

BRAIN, COGNITION & LANGUAGE

BILINGUALISM: Across Spoken & Signed Languages

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Science & The Public Good

Scientists undertake research for many reasons. Some research stems from humans' natural curiosity about our world, universe, our human origins, and how things work. Some research studies yield knowledge that can be applied to real-world challenges and that can guide policy decisions in a variety of areas, such as climate change, physical and mental health, education, and child development. Much of the research conducted by members of the CT Institute for the Brain and Cognitive Sciences has the potential to help lawmakers develop policies that will benefit individuals, families, communities, and our society overall.

A better understanding of how children learn language, and of how language and reading are acquired in the brain, can assist education administrators in developing appropriate policies for bilingual children who come from fami-



Dr. Marie Coppola, Director of the Study of Language and Math (SLaM) Project, asks a young Deaf user of ASL to count the colorful fish as an example of the games her team plays to learn about how language influences children's counting and number understanding.

lies who use more than one language at home, or whose experience includes spoken language, sign language, or both. Research examining the social interactions and engagement that support optimal language and cognitive development for children from many different kinds of families is essential. This knowledge can be used to identify children who might be at risk for language or reading

delays and provide them and their families with evidence-based services to ensure optimal development.

Policies informed by research establish guidelines for administrators, teachers, and service providers to ensure that each child reaches their maximum potential in every language available to them. In the case of bilingualism, an additional benefit beyond that experienced by the individual child is an increased ability to communicate among different linguistic and cultural groups within our own country, as well as across national borders.

Student Feature



Photo by Mark Benjamin

Jessica Contreras is a Hispanic Deaf doctoral student at the University of Connecticut studying Developmental Psychology with a focus on the Neurobiology of Language. She is bimodal bilingual; her first language is American Sign Language (ASL) and her second language is written English. She received her B.S. and M.S. from Rochester Institute of Technology (RIT) in Psychology, while working as a research assistant. She graduated RIT under the guidance of Dr. Peter C. Hauser and the Rochester Bridges to the Doctorate program funded by the National Institute of Health with the mission to train and promote Deaf scientists.

Jessica is pursuing her doctoral degree at UConn with Dr. Marie Coppola; they both share a deep passion for increasing opportunities and accessibility in science for Deaf scientists. UConn has a growing community of sign language researchers, which presents many opportunities for the Deaf and/or signing community. Jessica seeks to better understand how experience with spoken, written, and signed languages promote cognitive development.

Brain, Cognition & Language Digest

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UNIVERSITY OF CONNECTICUT

FUN FACT

It is generally believed that **over half** of the world's population is bilingual

(Grosjean, 2010).



Terms to Know

Monolingualism is being proficient in one language (spoken or signed).

Bilingualism is being proficient in two languages (spoken and/or signed).

Bimodal Bilingualism is being proficient in a signed and a spoken/written language. Note that it is possible to be proficient in a language without speaking it (i.e. written proficiency).

American Sign Language (ASL) is a visual signed language using hands, facial expression, and movement. ASL is not like English; ASL has its own syntax and grammar.

Nicaraguan Sign Language (NSL) is a new sign language that emerged from Nicaraguan deaf children in the early 1980's. Prior to this time, no sign language existed in this community.

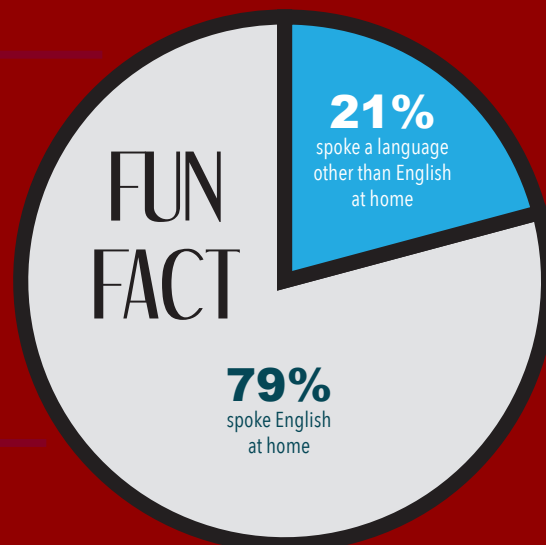
The term **Deaf**, with a capital D, is used when referring to an individual or group of individuals with little to no hearing who possess a strong identity of their own culture and share a common sign language.

