola, Naigles, Tabor*) and SLHS (*Grela*, *Spaulding*). *Sprouse* works at the intersection of linguistics and cognitive neuroscience, using EEG/ERP methods to test syntactic theories, and collaborates with several other T32-related faculty (**Hancock**, **Landi**, *Large*, **Magnuson**, **Skoe**) in supporting EEG/ERP research (co-leading a shared electrophysiology lab, providing basic to advanced courses on EEG/ERP, and participating in a weekly interest group). From past experience, we know that trainees with interest in questions that could be enhanced by contact with formal linguistics or the methods these faculty employ will find enthusiastic support with these colleagues.

B.2.b. Appointment of new faculty, removal of faculty. New faculty will be appointed to the program

when they have a qualified trainee who is selected by the admissions committee ***and*** the faculty mentor him/herself commits to contributing to the training program. At a minimum, this commitment should include participation in community events (Talk Shop, J-term workshops, Language Fest) and could also include serving as a breadth mentor to other trainees, participating in the Clinical Connections Practicum, etc. Should a new faculty member (i.e., one who is not part of the core team) be unable to fulfill his/her commitment to mentorship and research, then he/she may be removed from the program by majority vote of the ExCom, with trainee mentorship transferred to a new mentor with related expertise. Given the high standard for evaluating new faculty member's commitment to the program, we anticipate that this scenario is unlikely.

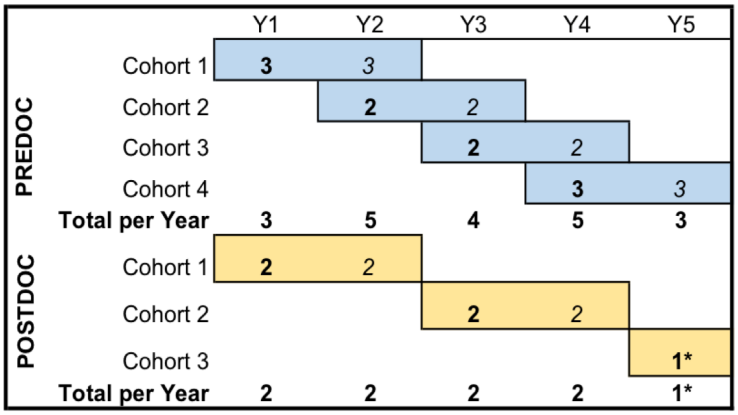

Figure 5. Timing of trainee appointments to the T32. Italics = trainees are continuing from a previous year; bold =new appointment . *second year of postdoctoral funding from UConn Program Support funds

B.3. Proposed Training

We will recruit a total of **ten** predoctoral and **five** postdoctoral trainees over the life of the grant for two-year fellowships. One postdoc trainee will be recruited in Y5 and funded by the T32 for the first year of training, with the second year of training (in the year following the funding cycle) coming from UConn Program Support funds from UConn (see **Administration LoS**). This will allow us to carry at least one trainee into the anticipated next funding cycle of this award and build continuity between those cycles. For instance, that trainee would be available to serve as a mentor for entering predoctoral trainees in a new funding cycle.

Trainees will be distributed across our four degree programs, in approximate proportion to the number of participating faculty in those programs. Trainees will be admitted in cohorts of 2-3 individuals (see **Figure 5)**, with overlapping cohorts for predoctoral trainees (but not postdoc trainees) keeping the total number of predoctoral trainees in the program at 3-5 per year, and the number of postdoc trainees at ~2 per year, over the life of the grant.

Goals. The overarching training goals are (1) competence in **neurobiological mechanisms and neuroscience methodologies**, (2) understanding **typical language architecture** and **how atypical communication informs theories of typical processing and development** and (3) deeper understanding of communication disorders through **contact with clinical populations**. Infused through the training is education in (4) **research competencies** to prepare trainees for research careers--these include training in project management, research ethics, data stewardship, networking and collaboration, postdoctoral, academic, and industry job searches, and other professional development topics. *The predoctoral and postdoctoral training plans share the same four training goals.* We also aim to provide all trainees with instruction and training in oral and written presentation and in the skills needed to apply for individual fellowship or grant support.

The training plan has three major components: (1) an **Individualized Development Plan**, where trainee/mentor groups design a customized plan to enhance training in neurobiology, typical and atypical communication, methodologies, and clinical contact; (2) formal training through **coursework and workshops**, including neuroimaging methods summer courses that are offered at other institutions (e.g., MGH) or as pre-conference workshops; and (3) a **trainee-led research project**. All trainees will complete coursework in the Responsible Conduct of Research, as detailed in the **Plan for Instruction of Responsible Conduct of Research**. These components are scaled to the needs of the predoctoral vs. postdoctoral trainee (**Figure 6**).

B.3.a. Individualized Development Plans. Each trainee will prepare an individualized development plan (IDP), in consultation with his/her mentor, which will be submitted to the ExCom for review at the beginning of Year 1, then updated and re-submitted for review at the beginning of Year 2 (**Appendix**). As seasoned mentors, we recognize that there is no "one-size-fits-all" curriculum or training plan that will meet the needs of all trainees. Some trainees will arrive with substantial methodological or clinical expertise, for instance, whereas others may be getting their first introduction to working with clinical populations or neuroimaging. Some trainees wish to pursue a research career in academia; others gravitate towards researcher-clinician routes or research careers in industry (see "**Beyond academia: Training for other careers**.", **§B.3.f**). While some components of our training plan will be mandatory (formal coursework for predoctoral trainees, the

