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STRUCTURES INVOLVED IN THE TRAJECTORY OF THE AUDITORY SYSTEM (PART I): COCHLEAR NUCLEI

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This bulletin provides information about the structures involved in the trajectory of the auditory system, structures that are essential for processing auditory information.

Knowledge of the neuroanatomy and neurophysiology of the Central Auditory Nervous System (CANS) by health professionals is important and underlies appropriate patient care. This bulletin describes the cochlear nuclei (CN). This is the first bulletin on the topic, and readers can follow us to learn more.

The CN are the first structures of the CANS. They are located in the anteroposterior region of the pons and receive fibers from the auditory nerve. They have three divisions:

- **Dorsal CN**
- **Posterior ventral CN**
- **Ventral anterior CN.**

In turn, the CN complex is made up of several types of cells:

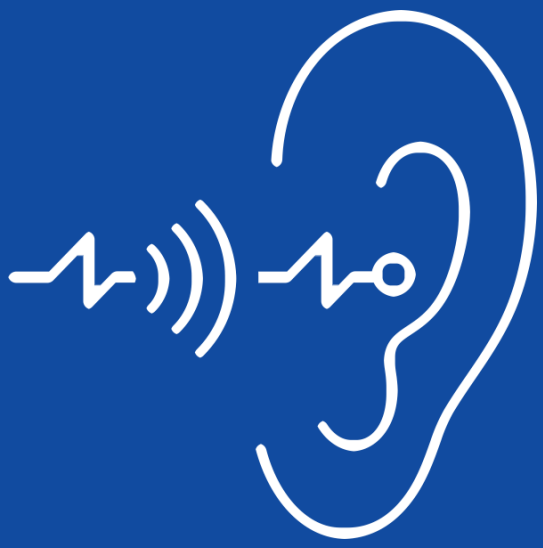
- **Pyramidal**
- **Octopus**
- **Globular**
- **Multipolar**
- **Spherical.**

ALTHOUGH THERE ARE RAMIFICATIONS AND DIFFERENT TYPES OF CELLS IN THE CN, IT CAN BE SAID THAT IN GENERAL EACH AREA HAS A SPECIFIC AND WELL-ORGANISED TONOTOPIC ARRANGEMENT.

The tonotopic mapping in the CN is similar to that found in the auditory nerve, so that low-frequency sounds (of low pitch) are perceived separately to high-frequency (or high-pitched) sounds. Furthermore, the rate of neural firing increases as the strength of an acoustic stimulus increases.

More neurons are devoted to signaling high intensities, although the threshold for the vast majority of fibers is 30 to 40 dB.
In 2000, it was discovered that the CN also have the ability to process amplitude-modulated tones.

However, the cytoarchitecture (the composition of body tissues at the cellular level) of the CN varies greatly between humans and animals. These differences are not yet clear, so for now animal studies must be interpreted with caution.