A **hearing aid** is an electronic apparatus placed in the ear that amplifies sounds.

A **cochlear implant** is a small complex electronic apparatus that is surgically placed in the ear canal to provide sound signals to the brain.

Definitions credit to Katherine Griffin and Elizabeth Roffe

According to the 2010 U.S. Census Bureau, of **291.5 million people in the U.S. aged 5 and over**, 60.6 million people (21 percent of this population) spoke a language other than English at home.



Q: Did you know that babies are born with the ability to recognize the sounds in every spoken language?

A: During the first year of life, the brain changes dramatically based on language exposure. One aspect of this is specialization in the perception of the speech sounds of our native language. Early in life, infants are able to hear differences between all the speech sounds from all languages, but as they gain more experience in their native language, they can only tell the differences between the sounds that are used in their native language. Bilinguals, however, continue to tell the difference between speech sounds that are used in both of their languages.

Citations: Garcia-Sierra, Ramírez-Esparza, & Kuhl, 2016; Werker & Tees, 2002

Q: Did you know that neuroimaging data indicates less growth for individuals who receive late language input?

A: Researchers attempted to study the brain growth within a population of deaf and hearing individuals to understand the importance of early language exposure. Findings indicate that individuals who received language (spoken or signed) late show less brain development. Deaf individuals who received early ASL did not differ from hearing individuals. This research has important implications for the need to ensure that all children — deaf and hearing — receive early language input.

Citations: Pénicaud, Klein, Zatorre, Chen, Witcher, Hyde & Mayberry, 2012

Q: Did you know that the way you talk to your child can impact your baby's language development?

A: One recent study showed that children's future language development was related to how much their parents spoke to them in one-on-one interactions, but not to how much language input they received overall. This finding was observed in both monolingual and bilingual infants. This research indicates that quality of the interaction between parents and infants is important for language development.

Citation: Ramírez-Esparza, Garcia-Sierra, & Kuhl, 2014

Q: Did you know that babies are also born with the ability to recognize distinctions in sign languages, even if they eventually lose that ability?

A: Being bilingual does not apply only to spoken languages but also to sign language. At very early ages, all infants — hearing or deaf — are able to distinguish between the different handshape categories that are used in American Sign Language (ASL). From around their first birthday, however, infants who have not received continued ASL exposure are no longer able to discriminate between different handshapes.

Citations: Palmer et al 2012; Werker, 1984

Q: Did you know that being exposed to a second language early in life does not interfere with development of a first language?

A: A number of studies have suggested that when it comes to language development, bilingual children trail behind their monolingual peers. However, this may simply be because bilingual children receive relatively less input in the language of their monolingual peers. Indeed, one recent study found that when controlling for language input, monolingual and bilingual children showed similar brain responses associated with language learning. Research also shows that bilingual children eventually do catch up to their monolingual peers.

Citations: Bialystok, 2010; Garcia-Sierra, Ramírez-Esparza, & Kuhl, 2016; Hoff & Core, 2015

Q: Did you know that there may be cognitive advantages to learning two languages in infancy?

A: In order to learn two languages simultaneously, infants must also learn how to keep the two languages separate mentally and only use the language relevant to the current situation. A number of researchers have proposed that having to do this language separation may result in cognitive advantages for the infant and that these advantages may persist into adulthood.

Citation: Bialystok, 2001, 2011; Werker, 2012

Q: Did you know some people consider bimodal bilingualism bad?

A: When children are born deaf, neural regions that would ordinarily respond to auditory stimuli begin to respond instead to visual stimuli. Some people have speculated that if exposure to sign language intensifies this cortical reorganization, it might be more difficult for a child to acquire spoken language after cochlear implantation (CI). However, a recent UConn study found that Deaf children from Deaf families demonstrated spoken English skills that were statistically indistinguishable from those of hearing children from Deaf families and better than those of non-signing CI users. This study demonstrates that while early exposure to sign may involve cortical reorganization, it clearly does not prevent signing children from acquiring spoken language.