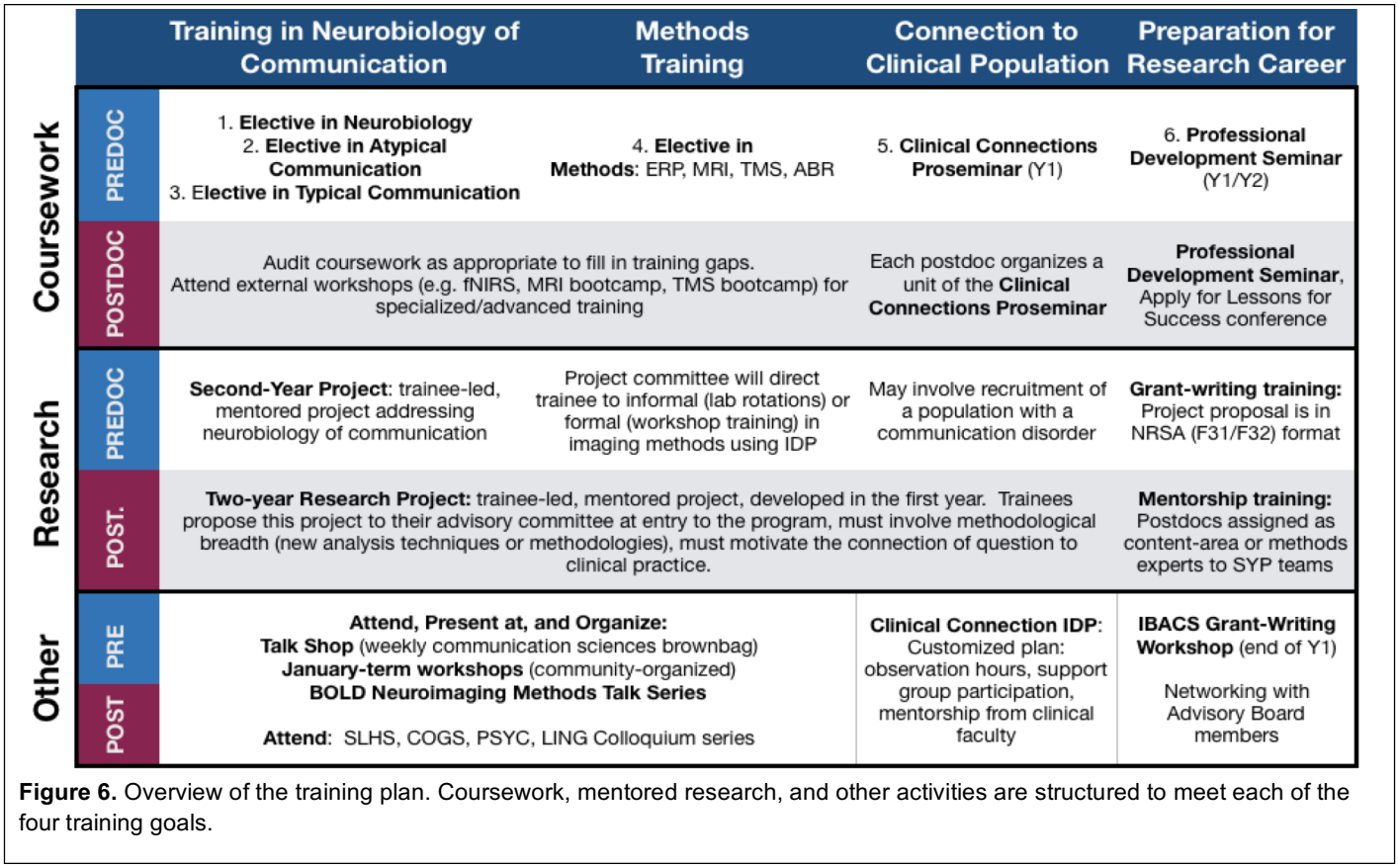

Figure 6. Overview of the training plan. Coursework, mentored research, and other activities are structured to meet each of the four training goals.

Clinical Connections Seminar, a mentored research project), within these bounds we encourage trainees and mentors to customize coursework, lab rotations, and clinical experiences to meet a trainee's specific needs in the context of the four training goals.

To start the IDP development process, trainees will complete the myIDP Science Careers tool, sponsored by AAAS (https://myidp/sciencecareers.org). This online tool helps the trainee scientist to identify areas of strength and weakness, set long-term and short-term training goals, and explore science career opportunities; a sample report is shown in **the Appendix**. The trainee and mentor will use this tool as a framework for discussion of short-term and long-term goals and of the resources, training and skills needed to reach those goals; see also Evaluation, **§B.4**.

Year 1 IDP. As predoctoral trainees enter the program, they will create an IDP that focuses primarily on the **coursework** plan that meets the training goals. Postdoctoral trainee IDPs will include a combination of audited coursework, external training workshops, and mentored research and mentoring experiences. Predoctoral and postdoctoral trainees will identify a clinical area of interest, a methodological area of interest, and a breadth mentor from our team who can provide additional training in either of these domains. For postdoctoral trainees, the methods training should extend skills into a new domain or method. For instance, the trainee who enters with substantial EEG experience might want to concentrate his/her training goals on acquiring skills in simultaneous EEG/fMRI methods.

Year 2 IDP. In Year 2, predoctoral trainees will begin the transition away from coursework and focus on their Second Year Project. Predoctoral and postdoctoral scholars alike will use Year 2 to develop a plan to gain depth in expertise in one clinical population, outlining a Clinical Connection Plan that includes at least 20 hours of observation or contact with members of the clinical population. Trainees will also meet with clinical faculty for at least 5 hours of debrief time to discuss the cases they observe. Clinical Connection IDPs will be customized by trainees and their mentors to provide depth of training in a disorder of the trainee's choice. For instance, a Clinical Connection IDP for a trainee interested in aphasia might include attendance at the weekly Aphasia Groups in SLHS, planned observations of assessments of several people with aphasia, and monthly meetings with a clinical supervisor in SLHS with expertise in adult neurogenic language disorders. Postdoctoral trainees will also set goals in the Year 2 IDP to allow them to transition to the next stage in their career, focusing on independent grant-writing, the academic and industry job search, and preparation of research projects for publication.

