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The non-classical pathway: Too great to be ignored

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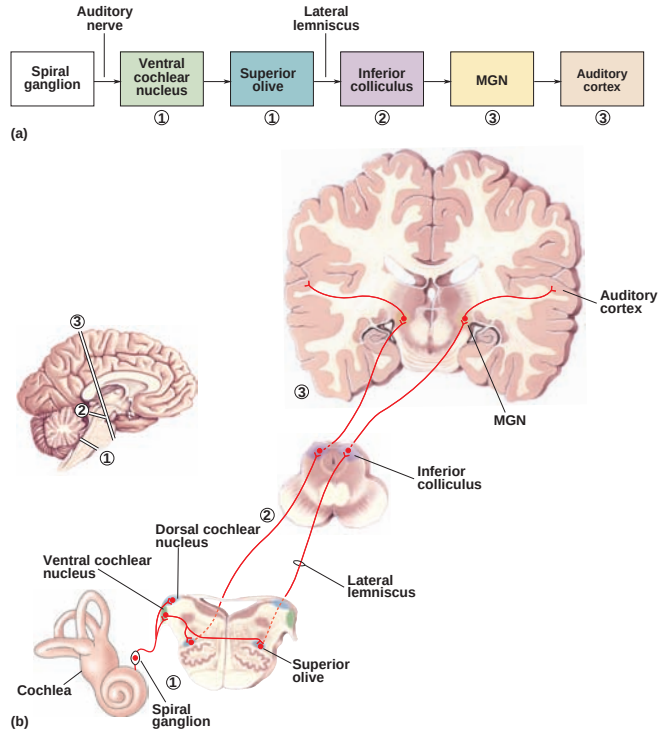
The non-classical pathway: Too great to be ignored

By Frank Musiek, PhD, Angeli Mohanani, Erin Wierzbinski, Gloria Kilgore, Jacob Hunter, and Jamie Marotto

Sensory information, whether auditory or tactile, ascends to cortical centers by the classical or the non-classical pathway. Although audiologists are aware of the route sound takes to be perceived and understood, many have not even heard of the non-classical pathway. Studies from the 1970s first defined the structures of this pathway, but little is known about its anatomy and physiology other than the non-classical system ascends parallel to the classical ascending auditory system.

The classical ascending pathway starts from the cochlear nucleus, to the superior olivary complex, through the relay pathway of the lateral lemniscus, and then to the inferior colliculus and medial geniculate body. Sound reaches its destination in the auditory cortex located in the temporal lobe.

The anatomy of the non-classical ascending pathway is considered to be diffused, and it receives input from many systems besides the auditory one. Experts speculate that the information traveling through the non-classical pathway projects from the external nucleus of the inferior colliculus through the reticular formation into the dorsal and medial thalamus and various parietal association cortices. Sound bypasses the primary cortices, in this case, the auditory cortex.



Neural signals can travel from the spiral ganglion to the auditory cortex via numerous pathways. This illustration shows a primary pathway through brain stem cross sections.

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Subcortical connections to limbic structures also exist, particularly in the amygdala, the part of the limbic system responsible for emotional learning, touch perception, and other primitive behaviors. The dorsal thalamus provides direct connections into the amygdala, which is also called the low route. Unlike the information that travels to the primary cortices in the classical route, this information is not highly processed and is little influenced by other centers of the brain. The non-classical pathway also receives input from other sensory systems, such as the somatosensory system, by way of the dorsal column nuclei and median nerve.

THE IMPACT OF THE PATHWAY

According to Moller et al, neurons in the non-classical system (extralemniscal) respond to sounds in a less specific way than neurons in the classical system (lemniscal). They are broadly tuned and respond irregularly to sounds of different frequencies.[1] The neurons of the lemniscal pathway only respond to auditory stimuli, not to other sensory modalities. In contrast to the lemniscal system, the extralemniscal system has connections to the somatosensory system.

Responses by the extralemniscal and lemniscal systems, called nonspecific-extra-lemniscal evoked responses (EL-ERs), can be measured by using macro electrodes. These responses can be evoked by somatosensory and visual stimuli. EL-ERs activate, integrate, and focus attention on incoming sensory stimuli, which may be important for patients with severe tinnitus and autism.