Citation: Davidson, Lillo-Martin, & Chen, 2014

Q: How do we know if infants can discriminate between two different speech sounds? We can't exactly ask them.

A: Scientists have developed a number of ways to determine if infants can tell the difference between two speech sounds, or phonemes. One is with a "head turn" procedure, in which infants are trained to turn their head when they hear a change in sounds. (A correct head turn is rewarded by the presentation of something the child enjoys, such as a toy dancing in a window.) The experimenter then plays the same phoneme (e.g., da) several times in a row before playing a different phoneme (e.g. ta). Infants who can tell that the last sound is a different phoneme will turn their heads, but an infant who cannot hear the difference will not.

Citation: Werker, 1984

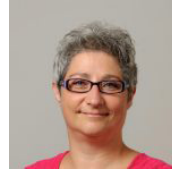
RESEARCH SUMMARIES



DR. NAIRÁN RAMÍREZ-ESPARZA

Is bilingualism better? Previous work shows that bilinguals have an advantage over monolinguals in cognitive flexibility.

Dr. Ramírez-Esparza's lab has recently published a paper where they demonstrate that bilingualism also provides an advantage in social flexibility, which they define as the ability to switch with ease, and adapt between different social environments, and accurately read social cues in the environment. In their study, they also demonstrated that bilinguals' social flexibility gave them an advantage over monolinguals in the frequency of social interactions. This study suggests that as bilinguals alternate between two languages, they also alternate between two cultural worlds, providing tools to adapt to different environments and facilitating the frequency of social interactions.



DR. MARIE COPPOLA

Cochlear implants (CIs) have become the go-to solution for children born deaf, 95 percent of whom are born to hearing parents. Parents of children with CIs are often advised not to use sign language because it may interfere with their child's ability to learn to hear and speak. This may unintentionally leave children with little to no access to language, since CIs have varying and unpredictable degrees of success. Recent research, however, supports educating deaf children bilingually – that is, using both a sign language and a spoken language from birth.

At UConn, Dr. Marie Coppola studies cognitive development in deaf and hard of hearing (DHH) children, focusing on the impact of early language experiences on the development of basic number concepts. One study compares the numerical skills of (1) hearing children learning spoken English, (2) DHH children who learn ASL from birth, and (3) DHH children who receive sign or spoken language input later in development, as is the case for the vast majority of DHH children. The project explores the idea that DHH children struggle to learn because of limited early language input. She hopes her work will support bilingualism for DHH children.

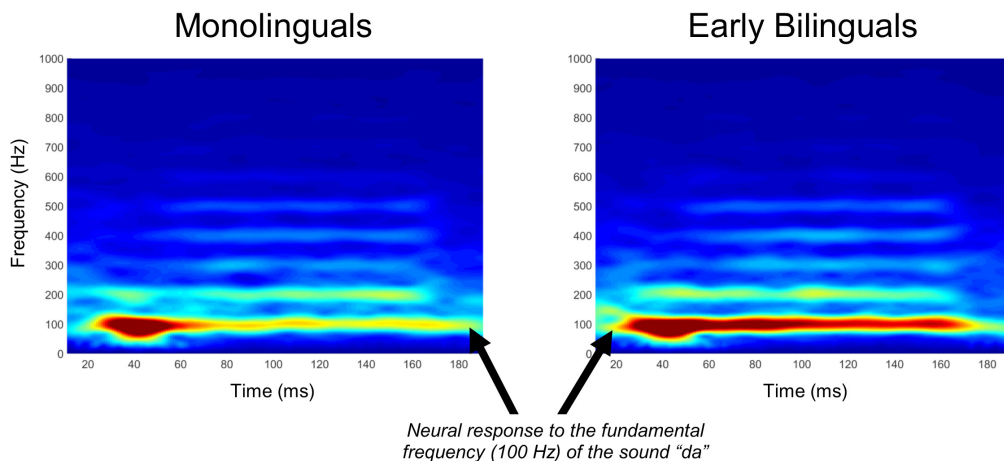
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DR. ERIKA SKOE