B.3.b. Didactic Coursework. Predoctoral trainees will complete four courses, one each in **Cognitive Neuroscience**, **Typical Communication**, **Atypical Communication**, and **Cognitive Neuroscience Methods**. In each domain, trainees will select course options that meet the needs of their training and research goals. Traditional coursework will be supplemented with a required 1-credit **Clinical Connection Practicum** (taken twice) and a 1-credit **Professional Development Seminar**. Overall, the courses proposed here will also meet requirements for the standard degree; the particular "package" listed here along with several additional courses, provides the unique content of the T32. As such, time to degree is not increased (see **Figure 7**).

Cognitive Neuroscience: The Cognitive Neuroscience requirement will be met by **Fein**'s *Foundations of Neuropsychology* seminar (team taught with Behavioral Neuroscientist John Salamone), or the *Cognitive Neuroscience of Language Across the Lifespan* course team-taught by **Landi** and **Myers**. **Hoeft's** *Cognitive Neuroscience* seminar can also be used to fulfill this requirement.

Electives: Typical Communication. Trainees will select one of the many offerings in Psych, SLHS, or Linguistics. These include (but are not limited to) *Psychology of Language* (*Altmann* and *Yee*), a PAC requirement; *Advanced Speech Science II* (**Myers**), Development of Language (*Naigles*), *Sentence and Discourse Processing* (*Tabor*), *The Mental Lexicon* (**Magnuson**), *Neurobiology of Reading* (*Pugh*), *Bilingualism* (*Garcia-Sierra*) or other special topics courses routinely offered in PAC, LING, SLHS, and DEV every semester.

	SLHS		PAC		DEV		CLIN	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
Year 1	(3) STAT 5505	(3) STAT 5605	(3) PSYCH 5104 (Stats)	(3) PSYCH 5105 (Stats)	(3) PSYCH 5104 (Stats)	(3) PSYCH 5105 (Stats)	(3) PSYCH 5104 (Stats)	(3) PSYCH 5105 (Stats)
	(3) Language Development	**(3) MRI Methods**	**(3) Psych of Language**	**(3) Cog. Neuro. of Language Across the Lifespan**	**(3) Language Development**	**(3) Neurobio. of typical and atypical lang. dev.**	**(3) Psych of Language**	Cognitive Assessment
	(1) Prof. Development	(3) Research Practicum	*(1) Prof. Development*	(3) Neural Foundation of	*(1) Prof. Development*		*(1) Prof. Development*	Adult Psychopathology
	(1) Clinical Connections	*(1) Clinical Connections*	*(1) Clinical Connections*	*(1) Clinical Connections*	*(1) Clinical Connections*	*(1) Clinical Connections*	*(1) Clinical Connections*	*(1) Clinical Connections*
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
Year 2	(3) STAT 5665	(3) Research Practicum	(3) Cognition	**(3) Cognitive-Communication Disorders**	(3) Infancy and the Early Effects of Experience	(3) Neurodevelopment and plasticity	**(3) Neuropsych.**	**(3) MRI Methods**
	(3) Aphasiology	(3) Biligualism	**(3) Timecourse (ERP) Methods**	(3) Event Cognition	(3) Cognitive Development	(3)Developmental Systems	Personality assessment	Methods of Child and Family Psychotherapy
	(3) Neuropsych.	**(3) Neurobio. of typical and atypical lang. dev.**	(3) Connectionist Models		**(3) Cog. Neuro. of Language Across the Lifespan**	*(3) Auditory Electrophysiology*	Psychodynamics	Developmental Psychopathology

Key:	Typical Comm.	Atypical Comm.	Cog. Neurosci.	Neuroimaging Methods	Other T32 Program Requirements

Figure 7. Sample curricula in each of the four participating graduate programs. Courses in **bold** overlap with program requirements in the home department. Courses listed in *italics* are in addition to the "basic" program requirements. For SLHS and PAC, only 3 credits of course work cannot be used to fulfill regular degree requirements, for DEV, 6 credits, and for CLIN, 9 credits.

Electives: Atypical Communication. Trainees will complete at least one course on acquired or developmental communication disorders. Trainees have many options, including courses on *Aphasia* and *Cognitive-Communication Disorders* (*Mozeiko* and *Coelho*), atypical *Language Development(I/II)* (*Spaulding*), or *Neurobiology of Typical and Atypical Language Development*, team-taught by *Naigles* and **Eigsti. Hoeft** will teach a course on the *Neurobiology of Reading Disorder*. Courses on disorders of audition from the Audiology curriculum include *Pediatric Audiology*, *Cochlear Implants*, *Central Auditory Processing and Disorders* and *Aural Rehabilitation*. Notably, some of this coursework is also in the MA/AuD clinical training programs and has a strong focus on treatment and assessment strategies for communication disorders. These clinically-oriented courses may be especially beneficial for trainees without a clinical background (e.g., those who do not have a clinical degree in-hand or in-progress) in that they add a more person-focused and applied perspective on the disorder. *Due to their substantial coursework requirements*, students in CLIN or who are jointly pursuing an AuD/PhD may fulfill this requirement through clinical contact hours, lab rotations, and directed readings with a mentor, subject to approval of the trainee's committee and the ExCom.

Neuroimaging Methodology Elective: Trainees will take *at least* one course focused on neuroimaging methods (and will be encouraged to take more than one). **Hancock**'s *Neuroimaging Methods* course provides

a hands-on introduction to the design and analysis of MRI experiments. **Skoe**'s *Auditory Electrophysiology* course gives trainees applied experience in otoacoustic emissions, auditory brainstem responses, electrocochleography, auditory steady state potentials, and frequency-following responses. **Magnuson**'s *Time Course Methods* course covers EEG and eyetracking methods as used in psycholinguistics. **Hoeft's** *Neuromodulation Techniques* covers TMS and tDCS. Students who seek training in fNIRS will register for an Independent Study with **Aslin**, will attend a full-day workshop in the fNIRS lab at Haskins Laboratories, and can work directly with **Aslin** and his staff, which includes four fNIRS postdocs. **Aslin** has also committed to programming a J-term course and to contributing lectures within other methods courses.

