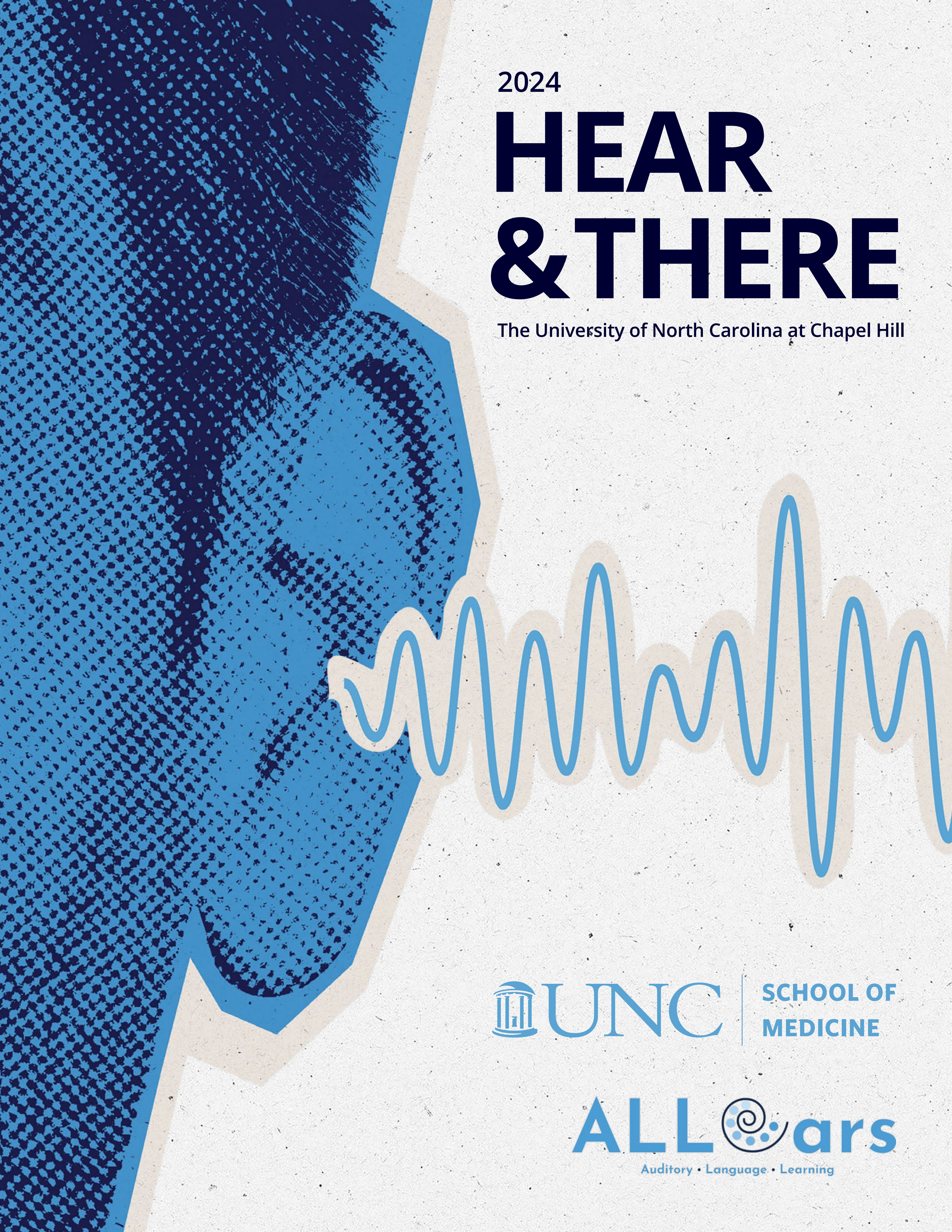

2024

HEAR & THERE

The University of North Carolina at Chapel Hill

UNC | SCHOOL OF MEDICINE

ALL ears

Auditory · Language · Learning

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A LETTER FROM THE PRINCIPAL INVESTIGATOR

It is my delight to share our inaugural issue of the Hear & There — a magazine style publication put together by our research lab to disseminate research findings to the broader community. This publication reflects the commitment of our research lab to create accessible resources for students, clinicians, community members, researchers, and stakeholders to learn about ongoing science in our lab and beyond. The selected theme for this year's issue was "Plasticity", which seemed particularly timely since there are growing considerations for how to improve treatment and management options for individuals with speech, language, and hearing impairments. Throughout the issue, we will use the term "plasticity" to describe the brain's ability to reorganize and adapt in response to experience. In the following sections, you will find an array of research summaries and interviews exploring plasticity in different contexts, including plasticity of the auditory system to learn new speech signals, developmental considerations of plasticity, and plasticity-related changes that underpin rehabilitation success with devices like hearing aids or cochlear implants.

A huge thank you to the team of undergraduate and graduate students who directly contributed to the writing and content creation of this issue: Sarah Bayer, Talia Mango, Emily Jedlowski, Bethany Rose, Cameron Thomas, Kayla Huynh, Anne-Estelle Strawn, Meghan Brianas, and Julianna Winfree.

