Neural Synchrony: Opening an Umbrella

By Nina Kraus, PhD

In the early 1980s, a young man came to my lab. His parents were deeply frustrated. Although their son was bright and precocious, he had substantial hearing problems.

He responded inconsistently to sound and exhibited large discrepancies between his excellent visual cognition and poor auditory skills. The young man had normal audiometric thresholds, yet his auditory brainstem response (ABR) was absent.

This year marks the 30th anniversary of the paper in which we presented his case, and several others, identifying the dyssynchrony disorder that is now called auditory neuropathy (AN; ***Laryngoscope* 1984;94[3]:400-406**).

The field has come a long way since then, and we now view neuropathy as a spectrum encompassing several pathologies, including disorders of the brainstem, auditory nerve, and ribbon synapses (***Brain* 1996;119[pt 3]:741-753; *J Basic Clin Physiol Pharmacol* 2000;11[3]:215-230**).

In this editorial, I propose we extend that spectrum to include another confounding and frustrating condition that audiologists must tackle—central auditory processing disorder (APD)—viewing both conditions under the biological umbrella of neural synchrony.

Turn to our cover story on page 8 for best practices in identifying and managing auditory neuropathy spectrum disorder.

INCONSISTENT FIRING

Auditory neuropathy and auditory processing disorder are characterized by normal cochlear function, at least as evaluated by conventional tests, coupled with downstream (central) dysfunction.

Both patient groups have problems with auditory attention and excessive difficulty understanding speech when the signal is degraded or the listening environment acoustically challenging (***Nature* 1997;387[6629]:176-178**).

Whereas patients with AN are deaf in noise (***J Assoc Res Otolaryngol* 2000;1[1]:33-45**), those with APD understand speech much better, albeit abnormally.

We have investigated the neurobiology of APD, and of language-learning problems more broadly, using the auditory frequency following response (FFR).

Like the auditory brainstem response, the FFR is generated by summed synchronous firing of brainstem nuclei. The FFR is the product of sustained phase-locking to periodic sounds (***Ear Hear* 2010;31[3]:302-324**).

Unlike the ABR, the frequency following response reflects the confluence of cognitive and sensory processing.

Experiments in my lab have revealed the systematic relationship of reading and language ability with FFR consistency (***J Neurosci* 2013;33[8]:3500-3504**).

FFR consistency improves through early childhood (***Cereb Cortex* 2013; doi: 10.1093/cercor/bht311**); children with auditory processing disorder may experience deviant or developmentally delayed responses.

With older age, consistency declines (***J Neurosci* 2012;32[41]:14156-14164**).

Our findings suggest that subcortical neural synchrony exists on a continuum that tracks with auditory skills and, I believe, represents the bottleneck in a substantial number of auditory processing disorder cases.

Certain cases of dyssynchrony are treatable. We have shown that assistive listening devices (***Proc Natl Acad Sci U S A* 2012;109[41]:16731-16736**) and auditory training, including music (***Front Aging Neurosci* 2012;4:30**), language experience (***Brain Lang* 2014;128[1]:34-40**), and computer training (***Proc Natl Acad Sci U S A* 2013;110[11]:4357-4362**), improve neural synchrony and communication skills.

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Lippincott Williams & Wilkins
333 Seventh Avenue, 19th Floor
New York, NY 10001
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