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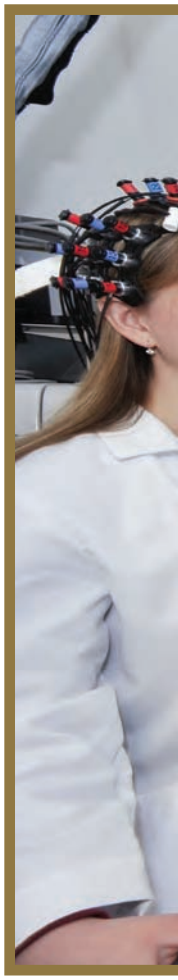
Right: Petitto studies how the brain builds and understands human face-to-face conversations using two brain imaging systems for the first time.



REVOLUTIONS IN THE SCIENCE OF LEARNING:

a new view from a new center

visual language and visual learning

By Laura-Ann Petitto

Revolutions can happen in different ways. About six years ago, a very particular type of revolution began in a cluster of rooms on the main campus of Gallaudet University. There, a handful of individuals began a *quiet revolution* guided by an overarching passionate mission to conduct groundbreaking science that would have widespread benefits for education and society. Launched with a coveted award from the National Science Foundation, our Science of Learning Center—called Visual Language and Visual Learning, and affectionately referred to as VL2—became one of only six Science of Learning Centers established in the National Science Foundation's history.

One radical—indeed revolutionary—idea underlying VL2 is its existence as a virtual entity. Initiated by Dr. Thomas Allen, VL2's co-principal investigator and a professor in Gallaudet's Department of Educational Foundations and Research, with a team of outstanding deaf and hearing individuals on campus, the Center connects approximately 250 scientists, students, and educators spanning 15 laboratories in the United States and Canada, and over 90 schools, through a structure that is digital and a space that is cyber.

The purpose of VL2 is to advance the nation's knowledge of the science of learning by studying how aspects of higher cognition, language, and reading are

Photos courtesy of Laura-Ann Petitto

realized through one of our most central senses, the human eye. We advance a new perspective on human learning by using the widened vantage point of studying deaf individuals and signed language as an exciting new lens into the flexibility and structure of the human mind. We study monolingual and bilingual children and adults in order to promote optimal practices in education, both in and out of the classroom. VL2 has as its mission the development of rich translational outcomes as well as the promotion of *two-way*, mutually respectful communication among scientists and the greater community, parents, schools, and educational policymakers.

VL2 Center Advances in the Science of Learning

It is said that "good things come in threes" and, to summarize our Center's contributions thus far, I'll highlight three of its exciting scientific research advances. To stay true to our mission of translation, each of the three advances contains a *Tip for Teachers*. This is the "bottom line" translational and educational impact of this set of research discoveries. For us, what is critical is that teachers and parents be able to put our discoveries in research to use in furthering the understanding and advancement of all children, especially children and adults who are "visual learners." By way of a brief definition, I use the term "visual learner" for two reasons. First, I hope to underscore the fact that all humans are visual learners, and that knowledge from VL2 Center discoveries has the potential to be broadly applicable. A "visual learner" includes a hearing child learning spoken language, a deaf or hard of hearing child learning signed language, a child who is deaf with a cochlear implant learning speech, and all language combinations in between, with the children differing, of course, in the degree of their use of the visual modality. Because we have discovered rather remarkable ways in which young deaf children—especially those visual learners exposed to signed language—are advantaged in many critical higher cognitive functions, here I use the term "visual learner" and "deaf child" interchangeably. The second important reason that we at VL2 use the term "visual learner" is this: Rather than focusing on a child's disability (loss of hearing), we have been dazzled by how all children, especially deaf and hard of hearing children, learn through the visual pathways in advantaged ways when they've had very early exposure to signed language! Following my summary of three of the VL2 Center's scientific advances, I provide a summary of VL2's new translational products and the two-way communicative activities presently at our doorstep—with so much more to come!

