SPECIAL EDITION

InsideSARGENT

Boston University College of Health & Rehabilitation Sciences: Sargent College

ACHIEVEMENTS IN **SPEECH, LANGUAGE & HEARING SCIENCES**

< 2

TAKING HEALTH CARE HIGH TECH
Sargent uses technology to develop innovative solutions for people with disabilities

7

WHERE THE TROUBLE BEGINS
There is more to dyslexia than meets the eye. One researcher believes it starts with sound

8

TO MOOP OR NOT TO MOOP
Nonsense verbs have broadened our understanding of how children learn to speak

10

HEARING AID OF THE FUTURE
How people with hearing problems could cut through competing sounds—just by looking

12

CAN HE READ YOUR MIND?
Neuroscientist Frank Guenther doesn't read lips, he reads brain waves

BOSTON UNIVERSITY

FPO

Dear Friends,

As Sargent College's dean, it is my honor and privilege to highlight our faculty, our programs, and our extraordinary students in the Department of Speech, Language & Hearing Sciences (SLHS). During my first year at Sargent, I have been astounded by the trajectory of growth and accomplishment here at Boston University, at Sargent College, and particularly in SLHS. Our program in Speech-Language Pathology is supported by a broad research base that brings the innovations of tomorrow to today's classrooms.

The foundation of any academic program is its faculty, and I am thrilled to be working with such a distinguished group of scholars. In this issue, you'll read about a few of these exceptional individuals, including Professor Frank Guenther and his internationally recognized work in the DIVA neural network model of speech motor skill acquisition and speech production. In addition, Professor Swathi Kiran's breakthrough aphasia rehabilitation therapies incorporate advanced approaches to telemedicine that have been particularly successful for bilingual patients. This issue also features Professor Gerald Kidd's technological innovation in visually guided hearing, which promises to drastically reduce the auditory clutter that is so frustrating for many hearing aid users.

The SLHS faculty also includes some of the discipline's rising stars: Assistant Professors Cara Stepp, Tyler Perrachione, and Sudha Arunachalam are leading active lab groups addressing challenging questions in voice production, velopharyngeal insufficiency, language impairment, language processing, neuroplasticity, and auditory processing. Included in this issue are highlights of Professor Perrachione's remarkable work on dyslexia as well as Professor Arunachalam's research on language acquisition, especially with regard to children with autism. These researchers are making new discoveries about the nature of these phenomena while at the same time uncovering new paths for effective diagnosis and treatment.

Our eight clinical centers on the BU campus offer multidisciplinary treatment options for our patients and invaluable hands-on learning opportunities for our students. Our innovative Intensive Stroke Program, run by Clinical Associate Professor Elizabeth Hoover, has operated since 2011, serving 25 participants and engaging more than 50 Sargent graduate students. This inter-professional program brings together students and faculty from speech, language & hearing sciences, occupational therapy, physical therapy, and nutrition to maximize patient outcomes and student learning opportunities. These clinical opportunities ensure our graduates are not only up to date with treatment approaches, but perhaps more important, are thoroughly acculturated in their understanding of the speed of change in treatment research.

I'm extremely proud that the program in Speech-Language Pathology continues to advance as a leader in our discipline. Our faculty are foremost authorities in their respective areas and are committed to the development of advanced clinical procedures. Recent faculty honors included the recognition of Professors Kiran and Elizabeth Gavett as ASHA Fellows and Professor Stepp as a National Science Foundation Career Award recipient.

It is my absolute pleasure to be part of the team at Sargent College. I hope that you will enjoy this special issue of *Inside Sargent*, and I welcome your thoughts and feedback at mooreca@bu.edu.

Sincerely

Christopher A. Moore
Dean and Professor

> "OUR PROGRAM IN SPEECH-LANGUAGE PATHOLOGY IS SUPPORTED BY A BROAD RESEARCH BASE THAT BRINGS THE INNOVATIONS OF TOMORROW TO TODAY'S CLASSROOMS."

SPECIAL EDITION **Inside**SARGENT

Dean
Christopher A. Moore

Department Chair
Melanie L. Matthies

Communications Manager
Stephanie Rotondo

Contributors
Lara Ehrlich, Rachel Johnson, Patrick L. Kennedy, Julie Rattey, and Andrew Thurston

Designers
Kim Cable and Hy Zhitnik

Photography
Boston University Photography, unless otherwise noted

Produced by Boston University Marketing & Creative Services

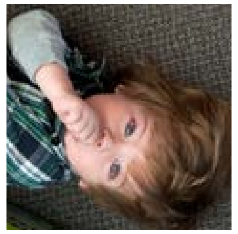
About
Inside Sargent, Achievements in Speech, Language & Hearing Sciences is a publication of Boston University College of Health & Rehabilitation Sciences: Sargent College that compiles previously published articles from the Sargent College publication, *Inside Sargent*. For additional copies, or more information about BU Sargent College, contact Stephanie Rotondo at rotondos@bu.edu or 617-353-7476. You can also visit us at bu.edu/sargent.

BOCHICCIO PHOTOGRAPHY

Boston University College of Health
& Rehabilitation Sciences: Sargent College

SPECIAL EDITION **Inside**SARGENT

Achievements in Speech, Language & Hearing Sciences

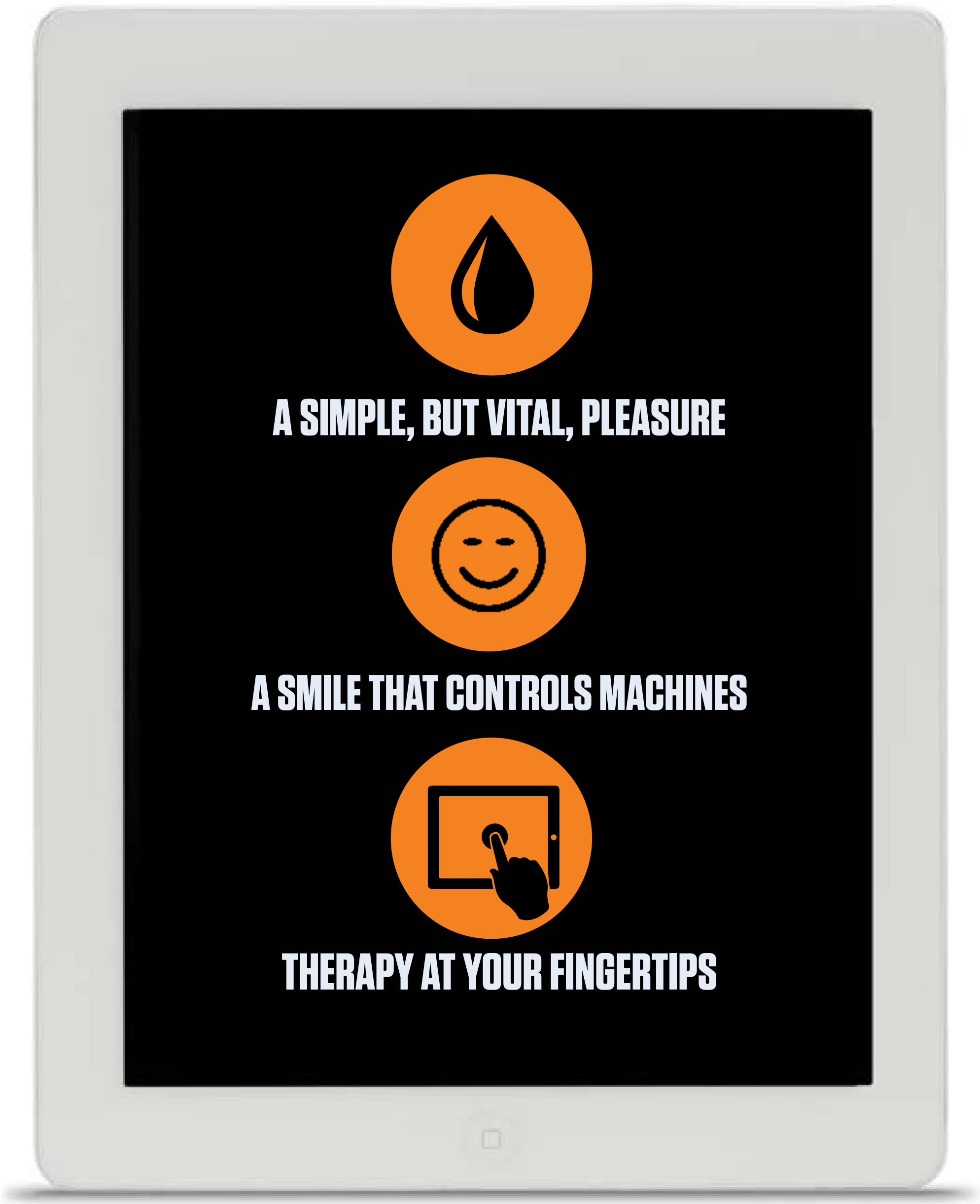


FACTS, FIGURES & MORE

Follow BU Sargent College on:

