Neuroplasticity: The New Frontier in Audiology

By Dennis A. Colucci, AuD

Neuroplasticity is powerful and relevant to patient care, especially when learning and memory are affected. It refers to changes in neural pathways and synapses, which are due to changes in behavior, environment, neural processes, and changes resulting from bodily injury. Neuroplastic changes in audiology drive a patient's success with amplification and sound therapies.

A 25-year-old woman with complete left hemisphere brain injury at 1½ years old is trained for successful speech communication and independent living as a result of reorganization in the remaining hemisphere. (*J Med Life* 2011;4[3]:291.) A long-term study from Johns Hopkins University in Baltimore has shown that patients with hearing loss are at risk of developing dementia two to five times greater than those without hearing loss. (*Arch Neurol* 2011;68[2]:214.) These studies remind us that senses and functions such as hearing, vision, learning, and memory are tightly intertwined and dramatically affect one another.

Three primary types of anatomical changes may occur when looking at how neuroplasticity works in hearing. First, synaptogenesis and pruning are the processes of developing or removing whole synapses or synaptic groups that modify connections between neurons. Pruning occurs when a stimulus is inhibited or a new experience is deemed to be more functional. A good example is a patient who becomes hearing impaired, and his auditory skills diminish when experience is not reinforced. This is where the old adage "use it or lose it" becomes anatomical. Connections can, in a matter of weeks, develop and reorganize when functional hearing is restored. (*Hum Brain Mapp* 2000;10[1]:28.)

Secondly, neuronal migration allocates neurons as they extend across the brain to connect processing areas. This function is especially important to the developing brain because maturational changes will set up how the brain cells should operate together. This is a specialized process, and research has shown that specific proteins influence tonotopic organization throughout the auditory system. (*PLoS One* 2011;6[10]:e26192.)

Finally, neurogenesis, as its name implies, generates new neurons from fetal through early adult development but not at the same rate after that. Infants with cochlear implants are a great example of how neurogenesis works. Early implantation continues new cell development in the auditory system and related connections. It is clear that the deleterious effects of sensory deprivation are for the most part avoided by providing a foundation for stimulus-driven learning. (*Trends Neurosci* 2012;35[2]:111.)

Understanding neuroplasticity's role in hearing loss is important because behavior changes often reflect outcome measures, which can be useful indicators of treatment success. A patient may say, for example, that he is not asking people to repeat words or that his family thinks he is more conversational.

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Audiologists are trained to maximize individual hearing instrument performance and use measures to ensure that audibility and suprathreshold events meet patients' needs. It is impossible to determine the efficacy of amplification without these measures. I could not help patients without my real-ear probe system because I would not know how far off fitting formulas and a best fit were without it. I frequently find that changes to the default prescription, after ear probe, have no relationship to the suggested settings.

The brain can continue to overwork at communication, and the expected neuroplastic changes may not occur when the fit is poor. This is because gain, compression, or output are not matched precisely to the patient's loudness contours, or automated fitting options conflict with the patient's performance needs. The outcome to the clinician may be compromised and the hearing aids returned.

Currently most audiological neuroplastic measures are subjective, although MRIs are demonstrating remarkable findings in musicians. A functional MRI, EEG, or other physical measure of neuroplasticity will allow clinicians in the future to maximize the benefits of amplification and therapy to patients with hearing loss.

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