What Research Tells Us

1. VISUAL EXPERIENCE CAN MEAN COGNITIVE ADVANTAGE

Our Center's studies of visual and cognitive plasticity reveal that different early sensory experiences do alter the human brain. Remarkably, increased visual sensory experience in the young deaf visual learner can alter the human brain in ways that, in turn, can afford stunningly higher cognitive advantages. Our VL2 research has shown that this is especially true if young visual learners receive early visual signed language. For example, VL2 researchers David Corina (University of California, Davis), Jenny Singleton (Georgia Institute of Technology), Rain Bosworth (University of California, San Diego), and others have found that early exposure to a signed language in young visual learners changes their visual attention processing which, in turn, has an "upstream" positive impact both on higher cognition and on social-emotional self-regulation. These early sign-exposed deaf infants attend more robustly to adult signers' faces and eye gaze as compared to deaf and hearing infants with little or no exposure to signed language. Infants exposed to signed language attend less to the hands and more to the direction and trajectory of the adult's eye gaze. In turn, this aids the infant in learning vocabulary rapidly. Here, the capacity to track adult eye gaze facilitates the infant in making connections between a given sign and its intended meaning. Related VL2 studies of older deaf toddlers during book reading with their signing parents have found that the toddlers' eye gaze tracking ability is indeed vital to early vocabulary, language, and literacy mastery, both in American Sign Language (ASL) and in English. Further, other Center researchers, including Keith Rayner and Nathalie Bélanger (University of California, San Diego) and Matthew Traxler (University of California, Davis), have discovered advantageous changes in visual processing in deaf adults who are skilled readers in English. Thus, an important consequence of exposing young visual learners to a natural signed language early in life is that it affords an advantaged visual capacity that facilitates the child's ability to achieve healthy and developmentally appropriate cognitive, language, and reading milestones.

Through synergistic collaborations, best made possible by being in a "Center," one team of VL2 researchers built upon the above findings from several of our labs and, in turn, asked whether parental training in ASL can facilitate communication in the home so that language and pre-literacy skills are in place for children prior to school entry. Here, they specifically train parents of young visual learners in the visual language of ASL as a direct tool to enhance their children's vocabulary acquisition as well as their overall language, reading, and literacy success.

Tip for Teachers: Early exposure to a natural signed language is highly beneficial to normal human language development and can impact the brain's visual attention systems in powerfully positive ways (e.g., by affording heightened visual attention that can result in cognitive, language, and reading processing advantages in the young visual learner).

2. BILINGUAL EXPOSURE CONFERS READING ADVANTAGE

The brain and behavioral studies of language development and bilingualism at VL2 have found that early exposure to a signed language—and, most importantly, early *bilingual exposure* to a natural signed language and a spoken language—afford cognitive and, newly discovered, surprising language and reading advantages over age-matched monolingual children and adults. (This finding holds for both deaf and hearing bilingual children.) These discoveries have emanated from the VL2 laboratories of Peter Hauser (Rochester Institute of

Technology), my own research laboratory, and other VL2 members. Notably the studies reveal that early bilingual signed and spoken language exposure provides linguistic processing strengths across both languages, and that access to a signed language *improves* a deaf child's performance in reading English. Moreover, early bilingual exposure affords the most robust and optimal lifelong cognitive and linguistic advantages over later dual or second language exposure.

Tip for Teachers: Early exposure to a natural signed language and, in particular, early exposure to two languages (e.g., ASL and English) are a societal and educational imperative for the young visual learner. Old fears of language contamination and/or language delay when exposing a child to two languages early in life are scientifically unfounded. Similarly, old fears that early exposure to a signed language will hurt deaf children's acquisition of a spoken language are also scientifically unfounded, as instead we find powerful language and reading advantages in deaf children exposed early and bilingually to signed and spoken language.

3. VISUAL LEARNERS REVOLUTIONIZE OUR VIEW OF BILINGUALISM AND THE ROLE OF "PHONOLOGY" IN EARLY READING

From our brain and behavioral studies of reading and literacy in visual learners comes a new view of bilingualism and a revolutionary understanding of how experiential change can impact the brain's structures and related functions. Emerging from VL2 research—for example, that of Jill Morford (University of New Mexico), Karen Emmorey (San Diego State University), David Plaut (Carnegie Mellon University), my own BL2 lab, and others—comes a new view of bilingualism as including young sign-exposed deaf children whose primary access to their other primary language is through printed text. Said another way, one language in the bilingual pair is accessed through a full natural signed language and the other, remarkably, through print alone. They are "bimodal-print bilinguals."

