*Educational Module*

# Tympanometry

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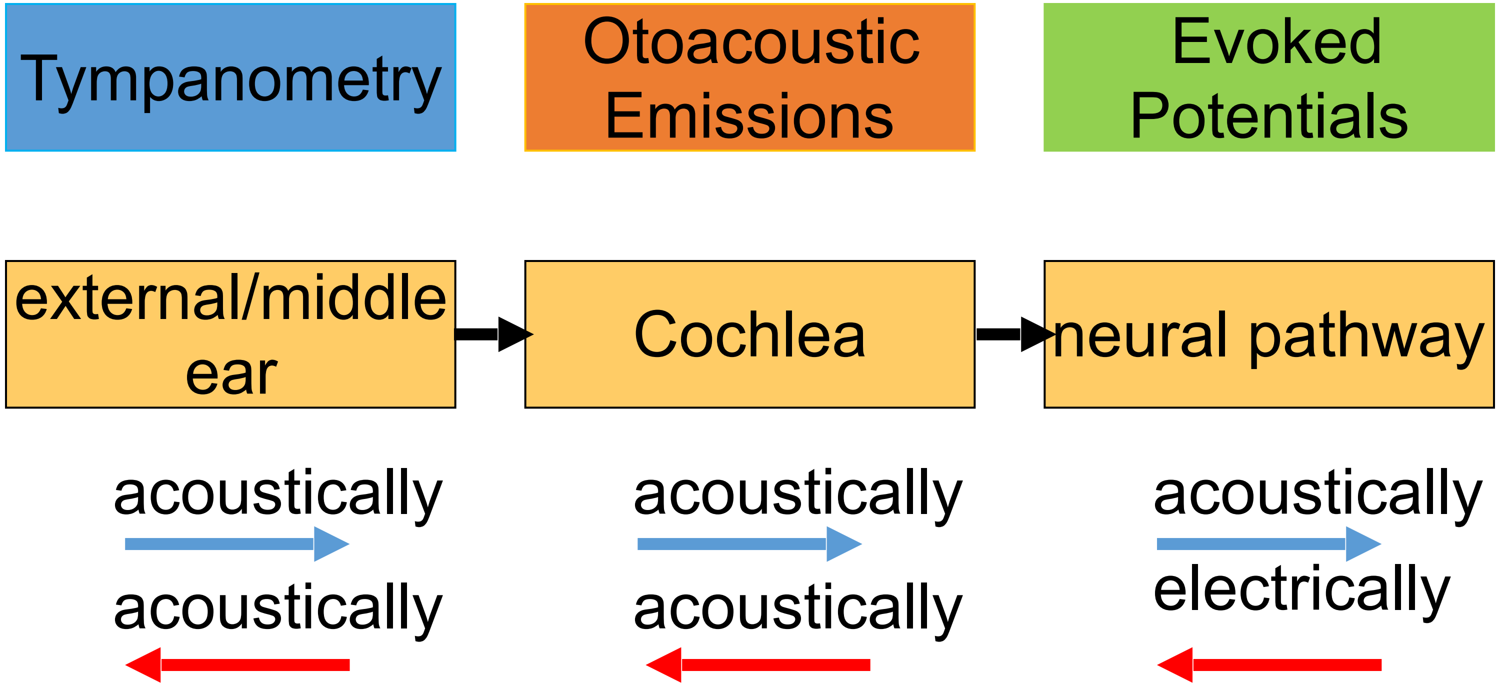
# *Our educational modules*

are made for providing information on how the hearing organ works and which test procedures are used to test the functionality of the sound processing elements along the auditory pathway.

With that knowledge the user of our devices should be prepared to use our test modules efficiently.

# *Physiological tests*



# Physiological tests



Physiological test procedures reflect the mechanical and neural function of the auditory system. Therefore, physiological tests are used for reliably detecting the site of impairment along the auditory pathway. Tympanometry (Tymp), oto-acoustic emission (OAE) and auditory evoked potential (AEP) are able to differentiate between middle-ear, cochlear, and neural disorders. In case of Tymp and OAE, both, stimulus and response are acoustic signals. In contrast, in case of AEP there is an acoustical input-signal and an electrical output-signal.