Clinical Connections Proseminar: Eigsti and **Myers** will lead a new, one-credit course developed specifically for this training program. Both postdoctoral and doctoral trainees will take this course twice (both semesters of Year 1) and then revisit the course as relevant in Year 2 and beyond. Each 3-4 week unit will focus on a communication disorder, including hearing loss, aphasia, developmental language disorder (DLD), reading disorder, and autism spectrum disorder (ASD). Within a unit, we will invite research experts to present on their own work, providing sufficient background to understand the fundamental challenges and open research questions for the disorder. Expert clinicians will then present on the challenges of assessment and intervention for that disorder. Finally, individuals and families with personal experience of the disorder will be invited to discuss their lived experience with trainees. Each unit will culminate in a social event to which we will invite these researchers, clinicians, and community members. Our clients already play a key role in educating our clinical MA & AuD students, and they have been happy to participate in educational experiences. For instance, we have active aphasia and TBI support groups whose members frequently speak in graduate and undergraduate classes about their experiences. Similarly, **Eigsti** invites individuals with ASD and their caregivers to visit her ASD seminar. UConn students who experience reading disorder or language impairment serve as student ambassadors for people with disabilities. Clinic Directors *McMahon* (Speech and Hearing Clinic) and *Barton* (Psychological Services Clinic) will help the organizers identify clinicians and clients who are interested in participating. *The overarching goal of this course is to allow students to draw the connections between research, clinic, and client, to gain respect for the challenges that people with communication disorders face, and to inspire them to pursue research questions that have a greater chance of affecting clinical outcomes*.

Professional Development Proseminar: Co-offered with the NRT training program, this 1-credit Seminar includes standard professional development and ethics training, but will also provide the "missing manuals" to topics essential in PhD careers but seldom addressed in training (e.g., managing time, projects, and budgets; teaching; grant writing; reviewing; networking; reproducibility; project preregistration, p-hacking, etc.). The seminar will also cover NIH requirements for clinical trials [https://grants.nih.gov/policy/clinical-trials/reporting/index.htm]. Trainees take the full seminar once for credit, and can "drop-in" for topics of interest throughout their training.

B.3.c. Trainee-led, mentored research projects. Ultimately, the goal of any graduate training program is to prepare the next generation of scholars to conduct cutting-edge, high impact research. *It is vital that trainees get experience early in their careers in developing independent research topics of publishable quality*. To support this goal, all trainees will pursue independent research within the domain of the neurobiology of typical and atypical communication. Predoctoral trainees will be provided with significant support and mentorship in this process, devoting their first fellowship year to developing a proposal for their Second Year Project (SYP). Postdoctoral scholars will have the skills to transition to independence, and will develop their project plan during Fall of the first fellowship year. All trainees will be expected to present their project internally (initially in the Research Design Studio; later, at Talk Shop or BOLD talk series), and they will hone the proposal during the Grant-writing Seminar in summer after Year 1. To promote synergy across training in research, ethics, data management, and new best practices for promoting reproducibility in research, all trainees will be required to prepare a formal preregistration of their SYP to document *a priori* hypotheses and analysis plans following the model provided on the Open Science Framework, which will serve as the repository for T32 SYP preregistrations. We expect that all projects will ultimately lead to publication. We value the contributions of our junior scientists, and our default assumption is that trainee-led projects will be first-authored by those trainees, assuming they meet the usual criteria for first-author position. Through a contribution from UConn, trainees will have access to a pool of 240 MRI scan hours that can be used for these projects, and UConn-provided Program Support funds can also cover consumable supplies related to EEG and TMS projects.

Predoctoral Research Requirement: Second-Year project (SYP). The second-year project will focus on the neurobiology of typical or atypical communication; students will be encouraged (although not required)

to use neuroimaging methods in this project. Importantly, the SYP will also fulfill degree requirements in SLHS (2nd-year project requirement) or the PAC, DEV or CLIN programs (MA thesis), so it need not add to time-to-degree. In Fall of Year 1, the student will form a SYP advisory committee, consisting of the trainee's mentor, at least one other member of the core T32 team, and other committee members drawn from the community as relevant. The student will work with this committee to develop the project plan over the course of the first year. The ExCom will help keep track of whether trainees have completed this task.

Postdoctoral Research Requirement: Two-Year Project (TYP). As soon as postdoctoral traineeships are awarded, postdocs will begin work with their mentor to develop a research project on a question related to typical and atypical communication. The postdoc will submit a project proposal to his/her mentorship team, outlining the importance of the research question with respect to clinical applications, the theoretical foundation of the question, and a methodological approach. Postdocs will be required to select a breadth mentor outside his/her lab to help guide the project. This project should be ambitious in scope, and the trainee should identify at least two possible publications that might emerge from it. Projects should involve some breadth in methodology (e.g., acquiring skills in a new imaging modality), and in content area (e.g., applying the postdoc's expertise in one domain to a new population). Postdocs will be expected to present their research externally at national and international scientific meetings, funded by T32 travel allowances. Finally, in order to provide mentoring experience, postdocs will join one or more Second Year Projects to provide expert content area or methods guidance. This will promote postdoctoral trainees' development of much-needed mentorship skills, and we expect that successful projects will also lead to authorship opportunities for postdocs.