facebook.com/busargent
instagram.com/busargent
twitter.com/busargent

bu.edu/sargent/slhs



SARGENT IS TAKING HEALTH CARE HIGH TECH

BY LARA EHRLICH AND JULIE RATTEY

INDIVIDUALS WITH SPEECH AND SWALLOWING DISORDERS are regaining control of their muscles. Patients dealing with the effects of a stroke are relearning everyday skills. People with spinal cord damage may soon have new ways to communicate. Sargent's professors, researchers, and students are using technology to develop innovative solutions for people with disabilities. Here are three projects that will benefit patients, health care providers, and caregivers.

THE SCIENCE BEHIND A SIMPLE, BUT VITAL, PLEASURE

A SPEECH SCIENTIST STUDIES THE MECHANICS OF SWALLOWING TO PROVIDE CLINICIANS WITH NEW TREATMENTS

WHAT'S GOING ON ACOUSTICALLY when someone with dysarthria utters a vowel? Can people with swallowing disorders control their throat muscles for tasks other than swallowing? How might computers help stroke patients recover their speech production?

Ask Cara Stepp, an assistant professor of speech, language & hearing sciences and biomedical engineering, who brings her engineering training to the study of normal and disordered speech and voice. The STEPP Lab's long-term goal is to use its findings to help rehabilitate people who have experienced a stroke, Parkinson's disease, brain injury, or other conditions that impair speech and swallowing.

Two of its five projects use interactive computer games for assessment and rehab. "In upper limb rehab," Stepp says, "there are lots of studies showing that engaging individuals in motor rehab with a video game is really effective." The release of dopamine during game play actually encourages brain plasticity, improving one's ability to learn new muscle functions. "We're adapting that to swallowing and velopharyngeal dysfunction."

In the first project, Stepp wants to train people with dysphagia, those whose normal swallowing function has been impaired by a brain injury, to control their anterior laryngeal musculature in response to visual stimuli. A test subject wears four sensors on her neck, three to record signals and one to send signals to a computer game in which she moves a fish up or down, eating smaller fish and avoiding a big shark. The subject sends these signals by tensing the muscles normally used for swallowing. "We're not asking anybody to do anything more, activity-wise, than they already can. So it's not strength-building; it's coordination. So far nobody can't do it." Stepp found that someone who has had a stroke, over time, was able to synch up both sides of her neck: "That was pretty promising, that the impaired side started to look more like the healthy side as she was playing the game."

The other study of this type concerns individuals with velopharyngeal dysfunction. At the back of the throat, the velum is responsible for closing off the nasal cavity when we speak. "When it's shut, we produce speech without any of the acoustic energy going through our nose," says Stepp. "When it's open, we purposefully, usually, do that to create nasal sounds—*nnn*, *mmm*, *nng*. But if you don't have control over this, then you get nasalization when you don't mean to. And that's extremely common in individuals with hearing disorders." That's because the difference isn't perceptible by sight: if you were to watch a clip of someone saying, "Mom" (nasal), with the sound muted, it would be indistinguishable from "Bob" (nonnasal). "If you don't have good auditory feedback, then you don't learn how to control this," Stepp explains.


Cara Stepp

CYDNEY SCOTT

To pinpoint the subtle acoustic differences, the lab has developed a sensor and signal processing system in which a microphone measures acoustic energy emitting from a subject's mouth and nose while an accelerometer picks up vibrations from his nose as he plays a game involving a paper airplane, moving it up and down based on his nasalization of words. "The visual feedback should motivate people to try to rehab," says Boris Virnik (ENG'12), who helped design the program. "That's really important. So we're trying to make the sensor something that's fun to use." →

This article is compiled from articles previously published in the 2012–2013, 2013–2014, and 2014–2015 issues of *Inside Sargent*.

→ CONTINUED FROM PREVIOUS PAGE

Stepp appreciates having a team of students working with her in the lab. “The BU undergrads are phenomenal,” she says. “They bring hours of work, of course, but it’s more than that; they take responsibility and they contribute creatively. That’s a combination that is not common.”

Currently, the velopharyngeal study is gathering control data from healthy adults, and the plan is to test the sensor on children with hearing disorders as well as cerebral palsy and cleft palate.

Other STEPP Lab projects include a study of the acoustic signals in the speech of people newly diagnosed with Parkinson’s disease. “By the time someone is diagnosed, they may have been living with it for eight to ten years, and have lost half their brain stem,” Stepp explains. “How is it that nobody notices it until then? One reason I believe is that humans are so good at compensating [while listening]. Our speech perception is specifically trained to hear intelligible speech. What I wonder is whether we can identify the perceptually subtle changes using acoustic analyses.”

BU Sargent College has proved to be the perfect fit for the engineer’s work in research and rehab. “I’m not a clinician, so I have to be really careful to talk with, at every opportunity, clinicians who see patients all the time,” says Stepp. Fortunately, she gets to consult colleagues such as Clinical Professor Susan Langmore, “probably a top-five-in-the-country swallowing researcher. She’s an amazing clinical resource.”

“I think a lot of engineering projects that go awry do so because the engineer has no understanding of the pragmatics,” Stepp says. “So they design something that is really elegant but has little to do with what patients actually want and need. I try not to fall into that trap, and that’s one of the major attractions of Sargent for me: I can get the ideas and opinions of clinicians right here in this building.”

A SMILE THAT CONTROLS MACHINES

SLHS STUDENT CAROLYN MICHENER’S RESEARCH HELPS PEOPLE USE TECHNOLOGY THROUGH FACIAL MOVEMENT

IMAGINE TURNING ON THE LIGHTS, adjusting the thermostat, or operating a DVD player simply by smiling. For people who are visually or verbally impaired, or who have limited motor skills, this could be a major advance in communication. Carolyn Michener (’16) is working to make it a reality.

An undergraduate in the speech, language & hearing sciences program, Michener says her lifelong stutter and interest in engineering sparked a passion to develop technology to help others communicate. Working in the STEPP Lab for Sensorimotor Rehabilitation Engineering at Sargent College, she’s collaborating on a project to help people use facial movement and sound to work with human machine interfaces (HMIs)—controls like keypads and touchscreens through which people operate machines, systems, and devices.

“An HMI needs some kind of feedback to properly tell the user what it’s doing,” says Michener, who joined Cara Stepp and Sargent research engineer Sylvain Favrot on the project in 2012. Often this feedback is visual—for example, a control panel flashing a colored light or displaying a message confirming that an action has been completed. “But this can be difficult for people who are visually impaired or who find the visual stimuli distracting,” says Michener. The STEPP Lab project enables people to communicate with machines through sound—no seeing or touching required. Plenty of machines already do this—such as iPhone’s Siri, which allows users to send messages or search for information—but these systems often require voice commands, which are not applicable to people with impaired speech. With the new STEPP Lab technology, users can communicate with machines by using facial movements to create sound.

To test the technology, Michener trained study participants in what she describes as an auditory matching game, using preexisting STEPP Lab software that Favrot modified for the project. Sitting in a soundproof booth in the lab, Michener demonstrates how the game works.

She opens communication between the player and a computer, connecting them by way of two electrodes placed on either side of the lips. This connection enables the computer to translate the facial muscles’ electrical signals from the skin, a process called surface electromyography. The player undergoes a quick calibration procedure, dons a pair of headphones, receives Michener’s instructions—and is ready to begin.