Julia R. Drouin, Au.D., Ph.D., CCC-A
Principal Investigator
Auditory Language Learning Laboratory (ALLears Lab)

GET TO KNOW OUR LAB

The Auditory Language Learning Laboratory (ALLears Lab) at UNC-Chapel Hill is directed by Dr. Julia Drouin and is supported by a team of graduate and undergraduate students. Our lab is located on the second floor of Bondurant Hall. The lab enjoys working with students from various backgrounds and disciplines on research questions related to speech perception, learning, adaptation, and hearing loss. Students in the lab have a range of career goals including audiology, speech-language pathology, physical therapy, clinical psychology, and research.

GRADUATE STUDENTS

Emily Jedlowski (Clinical Au.D. trainee)

Sarah Bayer (Clinical Au.D. trainee)

Talia Mango (Clinical Au.D. trainee)

Bethany Rose (Clinical Au.D. trainee)

Alexandria Swaine (Clinical Au.D. trainee)

UNDERGRADUATE STUDENTS

Kayla Huynh
Psychology & Human Organizational Leadership and Development

Cameron Thomas
Psychology; Minor in Cognitive Science

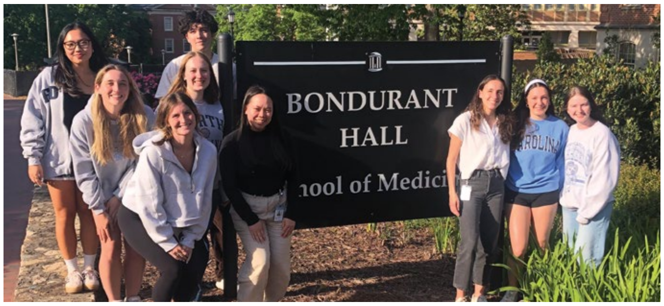
Anne-Estelle Strawn
Human Development and Family Sciences; Minor in Speech & Hearing Sciences

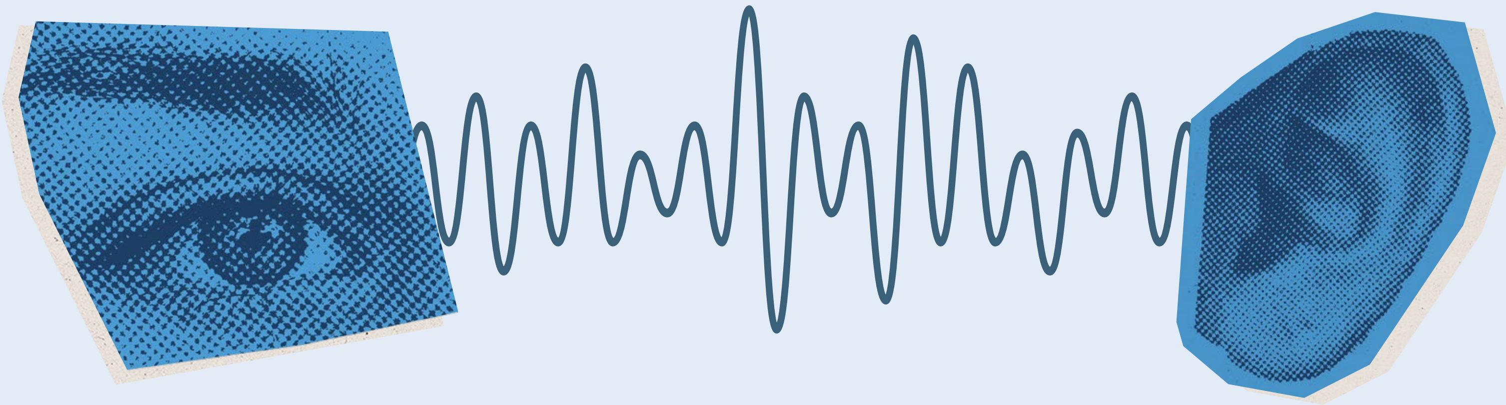
Julianna Winfree
Linguistics; Minor in Human Development and Family Sciences

Meghan Brianas
Neuroscience

RECENT LAB ACCOMPLISHMENTS

- The lab launched four new studies this academic year with trainees involved in each study
- Talia Mango was awarded the Student Research Grant in Audiology by the American Speech-Language and Hearing Association in October 2023
- Dr. Drouin gave a talk at the 2023 BeOnline Conference related to engaging cochlear implant users in online studies of speech perception
- Former lab trainee, Stephany Flores, was awarded a meritorious poster award for research presented at the 2023 American Speech-Language and Hearing Conference in Boston, MA
- Delaney Orr & Molly Whiteman, former lab trainees and current graduate students in the M.S. program completed 50 research hours towards their clinic degrees in speech-language pathology
- Talia Mango was awarded the Research Mentoring-Pair Travel Award to attend the 2023 American Speech-Language and Hearing Conference in Boston, MA
- Cameron Thomas presented ongoing research at the 2024 Celebration of Undergraduate Research in May
- The lab mentored two high school trainees, Ella Laws & Victoria Choi, who gave oral presentations of their research at the North Carolina School of Science and Mathematics (NCSSM) in April 2024
- The lab was awarded a UNC Junior Faculty Development Grant in January 2024 to pursue research related to sleep and fatigue in children with hearing loss



