



SPOTLIGHT
ON

AUDITORY PROCESSING AND HEARING IN NOISE

INTERVIEW WITH DR. NINA KRAUS

BY DAVID FABRY

In March 2014, Dr. Kraus delivered the 10th Anniversary Marion Downs Lecture in Pediatric Audiology at AudiologyNOW! in Orlando. Recently, *Audiology Today* had the opportunity to speak with her regarding her lecture and her research.



Nina Kraus investigates the neurobiology underlying speech and music perception and learning-associated brain plasticity. She studies normal listeners throughout the life span, clinical populations (poor readers, autism, hearing loss), auditory experts (musicians, bilinguals), and an animal model. In addition to being a pioneering thinker who bridges multiple disciplines (aging, development, literacy, music, and learning), Dr. Kraus is a technological innovator who roots her research in translational science. In March, she delivered the 10th Anniversary Marion Downs Lecture in Pediatric Audiology at AudiologyNOW! (AN!) in Orlando.

The Downs Lecture is funded annually by the American Academy of Audiology Foundation with generous grant support from the Oticon Foundation. *Audiology Today* recently had the opportunity to speak with her regarding her lecture and her research.

AT: Thank you, Nina, for the opportunity to speak with you regarding your lecture at AN!¹ What a well-deserved honor to be chosen as the 10th Anniversary speaker for this series. Did you have the opportunity to speak with Marion in advance? She really wanted to attend, but was unable to do so this year on the heels of her 100th birthday celebration.

Nina Kraus: No, I did not get to speak with her right before the lecture, and I was sorry that we did not have the opportunity to do so because she is always so wonderful to interact with.

It is just unfair that, at roughly half her age, I only have half of Marion's energy! She is indeed an amazing person, and AT was pleased to have the opportunity to visit with her recently.

One of the things that Marion Downs pioneered was the widespread use of infant hearing screening for objectively determining hearing thresholds. What I envision is a day where there will be suprathreshold screening to get a biological measure of hearing health. We have access in humans to how the nervous system responds to sounds with unprecedented precision.

To provide a measure of brain health, right from the onset.

Yes. And across the life span. We are able to understand what we are recording with respect to brain health and how that relates to communication skills. The communication skills that are of interest to me and to audiologists include hearing in noise and language-based skills, such as reading, which depend on auditory function. Taken further, I am interested in evaluating how information delivered through hearing aids is processed through the nervous system to provide information regarding auditory processing and its disorders. I can envision this becoming a standard of practice for audiologists in the future.

I think that this is a very important extension of early identification into early intervention with hearing aids or cochlear implants. One of the major challenges facing pediatric audiologists is to recommend the most appropriate treatment modality for optimal outcome, as early as possible. Are you saying that objective measures could soon be available to predict performance on cognitive tasks for suprathreshold stimuli?

Absolutely. We already know that this is the case with school-age kids through our ability to investigate how the nervous system processes sound biologically in individuals with auditory-processing disorders (Hornickel and Kraus, 2013). Specifically, "auditory neuropathy" is probably the hallmark of a neural-synchrony disorder, and it is possible to measure the consistency of neural firing in response to a stimulus, over repeated trials.

If the nervous system is not firing consistently from trial to trial, by definition, you have an auditory-processing disorder. If I were an audiologist, or was looking for an assessment for my own child who was having the kind of difficulties that bring a child to an audiologist for auditory-processing disorder assessment (including difficulty hearing in noise and challenging listening situations, some distractibility, and the presence of comorbid language disorders), I would want to know how the brain is processing sound for suprathreshold speech sounds, such as consonants and vowels. The brain transcribes these slow and fast speech sounds into slow and fast patterns of electricity that we can measure. This signifies a new piece of biological information

that, together with the rest of the clinical picture, represents a new and enlightening piece.

So, although it is certainly important to identify the presence of an auditory-processing disorder objectively, is there anything that can be done to improve performance on these objective measures after intervention? I seem to recall a longitudinal study you conducted on children with auditory processing disorders who had been fitted with FM devices (Hornickel et al, 2012).