Some children with developmental disorders may have emotional learning problems caused by the brain's inability to reduce the involvement of the non-classical pathway and the amygdala. Moller and associates hypothesized that abnormal interactions between the somatosensory and the auditory systems are present in autistic children because of the condition's connection to the extralemniscal system.[2] Children with autism often present with symptoms of hyperacusis—discomfort or pain from noise—and sensitivity to

touch. The abnormal interactions between the two systems indicate that autistic and non-autistic individuals process sensory information differently.

A second study by Moller et al established a connection between the non-classical ascending system, loudness perception, and severe tinnitus. The researchers found that loudness perception after electrical stimulation to the somatosensory system occurred in young children around age 8 but rarely in adults older than 20.[3] This finding is interesting because it directly correlates age and the developmental maturation of the auditory system. As children grow older, specialization occurs in the brain allowing the phylogenetically newer classical system to overtake the older non-classical system, which is unable to scrutinize sounds discriminantly. Age can be a factor in whether somatosensory stimulation can enhance or suppress the ability of the non-classical system to affect the perception of loudness.

> The non-classical pathway no longer takes a backseat in auditory processing

Hypothetically, an abnormal cross-modal interaction between the auditory system and the somatosensory system could be the cause of tinnitus. The amygdala's connection to the non-classic system is supported by fMRI scans, which have shown that parts of the limbic system are activated in patients with severe tinnitus. The low route connection to the amygdala provides a direct pathway for unprocessed auditory information to travel to the fear center in the brain. This connection may explain why some patients with severe tinnitus report having emotional reactions to sound. Moller suggests that this abnormal routing of auditory information to limbic structures may be a leading factor in causing hyperacusis and phonophobia as well.

The non-classical pathway no longer takes a backseat in auditory processing. New research has discovered its connections to the somatosensory system and other auditory and developmental disorders. Further research may open the gates for better treatments of severe tinnitus and a better understanding in other developmental disorders and sound. The non-classical pathway's role in the auditory system and its implications for treatment are too great to be ignored.

Frank E. Musiek, PhD, is Professor and Director of Auditory Research in the Department of Communication Sciences at the University of Connecticut. **Angeli Mohanani**, **Erin Wierzbinski**, **Gloria Kilgore**, **Jacob Hunter**, and **Jamie Marotto** are audiology students at the University of Connecticut. Readers are invited to ask Dr. Musiek questions to be answered in future Pathways columns at HJ@wolterskluwer.com.

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LETTERS TO THE EDITOR

You are invited to share your views with the readers of *The Hearing Journal*. Email letters to HJ@wolterskluwer.com. Letters may be edited for clarity.

ENVIRONMENTAL DESIGN ADVOCATE

Editor:

Thank you for Dr. Raymond Hull's article, "Environmental design enhances hearing rehabilitation" in the August issue (http://bit.ly/environmentaldesign). I have been involved for a long time in advocating for improved acoustics for persons with hearing loss. I had the opportunity to work with the Acoustical Society of America and the U.S. Access Board in developing the American National Standards Institute standards for classroom acoustics.

My true interest is for older adults, though, but because I am retired, my professional activities have waned. I also enjoyed the editorial Dr. Hull wrote in the *(J Rehabil Res Dev* 2011; 48[5];xvxviii; http://bit.ly/HullEditorial.*)* as well. Thank you very much.

Anne Seltz, CCC-A
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IN PRAISE OF THE ISRAELI MINISTRY OF HEALTH

Editor:

We were delighted to hear of the humanitarian efforts of the Starkey Hearing Foundation and the Chaim Sheba Medical Center at Tel Hashomer in Israel as reported in your July issue (http://bit.ly/Israel-PalestineMission). We must praise them for fitting more than 1,000 Palestinian children and adults with hearing devices.

The location of the mission was Khaled ben Said School in Tulkarem. The article identified that this is in Palestine, but there is no official state of Palestine. All health care is provided through the Israeli Ministry of Health. Because this was a mission of peace, we feel it is important to provide recognition to the Israeli Ministry of Health and the State of Israel, which are committed to humanitarian efforts.

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