B.3.d. Grant-writing. In the summer after Year 1, trainees will participate in the *IBACS Summer Grant-Writing Program*. This four-week workshop, led by **Landi** and other IBACS faculty with a track record of NIH and NSF funding, consists of two days of training in NIH grant writing and review geared toward the F31/F32 mechanisms, a three-week intensive writing period; a week-long peer review process; and a mock NIH F31/F32 review panel. Fellows learn to discuss their project with non-experts and prepare specific aims page; they review writing tips, drawing from successful proposals; and they learn about the NIH review process, including a discussion of summary sheets and how to revise a proposal. In addition, when trainees are successful in receiving F31 or similar fellowships their mentors are eligible for a $5000 incentive from the UConn Office of National Scholarships & Fellowships. Of the approximately 35 fellows who have participated over two program years, 20 (57%) have submitted individual NRSA (F31) applications and 4 have submitted proposals for other external grants or fellowships (e.g., NSF GRFP). Note that many of the remaining fellows were ineligible given US citizenship requirements; many of these students have helped their advisors write larger faculty grant proposals (e.g., R21, R01). This workshop positions predoctoral trainees to write F31 applications as they transition off T32 funding, and equips postdoctoral scholars with grant-writing skills to facilitate their transition to independence as researchers. Postdoctoral trainees will also be encouraged to apply for the ASHA *Lessons for Success* program, a 3-day workshop that provides "intensive training to a promising group of early career scientists in the areas of (a) grant preparation and funding opportunities, (b) development and management of a successful program of research, and (c) advancement of professional competencies" (https://www.asha.org/Research/L4S/) In general, transition to F31/F32 mechanisms is the goal for every trainee in our program. This goal is supported by the graduate programs themselves—SLHS and PAC require the dissertation proposal to be formatted like an F31 to encourage trainees to apply for external support for their dissertation work. The ExCom will track how many trainees submit F31 proposals as they cycle off T32 funding.

B.3.e Other Program Activities

January-term (J-term) workshops. J-term workshops are short courses scheduled during the January semester break, co-organized with the NRT-SLAC program. These "crash courses" serve to fill gaps in training, including content areas (e.g., genetics or dynamic systems), specific tools (e.g., Praat or MVPA), programming (e.g., Python), ethics (e.g., topics in the Responsible Conduct of Research), and advanced statistics (e.g., mixed effects models in R), etc. We will also offer an "ask the clinician" workshop. J-term workshops are organized by trainees to fill needs identified by the trainees themselves.

Disciplinary Brown-bags, "Talk Shop", and the BOLD series. Weekly area talks provide enhanced training within special topic domains. Trainees will attend weekly lunchtime *Brown-bag* talks in their primary discipline (e.g., SLHS, CLIN, PAC or DEV). In addition, *Talk Shop* is an interdisciplinary brown-bag attended by faculty and students from multiple disciplines: Linguistics, Behavioral Neuroscience, Philosophy, Computer Science, and Educational Psychology. Organized by students, this series comprises 30-minute presentations with an emphasis on interdisciplinary communication, followed by vigorous discussion. The *BOLD talk series* is organized by the BIRC, and includes neuroimaging methods-oriented talks on current research at the BIRC.

Research Design Studio. Discussion of a project in the very early planning stages is often of great value. Colleagues can point us to relevant literatures, to related symptoms in a different clinical population, to a more sensitive or complimentary method, etc. While Talk Shop and the BOLD and program brown-bags could in theory provide a venue for this type of freewheeling discussion, our experiences indicate that trainees prefer to showcase completed projects in these venues. The monthly Research Design Studio will provide an informal, low-key, venue for talking about research proposals over cake and coffee. Design Studio meetings will be held once-monthly, in the shared IBACS workspace adjacent to the shared EEG lab.

External workshops. Each trainee will be encouraged to apply to at least one external methods course or workshop per year (e.g., AFNI bootcamp, Freesurfer workshop, Connectivity course, Multimodality Short Course, etc., offered at NIH, the Martinos Center, Univ. of Pittsburg, the Max Planck Florida Institute for Neuroscience, etc.). UConn-supplied Program Support Funds will be used to support the trainee's attendance.

B.3.f Beyond academia: Training for other careers. Our training program is designed to attract and train the best and most diverse scientists, and to foster their success not only in academic careers but also industry pathways. As a faculty we recognize that training students only for tenure-track R01 positions is untenable, and does not reflect the diversity of ways the scientific training we provide may benefit the US population. Our community has been actively exploring how to mentor students as they pursue industry as well as academic career pathways, and we plan to include mentorship plans for trainees who choose to target industry and academic research careers alike. As an example, a graduate of our program recently secured a position in a biomedical startup testing drug interventions for hearing. She gave a presentation to our graduates and faculty about the industry job search, and provided peer-to-peer mentorship to students who are considering this path. Additionally, a current trainee is a Student Ambassador for Intel Artificial Intelligence and has organized two workshops on deep learning (which can be used to develop computational models of human communication) for the UConn community. Trainees from the existing IBRAiN program have also reported gaining valuable industry skills in the course of their training that have prepared them for industry interviews. Notably the *Neuroimaging Methods* course emphasizes computing and data science skills that are translatable to industry.

B.4. Training Program Evaluation

B.4.a. Evaluating program quality and effectiveness. As scientists, we know it is critical to develop objective and quantitative metrics of a program's quality and efficacy in producing transformative, productive, and independent scientists. Drawing on UConn Program Support funds, we will hold an annual **External Advisory Board meeting**, scheduled as a satellite meeting of the annual Society for the Neurobiology of Language conference. Our distinguished panel members are all pioneers in cognitive neuroscience, and with a focus on communication science, clinical populations or, in many cases, both. All have extensive experience managing large grants; indeed, two of our panel members (Love and Nelson) are themselves currently directors or significant leaders of a T32 training award. Panel members will be invited to critique the training and research aspects of our program, to identify weaknesses and to present opportunities to transform the program. This group will also serve as a bellwether of our program's reputation and that of our trainees, as we anticipate that they will work with some of these trainees during postdoctoral fellowships (see **LoS from Love**). We will also evaluate program quality in more quantitative fashion, using the two following approaches.