The “long” in “longitudinal” is no joke! These studies are difficult to do, but scientifically, one of the most rigorous approaches is to follow the same individuals over time because it represents a more tightly controlled study than what you get from cross-sectional studies of different populations. We worked with Hyde

Park Day School in Chicago, with a cohort of children who had normal hearing thresholds and dyslexia. One group of children spent a year at school wearing FM devices during the day, and one group did not. Each group received a battery of tests at the beginning and end of the school year that comprised measures of reading, cognitive function, and biological measures (including cABR).

What did you find?

Children who wore the FM device improved their language-related skills such as phonologic awareness and basic reading ability. They improved to a greater extent than the children with dyslexia who did not wear the device in the same classroom.

How about on the biological measures?

Initially, all of the children with dyslexia had less consistent responses to

complex sounds than we see in typically reading children. After a year of wearing the FM device, the cABR responses became more consistent, even when they weren’t wearing the device. In fact, they became like those of a typically developing child. The data suggest that, once the nervous system has learned to use sound more efficiently, it no longer needs the device for successful communication. While speculative, it suggests that the children weren’t tethered to the device for life, but that it helped them learn what aspects of sound were important.

Remarkable. Okay then, hypothetically, let’s say I’m an aging baby boomer who, despite minimal threshold loss, is beginning to struggle with hearing in noisy or challenging listening environments. Can the data from these children be used to extrapolate to my situation? That is, is there something that I can do to improve my benefit and satisfaction with hearing aids?

There are data that speak to this. Some of this work has been done in animals, and shows clearly that an animal’s experiences early in life affect how the animal learns and how the brain develops much later in life. So, the first thing that I would say is that healthy aging begins in childhood.

The early experience sets up the brain to deal with sound more efficiently?

Yes, setting up the nervous system to deal with sound as effectively as possible by speaking multiple languages or playing a musical instrument. Making sound-to-meaning connections through the corticofugal network strengthens how our nervous system responds to sound throughout life.



Chicago-based music students from the neuroeducation project.

Learning to play a musical instrument made a difference?

We have done two series of music studies in my laboratory; one in younger adults and the other in older individuals. In both, we studied people who had played music as children, but who were no longer playing an instrument when we tested them. For both studies, we matched subjects in every way, except that one group had taken music lessons for several years and the other had not. In the older adults, this gap may have been several decades.

And let me guess: the ones who previously played a musical instrument performed better than those who had never played?

That's exactly right. Importantly, for the older adults, they had more precise responses to consonant speech sounds. The timing and synchrony that is necessary to process consonants, which we know are especially vulnerable in noise, was better in those with musical experience.

So it begs the question: what if I decide to take up the musical instrument now, even if I didn't play in the past? Can an "old dog learn new tricks" that will provide the payoff in terms of hearing aid benefit?

Well, it's a tough comparison to make, because younger and older individuals are different in so many ways. What I can tell you, however, from animal work, is that older animals can learn new auditory tasks, and that their responses to sound become more synchronous with auditory training. We have data—not for music—that we collected on the Brain Fitness program from Posit Science. Over the course of eight weeks, the combined sensory and cognitive aspects of training led to modest changes in how the nervous



Student being prepared for cABR assessment in the neuroeducation project.

system processes sound. The timing and neural synchrony to consonants got sharper. Importantly, hearing in noise, working memory, and speed of processing all improved after training, too (Anderson et al, 2013).

So, using your terminology, the "sound-to-meaning connections" made in the past sculpt the way your brain processes sound in the present.

Correct. And returning to the study of adolescents, we have data from two "real-world" school projects that provide evidence for music as a means of improving the sound-to-meaning connections. In both situations, the school directors independently approached me with the observation that children who were involved in music were thriving in school, and were the better learners overall in comparison to their counterparts. They asked me to spearhead a study to determine if there was iron-clad evidence of the benefit of music on the nervous system and on communication skills.