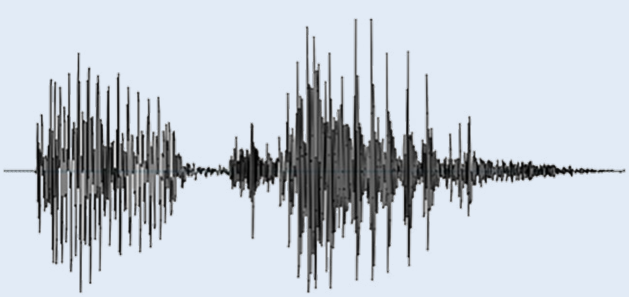


ARTICLE

EYES AS A WINDOW TO THE EARS

In the first few moments a word is spoken, the brain begins searching through our mental dictionary to identify what word is being said. For example, when we first hear the word "**b**erry", our brain *begins* looking for words that have the same initial 'b' sound (e.g., "**b**arrel") and simultaneously *stops* considering words that don't begin with that sound (e.g., "lobster"). This process of ruling in/out potential words based on the auditory input provided is referred to as lexical competition and it occurs outside of our conscious control. One of the interesting aspects of lexical competition is that researchers can measure it by examining how the eyes fixate to pictures on screen. That is, the eyes give researchers a window into how the ears process spoken language in real time.

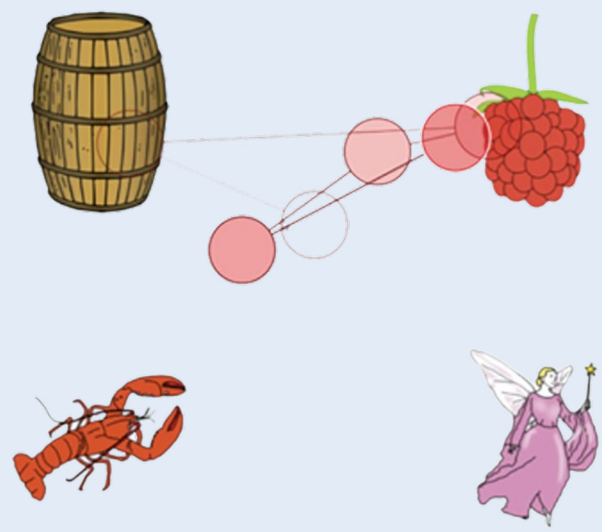
To measure lexical competition in the lab, listeners sit in front of a computer screen with four images, much like the picture to the right, while a recording of one of the words is played. Listeners are told to simply look at the picture of the object being said.



A waveform is a visual depiction of the auditory speech signal and shows the pitch and duration. This waveform shows the auditory recording of the word "beaker" produced by a female talker.

In the example below, the word being spoken is "berry" which shares the same starting sound ('b') with one of the other items on screen "barrel." When listeners hear the first milliseconds of the word "**b**erry" the eyes initially move back and forth between the pictures of "berry" and "barrel" since the auditory system is still processing which word is going to be said, and at this point in time, they can't rule out whether it will be "berry" or "barrel."

> **This process of ruling in/out potential words based on the auditory input provided is referred to as lexical competition and it occurs outside of our conscious control.**



Lexical competition from the auditory speech signal can be measured by tracking the eyes on screen. The listener views a display of four pictures and is asked to look at the picture of the word that is said. The pink circles represent the movement of the eyes as the auditory signal unfolds over time. In this case, the eyes move back and forth between "berry" and "barrel" within the first few milliseconds of hearing the talker.

This process is reflected in the picture below where the pink circles show the path of the eyes moving back and forth between the berry and the barrel. When more auditory information becomes available, the listener can start to rule out words that no longer overlap with the target word. **We use an eye tracker to study this lexical competition process, including capturing how much time a person spends looking at each image in their search and how quickly they arrive at the word being spoken.**

Research has found that **our ability to access spoken words depends on how *clear* the speech signal is.** This makes sense — if the auditory signal is noisy or difficult to hear, then listeners may activate more potential words because they are less certain about which word is being said. For example, when the word "berry" is clear, listeners might activate "**b**erry" and "**b**arrel" early in processing. However, when the acoustic signal for the word "berry" is less clear, the listener might activate unrelated words, such as "lobster" or "fairy" in addition to "berry" and "barrel," resulting in more looking across the screen. This has implications for listeners with hearing loss who use devices like hearing aids or cochlear implants, where their auditory signal is less clear than listeners with normal hearing. According to the World Health Organization, approximately 20% of people around the globe are living with hearing loss, many of whom communicate with spoken language and use assistive listening devices. **Research has shown that listeners with hearing loss who use cochlear implants may have difficulty recognizing the speech signal.** Cochlear implants are small medical devices that bypass damaged parts of the hearing organ and deliver an electric signal of sound to be processed by the brain. Since the auditory signal in a cochlear implant contains less acoustic information and is less clear, cochlear implant users experience an acclimation period, where the brain must get used to processing the new auditory signal. Audiologists and speech-language pathologists work closely with cochlear implant users to support the acclimation process, but it can take months or years of practice to start to recognize the auditory signal as speech. **In our lab, we explore eye-tracking as a window into how listeners with hearing loss process and understand spoken language and how lexical competition changes as listeners acclimate to their devices.**

Undergraduate research assistants, Anne-Estelle Strawn and Julianna Winfree, demonstrate the eye-tracking display for a research participant.