B.4.a.1. Trainee feedback (graduates). First, we will solicit feedback from recent trainees to collect baseline data on trainees who were not part of a training program. The *Department of Psychological Sciences* regularly administers an Exit survey, linked on our program website and emailed to graduates, to collect post-graduation outcomes and data. Graduates are asked to rate various aspects of training on a Likert scale, to provide qualitative information about strengths and weaknesses of the training experience, and to describe the first (and current) post-graduation positions they have held. They are able to join the department's LinkedIn and Facebook pages with a mouse click. The survey has also been shared electronically with alumni who graduated before the electronic survey was created. Data are compiled and stored in a database. Given the relatively small number of PhD graduates in that department, *SLHS* outcomes (post-graduation positions and further training) are currently compiled by individual advisors. T32 Staff will create a similar survey to distribute to graduates of both programs. This survey will be used to compare outcomes of the proposed T32 program's graduates with those of the broader trainee pool, to determine whether (as we predict) those supported in the current proposal are more satisfied with their training, more likely to complete the degree, and more likely to remain in research. Other relevant metrics for success include number of publications and abstracts, and successful bids for fellowship funding (e.g. F31/F32, NSF DDRI, or NSF SPRF awards), and time-to-degree. The Program Assistant will also compile information about trainee publications. This process will permit the careful tracking of career development and progression of trainees, including publications, additional training in

degree programs and postdoctoral fellowships, and subsequent jobs.

B.4.a.2. Progress reports. As described above (**§B.3.a**), trainees work with mentors to propose a personalized first-year IDP, focused on methods and coursework, and a second-year IDP, focused on continuation of research and methods skills, as well as a specific Clinical Connections plan. At the end of each semester, trainees and their mentors will review the current IDP, discussing clinical and course- and lab- based training experiences, research progress, and discussion of any unmet goals or impediments to progress. The trainee and mentor will expand the IDP, noting detailed goals for the following semester and broader goals for each year of their training period and for achieving their desired career path after their time at UConn. Mentors will help trainees to keep goals ambitious but realistic. Discussion will encompass issues specific to trainees from URMs or with disabilities. A written report will be submitted to the ExCom which will schedule a meeting each semester to discuss trainee progress as a group, making remedial plans as necessary for trainees and tracking the appropriateness of curricular and training requirements, in the context of overall program progress. The Clinical division of Psychology implemented this formula (IDP discussion with students, followed by a faculty evaluation meeting) in 2013. The process has proven particularly valuable in helping trainees to monitor growth and development in their interests and career plans on a regular basis, as well as their acquisition of needed skills. It has also helped the clinical faculty to adapt nimbly and quickly to concerns and opportunities at the trainee and program levels.

B.4.a.3. Evaluation Metrics. Our program goals are both conceptually *broad* (training in the cognitive neuroscience of typical and atypical communication; maintaining clinically-oriented and basic trainees in the science pipeline) and *specific* (equipping trainees with cutting-edge methodological skills and providing hands-on mentored access to these methods; connecting scientists with clinical populations to understand the concerns and experiences of affected individuals). We have proposed that the current program will substantially enhance trainee outcomes, given the unique and value-added nature of the proposed activities. To test this hypothesis, we will employ the following outcome metrics, which are directly tied to program goals and activities.

1. Trainees and program faculty will complete an annual survey on **progress, goals, and satisfaction**; keeping the survey brief will encourage wide participation. Quantitative data from this survey will index program "health."
2. The annual report required for this program requires tracking **degree/program completion, time to degree, publications, presentations, fellowships/honors, and continuation in research careers**. These data will compare funded fellows to students in the same discipline not funded via this program.
3. Google Scholar profiles for trainees will be linked to the program webpage (including alumni of the program), and we will track citations of these papers as well as attention to research in the press. Although we recognize that citation and impact indices are flawed measures of the impact of publications, we will monitor these indices to highlight research products that are widely-cited by other researchers. We will rely on the Advisory Board to provide feedback on the impact and clinical relevance of research products from our trainees.
4. Trainees will be encouraged to upload preprints on PsyArXiv; this process, which adopts NIH guidelines [https://grants.nih.gov/grants/guide/notice-files/NOT-OD-17-050.html] for posting preprints, serves to promote trainee work more quickly than is possible via conventional print (or even online) journals, given the measured pace of the peer review process; this process also provides earlier feedback on trainee work, from a potentially larger set of experts than typically participate in peer review. Program staff will track downloads.

B.5. Trainee Candidates

We concur with the NIH Physician-Scientist Workforce report, which describes how the challenges of clinical education, and the attractions of clinical-only positions, divert PhD-level clinicians *away* from clinical research. The current proposal will remedy this in part by front-loading research training (in this case, in neuroscience methods) early in the trainee's career such that they are prepared for independent work involving clinical populations upon conferral of the PhD, rather than after several postdoc training experiences. This effort is also consistent with the call to support clinician-scientists at early career stages.

B.5.a. Predoctoral Candidates. As shown in **Data Tables 6A** and **6B**, our programs receive substantial numbers of highly qualified applicants. Application numbers (237-414) are highest for the Clinical Psychology program, as is typical for these programs, and lowest (4-14) for the SLHS program, where clinical careers draw potential trainees out of the research pipeline (Myotte et al., 2011). Other divisions in PSYC draw about 30 applicants each per year, usually competing for 4-8 entry slots per division. Notably, the mean GPA (3.6) and number of months of research experience (~16 months) are competitive across all programs. Our applicant

pool draws applications from national and international scholars. Most enter the program with BA/BS degrees, although many have also received MA degrees, and some SLHS students enter as part of a dual degree (AuD/PhD) program.

Recruitment. Our MPDs, Mentors, and trainees are active participants in many conferences. We will distribute program information and applications at scientific meetings, and show links to the program webpage on materials we distribute (e.g., in email signatures). Flyers regarding the program will be distributed to undergraduate degree-granting programs. In addition, we will be active in recruiting members of URM groups, as described in **§C**. **Recruitment Plan to Enhance Diversity**. In materials about the program, we will make clear that members of URMs or persons with disabilities are particularly encouraged to apply.