A tone plays through the headphones for two seconds. This is the sound the player will try to match. Then, a second tone sounds. This is the player’s starting point, a low pitch in both ears that represents the player’s muscles at rest. The player now has 15 seconds to match the first sound’s pitch and location (left ear, right ear, or both) by contracting his or her facial muscles in just the right combination. Contracting left or right—in effect, smirking—creates a medium pitch in the corresponding ear. Contracting both sides—smiling—increases the pitch and activates the sound in both ears. The trial ends when either the player hits the target for 1 second or 15 seconds have expired. The player then receives a score representing how well he or she matched the target.

While the search for the target sound is an auditory task for the user, the game’s software visually records both the target location and the user’s performance on a graph Michener can review on the computer. She tested the game on 16 adults, each of whom completed three test sessions lasting 45 minutes.

After three days, users working with auditory feedback were able to communicate at an average speed of 40 bits per minute (bpm). While this speed is 50 times slower than typing on a keyboard and 15 times slower than the quickest computer mouse use, Stepp says, participants using auditory feedback were able to communicate with machines as effectively as participants using visual feedback in similar studies. “We can conclude that auditory feedback is a viable way to allow people to communicate with this kind of system,” says Michener.

Michener cowrote a paper about the project with Stepp and Favrot that she presented at the Acoustical Society of America’s biannual conference in May 2014. She continues to run trials of the game, this time to find out if players with a musical background perform better than others. Stepp says the team is also embarking on collaborations with Madonna Rehabilitation Hospital in Nebraska and the Perkins School for the Blind in Massachusetts to see how people who are blind and individuals with spinal cord injuries perform in and respond to the game.

“Ultimately I would like to see this technology in a device that can be used inside a patient’s home,” says Michener. Patients trained to associate certain musical notes with particular tasks, for instance, could match those notes using their facial movements to adjust the thermostat, operate an electric bed, turn on the TV, or communicate needs to a caregiver. Ultimately, the ability to easily interact with various machines and devices could help patients in rehabilitation and people with disabilities communicate more effectively and live more independently.

Carolyn Michener (’16) (above) is working with Sensorimotor Rehabilitation Engineering Lab Director Cara Stepp on a project to help people use facial movement and sound to control human machine interfaces—no seeing or touching required. Two electrodes placed on either side of the lips enable a computer to translate muscles’ electrical signals, which correspond to auditory feedback. By contracting these muscles, a user is able to change the pitch and location of the sound, effectively communicating with machines.

THERAPY AT YOUR FINGERTIPS

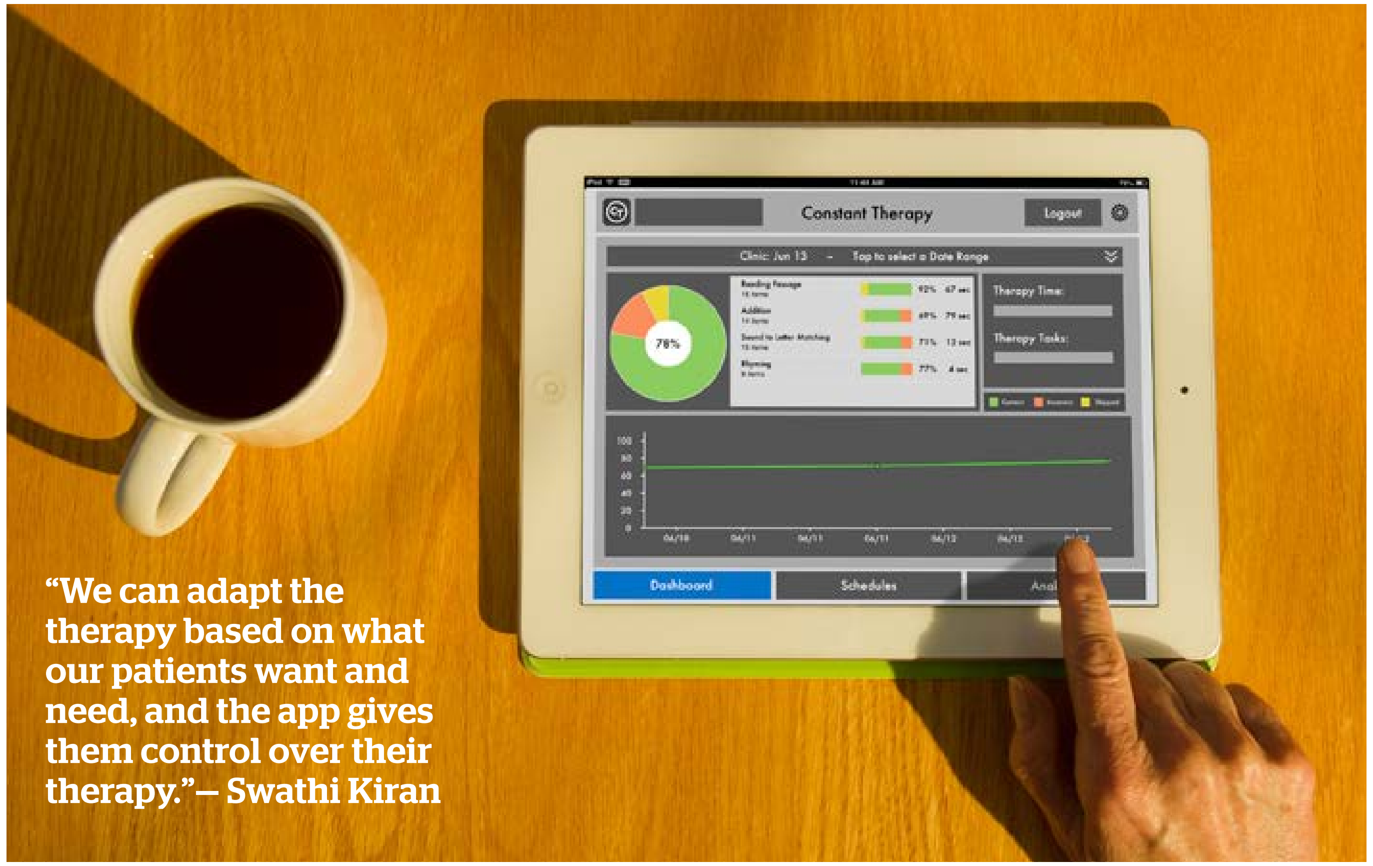
AN INTERACTIVE IPAD APP ALLOWS THOSE WITH SPEECH DISORDERS TO CONTINUE TREATMENT AT HOME

ROBERT ZIEGLER ARRIVES AT BU Sargent College for his weekly therapy session in a pressed shirt and slacks, with rain dripping from his nose. The 71-year-old has walked from his home in Cambridge, Massachusetts. He’d previously worked in that city, too, as a child psychiatrist and a Harvard professor, until he had a stroke that left him with aphasia. A language disorder caused by damage to parts of the brain, aphasia ranges in severity from difficulty remembering words to full loss of language. Three years ago, Ziegler began working with the Aphasia Research Laboratory at Sargent to relearn the skills he once took for granted.

Ziegler has made remarkable progress, thanks in part to Constant Therapy, an interactive aphasia therapy app that allows patients to continue their treatment at home on an iPad. Many patients require more treatment than is covered by their insurance, so Constant Therapy, which is available for download through iTunes, is reshaping the therapy field. Swathi Kiran, director of the laboratory and associate professor of speech, language & hearing sciences, developed the app with tech entrepreneur Veera Anantha and a team of BU student researchers, including Isabel Balachandran (’12), →

Swathi Kiran

MICHAEL D. SPENCER (TOP); KALMAN ZABARSKY (BOTTOM)



"We can adapt the therapy based on what our patients want and need, and the app gives them control over their therapy."—Swathi Kiran

→ CONTINUED FROM PREVIOUS PAGE

who is now Ziegler's clinician. A leader in the area of stroke and language, Kiran was recently named a fellow of the American Speech-Language-Hearing Association, one of her profession's highest honors.

At the weekly therapy session, Balachandran turns on Ziegler's iPad for his progress report. Ziegler can review his work at home on the app's user-friendly feedback screen, but prefers to have Balachandran talk him through his scores. In the last week, he has achieved a 95 percent score on his multiplication, and it's time to advance from level 1 (multiplying single-digit numbers) to level 2 (multiplying double-digit numbers by single-digit numbers). He is hesitant to leave the level in which he has gained competency, and the first new problem, 62 x 9, gives him pause. Balachandran helps him work through it, and when Ziegler finally reaches the answer, he slumps in his chair and says, "Oy."