In the VL2 studies of good readers among the deaf ASL-English print bilingual children and adults, both neural and behavioral studies lay bare the brain's potential to develop alternative gateways to sound-based phonological representations typical of, for example, a young hearing reader's use of phonological representations to access meaning from the printed word. Among the multiple cues used by young hearing readers (phonological, orthographic, semantic, and syntactic), young signing deaf readers appear to be using the same multiple cues, including the phonological level of language processing. To be sure, there is now growing and very exciting evidence that visual learners also have—and use—a "phonological" level of language representation when accessing meaning from printed words. Here, young deaf readers are not directly accessing sound phonology when they derive meaning from a printed word such as "c+a+t." Instead, what's in the brain's phonological representations for visual learners appears to be more akin to visual units, such as bits of fingerspelling, and parts of rhythmic, phonetic-syllabic movements and hand configurations at the heart of signed language phonological and prosodic structure (see especially the studies and theoretical articulation of this topic by Petitto).

That the human brain creates a visually based phonological level of language processing in the absence of sound is stunning in itself and reveals the centrality of this level of language organization in all human language processing. It also forces us to re-conceptualize the nature of human language as we see core levels of language organization being pushed out onto the hands and the tongue irrespective of language modality. Moreover, that there is now insight into what "phonological" representations may consist of in the brains of visual learners and, crucially, what role these sign-based representations may play in the decoding of meaning from English print for visual learners is thrilling. It further suggests clear translational implications that we are pursuing at our Center. For example, inspired by this Center research, one VL2 team of researchers is training teachers in the use of fingerspelling in the classroom when teaching young deaf children to read English print. Here, fingerspelling is used as a gateway to building healthy sign-based phonological representations when teaching children how to read in English.

Tip for Teachers: The brain's natural propensity to establish and utilize an intermediate level of language organization—a level called *phonological* because it was once believed dependent on exposure to sound—appears to be universal to all human languages whether they are signed or spoken, auditory, or visual. Moreover, the brain's natural propensity to utilize this intermediate level of language processing when accessing meaning from printed text appears to be vital in the very early stages of reading acquisition, especially involving reading systems that have "deep" orthography, or non-direct (non-transparent) sound to letter

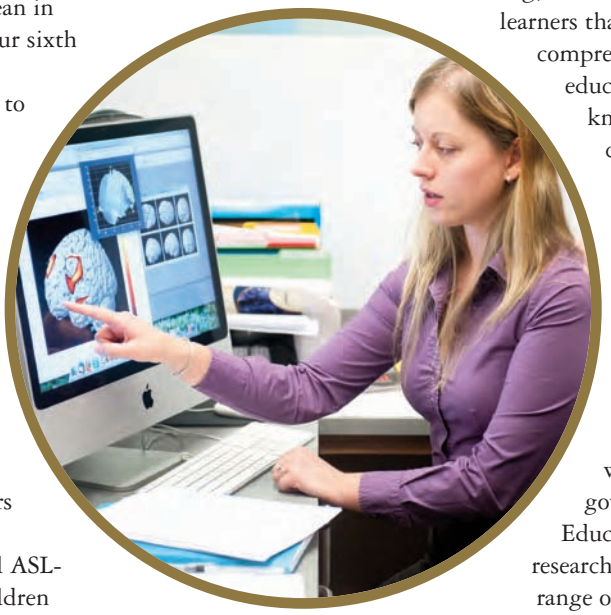
correspondences, such as is typical of the English language. Therefore, facilitating a visual learner's establishment and use of fingerspelling, sign-phonetic, and sign-syllabic organization appears to be an excellent means for promoting and successfully teaching reading to young visual learners.

At Our Doorstep, with More to Come! VL2's Translational Products and Communication Activities

One of the most exciting parts of conducting a research study is, frankly, when it is done. This is when we may discern the discoveries, disseminate the discovered information, and, most fun of all, translate what they mean in meaningful ways for society. Now in our sixth year, VL2 has reached our research and discovery stride. We now stand poised to move full speed ahead to embracing translation. Here, too, "good things come in threes."