Admissions. The Executive Committee will act as the admissions committee. Predoctoral trainees will be admitted into the training program as part of their admission to their home graduate program. During the graduate admissions process in the spring before the fellowship year, mentors will nominate their most promising prospective graduate students for the T32 award. The mentor and prospective trainee will submit a joint application to the program, each describing the fit between the prospective trainee's goals and the goals of the training program and the trainee's qualifications for the program. During selection meetings, the ExCom will strive to recruit and admit candidates with exceptional promise for study of typical and atypical communication. Among equally-qualified trainee candidates, priority will be given to candidates who add a diversity of perspective (e.g. balancing basic and clinical perspectives) and background to the trainee pool (see the **§ C. Recruitment Plan to Enhance Diversity** for further details), and to those who help us distribute trainees across mentors and degree programs. Trainees will explicitly commit to completing the training program, and also to continuing to stay active in the program beyond their fellowship years by attending weekly Talk Shop brown-bags, BOLD (MRI) Brown-bag talks, helping to organize the J-term workshops, and providing peer-to-peer mentorship on SYPs. Mentors will commit to supporting the trainee in the completion of the training goals, to working with the trainee to develop an IDP customized to the trainee's needs, to participating in community events (Talk Shop attendance, guest presentations in the Clinical Connections Practicum) and to serving as an associate mentor to other trainees in the program, as appropriate.

Reappointment. The criteria for reappointment will be strong performance in course- and lab-based training, and mentor endorsement for re-approval based on research progress; this progress will be actively monitored via the IDP process (see **B.4.a.2.**). In cases where a mentor does not recommend reappointment, the Executive Committee will review the case in detail. However, we shall endeavor to avoid this, and instead achieve our goal of 100% retention, and program and PhD completion.

B.5.b. Postdoctoral Candidates. As can be seen in **Data Table 6B**, our team has mentored 21 postdocs over the last 5 years, of which 13 would have been eligible for training. Because almost all of these trainees have come to us either with their own external funding (F32 or NSF SPRF mechanisms, for instance), or through existing research collaborations rather than through a general search, there is very little available data on the total applicant pool. (Applicant pool figures are given only for positions for which there was a general search, and so these figures can only be used to estimate the *proportion* of eligible trainees in the pool, but not the *overall size* of the potential applicant pool). Nonetheless, postdoctoral trainees are from top research programs, and typically arrive for training with at least 6 publications (3 first-authored). **Aslin** and **Hoeft** have particularly strong postdoctoral mentorship records, and they will strengthen our team's skills in attracting and mentoring strong postdoctoral candidates.

Recruitment. Recruitment plans will be similar to those for predoctoral trainees, with the addition of formal job search mechanisms. Postdoctoral searches will take place in Spring semesters in Year 0, Year 2, and Year 4. For the purposes of this T32 program, we will use a job search approach rather than direct recruiting. Notices will be placed in publications, newsletters, and websites of appropriate academic societies, as well as on our team's website. Our External Advisory Board will serve as another vehicle for advertising these positions. We will make clear that members of URMs or persons with disabilities are particularly encouraged to apply. We also recognize the challenge with postdoctoral recruiting; the pool of postdoc candidates from URMs is quite small. One innovative strategy we will employ is searching grant databases for federal PhD training grants (NIH, NSF, Education). Such grants include diversity mandates, and thus vital points of contact for finding URM candidates and getting the word out about our postdoctoral positions.

Admissions. Applicants will be required to have a PhD in a field related to our program, and have appropriate research and/or clinical experience in their field. The formal application will resemble that for our predoctoral trainees: they will describe how their career goals fit with the program goals, and will be asked to name a potential mentor and research focus. The admissions committee will pass applications for applicants meeting minimum criteria to suggested mentors, or mentors appropriate for a training theme. Those mentors

will decide whether to nominate the candidate for a fellowship. If they decide not to, other mentors in their area will be given the opportunity to do so. Nominations will include a letter of support from the potential mentor. The admissions committee will evaluate candidates based on qualifications, mentor support, and the need to balance numbers of trainees with primarily basic vs. clinical research orientations, numbers of trainees in each program, and diversity goals.

B.6. Institutional Environment and Commitment to Training

The UConn administration strongly supports the goals of this application and as such, has committed to several specific forms of institutional support to ensure the success of the program (see also **Administration LoS**). The Connecticut Institute for Brain and Cognitive Sciences (IBACS) offers additional resources.

Funding for trainees after the training period. UConn has committed to supporting predoctoral trainees for the remainder of their standard five years of PhD training after they cycle off T32 support, through a combination of Graduate Assistantship and Teaching Assistant support. In addition to the standard funding avenues (mentors' grants, TAships, fellowships such as the F31), there are several opportunities for subsequent predoctoral support. Supported by IBACS, **IBRAIN graduate fellows** receive a 75% stipend, plus summer support, and learn to support their own and others' neuroimaging research. Classroom and lab-based training helps them to support users of BIRC facilities in the design and implementation of experimental procedures for fMRI, EEG, tDCS, TMS etc., recruitment and prepping of participants, data analysis, and overseeing use of equipment by others. IBACS director Altmann notes that our trainees will be especially good candidates for this fellowship (see **Altmann LoS**). There are additional IBACS mechanisms, including the *IBACS Grant Writing Workshop* (described in **§ B.3.d**), and *Summer Fellowships* (Stipends to support graduate living expenses and research). Finally, Program Support funds provided by UConn will enable us to defray the added burden of supporting predoctoral fellows after they return to departmental funding sources by **providing two 10-hour fellowships each year** to be distributed to the home departments of graduate trainees.

Other supports to predoctoral trainees. The Graduate School has committed to ensuring that tuition, fees and health benefit costs beyond what can be covered by the training grant will be fully supported in accordance with University policy. Because the predoctoral T32 stipends are smaller than a typical UConn stipend, this support includes **funding to bring the stipend to the full-time UConn level, allowing us to offer competitive stipends as we recruit trainees**. Predoctoral trainees will be funded for 9 months on the T32 and 3 months on University Funds, but we will expect them to engage in this training plan for the full 12 months. Similarly, the T32 allowance for student training costs does not fully cover health insurance for predoctoral trainee; this support will provide the balance of these costs.

