THE SCIENCE BEHIND A SIMPLE, BUT VITAL, PLEASURE

A BIOMEDICAL ENGINEER STUDIES THE SCIENCE OF SWALLOWING TO PROVIDE CLINICIANS WITH NEW TREATMENTS.

BY PATRICK L. KENNEDY

< **Biomedical engineer Cara Stepp.** Photo by Kalman Zabarsky

WHAT'S GOING ON ACOUSTICALLY when someone with dysarthria utters a vowel sound? 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 an engineer. Cara Stepp, an assistant professor of speech, language & hearing sciences and biomedical engineering, runs the Stepp Lab for Sensorimotor Rehabilitation Engineering; she brings her engineering training to the study of normal and disordered speech and voice. The 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 condition that impairs 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.

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, a recent BU engineering undergraduate in the Class of 2012 who helped design the program. "That's really important. So we're trying to make the sensor something that's fun to use."

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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." IS