Dr. Erika Skoe's lab examines how different forms of environmental stimulation and deprivation affect how the brain processes sound. In a recently published study, Skoe

and her team compared adult monolinguals to bilinguals of diverse spoken language backgrounds, with the goal of understanding how low-level sensory processes are influenced by early exposure to multiple sound systems. Consistent with previous results in Spanish-English bilingual children, they found that bilingual adults from diverse language backgrounds have more robust neural responses to the fundamental frequency of the sound stimulus, an important acoustic cue for both linguistic and non-linguistic communication. Through this replication, Skoe believes they have identified a neural hallmark of bilingualism, a theory they will continue to test in their future work.

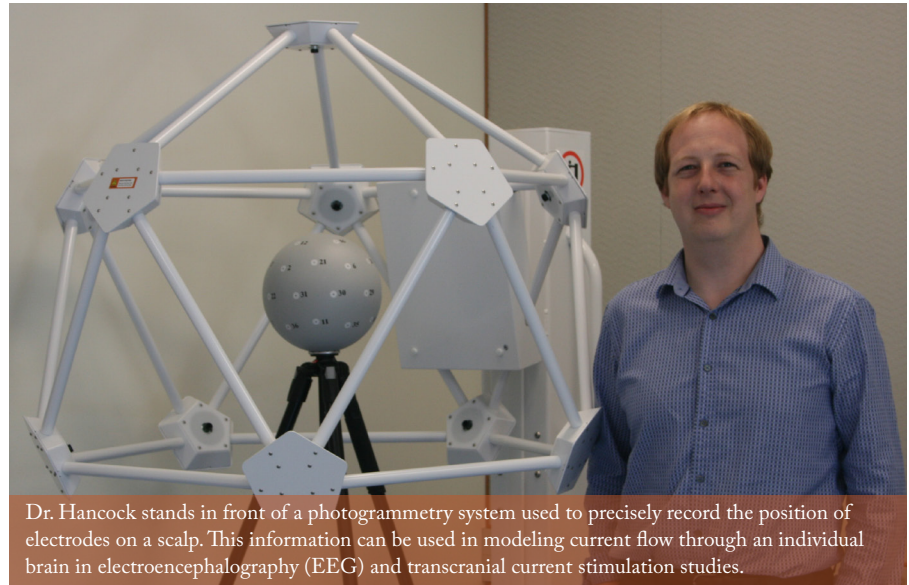


Bilinguals who learn two languages from an early age (before age 9) have more robust responses to sound. The figure above shows the neural response to a speech sound “da” in monolinguals and bilinguals. The horizontal stripes of color represent the neural response to different speech frequencies, with the lowest band at 100 Hz being the fundamental frequency. Notice that the bilinguals have a darker band of color at 100 Hz, indicating a stronger neural response to the fundamental frequency.

Dr. Roeland Hancock joined UConn this summer as an Assistant Research Professor in Psychological Sciences and Associate Director of the Brain Imaging Research Center (birc.uconn.edu). Dr. Hancock is interested in the neurobiological factors underlying individual variability in language processing and the application of new mathematical and computational techniques to understanding these processes. His current research interests include the use of magnetic resonance spectroscopy to study neural excitability in auditory and language processing; distinguishing genetic and environmental contributions to language pathways; and developing tablet-based games for cognitive and literacy assessment. He has a Ph.D. in cognitive science from the University of Arizona, a B.S. in mathematics, and was a postdoctoral researcher at the University of California, San Francisco Department of Psychiatry

and Weill Institute for Neurosciences. He looks forward to promoting the development of BIRC as a major resource for researchers across campus.

UConn Brain Imaging Research Center (BIRC)



Dr. Hancock stands in front of a photogrammetry system used to precisely record the position of electrodes on a scalp. This information can be used in modeling current flow through an individual brain in electroencephalography (EEG) and transcranial current stimulation studies.