"You're doing great!" Balachandran reassures him. And he is. Just a year ago, Ziegler was unable to add. He attributes his progress to Constant Therapy, which he uses for at least an hour every day to practice a wide range of skills, including reading maps, matching pictures by memory, and reconnecting everyday items with their names and sounds.

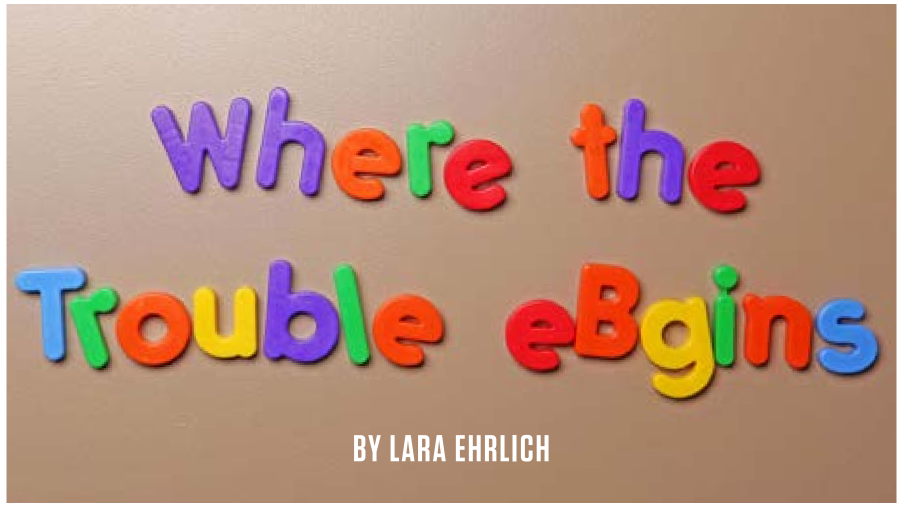
To develop these exercises, Kiran drew from her years of experience in aphasia rehabilitation, her own and her colleagues' research, and the comprehensive literature on cognitive therapy to determine the tasks that are most effective in helping those who have had a stroke recover their language and cognitive processing abilities. "Then we decided how to tweak the tasks and set them to be iPad-deliverable," she says. "The app is personalized, so each person has a different set of exercises for their specific level." Balachandran can access Constant Therapy remotely to monitor Ziegler's progress, and the app sends her a report every night so she can modify his therapy as needed. "We can adapt the therapy based on what our patients want and need, and the app gives them control over their therapy," Kiran says.

Since October 2012, 45 patients from Sargent's Aphasia Research Laboratory have used Constant Therapy on a trial basis as a part of a clinical research study, and "they see the power of it already," Kiran says. She hopes it will have even wider-reaching influence; the idea is for patients eventually to use the app as a social media device to communicate with other patients. "We are constantly connected to our friends and the larger world," Kiran says. "These individuals don't have any way to connect with other people, so the goal is for this app to become social, as well as clinical." IS

Web Extra
Visit **www.bu.edu/aphasiaresearch** to learn more about the Aphasia Research Lab and find links to a free trial of Constant Therapy.

CYDNEY SCOTT

STEVE PRUE



Where the Trouble eBgins

BY LARA EHRLICH

THERE IS MORE TO DYSLEXIA THAN MEETS THE EYE
ONE RESEARCHER BELIEVES THE PROBLEM STARTS WITH SOUND

READING IS A COMPLEX SKILL: you move your eyes across a page, sound out words, recognize visual patterns, retain information, and build sentence structure. There are lots of places where things can go wrong. And for people with dyslexia, who have no trouble comprehending spoken language, what goes wrong is their ability to decode words in print.

"There is something fundamentally different about the way their brains handle language that permits spoken communication, but makes written communication challenging," says Tyler Perrachione, an assistant professor of speech, language & hearing sciences. The difference, he believes, may be in the way their brains process variability, or variations in word sounds.

Researchers have identified two hypothetical—and historically competing—models to explain how the typical brain processes variability. According to the episodic model, the brain recognizes speech by comparing it to specific words it has heard before.

According to the abstractionist model, the brain strips away variability to access the underlying, or abstract, sounds of the words. When listening to speech, the brain also develops a catalogue of information about the speaker's voice; as the voice becomes more familiar, the speaker's words become simpler to understand. If two people with different accents speak the word *phone*, for example, the listener's brain removes the accents to focus on the phonology, or the fact that *phone* is constructed of the phonemes *f-ō-n*. It is here that Perrachione thinks the trouble begins for individuals with dyslexia.

When shifting from listening to reading, an individual must match word sounds to letters, recognizing that the *f* sound in the word *phone* is the same as in the words *floor, finish*, and *physical*. Because letters can combine in many ways to represent speech sounds, learning to read relies on having strong abstract representations of these sounds in the brain.

While researchers habitually debate which model the brain uses to process speech, Perrachione believes that the typical brain employs both: the abstractionist model enables it to recognize words more efficiently, while it can fall back on the episodic model to recognize words with more effort. In his research, Perrachione aims to discover whether individuals with dyslexia rely on one of these models at the expense of the other.

In collaboration with colleagues at Massachusetts Institute of Technology and Massachusetts General Hospital, Perrachione used functional magnetic resonance imaging (fMRI) to measure the brain metabolism of first- and second-grade children with and without dyslexia.

He instructed the children to read a series of words to themselves and press a button when two consecutive words began with the same sound. Perrachione found that children with typical reading skills showed more metabolic activity in areas of the brain that are related to reading and language. They also showed more activity in areas related to hearing because they heard the words in their heads when reading silently.

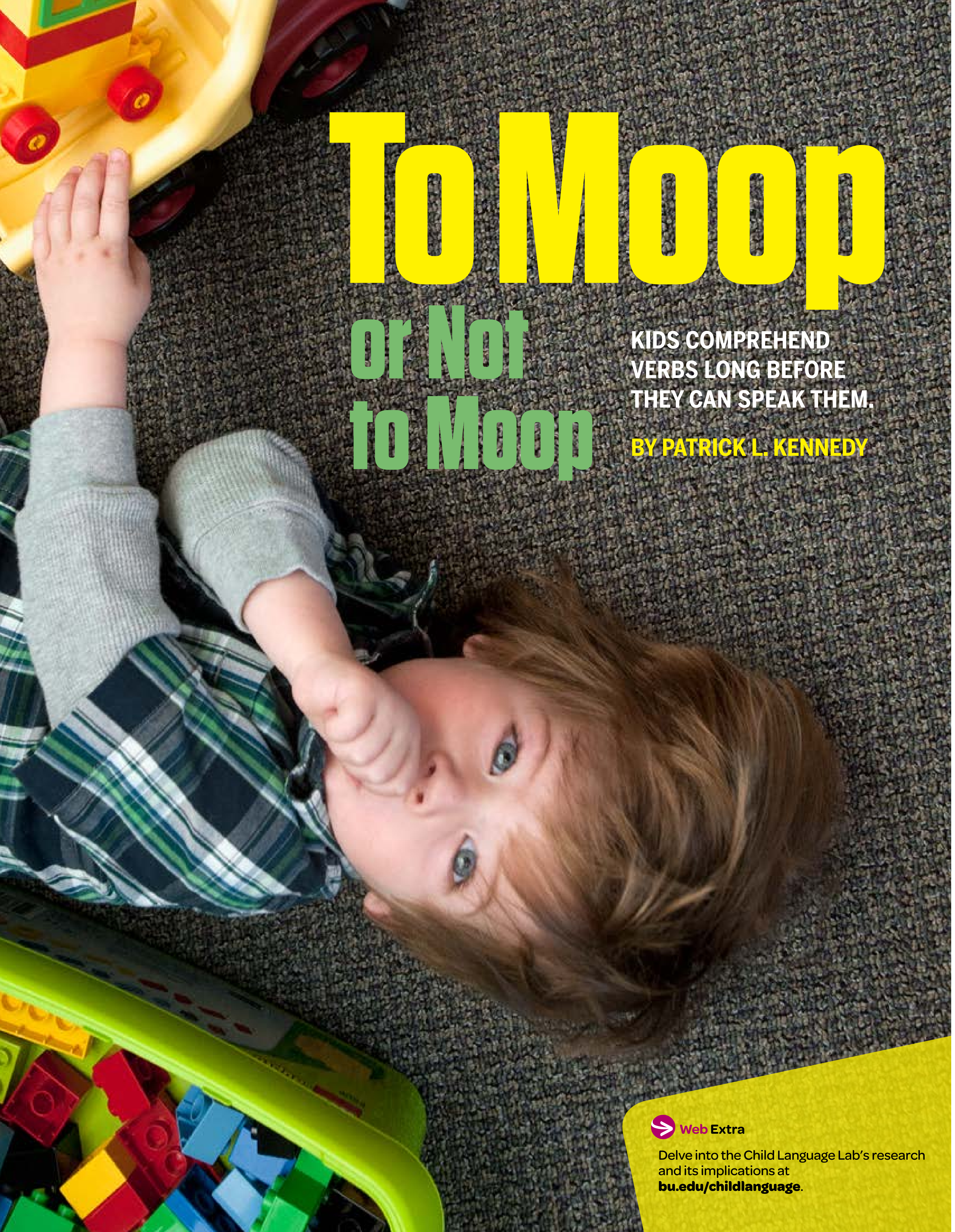
In the same study, children with dyslexia activated smaller areas of their brains. "When children with dyslexia are reading words and making decisions about sound, they're bringing their language network online less than children without dyslexia," Perrachione says. They're not activating the sound areas because they have difficulty connecting the phonemes to the printed words; for instance, they have more difficulty recognizing that the word *phone* comprises the sounds *f-ō-n*.

