Lec 2 Outer Ear

The pinna (which we can touch and feel) and the external auditory canal/external auditory meatus.

The outer ear/pinna/auricle is:

- Comprised of elastic cartilage (provides support and is flexible)
- Covered by skin
- Has muscles which are vestigial in humans, meaning they have no function), but in animals they function for sound localisation e.g. rabbits and cats move the muscles of their pinna to locate sound source in environment. Auricular muscles (superior, anterior and posterior muscles) are innervated by the facial nerve, but they're vestigial in humans. May be able to activate it slightly but we are unable to pinpoint a sound in space without physically moving our head towards the source of the sound.

-Startle reflex (look of surprise) and lateral eye movement: Moves pinna up and back & opens canal

- Pinna convolutions: Everyone has slightly different convolutions of the pinna. These individual differences have no known function. Pinna convolutions act as complex resonators for high frequency sounds.

Pinna Anatomy

- **The helix and antihelix slightly protect the external auditory meatus (which funnels sounds into the middle ear and cochlea) and the antitragus which is directly underneath.**

Pinna Deformities:

- Atretic ear canal (atretic external auditory meatus): Ear canal is completely closed or absent at birth

- Can often be corrected with surgery

- Microtia: Deformity of the pinna which can have varying levels.

- Can be corrected by surgery but also with prosthetics.

Hearing aids contain an externally warm speech processor which fits behind the ear if you have a pinna. The hearing aid has a microphone which goes directly into the ear and amplifies those speech signals into the middle ear but this is not very useful if the outer ear is deformed. So, in addition to this, you can have a microphone more directly into the external auditory canal itself or a bone anchored hearing aid (drilling into the temporal bone and use sound conduction through bone to overcome the lack of conductive mechanism due to the deformity of the pinna). These are treatments for conductive hearing loss, where either the outer ear or the auditory canal or both are not functioning properly but the cochlea itself is fine.

External auditory meatus (canal)

The external auditory canal:

- Protects, amplifies and localises sound

The outer ear itself does not go directly into the tympanic membrane.

- Cartilaginous part runs medially, upwards and posteriorly (from lateral to medial)

- The outer third of the external auditory canal is cartilaginous, the inner 2/3 of the canal has a very thin layer of skin that can be sensitive to damage.

The outer 1/3 has hairs which are oriented outwards to prevent debris from entering. It has a number of sebaceous glands which secrete sebum to lubricate the skin of the ear canal so it doesn't dry out. It also has cerumen glands which produce wax which protects our ears against insects as wax is noxious to insects. The sebaceous glands are directly located under the epidermis and oil travels up through the pores to lubricate the skin of the ear.

• Bony part runs medially,downward and anterior (from lateral to medial).

Anatomy of External auditory canal:

The ear canal is 2.5-3.5 cm long. It is not a straight canal and needs to be pulled directly in those planes in order to get a good visualisation of the tympanic membrane. This is the first tool for examining the middle ear.

Adults:

•Cartilaginous part runs in slightly upwards and backwards (~8 mm) then bony part runs in

slightly down and forwards (making the inner 2/3).

- straighten by pulling pinna up and backwards when you see a GP or audiologist

Neonates:

•Bony meatus less developed

- straighten canal by pulling pinna down and backwards

Function of the Outer Ear

Outer Ear Physiology:

Protection

- Pinna Tragus: provides the cartilaginous cover to the outer ear.
- Long (2.5 – 3.5 cm) narrow (5-7 mm) canal, bony part lying at angle to cartilaginous part
- Not a straight canal
- Ceruminous glands (noxious to insects, antimicrobial, hydrophobic)
- Sebaceous glands (lubricating)
- Hairs, oriented towards exterior

Amplification

- Collects and directs sound waves onto the eardrum (tympanic membrane)
- Sound pressure is increased by the outer ear due to resonant properties of outer ear (concha and EAM/external auditory meatus)
- Natural (resonant) frequency of concha is ~5,000 Hz versus EAM ~ 2,500 Hz. This is within the frequency range of human speech.
    - As it resonates, it amplifies the sound pressure that reaches the tympanic membrane.
    - The resonance of each cavity is such that each structure increases the sound pressure at its resonant frequency by about 10 -12 dB

- EAM amplifies sound by selectively boosting sound pressure at frequencies ~2,000 - 2,500 Hz up to 4000 Hz (within main range of human speech).

This is best illustrated by describing a hypothetical experiment:

Speaker producing sound at 70 dB (amplitude i.e. volume) and produces sounds at 3 different pure tones (frequency). What is happening with the sound pressure measured at the eardrum across the 3 different frequencies bearing in mind the base line is 70dB?

- 1.4 kHz: Not much sound amplification at the tympanic membrane if presented with a pure tone at 70dB.

- 2000-5000 Hz range (2-5 kHz): the sound pressure level is boosted by 10-12 dB

- Above this range e.g. 10 kHz: not much amplification again.

This shows that the concha and the external auditory meatus resonate within this frequency range so as to boost the sound pressure level that's arriving at the ear drum. This is important because this is the key range of frequencies for human speech.

The outer ear not only amplifies sound but it also localises sound.

-Horizontal plane/ azimuth: 0 degrees

- Distance: sound is louder depending on where you are in relation to the source of the sound.

- Elevation

-There is also an element of time for sound localisation.

Sound localisation in humans via:

- timing
- intensity (loudness)
- spectral qualities (changes in spectral shape incl. reflection, diffraction via pinna)

For both timing and intensity (binaural cues used to localise sound), we need both ears.

Spectral qualities: Referring more to sound which occurs at different elevations--- the spectral qualities of sound and how it changes based on the degree about the azimuth and where the sound is coming from in terms of the vertical plane.

Localisation of sound in the Horizontal plane

Horizontal plane cues are binaural cues.

- Timing is key in terms of sound localisation. This is called interaural timing difference (ITD), can pinpoint sound location based on the timing of sound arrival at one ear versus the other ear. E.g. sound from left reaches left ear before the right ear, sound from in front of you reaches both ears at the same time. ITD is especially important for localising low frequency sounds.

Interaural loudness difference (ILD)/ Interaural intensity difference (IID) is more important for localising high frequency sounds because of the effect of head