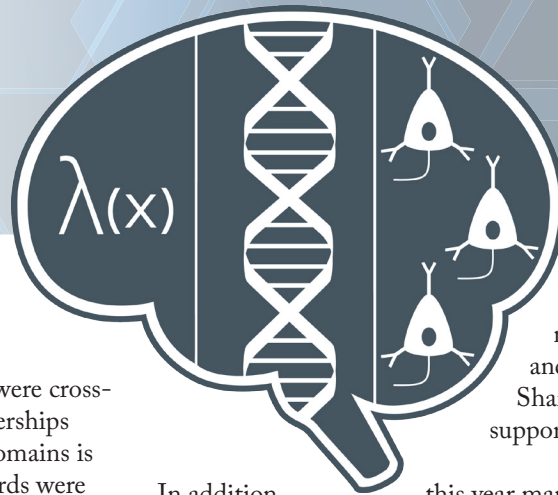
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CONNECTICUT INSTITUTE FOR THE BRAIN AND COGNITIVE SCIENCES

The Institute for the Brain and Cognitive Sciences (IBACS) has enjoyed a tremendous period of growth in our second year. The Institute's base of faculty and graduate student researchers has doubled, and IBACS funded around 20 seed grants for research projects that were cross-collaborative in nature. Fostering interdisciplinary partnerships to promote research that moves in new directions and domains is a vital component of the Institute's mission. Half of awards were provided to more cognitive/behavioral grants, and the remainder to bench or animal neuroscience grants (including genomics). All awards are described on the IBACS website (ibacs.uconn.edu/research/).

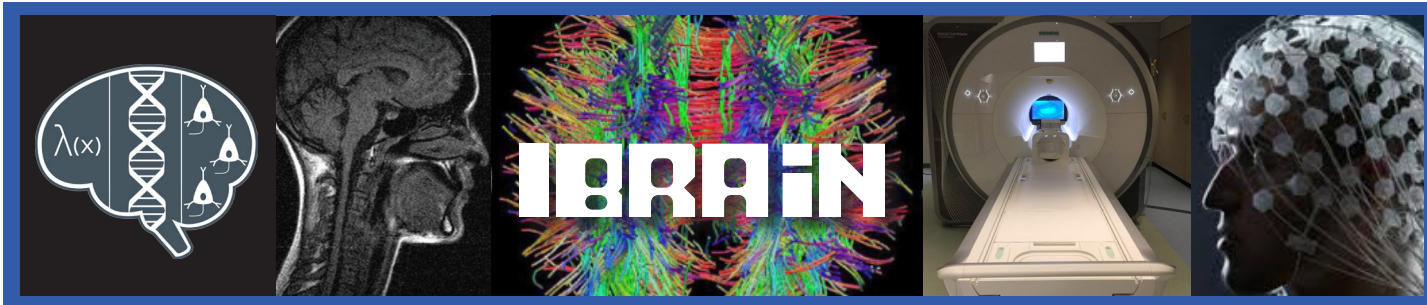
The Institute also funded support for research labs such as the Brain Imaging Research Center (BIRC) which offers fMRI with an in-scanner eye-tracking system and tDCS (transcranial direct current stimulation) technology, the Murine Behavioral Neurogenetics facility which allows for research with mouse



models (linking cognitive behavior to neuroscience and genetics), and the Cognitive Sciences Shared Electrophysiology labs, supporting EEG research.

In addition, this year marked the advent of the IBACS External Application Review, which is a service to help UConn investigators develop high quality grant proposals by offering a mechanism for "mock review" of in-development proposals and facilitating mentoring in grant writing.

The Institute for the Brain and Cognitive Sciences is looking forward to our third year and is anticipating continued expansion of our programs, services, and outreach for the science being conducted here at UConn.



THE IBRAiN PROGRAM: IBACS-BIRC RESEARCH ASSISTANTSHIPS IN NEUROIMAGING

Beginning in summer 2017, UConn's Brain Imaging Research Center (BIRC) has partnered with the Institute for the Brain and Cognitive Sciences (IBACS) to launch the IBRAiN program (IBACS-BIRC Research Assistantships in Neuroimaging). The IBRAiN program is designed to create a cohort of graduate students with the skills needed to design and implement MRI experiments and to apply standard and emerging analytic techniques to MRI data. Six students will receive graduate assistantships to work in BIRC for the next year. During the summer they received intensive training in MRI methods. Training will continue through the academic year, in part by working on ongoing projects, and in part by working with their advisors to develop and complete their own MRI experiments. The IBRAiN program serves the dual purposes of accelerating BIRC research and developing the next generation of cognitive neuroscientists, thus demonstrating the interrelatedness of the university's research and educational missions.

