

The Nobel Laureate Georg von Békésy's Hearing Theory

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Abstract: After Békésy the stapes base moves around two axes: for weaker sounds - rotates around its transverse axis; in case of a strong sound - it moves around its longitudinal axis. Békésy's place theory cannot alone explain the frequency-distinguishing ability of the ear. However, the existence of active amplification further sharpens the frequency-analysing ability of the cochlea. In addition, the different frequency sensitivity of afferent nerve fibres of inner hair cells synergizes with the mechanisms above. Peaked resonance curves are consequences of different threshold sensitivities of nerves connecting to individual hair cells. The frequency, which belongs to the lowest stimulus threshold, is called the characteristic frequency of a nerve. This place assignment of nerve frequencies are formed by the following mechanism in the cochlea. The place of amplitude maxima of progressive waves excited in the basilar membrane shows slight frequency dependence. The mechanism of active amplification forming in outer hair cells amplifies and sharpens the resonances of the basilar membrane. In 1961, nobleman Georg von Békésy received the Nobel Prize in Medicine: "for his discoveries of the physical mechanisms of stimulation within the cochlea".

Keywords: hearing theory, Georg von Békésy, Nobel-prize, anatomical structure of the human ear.

1. INTRODUCTION

In case of two sounds of different frequencies relative pitch is determined by the proportion of frequencies, which is also called the interval. An interval 2:1, which is well known from music, is called an octave. Above 1000 Hz, consonance for an octave means a frequency-ratio larger than 2. The frequencies of oscillations measured according to that differ from the harmonic octaves; this is the so-called melodic octave. Harmonic octaves (in Hz): 80 160 320 640 1280 2560 5120. Melodic octaves (in Hz): 80 160 320 640 1280 3540 7800. [1]

The ear transforms soft mechanical vibration of air particles into electrical signals, which reach the appropriate part of the cerebral cortex for processing by means of auditory nerves. The cerebellum interprets these complicated signals by determining pitch, tone, loudness, and placement of the sound source. [2]

The height of a sound is determined by the frequency of an acoustic wave (ν), namely the number of oscillations that the sound wave performs in the time unit. The higher the sound frequency, the „higher” the human ear perceives them. According to the frequency, the sounds classify as follows: infrasounds, ($\nu < 16$ Hz), proper sounds (16 Hz $< \nu < 20$ kHz), ultrasounds ($\nu > 20$ kHz). The infrasounds and the ultrasounds cannot be perceived by the human ear. [3]

The frequency range of hearing varies greatly from individual to individual; it is rare for a person to be able to hear the full hearing range of 16 to 20,000 Hz. The ear is relatively insensitive to low-frequency sounds; for example, at 100 Hz its sensitivity is roughly 1,000 times lower than at 1,000 Hz. The sensitivity of high-frequency sounds is greatest in infancy and gradually decreases throughout life, making it difficult for an adult to hear sounds above 12,000 Hz.

2. THE ANATOMICAL STRUCTURE OF THE EAR

The hearing analyser consists of two main systems: the peripheral hearing system, formed of the outer ear, the middle ear and the inner ear and the central hearing system, which contains the nervous pathways which ensures the transmission of the nervous influx and the hearing area where the information is analyzed and the hearing sensation is generated. The peripheral hearing system achieves the functions of transmission of the sound vibration, the analysis of the acoustic signal and the transformation of the acoustic signal in nervous inflow and the generation of the nervous response. [4]

The anatomical structure of the ear is shown in Figure 2. [5] In humans, the organ of hearing, a device for absorbing acoustic stimuli, is hidden in the clavicle of the temporal bone. An amplifier is connected to the receptor device.

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