INTERVIEW

HARNESSING NEURAL PLASTICITY FOR DUAL LANGUAGE LEARNERS

Our research lab had the pleasure of interviewing **Dr. Kimberly Jenkins, Ph.D., CCC-SLP**, to learn a bit more about her background, clinical experiences, and research interests as they connect to neural plasticity. Dr. Jenkins is an Assistant Professor in the Division of Speech and Hearing Sciences at UNC-Chapel Hill, and her research focuses on dual language learning in children, specifically learners of English and Spanish.

Dr. Jenkins began her career in the field as a speech-language pathologist primarily working in early intervention. In this specialized area of the field, clinicians work with infants and young children who have communication difficulties or disorders. Dr. Jenkins provided home-based therapy in early intervention for almost seven years before deciding to delve into research in speech and hearing sciences. She expressed to us that one of her reasons for transitioning to the world of research was that she wanted to "contribute to the field through a broader platform" by identifying and developing the most effective and appropriate assessment approaches possible and finding impactful interventions for dual-language learners. Dr. Jenkins continues to study language acquisition and development in dual language learners as a faculty member here at UNC.

In her current work, Dr. Jenkins studies factors that indirectly influence the brain and the development of language by examining language patterns and the developmental trajectories of dual language learners in preschool until first grade. She has primarily focused on the developmental trajectories of tense-marker use (English) and grammatical gender (Spanish). **In her work, she has found that some dual-language learners acquire aspects of language, especially grammatical patterns, at different paces and orders than children who are only learning one language.** For example, dual language learning children may acquire the use of certain English tense markers (i.e., grammatical forms that are used to denote the time of an event or a state of being) such as BE forms (e.g., is *hungry*; is *running*) before learning how to correctly use the past tense –ed (e.g., *jumped*). Dr. Jenkins looks at multiple factors that may impact the way dual-language learners acquire their languages "some of [which] would be considered internal to a child and then some that would be considered to be external to a child." Internal aspects depend on the child's individual characteristics, such as how well they can retain new words in their memory. Outside contributing factors relate to language use patterns at home and at school, including who the children are using their different languages to communicate with. Dr. Jenkins hopes that by forming a deeper understanding of these factors, we can develop more effective strategies for supporting bilingual children as they learn, as well as "the importance of [...] extra support if a child does have a language disorder, or language delay."

Dr. Jenkins' clinical and research interests relate to plasticity in many ways. First, her focus on language learning in children is relevant because plasticity is at its peak in childhood. In the earliest stages of life, our brains gather a vast amount of new information. When developing a study, Dr. Jenkins considers factors that could be considered mediators of brain development. She explained to us: "When I structure a study and I'm choosing a group of dual language learners, I'm considering age of acquisition" along with whether the child is "more broadly considered to be [a] simultaneous learner or sequential learner of their languages." The timing of language learning (that is, whether a language is learned before, after, or at the same time as another) relates to plasticity because the ease of language acquisition is affected by what the brain already knows about language. **Many find it difficult to learn a new language in adulthood because their brain has already created pathways related to the structure of their first language. A child learning their first language does not face these obstacles, making dual language learning an interesting and important area to study.**

Dr. Jenkins explained to us that "there have been studies that suggest children who are dual language learners may use certain sentence structures more often than their Spanish-speaking monolingual peers when the sentence structures are present in both languages. If a sentence structure is permissible in both of the languages, it might look a bit different if you were to compare them [dual language learners' to monolingual Spanish speakers." She said, "maybe it'd be the case that they might have... a bit more variety in that movement of where the subject is placed in the sentence." At the center of this work is an understanding of what the brain is exposed to and its continued capacity to learn more. Dr. Jenkins explained to us that she sees plasticity playing a role in future research and behavioral measures of intervention success. She views plasticity as being particularly helpful to understand how metacognitive strategies impact brain functioning.

Dr. Kimberly Jenkins, Ph.D., CCC-SLP
Assistant Professor
Division of Speech and Hearing Sciences