Meet the IBRAiN Students



Charles Davis

The brain activates and represents meaning in complex ways. At a cognitive level, we deal with meaning using concepts. My research uses fMRI to examine the functional and structural connectivity underlying concept networks, representationally and as they develop in learning, as well as electrophysiology to examine activation dynamics.



Monica Li

I'm interested in cognitive and neural mechanisms underlying spoken word recognition, such as how top-down (e.g., attention, context) and bottom-up (e.g., speech signal, noise) information interact to determine speech perception. I hope to use simultaneous fMRI and EEG to tap into the feedback and feedforward mechanisms in speech.



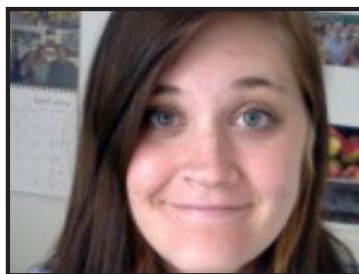
Timothy Michaels

My research utilizes a variety of neuroimaging methods, including fMRI, resting state connectivity (rsfMRI), diffusion tensor imaging (DTI), and magnetic resonance spectroscopy (MRS), to examine the neural correlates of perceptual abnormalities and cognitive deficits in patients with schizophrenia.



Yanina Prystauka

I am interested in the neural underpinnings of representing object tokens in their different states. The use of EEG + fMRI will allow me to track the time course of instantiating, maintaining and retrieving the representations of object token-states as a sentence unfolds, and identify neural pathways supporting this process.



Kayleigh Ryherd

I primarily study individuals with poor reading comprehension despite intact decoding ability. My research involves using fMRI to determine what may be contributing to the deficit in concept and category learning that I've observed in this population.



Monica Ly

My research aims to use rsMRI and DTI to improve the assessment of mild traumatic brain injury. I also assist at the BIRC in training researchers to acquire and analyze EEG data using our EGI equipment.

Faculty Feature

Dr. Adrian García-Sierra is an Assistant Professor at the Department of Speech, Language and Hearing Sciences at the University of Connecticut. Originally from México, Dr. García-Sierra learned neurophysiological techniques to research speech perception when he studied at the “Instituto de Neurobiología” in Querétaro, México. He pursued his Ph.D. in Communication Sciences and Disorders at the University of Texas at Austin. In Austin, he interacted with fluent bilinguals, specifically Mexican-Americans who learned two languages from birth. The ease by which bilinguals would alternate between their two languages made him wonder if the perception of speech sounds in bilinguals was influenced by the language being used at a given moment (language context). Using behavioral and neurophysiological techniques, he found that the brain responses of Spanish-English bilinguals were more akin to those of monolingual English speakers when using English, and more like monolingual Spanish speakers when using Spanish.



Dr. García-Sierra

The next step in Dr. García-Sierra’s research was to investigate how bilingual infants learn two languages simultaneously from birth. He developed a longitudinal study of speech development linking brain responses, language input received in the household, and later vocabulary development in bilingual infants. He found that bilingual infants reach their language development milestones at the same time as monolingual infants, but bilinguals’ language develops in accordance with the amount of language input they receive at home. In a more recent study, he reported that when the number of words received at home is carefully quantified, then it is clear that monolingual and bilingual brain responses associated with language learning are very similar.

At UConn, Dr. García-Sierra currently uses a broad array of research methodologies to study the development of infants’ and adults’ speech perception and its relationship to social/linguistic input and language abilities. For example, in addition to behavioral and electrophysiological techniques, he uses naturalistic paradigms to capture the social and language environments of monolingual and bilingual infants and adults. His research has been published in high tier journals such as *Brain & Language*, *International Journal of Psychophysiology* and *Child Development*.



Alumni Feature

Dr. Deanna Gagne received her Ph.D. in Developmental Psychology in 2017 under the mentorship of Dr. Marie Coppola. While at UConn, Deanna had the opportunity to travel to Nicaragua several times to work with and learn from the Deaf community there.

