Dr. Laura-Ann Petitto, senior scientist and director for the Brain and Language Laboratory (BL2) and co-principal investigator and science director for the National Science Foundation's Visual Language and Visual Learning Center (VL2) at Gallaudet, adjusts the probes on an fNIRS apparatus worn by undergraduate research assistant Kristine Gauna.

Paving the Way for
Groundbreaking Research in Bilingualism

By Allison Polk

For more than a century, scientists have been studying how knowledge comes into the human brain through sound. They believe that brain tissue they label as part of the auditory cortex is exclusively responsible for processing sound—and thus is a crucial tissue to stimulate in the pursuit of language acquisition. Dr. Laura-Ann Petitto has conducted studies that prove those years of conjecture wrong. What was believed to be only sound processing tissue, instead, processes both signed and spoken languages. Rather than being exclusively set to sound, parts of what was previously labeled "auditory tissue" is set to highly specific temporal patterns at the heart of all human language, be it language on the hands or the tongue.

"The human brain does not discriminate between the hands and the tongue," said Petitto. "People discriminate, but not our biological human brain."

Last December, Petitto, a world-renowned cognitive neuroscientist and a developmental cognitive neuroscientist, opened Gallaudet's state-of-the-art Brain and Language Laboratory (BL2). At this lab, Petitto and her team study the acquisition and neural processing of American Sign Language (ASL), how children learn to read, and the effects of early bilingual language exposure on the developing brain and its functions.

In Petitto's past work at the Montreal Neurological Institute, she tested the assumption that a spoken modality was somehow superior to a signed modality by posing the hypothesis that signed languages were not only equivalent to spoken languages in their behavioral expression and development, but biologically equivalent as well. The human brain would reveal the proof.

"When I began those studies, people said I was crazy. 'This is a revolution. You are going to be wrong. We won't publish your papers,'" said Petitto. "It really got an emotional reaction from many scientists in the community but, painstakingly, we did one study after the other. Study after study showed that for every level of language organization, signed languages and spoken languages were using the identical brain tissue."

Her findings *were* revolutionary; though sign languages had been deemed linguistically valid in the 1960s and 1970s and, subsequently, culturally valid in the following decades, Petitto's work confirmed American Sign Language's place as a real language in the human brain's own organic hardware.

Petitto came to Gallaudet last summer as the co-principal investigator and science director of one of six National Science Foundation Science of Learning Centers in the United States, the Visual Language and Visual Learning Center (VL2). She credited the "tremendous respect" she had both for the activities and research staff and for the educational team at Gallaudet and the VL2 Center as part of the reason she moved.

The opportunity to combine two of her passions was the other reason Petitto chose Gallaudet. "I had been conducting research on the front lines, on the floor of my lab for the past 30 years, and writing paper after paper, publication after publication, that got buried into the never-never land of scientific journals. I really reached the personal point in my life where I wanted a mechanism to translate the benefits of this science in meaningful ways for society," she said.

The VL2 Center members collaborate with 15 labs across the country, each of which focuses on different aspects of visual processing, language, and literacy, as well as innovative translation. The BL2 on Gallaudet's campus is one of those labs, and its team focuses on visual language processing, reading, and bilingualism.

"The contribution of [BL2] would very much be one of shedding new light on the impact of visual processing and early acquisition and the brain mechanisms that make possible early sign and spoken language acquisition, and what happens to the brain in particular when it is confronted with two languages instead of one language," added Petitto. "This also allows us to answer directly many of the calls from the public community about bilingual education. … In our lab, we've been able to answer fundamental questions, and this is the primary direction and contribution that we'll make to the overall VL2 Center."

For example, the assumption is still widespread that human language acquisition is driven by developing brain tissue thought to support speech and auditory processes. Using func-

tional Near Infrared Spectroscopy (fNIRS), Petitto and the BL2 team are able to look into young children's brains—both those exposed to sign language and those exposed to spoken language—to see whether the brain tissue is developing and behaving identically.

"We have been so thrilled by our discoveries showing that signed languages and spoken languages are processed identically in the human brain. … These are very exciting findings—really, first-time findings," said Petitto.

The fNIRS is the centerpiece of the BL2 Lab and is one of the world's most advanced brain imaging systems. The fNIRS monitors neural activity in the brain two different ways. First, when neurons in the brain are more active, they use up more oxygen. Second, the blood flow is affected by the increased oxygen use in specific parts of the brain. That oxygen-rich blood absorbs light differently, and that difference is used to measure where neural activity is happening.

"Because the fNIRS only uses light, we can use this technology with a young infant's brain," said Clifton Langdon, a doctoral research fellow working with Petitto in the BL2 Lab. "Other technology like the fMRI doesn't allow us that look in an infant's brain. Using the fNIRS allows movement during language expression, but not the fMRI. It's really a revolutionary technology that's allowing us to look at how language is represented in the brain from infancy to adulthood."

Establishing a neuroimaging center like Gallaudet's is highly unusual for any university in the United States. Most higher education institutions that have them do so in collaboration with medical complexes and require researchers to share equipment time with medical personnel. Having an independent neuroimaging center at Gallaudet affords both undergraduate and graduate students research experience; it also allows BL2 researchers to dedicate the equipment full-time to tracking language acquisition and processing in children.

"It not only revolutionizes the idea of early detection but also the design of early remediation techniques that are really targeted for where the child's brain development is at that period," added Petitto.

The findings resulting from the use of technology like that at BL2 also indicate that biologically, the human brain performs better with early exposure to multiple languages. "It's almost as if the monolingual child's brain is on a diet and the bilingual child's brain stretches to the full extent and variability that Mother Nature gave it to use language and exploit human language," said Petitto.

The BL2 team will continue to take part in neuroimaging and behavioral studies in pursuit of new knowledge about the biological mechanisms and environmental factors that, together, make possible the human capacity to learn and convey language. Particularly, now that Petitto's studies show that the brain is not necessarily sound-hungry, but pattern-hungry, her current working hypothesis centers around the temporal patterns the brain seeks in order to create meaning out of language.

As the BL2 team moves forward with its work, Petitto's goals are threefold: continuing her basic scientific research, providing findings that will help in developing remediation strategies for children with learning and reading challenges, and communicating the work of BL2 to the public.

The research BL2 performs has implications that benefit both the deaf community and the larger educational community. Knowing more about the specifics of the language patterns sought by the brain is important because "it would really provide us with tangible mechanisms for remediation in young children who have dyslexia or young autistic children because we have seen that training children in temporal patterning can cause that brain tissue that's not working to not only reorganize but to become re-engaged," said Petitto.

Development of new communication strategies is also on Petitto's agenda: Personnel within the VL2 Center are currently working on communication packages, including apps for the iPhone and iPad for the general public that will make information about ASL, bilingualism, and methods for teaching reading and literacy readily available in a user-friendly format.

"The parents are dying to know the information; the teachers are brilliant and passionate to know what is in the lab and to share with us their insights. The schools are interested. …. the next frontier is to find the bridge to the policy makers. That's the challenge," said Petitto. "I am passionately committing to taking all of the fruits of the VL2 Center and my own lab, BL2, and finding new mechanisms to bridge out to educational policy makers."

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