Typical readers use both methods of processing language, Perrachione says, which allows them both to recognize new words and to process familiar speech efficiently. They compare only unfamiliar speech to their catalogue of stored words. Children with dyslexia seem to compare every word to their catalogue, which requires their brains to exert more effort.

"If they don't have the abstract phoneme representations of speech sounds to serve as an intermediary, then it's harder to get to the word," Perrachione says. "It's being blocked by not having a good way to translate between print and speech." Perrachione's goal is to devise training strategies to help children with dyslexia perform this translation process, enabling them to read more quickly and efficiently.

Web Extra
Further information about the work of Tyler Perrachione can be found at **go.bu.edu/sargent/inside-sargent.**

This article was originally published in the 2014–2015 issue of *Inside Sargent.*



To Moop or Not to Moop

KIDS COMPREHEND VERBS LONG BEFORE THEY CAN SPEAK THEM.

BY PATRICK L. KENNEDY

Web Extra

Delve into the Child Language Lab's research and its implications at **bu.edu/childlanguage**.

VERNON DOUCETTE

THEY DON'T TALK MUCH, but they listen. And learn. Even the youngest toddlers are rapidly building a vocabulary, even if they aren't able to reproduce aloud all they've learned. In fact, when a child hears an unfamiliar verb, even absent a visual cue, she will usually figure out from the context of the sentence whether it's transitive or intransitive, then file it away and retrieve it when she encounters a likely definition. (She sees her brother rubbing Fido, then remembers Mommy spoke of *petting* the dog.)

That's the finding BU Child Language Lab Director and Assistant Professor of Speech, Language & Hearing Sciences Sudha Arunachalam published in a 2012 edition of the journal *Language and Cognitive Processes*.

"Learning language is really one of the great mysteries of human cognition," says Arunachalam. "Children understand more than they say."

In the past, the language scientist explains, studies of lexical acquisition focused on nouns, because, generally, the first words out of a child's mouth are indeed nouns. Parents naturally think teaching words means, "I hold up a ball and say, 'Look, here's a *ball*. Do you see the *ball*?'" Arunachalam says. "But real-world learning is much more complicated than that, and verbs in particular are more complicated, which is why we chose to look at them."

In a 2010 study, Arunachalam and colleagues established that 27-month-olds are capable of correctly identifying a verb's syntactic properties. They showed children a video of a conversation with a made-up verb cast as either transitive ("The boy wants to *moop* the ball") or intransitive ("The boy and the dog want to *moop*"). Then, the toddlers watched two scenes side by side: one depicted a boy spinning a girl in circles; the other, the boy and girl each waving one hand. Finally, the kids were asked to point to the scene that showed *mooping*. Those who'd started with the dialogue video in which *moop* was transitive picked the transitive video (the boy acting upon the girl by spinning her) and those who'd watched the intransitive dialogue picked the intransitive scene (the boy and girl together performing an action, waving, with no object).

In her latest study, Arunachalam tried the same experiment but with even younger children—most 21 months, some just 19 months—and with a technological twist: instead of asking the toddlers to indicate their choice by pointing, she used a corneal reflection monitor to track their eye movements upon hearing the question. "It's kind of extraordinary," she says. "We can measure their comprehension by almost literally looking through their eyes."

DESPITE THE CHALLENGES of working with such young subjects (the journal article notes that "nine toddlers were excluded from analysis due to fussiness"), Arunachalam and colleagues again found that most kids got the transitive-intransitive distinction. "Clearly, then, 21-month-olds have what it takes to benefit from cross-situational learning," she wrote, meaning "they can glean whatever information is available about a novel verb in one encounter, and access that information in a subsequent encounter."

That held true for the study's few 19-month-olds, Arunachalam adds. "Most 19-month-olds are barely putting words together in a sentence—and they aren't producing transitive or intransitive structures. But our study made clear that not only can they learn new verbs, they can learn them just from hearing this kind of syntactic information."

It's a remarkable advance in our understanding of how children learn words, and Arunachalam isn't finished by a long shot. She's also planning to study the effect a good nap has on word learning: "Sleep has been shown to have a large role in memory consolidation, but there's been very little work on memory for language, and *no* work on memory for word meanings in children."

Currently, Arunachalam is running the eye-tracking test again, but this time "extracting the social context from the situation to make it even harder," she says: rather than a video of a conversation, children are shown a dull video of shapes moving while they hear the novel verb spoken within a stream of unrelated sentences. It's too early to draw a conclusion, she says, but so far, "The trend is in the right direction. They do seem to be learning."

This study may have implications for teaching language to children suffering from autism. "Perhaps this would be helpful for them," Arunachalam says. "Maybe they would learn more easily in a context in which they didn't have to sit next to somebody or look at somebody or be explicitly taught something, but rather they could pick up information more from ambient noise." At the least, she says, this exercise could provide the children a foundation for later learning.

Assistant Professor Sudha Arunachalam has found that although 19-month-olds don't produce many verbs, they can learn them.

The biggest challenge for the language lab is simply getting participants. "We need 80 kids per study—80 kids whose data we can use," Arunachalam says. "Occasionally a kid will walk in the room and just want to leave. Or he'll keep holding a cup of Cheerios in front of his face, and we cannot get him to put that cup of Cheerios down." Nevertheless, she adds, "We've had tremendous success."

For *Inside Sargent* readers who are parents of toddlers, Arunachalam offers this takeaway: "Children are listening and learning, even when they are just overhearing speech that isn't directed specifically to them. So keep the household conversation going!" IS

This article was originally published in the 2012–2013 issue of *Inside Sargent*.

HEARING AID
OF THE FUTURE

EYE-TRACKERS AND MICROPHONES HIDDEN IN GLASSES COULD HELP PEOPLE WITH HEARING PROBLEMS CUT THROUGH COMPETING SOUNDS—JUST BY LOOKING

BY JULIE RATTEY

KATH HARDING

CHITOSE SUZUKI (TOP); CYDNEY SCOTT (BOTTOM)

THE WHITE STRIPES is one of Erick Gallun's favorite bands. But years before the rock duo officially split in 2011, he'd stopped going to see them. Gallun recalls his last, ill-fated attempt, when he was a postdoctoral fellow at BU and the band was performing in a New Hampshire hockey rink. His wife had a great time, but for Gallun, who's deaf in one ear, the experience was a bust. His right ear couldn't filter out the reverberations in the rink, making the event about as frustrating as a feedback-riddled cell phone conversation. "The concert was essentially ruined," says Gallun.