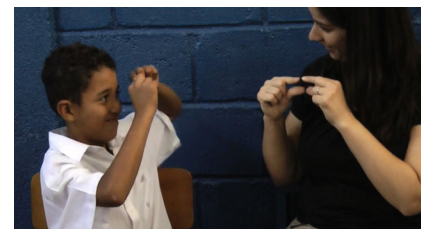


Dr. Deanna Gagne

Nicaraguan Sign Language is only 40 years old, and as such, parts of the language did not develop completely in the first generation of signers. Dr. Gagne worked with the bilingual bimodal children (who use spoken and signed language) born to this first generation of signers to investigate how having peers may influence the evolution of a relatively new language. Notably, these children signed with their deaf parents but did not sign with same-age peers. Dr. Gagne showed that individual children are able to create consistent patterns, but they may differ from expected patterns from deaf children who have both peers and adults to sign with. Her work helps us understand the development of language in two other groups: bilingual children who do not have peers to use their home language with (e.g., children of immigrants), and deaf children in “mainstream” schools who only have an adult interpreter with whom to sign, but no friends who can sign fluently.

Dr. Gagne looks forward to her upcoming postdoctoral position at Boston University’s School of Education, under the direction of Dr. Amy Lieberman. With Dr. Lieberman, Deanna will have the opportunity to apply her experiences working with language acquisition and its impact on cognitive development. Specifically, she will investigate how deaf infants and children with varying levels of access to language acquire the visual attention skills needed to quickly and effectively process language and environmental input visually.

To all aspects of her work, Dr. Gagne brings her unique perspective as a native bimodal trilingual of American Sign Language, English and Spanish. Her ultimate goal is to translate science for the benefit of society; she believes that scientific research ought to be done not only for the benefit of the researcher, but as a contribution to policies and approaches that will benefit future generations.



CT Institute for the Brain and Cognitive Sciences Research Digest is Published for the purposes of community outreach. This issue has particular input from Psychological Sciences, Linguistics, and Speech, Language, Hearing Sciences.

TO LEARN MORE:

- Online at ibacs.uconn.edu
nbl.cogsci.uconn.edu
- Call us 860-486-4937
- Email us ibacs@uconn.edu

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IBACS STATS


\$228,000

Awarded in
Seed Grant Funding for Collaborative
Research for year 16/17

12

Undergraduate
Fellowships
Awarded
in year 16/17

23

Summer Graduate
Fellowships
Awarded
in year 16/17

150

Affiliated Researchers

across **12** Departments

at UConn and UConn
Health Center

Our Research Community

Who are we?

The CT Institute for the Brain and Cognitive Sciences (CT IBACS) serves as an incubator for research across the brain and cognitive sciences at UConn and beyond, promoting and supporting the interdisciplinary science of the mind and its realization in biological and artificial systems. The Institute was conceived through cross-department discussion and collaboration fostered by the Neurobiology of Language program (nbl.cogsci.uconn.edu) and the Cognitive Science program (cogsci.uconn.edu). It has since grown to encompass a broad scientific community across the UConn campuses.

What do we do?

Our goal is to further the scientific understanding of the mind and its biological instantiation through a cooperative and integrative approach. This requires that new methods and frameworks be developed and that familiar approaches to cognition be combined with biological and computational ones so that researchers may learn and become familiar with the theories and methodologies of their peers from other disciplines. These methods include computational and linguistic modeling, behavioral studies, electrophysiology, behavioral and bench neuroscience, genetics, and animal models.

A key area of Brain and Cognitive Sciences research at UConn is language development. There are still a lot of unanswered questions about how children acquire language, whether they are developing as monolingual, bilingual, or multi modal language learners. Thus, our students and faculty do work on all types of language development, aiming to build a comprehensive picture of language development as a whole through studies spanning genetic, neural, theoretical, and behavioral aspects of language development. Contained in this issue is a small selection of our research findings on bilingualism in children's language development.

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(((Haskins Laboratories))) THE SCIENCE OF THE SPOKEN
AND WRITTEN WORD