ARTICLE

SLEEP TO LEARN

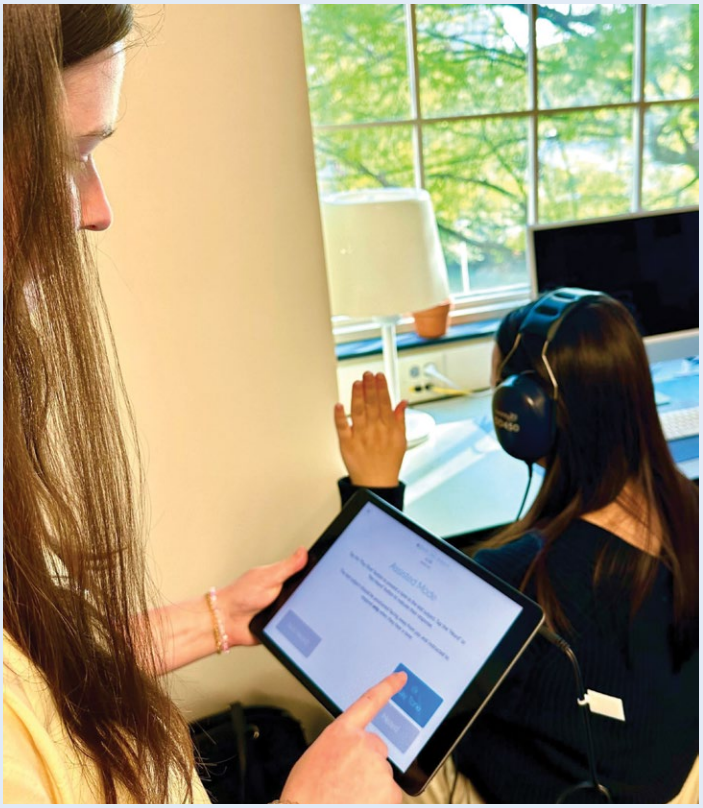
On average, we spend about a third of our lives sleeping, and yet for many, quality sleep can be hard to prioritize. The benefits of a good night's sleep are wide-ranging. Maybe you notice you're in a better mood than usual, or you wake up feeling particularly energized for the day. **Growing research suggests that quality sleep may have more benefits than we think — especially when it comes to memory and learning new speech signals.**

When might we need to adapt to a new speech signal? Consider the last time you met someone with an accent or dialect. Initially, you may have found that person difficult to understand, but within a few minutes, most listeners notice that the once challenging speech signal becomes easier to recognize. This process of speech adaptation relies on the plasticity of our auditory system to dynamically adjust how our brain maps unfamiliar auditory information onto meaning. A similar process occurs in listeners with hearing loss who use devices

Undergraduate research assistants show off the actigraph, a device designed to measure sleep-wake cycles.

like hearing aids or cochlear implants. These assistive hearing devices allow many listeners the opportunity to better access the auditory signal, but the input that is transmitted through these devices is often less clear or less robust compared to normal hearing. As a result,

individuals with hearing loss often work harder to correctly perceive and understand the speech sounds they hear. Remarkably, the brain is flexible and can be trained to get better at recognizing the new speech input with practice, similar to how we adapt to new accents.



Graduate research assistants, Bethany Rose and Emily Jedlowski, demonstrate a hearing screening in the lab.

Previous research suggests that sleep may help the learning process for listeners adapting to unfamiliar speech signals by supporting memory consolidation. Memory consolidation, or the process whereby short-term memories move to long-term memory in the brain, relies on the hippocampus and the cortex of the brain and consolidation can be engaged through sleep. The process of strengthening the connections between synapses — the tiny spaces between different neurons — makes learned information easier to recall in the future. When learning a new speech signal, growing research suggests that memory consolidation via sleep may help to stabilize the learning process and make it easier for the listener to generalize to new speech signals in the future, such as new words, sentences, or even talkers. In ongoing research, we are investigating the process of memory consolidation and speech learning for listeners adapting to acoustically degraded speech, or speech that contains less acoustic information than clear speech. Like accented speech, acoustically degraded speech can be difficult to recognize at first, but with some training most listeners get significantly better at understanding the speech signal. We chose this acoustic degradation because it closely parallels the listening experience of a listener with a cochlear implant. Because of this parallel, studying adaptation to degraded speech can provide insights into how to optimize the speech learning process for listeners with hearing loss.

> **“When learning a new speech signal, growing research suggests that memory consolidation via sleep may help to stabilize the learning process.**

The study follows listeners over a week and measures their speech learning rates and sleep. First, participants are recruited to the lab for a baseline visit where they complete questionnaires related to their speech and language backgrounds and a hearing screening. Participants are outfitted with a sleep-wake tracking watch called an actigraph to track their sleep and wake cycles over the course of the week. **One cool thing about the study is that all follow-up testing is completed outside of the lab, in the comfort of the participant’s home.** This way we do not disrupt participant’s regular sleep routines. Participants complete their training and testing on a computer at home either right before their normal bedtime or after waking up from sleep. We monitor progress over the week, all while the participant wears the actigraph so we can measure how sleep impacts the speech learning process.

In a related study of sleep, our lab is measuring sleep and wake patterns in school-age children with hearing loss. While it is well-known that sleep is involved in learning, attention, and academic performance in children, we know less about the sleep needs for children with hearing loss compared to children with normal hearing. This is important to consider, as children with hearing loss often show greater levels of fatigue associated with listening throughout the day. Results for both studies are in progress, and we hope to learn more about the role of sleep in speech learning for adults and children with hearing loss.