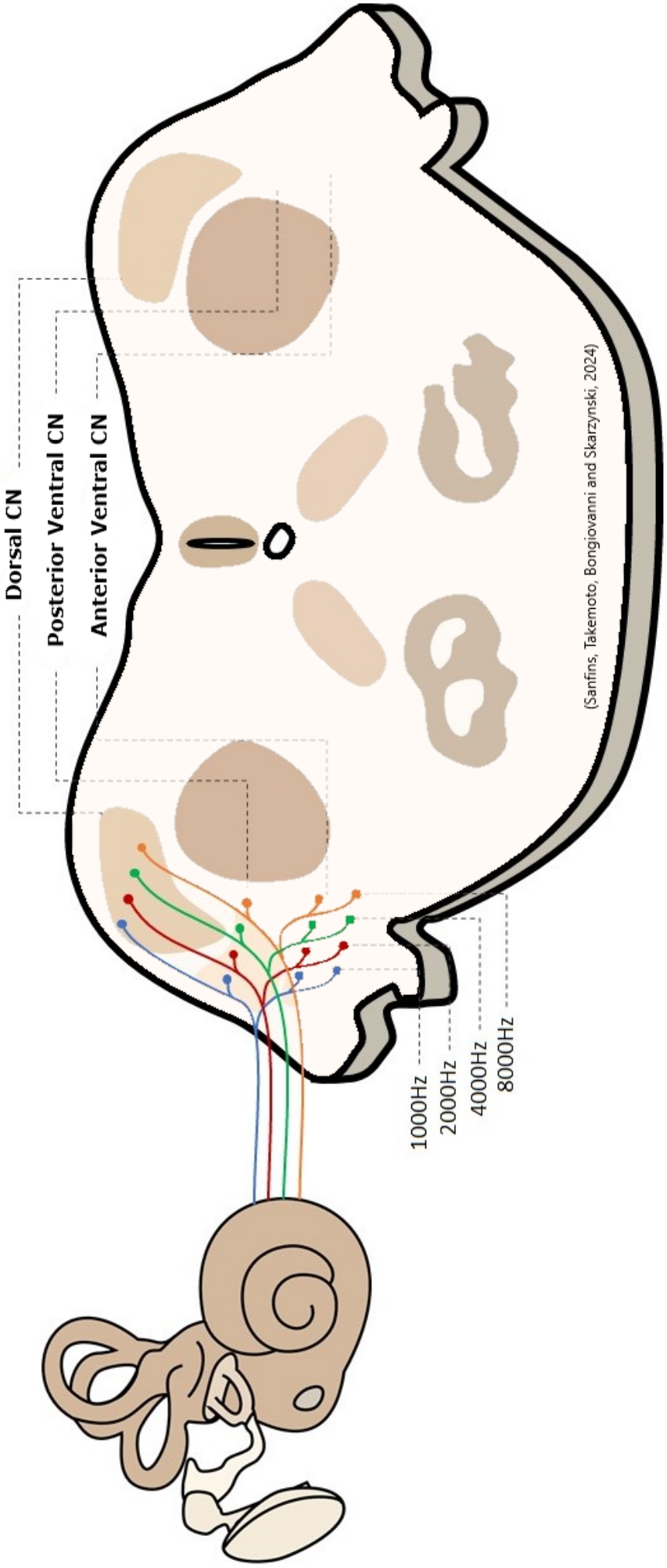


Figure 1: Diagram of the cochlear nucleus.

A recent and very interesting study by Hockley and collaborators (2023) exposed animals to noise with the aim of obtaining a picture of cochlear synaptopathy.

.This was the first study on the effects of cochlear synaptopathy on sound coding by CN neurons.

The researchers found that TIN (tone-in-noise) detection thresholds were unaffected by cochlear synaptopathy, but in animals with cochlear synaptopathy there was impairment of suprathreshold TIN coding.

This might be explained by the contributions of other structures that make up the auditory trajectory and which play a role in maintaining neural firing and the processing sound stimuli. It would be interesting to have new studies with different and expanded sound stimuli to confirm these findings.

We strongly recommend reading this study!
The literature reports a strong connection between the CN and the perception of tinnitus. Explanations involve the observation that the CN receives input directly from the auditory nerve, and so any problems in the nerve could well cause long-term problems in the CN. Individuals exposed to noise could receive hyperstimulation of the CN, and this might generate changes in the CN that could provide a mistaken perception of sound – that is, tinnitus.

It is also worth noting that tinnitus and hyperacusis often appear together, with an associated incidence rate of around 60%. The joint appearance of tinnitus and hyperacusis appears to be greater in cases where there has been exposure to noise, although both tinnitus and hyperacusis can occur in isolation. Therefore, when analysing patients with tinnitus or hyperacusis, special attention should be paid to procedures that can check the integrity of the CN.

THE CELLS OF THE CN ARE INTRIGUING BECAUSE THEY INTEGRATE INFORMATION FROM THE COCHLEA WITH THAT FROM OTHER SENSORY MODALITIES.

The interactions seem to be associated with sound localisation, perhaps involving movement of the head as the subject searches for acoustic cues. There also appears to be a correlation with somatosensory inputs and the suppression of acoustic signals. Animal studies have shown that the CN play a central role in integrating sound and tactile stimuli. Different head positions provide different acoustic cues, information which allows you to determine the location of a sound through differences between the right and left ears.

In terms of auditory tests and their correlation with the CN, it is known that when one records brainstem auditory evoked potentials using clicks, wave III is formed when the stimuli reach the CN. There are still controversies regarding how to interpret wave III responses, so it is important that new studies be done to correlate the findings with different pathologies and conditions. However, some key indications are presented in the accompanying table.

PATHOLOGY OR CONDITION	RESPONSE OF CLICK-ABR WAVE III
Aging (Tessele et al, 2022)	**Prolonged wave III latency**
Autism (Liu et al, 2023)	**Prolonged wave III latency in the right ear**
Hyperbilirrubinemia neonatal (Mandour et al, 2023)	**Prolonged wave III latency**
Listening difficulties (Hunter et al, 2023)	**Reduced wave III latency**
Long Covid-19 (Dorobisz et al, 2023)	**Prolonged wave III latency**
Multiple Sclerosis (Srinivasan et al, 2021)	**Prolonged wave III latency**
Otitis Media (Colella-Santos et al, 2019)	**Prolonged latency and reduced wave III amplitude**
Pathogenic neurovascular compression of the 8th cranial nerve in vestibular paroxysmia (Sun et al, 2021)	**Prolonged wave III latency**
Sleep Apnea (Bernáth et al, 2009)	**Prolonged wave III latency**
Tinnitus (Montazeri et al, 2023)	**Reduced wave III amplitude**
Traumatic Brain Injury (Buriti et al, 2022)	**Reduced wave III amplitude**

Table 1: Analysis of click-ABR wave III responses in different pathologies and conditions

Table 1 demonstrates that CN functioning can be affected by various pathologies and conditions.

The table specifically refers to wave III findings. However, the studies listed have also analysed other click-ABR components (wave I, wave III, wave V, interpeak interval I–III, interpeak interval III–V, and interpeak interval I–V), and these have been associated with other conditions.

Therefore, to better understand the findings, we suggest the reader consult the references provided.

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