Among the many translational products and communication activities to come:

- **LEARNING PRODUCTS.** Melissa Malzkuhn, VL2 community engagement coordinator, and team are pioneering ways to promote productive and successful lives and learning for visual learners through the creative design and production of Interactive Bilingual ASL-English iPad apps for teaching children how to read—a real first. All such translational apps will be the result of a solid foundation of basic VL2 research.
- **ASSESSMENT TOOLS.** Thomas Allen, VL2 co-principal investigator, and team have gathered five years of groundbreaking research findings and used them creatively to answer calls from the community for an ASL Assessment Toolkit that can be used to assess the language and literacy skills in young visual learners, both in English and in ASL. Accompanied by a comprehensive book that provides findings from years of research, statistical analyses, and invaluable data interpretation to support and explain the Assessment Toolkit, this is again a first in the field!
- **MULTI-MEDIA PARENT EDUCATION PACKAGE**. Kristen Harmon, leader of the Center's Integration of Research and Education strategic focus area, and team have built a stunning, first-time resource for parents of visual learners that is intended to be the first comprehensive and research-based parent educational product that provides knowledge about optimal communication pathways with young children. Drawing from a wealth of research (both her own and VL2), Harmon has produced a rich and multifaceted resource package for parents that presents state-of-the-art summaries of knowledge about sign and spoken language acquisition as well as community and governmental resources. The Parent Education Package also contains solid, research-based information on the rich range of educational and, crucially, communication choices that parents of a newborn deaf child and older deaf children have—providing the first truly comprehensive resource of its kind. This parent package will ultimately be available in multimedia formats, including print, DVD, and interactive iPad apps. In addition to direct distribution to parents where possible, it is planned for the parent package to be available through doctors' offices, hospitals, schools, the web, and other venues—essentially, the intent is for distribution methods to be most inclusive of parents with and without the availability of home technology.



Above: Petitto's graduate student analyzes language processing in the brains of bilinguals. **Below:** Laura-Ann Petitto with the state-of-the-art brain imaging equipment, called functional Near-Infrared Spectroscopy (fNIRS), in her BL2 Laboratory at Gallaudet University.

Vibrant Partnership VL2, the Clerc Center, and Greater Community Schools

Our relationship with Gallaudet University's Laurent Clerc National Deaf Education Center has been enriched this year through fruitful discussions and event planning, especially with Dr. Susan Jacoby, executive director of Planning, Development, and Dissemination. For example, on March 18, 2012, VL2

PHOTO BY SUSAN FLANIGAN

Above: Students Kaja Jasinska (left), Clifton Langdon (seated), and Millicent Musyoka (right) receive training from Dr. Petitto (middle) on the advanced neuroimaging system in the BL2 Laboratory at Gallaudet.

embarked on a new type of two-way communication involving VL2 participants, members of the Clerc Center, and educators from a variety of schools. At this event, VL2 members, Clerc Center members, and approximately 80 teachers from mid-Atlantic schools came together to exchange new research and teaching ideas and to carve out new research and teaching solutions in a mutual exchange.

Following VL2's commitment to two-way communication between researchers and teachers, the Center is also in the process of recruiting a P-12 school engagement coordinator, an individual who will be co-appointed at the Clerc Center. This vital individual will bridge activities and interests among VL2 researchers, the Clerc Center's priorities and goals, and schools, students, and parents.

More to Know... and More to Come!

There is, of course, much more to do, much more to know, and much more research to come from VL2, and our work is advancing at a thrilling pace. To learn more about the Center's resources—our vibrant Center lectures, Open Lab meetings, our new Cognitive Neuroscience seminar series, and a whole host of rich research discoveries, activities, and events that occur on a daily basis at our Center—check out our website and related links (*http://vl2.gallaudet.edu*). We also regularly make available our presentations with live web streaming and our VL2 newsletters, available through subscription at our website.

While VL2 began as a quiet revolution in a few small rooms on Gallaudet's main campus, the fruits of its endeavors are proving to be resounding. In the end, a true revolution comes with a revolution in thinking. It comes from the revolutionary knowledge that follows from a collective body of work.

This body of work is being collected and we now understand a lot. Old myths about the detrimental impact of early exposure to signed language came crashing down with VL2 findings. Early language exposure to a signed language, and especially early bilingual exposure to ASL and English, affords striking advantages in language, reading, and cognitive processing that facilitate reading in English. Moreover, old fears of "losing" a young deaf child if he or she is exposed too early in life to a signed language and/or language delay by exposing a child to two languages early in life are now widely understood to be scientifically unfounded. The only thing left to do is to take the actions that follow from this revolutionary knowledge and change educational policy and practice in ways that both fulfill the potential and celebrate the strengths of the visual learner.