INTERVIEW

USE IT OR LOSE IT:

LEVERAGING PLASTICITY TO SUPPORT AUDIOLOGIC REHABILITATION

In the spirit of exploring neural plasticity in the clinical setting, our lab had the opportunity to chat with **Dr. Stephanie Sjoblad, Au.D.**, who serves as a Professor in the Division of Speech and Hearing Sciences at UNC-Chapel Hill and the Clinic Director for the UNC Hearing and Communication Center. Dr. Sjoblad's clinical and research interests center around hearing technology and audiologic rehabilitation for adults with hearing loss, which reflects both her professional training and personal experience with hearing loss. When asked about her life and background, Dr. Sjoblad shared that she "had hearing loss [her] whole life. [She] was identified at age 6, kind of by accident" when her brother was taken for testing, and she tagged along. She finds it likely that she has always had hearing loss, but that "everybody in [her] family was probably raising their voices, probably using a lot of good communication strategies" so it was missed initially. Dr. Sjoblad's journey to her career in audiology was a long and winding one. "I have a degree in business," she explained, "and went to school for that and a career in business before I found my way to audiology." While "there were things that were drawing [her] toward doing something with people with hearing loss," she initially thought she wanted to work for a manufacturer. However, during her training, Dr. Sjoblad quickly fell in love with clinical work and patient care in the audiology field.

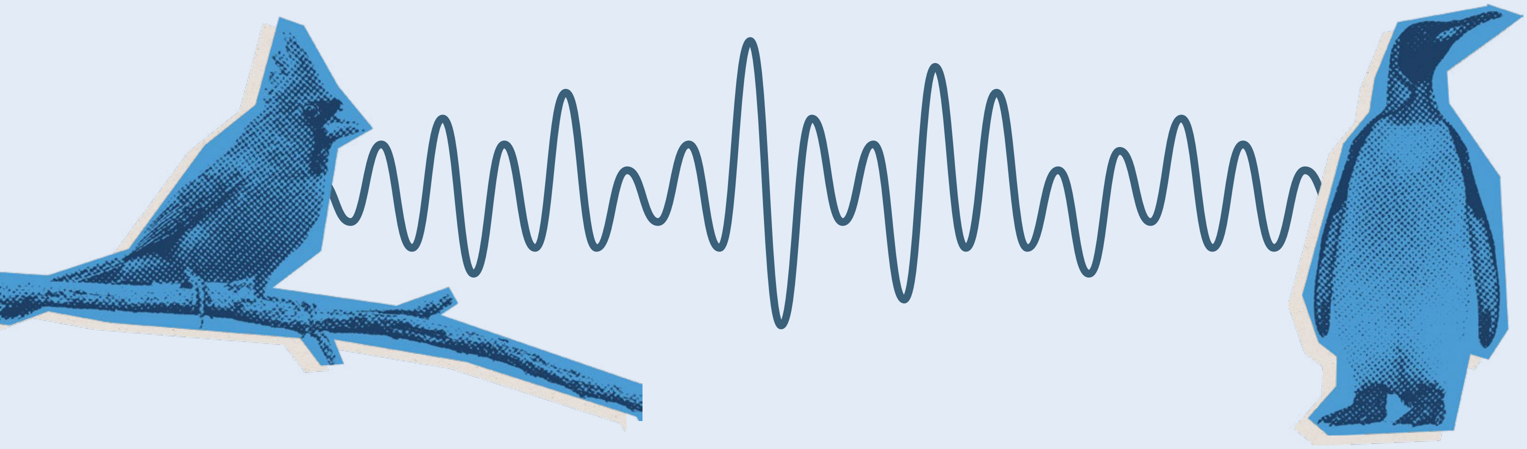
In the clinic, Dr. Sjoblad spends much of her time thinking about ways to optimize rehabilitation for adult patients diagnosed with hearing loss. Neural plasticity is a term often used in the context of audiologic rehabilitation. When someone is diagnosed with hearing loss, audiologists often recommend devices that provide access to the auditory speech signal, including hearing aids or cochlear implants. Learning how to listen to the auditory signal transmitted through these devices isn't always easy, however, and requires a period of adjustment on the part of the brain. **Namely, the brain needs time to acclimate to a hearing device in order to make sense of the new, unfamiliar auditory signal as speech.** As a result, individuals with hearing loss may work closely with an audiologist and/or speech-language pathologist to help the brain learn to interpret the new auditory signal as speech, which can take both time and effort. Dr. Sjoblad describes the process as similar to physical therapy, "You break your arm, you know, it takes time to learn to use that muscle again and the same for the pathway of sound when the sound has disappeared for a long time, sometimes it takes time."

We asked Dr. Sjoblad about how neuroplasticity plays into her work clinically, and she emphasized the work patients must put in to overcome hearing loss. **Dr. Sjoblad explained "It's just so much better if you start [rehabilitation] early, before you've lost the ability to hear the sound."** With patients, Dr. Sjoblad tries to "stress that it's a therapeutic process. There isn't a device that just cures hearing loss, but that you have to sort of put the time in, you have to be motivated, you have to do your homework, read to yourself, listen to sound, wear them, come in for your appointments and then use strategies in combination with technology to help you get the message. **It's as much an art as it is a science, helping people to hear better."** In addition, she explained the potential challenges of plasticity in the context of helping patients with hearing loss. "There is some data showing [...] the brain's use of sound when provided and then when it's not used, how it refocuses, and it goes in a different direction." This phenomenon, cross-modal plasticity, occurs when the brain begins to reorganize and use neural pathways associated with other senses. For example, individuals with long-term hearing loss may demonstrate processing of visual information in brain regions that are typically involved in processing auditory information because those brain regions are no longer receiving auditory stimulation. Thus, patients with hearing loss face a race against the plasticity clock, so seeking out hearing care early is recommended for patients who are noticing hearing difficulties.