Though Gallun didn't have a hearing aid then, he doubts the one he's using now would have made much difference. But he recently tested a device he believes could get him back into the rock music scene: the Visually Guided Hearing Aid (VGHA).

The VGHA can approximate or even surpass the normal human ear's ability to choose what to tune into and what to ignore. It does this by making two preexisting technologies—an eye-tracker and an acoustic beam-forming microphone array—work together to counter some of the problems in typical hearing aids. Right now, the VGHA is a lab-based prototype whose components connect via computers and other equipment, but with further development, it could become a pair of portable hearing aid glasses. Professor Gerald Kidd, a specialist in psychoacoustics (the study of the perception of sound), came up with the idea for the VGHA in 2011. He's now put it together at BU Sargent College's Sound Field Laboratory, with the help of an international research team and grants from the National Institutes of Health. As far as Kidd knows, his team, which includes research engineer Sylvain Favrot and Sensimetrics Corporation of Malden, Massachusetts, is the first to integrate these two technologies. And the test results are impressive: no other hearing aid, Kidd says, can do what this device can.

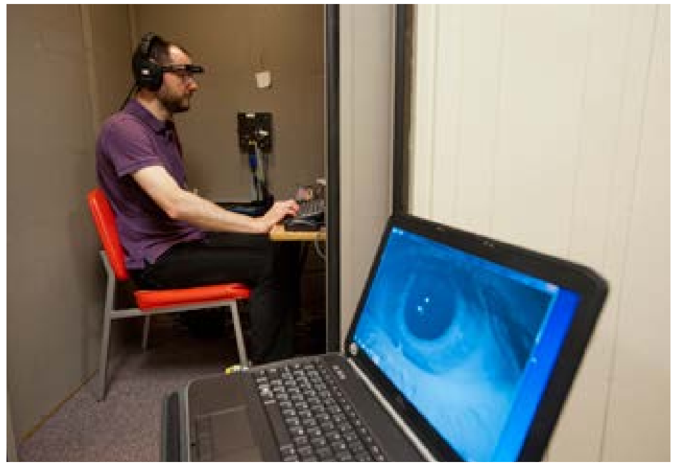
The VGHA is the latest advance in Kidd's work to solve "the cocktail party problem," in which people with hearing loss struggle to follow conversations in noisy environments. It's a big issue: nearly 20 percent of Americans age 12 or older have severe-enough hearing loss to make communication difficult, reported Johns Hopkins Medicine in 2011. Typical hearing aids may not help much in some situations, says Kidd; they amplify everything, even those voices and sounds you want to tune out. One hearing aid in development tries to fix this, says Kidd, by using the wearer's head movements to guide the aid's microphones. But this can tire the user, he says, and it's relatively slow: we can't turn our heads as quickly as we turn our attention. The VGHA addresses these problems by using eye movement (which is quicker than head movement) to steer the aid's microphones, "like an acoustic flashlight that you're shining on what you want to listen to."

Gallun, now a research investigator at the National Center for Rehabilitative Auditory Research, had the opportunity to test the VGHA as a consultant on the project—with exciting results. While sitting in a listening booth at Sargent and wearing the VGHA's eye-tracking component—Mobile Eye-XG—Gallun listened to recorded voices speaking from slightly different directions. He was told to pick out what one particular voice was saying—no easy feat with Gallun's impaired hearing, given that all the voices were speaking at once. But by looking in the direction of his cue, Gallun "told" the eye-tracker to make the VGHA's microphone component amplify the voice he wanted, thereby helping him hear what it was saying. "I'll take two!" an enthused Gallun quipped to the team. He's excited about the VGHA's potential not only for himself, but also for the veterans he works with at the Portland Veterans Affairs Medical Center in Oregon, many of whom are hearing impaired as a result of blast exposure.

Although the VGHA is still a prototype that needs further testing, Kidd hopes enthusiasm for the technology will propel its development. Interested hearing aid companies, he suggests, could make the device wearable and attractive. Kidd and Favrot also speculate that the VGHA could piggyback on technologies like Google Glass—lightweight glasses whose capabilities range from projecting driving directions to responding to voice commands.

Whenever the VGHA reaches consumers, you can expect Gallun to get his hands on one. All he'll need then is a White Stripes reunion. IS

> **The Visually Guided Hearing Aid, says Gerald Kidd, works "like an acoustic flashlight that you're shining on what you want to listen to."**



Research engineer Sylvain Favrot wears the portable eye-tracker component of the VGHA developed with Professor Gerald Kidd (top) and other researchers.

This article was originally published in the 2013–2014 issue of *Inside Sargent.*

CAN HE READ YOUR MIND?

NEUROSCIENTIST FRANK GUENTHER HAS DECODED THE SIGNALS OUR BRAINS FIRE OUT WHEN WE WANT TO TALK. NOW HE'S USING HIS EXPERTISE—AND SOME TELEPATHIC TECHNOLOGY—TO HELP THOSE WITH SPEECH PROBLEMS

By Patrick L. Kennedy

VERNON DOUCETTE (LEFT); KALMAN ZABARSKY (RIGHT)

For thousands of years, before humans ever wrote anything down, we spoke. Noam Chomsky and many other linguists argue that speech is what sets *Homo sapiens* apart in the animal kingdom. "Speech," wrote Aristotle, "is the representation of the mind."

It is a complex process, the series of lightning-quick steps by which your thoughts form themselves into words and travel from your brain, via the tongue, lips, vocal folds, and jaw (together known as the articulators), to your listeners' ears—and into their own brains.

Complex, but mappable. Over the course of two decades and countless experiments using functional Magnetic Resonance Imaging (fMRI) and other methods of data collection, neuroscientist Frank Guenther has built a computer model describing just how your brain pulls off the trick of speaking.

And the information isn't merely fascinating. Guenther—a professor in Sargent's speech, language & hearing sciences department—believes his model will help patients suffering from apraxia (where the desire to speak is intact, but speech production is damaged), stuttering, Lou Gehrig's disease, throat cancer, even paralysis.

"Having a detailed understanding of how a complex system works helps you fix that system when it's broken," says Guenther, a former engineer who left Raytheon ("I hated being a corporate cog") to earn a PhD in cognitive and neural sciences from BU. "And a model like this is what it takes to really start understanding some of these complicated communication disorders."

PURPOSEFUL BABBLE

Guenther's virtual vocal tract, Directions Into Velocities of Articulators (DIVA), is the field's leading model of speech production. It is based on fMRI studies showing what groups of neurons are activated in which regions of the brain when humans speak various phonemes (the mini-syllables that compose all words). The DIVA system imitates the way we speak: moving our articulators (tongue, etc.) and unconsciously listening to ourselves and auto-correcting. When Guenther runs a fresh program, the model even goes through a babbling phase, teaching itself to produce phonemes, just as human babies do.

"IT WON'T COST PATIENTS $50,000, AND THEY WON'T HAVE TO UNDERGO BRAIN SURGERY. IT'S THE KIND OF OFF-THE-SHELF THING THAT THEY CAN BUY AND USE TO COMMUNICATE WITHIN A DAY OR TWO OF PRACTICING."
—FRANK GUENTHER

