# How Noise And Nervous System Get In Way Of Reading Skills

ScienceDaily (July 14, 2009) — A child's brain has to work overtime in a noisy classroom to do its typical but very important job of distinguishing sounds whose subtle differences are key to success with language and reading.

But that simply is too much to ask of the nervous system of a subset of poor readers whose hearing is fine, but whose brains have trouble differentiating the "ba," "da" and "ga" sounds in a noisy environment, according to a new Northwestern University study.

"The 'b,' 'd' and 'g' consonants have rapidly changing acoustic information that the nervous system has to resolve to eventually match up sounds with letters on the page," said Nina Kraus, Hugh Knowles Professor of Communication Sciences and Neurobiology and director of Northwestern's Auditory Neuroscience Laboratory, where the work was performed.

In other words, the brain's unconscious faulty interpretation of sounds makes a big difference in how words ultimately will be read. "What your ear hears and what your brain interprets are not the same thing," Kraus stressed.

The Northwestern study is the first to demonstrate an unambiguous relationship between reading ability and neural encoding of speech sounds that previous work has shown present phonological challenges for poor readers.

The research offers an unparalleled look at how noise affects the nervous system's transcription of three little sounds that mean so much to literacy.

The online version of the study will be published by the *Proceedings of the National Academy of Sciences (PNAS)* on July 13.

The new Northwestern study as well as much of the research that comes out of the Kraus lab focuses on what is happening in the brainstem, an evolutionarily ancient part of the brain that scientists in the not too distant past believed simply relayed sensory information from the ear to the cortex.

As such, much of the earlier research relating brain transcription errors to poor reading has focused on the cortex -- associated with high-level functions and cognitive processing.

Focusing earlier in the sensory system, the study demonstrates that the technology developed during the last decade in the Kraus lab now offers a neural metric that is sensitive enough to pick up how the nervous system represents differences in acoustic sounds in individual subjects, rather than, as in cortical-response studies, in groups of people. Importantly, this metric reflects the negative influence of background noise on sound encoding in the brain.

"There are numerous reasons for reading problems or for difficulty hearing speech in noisy situations, and we now have a metric that is practically applicable for measuring sound transcription deficits in individual children," said Kraus, the senior author of the study. "Auditory training and reducing background noise in classrooms, our research suggests, may provide significant benefit to poor readers."

For the study, electrodes were attached to the scalps of children with good and poor speech-in-noise perception skills. Sounds were delivered through earphones to measure the nervous system's ability to distinguish between "ba," "da" and "ga." In another part of the study, sentences were presented in increasingly noisy environments, and children were asked to repeat what they heard.

"In essence, the kids were called upon to do what they would do in a classroom, which is to try to understand what the kid next to them is saying while there is a cacophony of sounds, a rustling of papers, a scraping of chairs," Kraus said.

In a typical neural system there is a clear distinction in how "ba," "da" and "ga" are represented. The information is more accurately transcribed in good readers and children who are good at extracting speech presented in background noise.

"So if a poor reader is having difficulty making sound-to-meaning associations with the 'ba,' 'da' and 'ga' speech sounds, it will show up in the objective measure we used in our study," Kraus said.

Reflecting the interaction of cognitive and sensory processes, the brainstem response is not voluntary.

"The brainstem response is just what the brain does based on our auditory experience throughout our lives, but especially during development," Kraus said. "The way the brain responds to sound will reflect what language you speak, whether you've had musical experience and how you have used sounds."

The Auditory Neuroscience Lab has been a frontrunner in research that has helped establish the relationship between sound encoding in the brainstem, and how this process is affected by an individual's experience throughout the lifespan. In related research with significant implications, recent studies from the Kraus lab show that the process of hearing speech in noise is enhanced in musicians.

"The very transcription processes that are deficient in poor readers are enhanced in people with musical experience," Kraus said. "It makes sense for training programs for poor readers to involve music as well as speech sounds."

The co-authors of the PNAS study are Jane Hornickel, Erika Skoe, Trent Nicol, Steven Zecker and Nina Kraus.