As an evidence-based clinician, Dr. Sjoblad hopes that there will be more "retrospective studies of people who started [rehabilitation] early, and we maybe see really good progress with them on word recognition, retention, and other things and maybe that might help support other people doing things about their hearing loss sooner." She emphasizes, "It wasn't until about 10 years ago, a lot of other disciplines started to see how important it was to treat hearing loss, because it reduced risk of falls, hospitalizations. I think the research can just continue to focus on how if you treat hearing losses, other health things are better.” **In training the next generation of clinicians, Dr. Sjoblad has an eye towards best practices and meeting the needs of patients from all backgrounds.** She approaches patient care creatively and often asks trainees, “What does the research say should be done?”

The UNC Hearing and Communication Center is celebrating their 20th anniversary with Dr. Sjoblad involved since its inception!

Dr. Stephanie Sjoblad, Au.D.
Professor
Division of Speech and Hearing Sciences

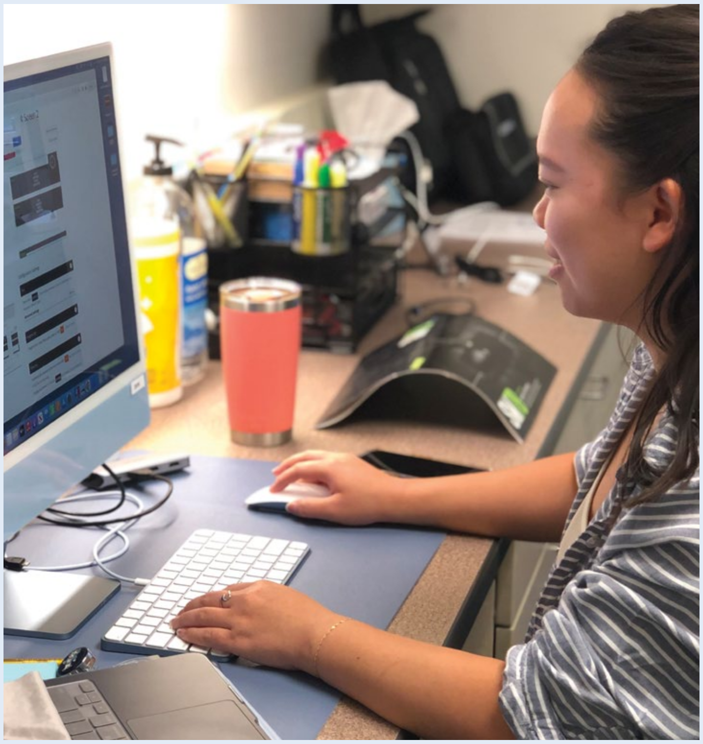


ARTICLE

WHAT’S IN A WORD?

Language is constantly evolving. It is a truth universally acknowledged that “YOLO” [the acronym for the phrase: You Only Live Once] hasn’t always been a common saying in the English language, let alone an entry in the dictionary. In fact, the Oxford English Dictionary adds brand new words and updates word definitions every three months. This begs the question — how do words become real words?

Typically, a “word” is defined as “any sequence of one or more sounds, constituting meaningful speech used to form a sentence in language.” Words come into existence via usage across wide areas and over extended periods of time. It is through that widespread and long-standing use that shared meaning of words develops. For example, if someone were to say the word “apple”, two people generally have a common understanding – or shared meaning — of what an “apple” is [red, green, crisp, fruit,



Graduate research assistant, Emily Jedlowski, sets up a research study using online research software.

round, short stem]. Shared meaning is the idea that the words we use signal a consistent meaning across individuals, like that when I say “apple” I mean that red fruit on the counter and not the yellow lemon sitting next to it. If words develop through shared meaning, how does shared meaning form?

The answer begins with experiences. Each person moves through and interacts with the world differently based on where they live, who they interact with, their schooling, their jobs, and their communities. For example, when you think of your concept for the word “bird,” what pops into your head? For many, the concept of a bird may bring to mind a small flying animal with wings or even a particular type of bird like a robin or cardinal. However, consider someone living in Antarctica who has a very different exposure to birds. Based on their experiences with birds, they may more readily picture a penguin, as penguins are common to the area, but have less in common with flying birds. The same goes for highly specialized occupations. A chef trained in cooking has a unique vocabulary of culinary terms that an astronaut would not share the same knowledge of, and vice versa with cosmic terminology.