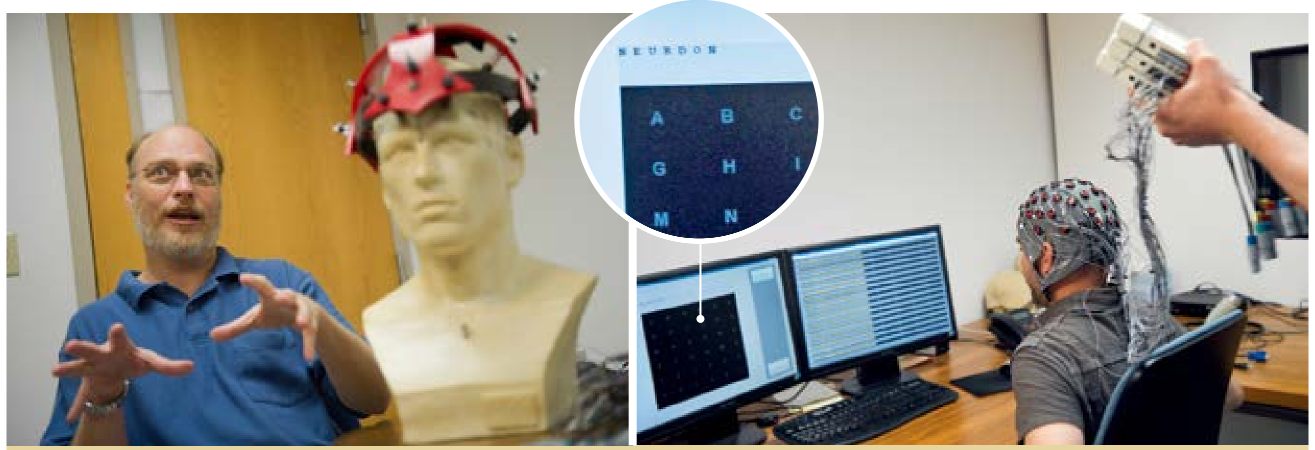
Guenther and colleagues in his lab, which he recently moved to Sargent from BU College of Arts & Sciences, continue to perfect the model, but primarily, they're focused on "using insights from the model to help us address disorders like stuttering," Guenther says. "What we'll do is modify the model by damaging it to mimic what's going on in these disorders." As they learn more about the physiological differences in the brains of stutterers, for example, Guenther's team comes closer to "having more precise hypotheses about which receptor systems a drug should target, which should lead us more quickly to a drug that doesn't cause other behavioral problems."

GIVING VOICE TO A THOUGHT

A large part of Guenther's work consists of devising "brain-computer interface methods for augmentative communication," he says. The most dramatic example has been a collaboration with pioneering neuroscientist Phil Kennedy of Neural Signals, Inc., in Georgia, in which software developed by Guenther's lab helped a paralyzed man articulate vowels with his mind.

"In locked-in syndrome, the cortex, the main parts of the brain that the model addresses, are actually intact," says Guenther, explaining the condition of a patient who is physically paralyzed but mentally sound. "What's messed up is the motor output part of the brain. So the planning of speech goes on fine, but there's no output." Guenther had speculated that, "If we knew what their neural signals were, how they were representing the speech, then we should be able to decode the speech. And it turned out that Kennedy and his team had implanted somebody with an electrode in that part of the brain—the speech motor cortex—but were unable to decode the signals." →

This article was originally published in the 2011–2012 issue of *Inside Sargent.*



Pick a letter and these caps can probably guess which one you're thinking of. Sensors in the caps—the red one manufactured by Frank Guenther, the gray one modified by his team from an existing product—pick up the brain's electrical signals and transmit them to the computer screen. In this experiment, the subject watches a screen full of letters; when he concentrates on a single letter, it automatically pops up at the top of the display. Although the technology is in its infancy, it could eventually be a lifeline for those who can't speak. The caps can also help patients with normal brain function but faulty muscle control reconnect with the outside world for a relatively low cost and without potentially risky brain surgery.—Andrew Thurston

→ CONTINUED FROM PREVIOUS PAGE

The volunteer who received the implant was Erik Ramsey; he had suffered a severe stroke following a car crash, and could communicate only by answering questions with "yes" or "no" using eye movements. With a grant from the National Institutes of Health, Guenther and colleagues built Ramsey a neural prosthesis in 2008. With his electrodes hooked up to a wireless transmitter, Ramsey imagined speaking vowels, activating neurons that powered a real-time speech synthesizer (emitting a robotic "ahhhhoooooeeee . . .") while the researchers watched his progress on a monitor that showed his formant plane—an X-Y axis graph representing "what we call the formant frequencies—where the tongue is, basically."

Guenther explains that "by the end of the experiment, he was hitting the auditory targets about 80 percent to 90 percent correctly."

FUZZY MIND READING

There are less invasive neural-prosthetic options, which Guenther's lab is also pursuing. Electroencephalography, or EEG, involves picking up the brain's electrical signals through sensors resting on the subject's head, externally. Guenther's colleague Jon Brumberg (now an assistant professor at the University of Kansas in the department of Speech-Language-Hearing) is testing an EEG system in which one imagines moving one's left or right hand or foot, thereby moving a cursor on a screen. Another method involves choosing letters by staring at them on an alphabet grid.

These laborious methods have advantages, Guenther says. "First of all, it won't cost patients $50,000, and they won't have to undergo brain surgery. It's the kind of off-the-shelf thing that they can buy and use to communicate"—albeit slowly—"within a day or two of practicing."

However, Guenther says, thanks to interference from the skull, EEG signals have limited value. "Imagine an old TV antenna where you get a fuzzy picture. That's what EEG is like.

"For real-time control of a synthesizer to produce conversational speech, I think the best way is going to be intracortical, intracranial, because you're always going to get higher-resolution signals." And Ramsey succeeded in producing vowels with only two output channels, while "the next system will have up to 96 channels."

Guenther points out that "these are the initial attempts. It's like the first rockets that went up but didn't even go into orbit. This is going to get more and more refined over the next decades. But it will happen . . . . I can imagine a day when these surgeries become so routine that it's not a big deal. Somebody might wear such a device as a necklace with a speaker on it."

INSIGHTS FOR CLINICIANS

Guenther relishes his work as a pioneer at the nexus of engineering, neuroscience, and now rehabilitation. "Coming to Sargent College has been good timing for me because my earlier career was building up this model of normal human brain function, and now that we're starting to look at the disorders, like stuttering, we're getting insights by talking to clinicians, and getting access to clinical populations, at Sargent."

What hasn't changed is Guenther's fascination with the human brain. "It's such an unbelievable machine. I've studied computers, and the brain does many things so much better than computers. And if you figure out how the brain works, you understand the mind, and you understand some of life's great mysteries." IS

KALMAN ZABARSKY

CYDNEY SCOTT

STARTING A CONVERSATION

"I DON'T WANT TOO MUCH DISTANCE FROM MY PATIENTS BECAUSE I WANT TO HELP PEOPLE, AND I THINK THAT BECOMES HARDER IF YOU CUT YOURSELF OFF. THERE ARE ALL THESE LIFE-CHANGING EVENTS THAT WE CAN'T FIX; BUT THERE ARE OTHER THINGS WE CAN TAKE ON."

WILL EVANS, PhD (SHOWN AT MASSACHUSETTS GENERAL HOSPITAL)

WORKING WITH PATIENTS MOTIVATES A DOCTORAL STUDENT TO PUSH BOUNDARIES IN THE LAB AND THE CLINIC

BY RACHEL JOHNSON

IMAGINE KNOWING WHAT YOU WANT TO SAY but not being able to say it. For people recovering from acquired brain injuries (ABIs)—such as those resulting from accident, stroke, surgery, or cancer treatment—language problems can pose one of the greatest challenges in their recovery, affecting their ability to resume a normal life. Will Evans ('10, '13) has seen how devastating these impediments can be during his clinical fellowship at Boston's Massachusetts General Hospital (MGH), part of his PhD work in SLHS. "There's a lot of grieving," he says, "because people are dealing with the realization that they might not get to live the life that they were expecting." Witnessing language loss has motivated Evans to help develop therapies that bring back some level of communication to patients.

He works with adult outpatients at MGH, treating a number of language-related disorders, including aphasia, a problem with the ability to produce or understand language, and dysarthria, a muscle control impairment. The work allows Evans to put abstract classroom concepts into action. "An adult already had a fully developed language system that was fine to begin with," he says, "but now something's happened to it. So I have to think, 'How do I get the best sense of where they are? What are the difficulties that they're having?' Then I can come up with the strategies and training that will help."

Evans is working behind the scenes in Sargent's Language Science Lab to help develop some of those strategies. He's been at the lab for the past five years and has won plaudits for research on the use of eye-tracking technology to monitor language processing. "The major benefit to using eye-tracking is that you can present slightly different versions of similar sentences and see in real-time if the way people read them changes," he says. "If they reread certain parts more often or take longer on a specific word in one sentence than they do in a similar sentence, you can draw conclusions about how their language processing system is set up."

But, even as Evans and other researchers make technical advances in diagnosis and treatment, regaining speech functions after an ABI can be a draining process—for both patient and clinician.

"It's really important to address these emotional aspects," says Evans. "I don't want too much distance from my patients because I want to help people, and I think that becomes harder if you cut yourself off. There are all these life-changing events that we can't fix; but there are other things we can take on."