Program supports. The Office of the Vice President for Research and the College for Liberal Arts and Sciences will each commit $60,000 a year for five years (for a total of $120,000 each year) to cover costs including recruitment and admission events, External Advisory Panel visits, and 25% salary of an Administrative Program Assistant. The College of Liberal Arts and Sciences (CLAS) has committed to one course release per year for the MPDs (for a total of five course releases). **Eigsti** and **Myers** will alternate in years 1-4 and in Year 5, when the administrative burden will shift, will split the resource. CLAS will also provide 240 hours of MRI scan time for training purposes over five years, to enable trainees to implement neuroimaging research. Finally, the current and incoming Director of the *Brain Imaging Research Center* (**Eigsti**, MPD, and **Hoeft**) will provide BIRC resources including training, access to imaging methods, and computing resources for data processing; see **BIRC LoS**.

B.7. Qualifications of Trainee Candidates and Admissions and Completion Records

The participating programs are highly selective, admitting on average 4.3% of applicants (ranges from CLIN: 2%, to SLHS: 38%). As detailed above (**§B.5**) these trainees come to us with solid research experience -- over a year of prior research experience, on average -- and excellent academic credentials (such as an average GPA of 3.6). They arrive with degrees from strong R1 private and public universities, as well as small colleges where they received excellent advising and intensive research experience. Given the qualifications of applicants at the predoctoral and postdoctoral levels, the program should be able to identify and admit the number of trainees as proposed (10 predoctoral and 5 postdoctoral).

Retention. Retention rates in both PSYC and SLHS degree programs are high, with approximately 95% of entering students completing the programs with a PhD While we do support trainees who decide to leave the program if they discover that the research PhD is not their chosen path, we believe we can (and must) be proactive in ensuring that all trainees have adequate support as they move through the degree program.

We recognize that retention may be especially challenging for trainees with fewer economic resources, those from underrepresented groups, individuals with disabilities, and for trainees with family obligations. According to a recent report by the American Speech, Language and Hearing Association (ASHA)

[https://www.asha.org/practice/multicultural/recruit/litreview.htm], poor retention in graduate training programs is often associated with (a) absence of mentors and role models on campus, (b) lack of adequate social support and integration, and (c) lack of professional networking. We will establish multiple support mechanisms that address these issues for all trainees, and especially those from underrepresented groups. *Role models, peers,* and *social integration* are particularly important concerns. Trainees, especially those from underrepresented groups, will be encouraged to take part in Graduate School workshops on professional development, and to take advantage of counseling and other resources for individuals from underrepresented groups, including the tools at the Career Development Center (many of which focus on the particular needs of graduate students from underrepresented groups).

The language community at UConn has been particularly active in recruiting graduate students from the Deaf community. While the experience of these students was initially somewhat uneven, *Coppola*, *Lillo-Martin*, *Altmann*, and **Magnuson** were successful in pushing for the hire of a full-time interpreting coordinator and multiple full-time interpreters. The Center for Students with Disabilities has been a resource for many of our trainees, including those with learning or reading disabilities, and the UConn Interpreting Service within this office has been particularly active in educating the broader community about the inclusion of Deaf students. The UConn campus is culturally inclusive, and students may find social support through the African American, Asian American, and Puerto Rican/Latin American Cultural Centers. While we strive for 100% retention and completion of the PhD, trainees who elect to leave the training program will be referred to services in the UConn Center for Career Development that are specially designed to help graduate students explore alternative career pathways (including non-academic routes) and prepare for job searches.

C. RECRUITMENT PLAN TO ENHANCE DIVERSITY

We are committed to diversity on multiple fronts. In prior training programs, we have seen the tangible benefits of recruiting a broad and diverse group of trainees, who bring their unique perspectives to the research community. We have had an excellent record of recruiting a high proportion of individuals from URGs to our prior graduate training programs (IGERT, NRT); across the four programs in this proposal, an average of 18-20% of our new trainees hail from URGs. We will draw on that experience to further diversity our community. Our recruitment efforts for this program will focus on mechanisms with a proven track, as follows:

1. We will target of Historically Black Colleges and Universities (HBCUs) for recruitment, through postings on listservs and personal visits. We will also draw on personal connections with CUNY-Medgar Evers and the University of Puerto Rico-Mayaguez. Our partner T32 program at SDSU/UCSD has excellent representation from Hispanic/Latinx groups and this connection may help us expand diversity in postdoctoral trainees recruited from their program.
2. Faculty will attend meetings of organizations that aim to boost recruitment of URMs in doctoral training, including the Annual Biomedical Research Conference for Minority Students (AMRCMS) and the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS). We will invite current students from URMs to be envoys along with faculty in these activities.
3. We will build on our membership (**Eigsti**) on UConn's Council on Diversity, Equity and Inclusion, at which Department, Institute, and Center Directors share strategies for mentoring students from URMs.
4. We will provide mentoring that goes beyond research, via our Professional Development course, which includes mentoring discussions of networking and collaboration; how to negotiate (salary, benefits); how to negotiate service requests; and other aspects of professional life that our diverse students have reported as particularly challenging.
5. We will connect with URM students via the Young Scholars Senior Summit program, sponsored by the Jack Cooke Foundation, which brings high school students from around the country to our university to participate in lab experiences. Finally, while not serving trainee diversity directly, programs that target high school students help to "prime the pipeline" by engaging junior prospective scientists in research.

Reflecting UConn's commitment to diversity and inclusion, UConn Program Support funds from the Administration will be used to support trainees and faculty in making recruitment trips (see **Administrative LoS; § B.6. Institutional Environment and Commitment to Training**. In addition, via the *Center for Career Development* at UConn, we have access to the National Mentoring Network, a website providing recruitment resources and a diversity toolkit. There is much more to do, particularly at the postdoctoral level (e.g., **Data Table 6B)**, where the pipeline is the narrowest in programs across the nation. We have a strong track record of recruiting diverse predoctoral trainees, as shown in **Data Table 6A**, and will build on these successes.