In a similar way, our sensory experience of the world deeply influences how we represent meaning, also known as conceptual knowledge. For example, tasting a sour lemon helps you to know that lemons are sour, smelling a cup of coffee helps you to associate the smell of coffee

> **Our sensory experience of the world deeply influences how we represent meaning, also known as conceptual knowledge.**

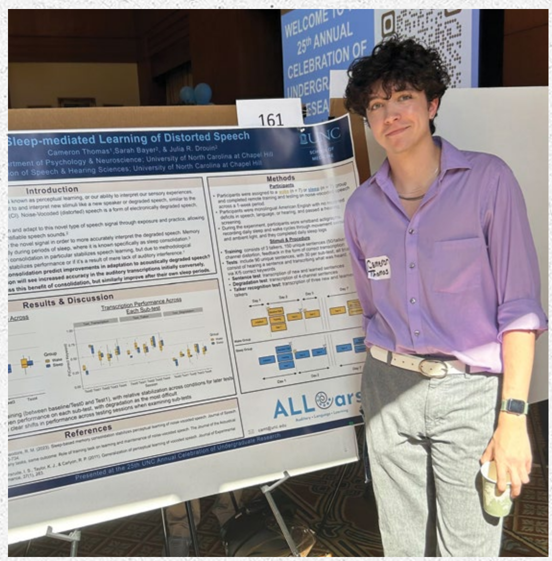
with your concept of coffee, and seeing a fluffy poodle strengthens associations with the visual appearance of that breed of dog. Growing research suggests that differences in how we process sensory information may lead to differences in how conceptual knowledge is represented. In one study, individuals with normal vision tended to use color as a defining characteristic in how they represented fruits or vegetables. However, individuals with vision loss relied less on color and instead used other sensory cues to represent those items. This difference in concept representation can be partially explained by the plasticity of the perceptual system, such that the brain will reorganize to represent sensory information it has access to and minimize reliance on senses that are not readily available.

Using this framework, ongoing research in the lab explores concept knowledge in individuals with hearing loss who have limited access to the auditory modality. Much like vision loss can affect sensory and perceptual input, hearing loss may affect how conceptual knowledge is represented in the brain for words that have strong auditory associations (e.g., “music”, “piano”, “motor”). While this research area is relatively new, one study found that individuals who were born deaf or lost the ability to hear before learning spoken language relied more on non-auditory modalities — specifically vision and motor senses — to represent conceptual knowledge, in line with plasticity-related brain changes.

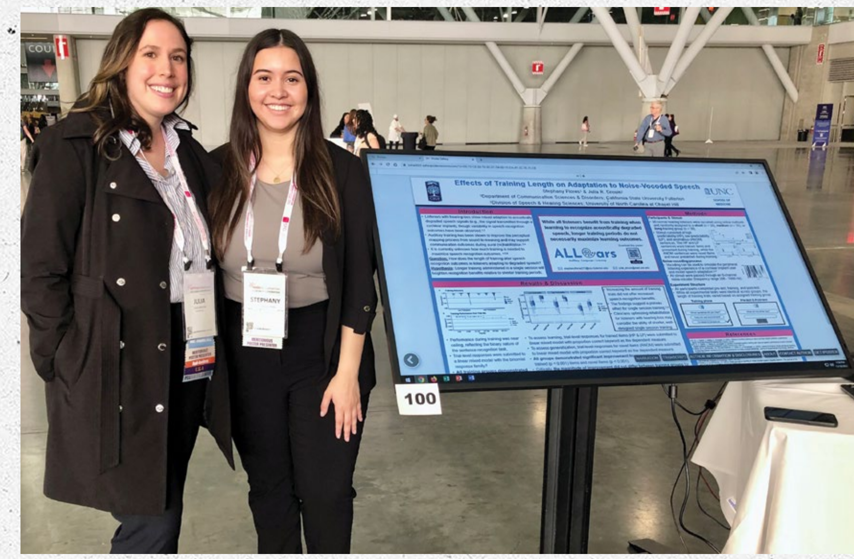
In our current work, we are collecting data from listeners with and without hearing loss to assess differences in concept knowledge. How do you measure concept knowledge? One task involves measuring how quickly participants associate auditory features with a set of concepts. For example, you might be faster to respond “loud” if it follows “thunder”, and slower if “chime” follows “thunder”. The speed with which a participant decides whether a property goes with a concept gives us insight into how strongly those words are associated in conceptual space – and it might be more quickly accessed if that feature is in a sensory modality that is readily available. We hope that this work will tell us about how concept knowledge changes with sensory changes in hearing and how auditory rehabilitation, through devices like hearing aids or cochlear implants, might alter how meaning is represented in the brain.

Undergraduate research assistants, Meghan Brianas, Kayla Huynh, Cameron Thomas, and Julianna Winfree, discuss research findings during a weekly lab meeting.

A LOOK INTO OUR LAB



Undergraduate research assistant, Cameron Thomas, presents preliminary research findings at the 2024 UNC Celebration of Undergraduate Research.



Former undergraduate research assistant, Stephany Flores, presents research findings at the 2023 American Speech-Language and Hearing Association Conference in Boston, MA. This presentation was recognized with a meritorious poster award.

Lab members Stephany Flores, Dr. Drouin, and Talia Mango celebrate their awards at the American Speech-Language-Hearing Association Conference in Boston, MA.

Research Assistants Bethany Rose and Emily Jedlowski show excitement running their first participants in the lab.

STUDENT INVOLVEMENT

Undergraduate or graduate students at UNC-Chapel Hill who are interested in joining the lab can visit our website.
med.unc.edu/healthsciences/allearslab/join-the-lab

RESEARCH INVOLVEMENT

We are currently recruiting school-age children for a research study. Details can be found at the link below.
med.unc.edu/healthsciences/allearslab/participate-in-research/