Eventually, Evans wants to research, teach, and work with patients. Earning his PhD will enable him to do all three: "Being a professor lets you add to the body of knowledge, so people in general can receive better help. But I love working directly with patients, too." Although his current dilemma is whether to teach, study, or treat first, he says all three routes are driven by the same ambition: "I want to help increase the knowledge of how the brain works and how knowledge is processed, and also to connect that to helping actual patients in the real world." IS

This article was originally published in the 2011–2012 issue of *Inside Sargent*.

Grant Awards

BU SARGENT COLLEGE'S SLHS FACULTY RECEIVED **$3,787,792** IN RESEARCH FUNDING IN 2014–2015. HERE IS A LIST OF OUR PROJECTS AND THE AGENCIES AND FOUNDATIONS SUPPORTING SLHS RESEARCH.

PRINCIPAL INVESTIGATOR	TITLE OF PROJECT	AGENCY/FOUNDATION	FUNDS AWARDED 2014–2015	YEAR OF AWARD	TOTAL AWARD
Sudha Arunachalam, assistant professor of speech, language & hearing sciences	A Non-Interactive Method for Teaching Noun and Verb Meanings to Young Children with ASD	Autism Speaks	$58,900	2 of 2	$118,886
Sudha Arunachalam	Toddlers' Representations of Verbs: Effects of Delay and Sleep on Verb Meaning	Northwestern University	$57,706	2 of 2	$119,847
Sudha Arunachalam	Mechanisms Underlying Word Learning in Children with ASD: Non-Social Learning and Memory Consolidation	NIH/NIDCD	$172,195	2 of 4	$688,018
Sudha Arunachalam	Individual Differences in Toddlers' Abilities to Learn New Verbs From Their Linguistic Context	Language Learning	$10,000	1 of 1	$10,000
Frank Guenther, professor of speech, language & hearing sciences	Neural Modeling and Imaging of Speech	NIH/NIDCD	$353,515	4 of 5	$1,862,227
Frank Guenther	Sequencing and Initiation in Speech Production	NIH/NIDCD	$344,384	4 of 5	$1,838,207
Frank Guenther	Minimally Verbal ASD: From Basic Mechanisms to Innovative Interventions	NIH/NIDCD	$347,133	2 of 4	$1,982,833
Gerald Kidd, professor of speech, language & hearing sciences	Spatial Hearing, Attention, and Informational Masking in Speech Identification	US Air Force	$233,739	3 of 3	$685,945
Gerald Kidd	Central Factors in Auditory Masking	NIH/NIDCD	$533,202	4 of 5	$2,745,301
Gerald Kidd	Top Down Control of Selective Amplification	NIH/NIDCD	$535,871	2 of 5	$2,756,185
Gerald Kidd and H. Steven Colburn, professor of biomedical engineering	Core Center Grant—Sound Field Laboratory (Core 1)	NIH/NIDCD	$212,929	5 of 5	$1,208,700
Swathi Kiran, professor of speech, language & hearing sciences	Theoretically Based Treatment for Sentence Comprehension Deficits in Aphasia	NIH/NIDCD	$0	5 of 5	$2,369,071
Swathi Kiran	The Neurobiology of Recovery in Aphasia: Natural History and Treatment-Induced Recovery	Subaward—Northwestern University	$398,289	3 of 5	$1,299,549
Susan Langmore, clinical professor of speech, language & hearing sciences	Non-Invasive Brain Stimulation for Swallowing Recovery After Dysphagic Stroke	Beth Israel Deaconess Medical Center	$115,990	2 of 5	$476,591
Cara E. Stepp, assistant professor of speech, language & hearing sciences	Career: Enabling Enhanced Communication through Human-Machine-Interfaces	NSF	$110,143	1 of 5	$537,538
Cara E. Stepp	Automation of Relative Fundamental Frequency Estimation	NIH/NIDCD	$163,700	2 of 3	$480,927
Cara E. Stepp	Development of an Electromyographically Controlled Electrolarynx (EMG-EL) Voice Prosthesis	Griffin Laboratories, Inc. (NIH/NIDCD)	$26,110	2 of 2	$49,615
Cara E. Stepp	Videogame-Based Speech Rehabilitation for Children with Hearing Loss	Deborah Munroe Noonan Memorial Fund	$80,000	1 of 1	$80,000
Gloria S. Waters, professor of speech, language & hearing sciences	Assessment of Comprehension Skills in Older Struggling Readers	US Department of Education (ED)	$0	5 of 5	$1,597,065
Gloria S. Waters and William Evans, doctoral student	Attention and Executive Control During Lexical Processing in Aphasia (NRSA)	NIH/NIDCD	$33,986	2 of 2	$70,032

Speech, Language & Hearing Sciences

FACULTY

Sudha Arunachalam Assistant Professor
Diane Constantino Clinical Associate Professor
Ann Dix Clinical Assistant Professor
Elizabeth Gavett Clinical Associate Professor and Clinic Director
Frank Guenther Professor
Elizabeth Hoover Clinical Associate Professor and Clinical Director, Aphasia Resource Center
Karole Howland Clinical Assistant Professor and Coordinator of Clinical Education
Gerald Kidd Professor
Swathi Kiran Professor and Director, PhD program, and Research Director, Aphasia Resource Center
Susan Langmore Clinical Professor
Melanie Matthies Associate Professor and Chair, Senior Associate Dean
Michelle Mentis Clinical Professor and Director, Master of Science Program
Christopher Moore Dean and Professor*
Barbara Oppenheimer Clinical Associate Professor
Tyler Perrachione Assistant Professor
Cara Stepp Assistant Professor
Kristine Strand Clinical Associate Professor and Director, Bachelor of Science Program
Gloria Waters Professor, Vice President and Associate Provost for Research

*New Faculty

AFFILIATED FACULTY

Rebecca Baars Lecturer
Jason Bohland Assistant Professor
Glenn Bunting Adjunct Clinical Assistant Professor
David Caplan Adjunct Professor
Anne Carney Lecturer
John Costello Lecturer
Lorraine Delhorne Lecturer
Meghan Graham Clinical Supervisor
Robert Hillman Adjunct Professor
Kara Larson Lecturer
Christine Mason Senior Research Scientist
Alfonso Nieto-Castanon Senior Research Scientist
J. Pieter Noordzij Associate Professor
Joseph Perkell Senior Research Scientist
Adele S. Raade Adjunct Assistant Professor
Sofia Rohter Lecturer
Rick Sanders Adjunct Clinical Associate Professor
Helen Tager-Flusberg Professor
Amanda Warren Lecturer

PROGRAMS OF STUDY

Bachelor of Science in Speech, Language & Hearing Sciences
Combined Bachelor of Science in Speech, Language & Hearing Sciences and Master of Science in Speech-Language Pathology
Master of Science in Speech-Language Pathology
Combined Master of Science in Speech-Language Pathology and PhD in Speech, Language & Hearing Sciences
PhD in Speech, Language & Hearing Sciences

ABOUT SARGENT

Boston University College of Health & Rehabilitation Sciences: Sargent College has been defining health care leadership for more than 130 years. As knowledge about health and rehabilitation increases and society's health care needs become more complex, BU Sargent College continuously improves its degree programs to meet the needs of future health professionals. Our learning environment fosters the values, effective communication, and clinical skills that distinguish outstanding health professionals. Our curricula also include an important fieldwork component, providing students in every degree program with substantive clinical experience. Clinical internships are available at more than 1,300 health care facilities across the country. The College also operates outpatient rehabilitation centers that offer a full range of services to the greater Boston community.

To keep up to date on Sargent news and events, visit bu.edu/sargent/about-us/news-events

Boston University College of Health
& Rehabilitation Sciences: Sargent College

NONPROFIT
US POSTAGE
PAID
BOSTON MA
PERMIT NO. 1839

Get in Touch
To visit BU Sargent College or learn more about our academic programs, research, and clinical practice, please contact us:

Email: slhs@bu.edu

Phone: 617-353-3188

Mail:
Boston University
College of Health & Rehabilitation Sciences:
Sargent College
635 Commonwealth Avenue
Boston, Massachusetts 02215

bu.edu/sargent/slhs

XX15