Both projects involved many schools and many teachers over several years in Chicago (four years) and Los Angeles (three years). We have published a study from the Chicago-based work (Tierney et al, 2013) showing that one year of music instruction was not sufficient to change the nervous system in ways that we could measure. After two years, however, the brain's response to consonant sounds presented in background noise became sharper and more synchronous only in the kids who had had music lessons—not in the "active" controls who were in athletic training rather than music.

Fascinating. What if the control students listened to music?

Engagement seems to matter. Even if they loved music and engaged fully, it isn't enough just to listen. The fact is, you are not going to get fit watching sports, and it appears from our data and those of others that lasting changes in the neurological system require the individual to actively play music.

(laughing) And I was wondering why I didn't lose weight when I watched every match of the World Cup this year!

Sorry to burst your bubble!

So are you looking at hard-of-hearing kids who take music classes to see if they do better than other hearing aid users who don't play an instrument? Should parents of hard-of-hearing kids insist that their children take piano lessons?

We aren't looking at children with hearing loss. There is so much work to do, and I hope that others will do that. However, I can speak to work that we have in older adults with hearing loss who are "lifelong" musicians. By that, I mean someone who has practiced music regularly (a minimum twice a week for 20 minutes); in these individuals, we see something called a "musician signature." I talk about this in a volume of *Hearing Research* that I edited (Kraus, 2014), as a way of bridging the neuroscience of music with auditory neuroscience.

That sounds like a "must-read" for someone interested in this topic. In my experience, a lot of psychoacousticians have had more than a passing interest in music perception.

Yes, at the very least I recommend that you read the introduction as well as the topics of the musician signature and music across the life span. Basically, the musician signature is faster neural timing in noise compared with nonmusicians.

I have to ask—does this apply to drummers?

Yes, drummers were included and they do show the musician's signature as well.

(laughing) I always find that I have good temporal abilities, but lousy spectral ones...especially if you've heard me sing!

(laughing) No thank you. But back to your original question regarding the value of musical training in hearing aid users. Older musicians

are probably performing much more poorly than they used to. So that information would be useful to know.

I'm sensing a trend developing here, and certainly points to the importance of moving beyond the audiogram to suprathreshold stimuli to capture the essence of auditory processing disorders. In addition, "auditory training" through speech, music, and other complex acoustic stimuli seems to improve objective performance, including neural synchrony.

That's right. The very biological properties that are deficient with auditory processing disorders are the same biological processes that are enhanced with music training. That is a very nice link, and a focus of the work in our lab is to tie together different, but

theoretically aligning, experiences into the overall topic of auditory learning. We look at the way that enrichment (e.g., music and multilingual language), and deprivation (hearing loss or auditory processing disorder) form an individual's experience. Then we investigate how enrichment or deprivation shape the way that the nervous system processes sound. One of my life goals is to make the biological assessment of sound accessible to the many scientists and clinicians who could use this information to advance knowledge of hearing health.

Thank you for taking the time to speak with us—I'm sure that you have stimulated a lot of interest here. For those who want additional information, they can also go to your Web site, right?

Dr. Kraus's 2014 Marion Downs Lecture in Pediatric Audiology, *Biological Assessment in Audiology: Spotlight on Auditory Processing and Hearing in Noise* (.15 CEUs), can be accessed on-demand at no charge at www.eaudiology.org, search keywords "Nina Kraus."

with hearing loss have the musician signature—better hearing in noise, better auditory working memory, and better speed of processing. What is interesting is that older musicians with hearing loss still do better than normal hearing non-musicians of the same age! Experience really matters and can trump some of the cochlear deficit.

So, I guess that I will sign up for those accordion lessons. It seems to me that these data help explain how two people with the same audiogram can perform so differently with hearing aids. It seems to me that musical experience should be a standard question on every "intake" counseling form for prospective hearing aid patients. And the reality is that, even for those musicians who perform comparably to others without hearing loss, they

Yes, it was a pleasure. Many of the publications may be found on the Web site (www.brainvolts.northwestern.edu) along with friendly overviews of my research. 🎧

Nina Kraus, PhD, is a Hugh Knowles professor at Northwestern University, where she directs the Auditory Neuroscience Laboratory. With her team at Northwestern, she investigates the neurobiology underlying speech and music perception and learning-associated brain plasticity.

