Sound Localization

- Purpose & Function (Azimuth Definition)
- Pinna and Sound Localization
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- HL and Sound Localization

Sound localization is the ability to determine which direction sound is coming from. The purpose of sound localization is for protection such as avoiding oncoming traffic, falling object and being able to locate a speaker for a comfortable listening experience. Advantages in binaural hearing is improvement in speech under noise conditions and the reduction of unpleasant background noise. Localization ability is benefitted by having two ears at 90-degree azimuth, the degree in relation to the person with 0 degree being directly in front and 180-degree being directly behind.

The convolutions and depressions of the pinna surface allow for the pinna to act as a resonator for high frequency sounds. These high frequency sounds change with changes in sound source which allow for horizontal sound localization cues by the pinna. The convolutions on the pinna provide spectral cues for vertical sound localization to help detect changes in sound source to decipher if sound is coming from above or below.

Horizontal localization relies on two cues (1) interaural time/latency differences (ITD) and (2) interaural level differences (ILD). The brain uses both cues to localize sounds. The interaural time difference is the difference between the time it takes for sound to arrive at each ear and the interaural level difference is the difference in the intensity of the sound at each ear. ITDs have a low frequency effect because low frequencies have longer wavelengths that curve around the head and results in a time difference between the two ears. ILDs have a high frequency effect due to the head-shadow effect that occurs because high frequencies cannot bend around the head due to their short wavelengths. Sounds with a wavelength greater than the diameter of the head will diffract to the contralateral side (low-freq sounds) and sounds that are short in wavelength are impeded by the head cause attenuation.

The duplex theory explains how horizontal localization can be attributed to both ITDs and ILDs. ITDs have a low frequency effect for frequencies below 1500 Hz in which the MSO encodes ITDs to the OHCs. ILDs have a high frequency effect over 1500 Hz in which they are attenuated due to head shadow effect.

There are two streams of the cochlear nucleus (1) the dorsal stream useful in sound identification and (2) the ventral stream which is useful for binaural sound localization. The dorsal nucleus of the lateral lemniscus is part of the binaural sound localization stream and it serves to increase accuracy contrast and dynamic range of localization information. The ventral stream has two divisions, the (1) lateral superior olivary complex (LSO) which compares the intensity of the stimuli between both ears and is excited by the ipsilateral side stimulus, and the (2) medial superior olivary complex (MSO) which decodes sound localization by comparing the time of arrival of sound from both ears. The ventral nucleus of the lateral lemniscus does not

receive any input from the SOC complexes and is not involved in binaural sound localization, but it does play a role in monaural sound localization.

The inferior colliculus is the primary location of the convergence of sound identification and localization and so cells in the IC show directional selectivity, so responses dominated by the contralateral input but enhanced by the ipsilateral input.

Symmetrical hearing loss has little effect on sound localization ability, but asymmetrical hearing loss can cause abnormalities in sound localization. Those with high frequency hearing loss do not have the ability to pick up sound localization cues by the pinna and the head-shadow effect and so they cannot detect the differences between frequency and intensity to localize sound. These people also have an abnormal precedence effect in which they have difficulty suppressing echoes due to widened tuning curves and a loss of frequency specificity.