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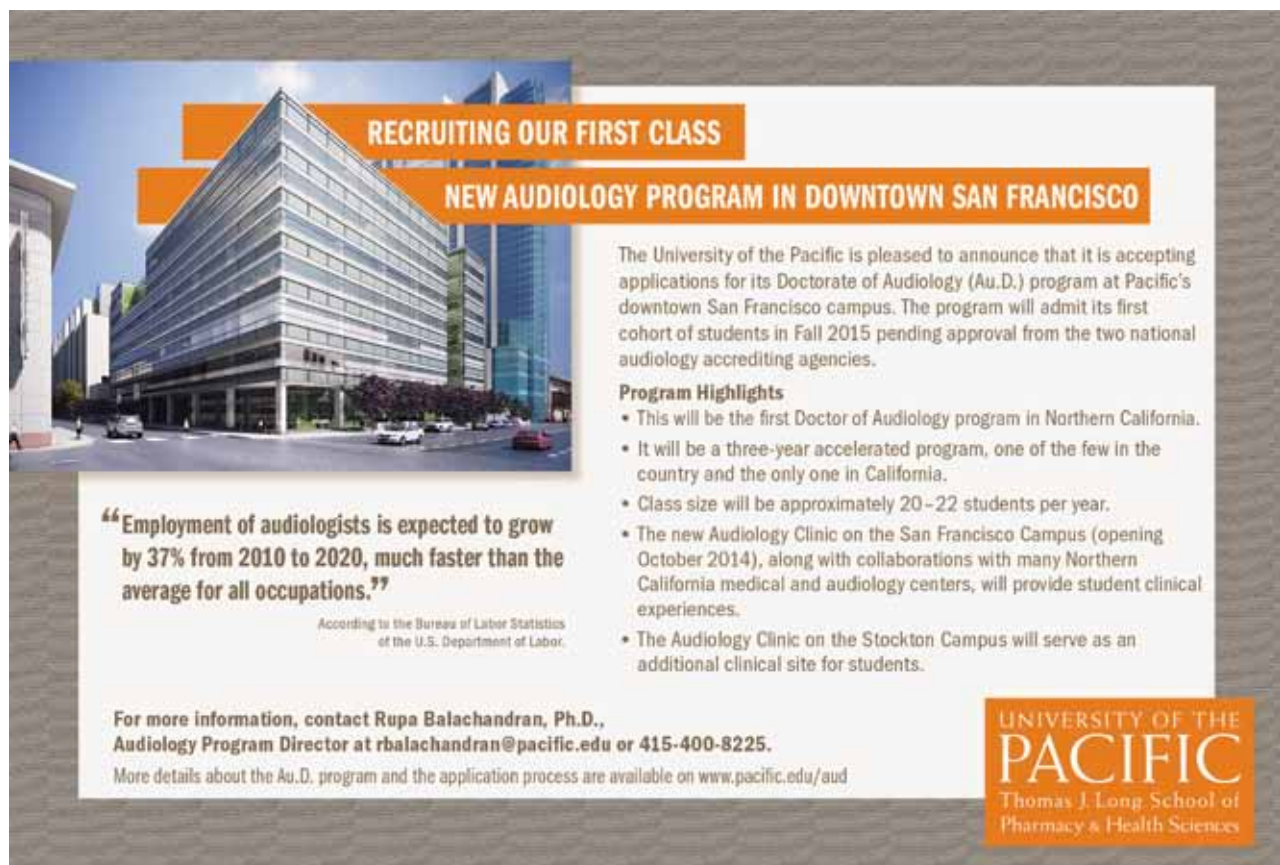
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Note

1. Kraus's AN! presentation can be viewed on YouTube (www.youtube.com/watch?v=oofx61-molw&feature=youtu.be) or eAudiology.org, for audiologists interested in earning CEUs.



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For more information, contact Rupa Balachandran, Ph.D., Audiology Program Director at rbalachandran@pacific.edu or 415-400-8225. More details about the Au.D. program and the application process are available on www.pacific.edu/aud

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