In view of an adequate therapy of a hearing impairment, it is important to known which stage of the auditory pathway is concerned. Tymp, OAE, and AEP allow for selectively assessing middl-ear, sensory (cochlear) and neural disorders. Behavioural testing is less reliable. This is true, especially, in infants and other non-cooperative patients, where psycho-acoustical tests cannot reliably be performed.

# *We have seven educational modules*

1 Sound - Physiology/Pathophysiology of Hearing

2 Tympanometry

3 Oto-Acoustic Emission (OAE)

4 Auditory Evoked Potentials (AEP)

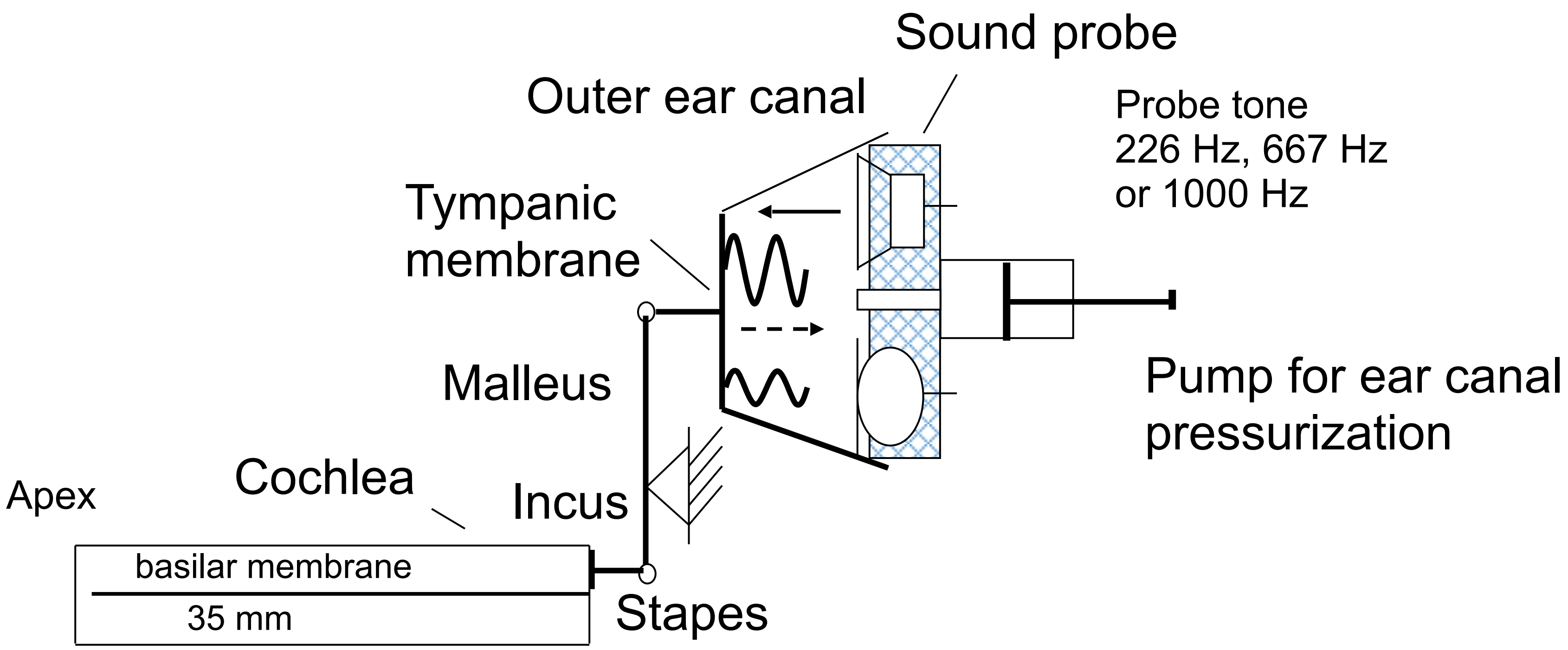
5 Hearing Screening (newborn, pre-school/school children, elderly)

6 Tracking

7 Occupational medicine

# Tympanometry





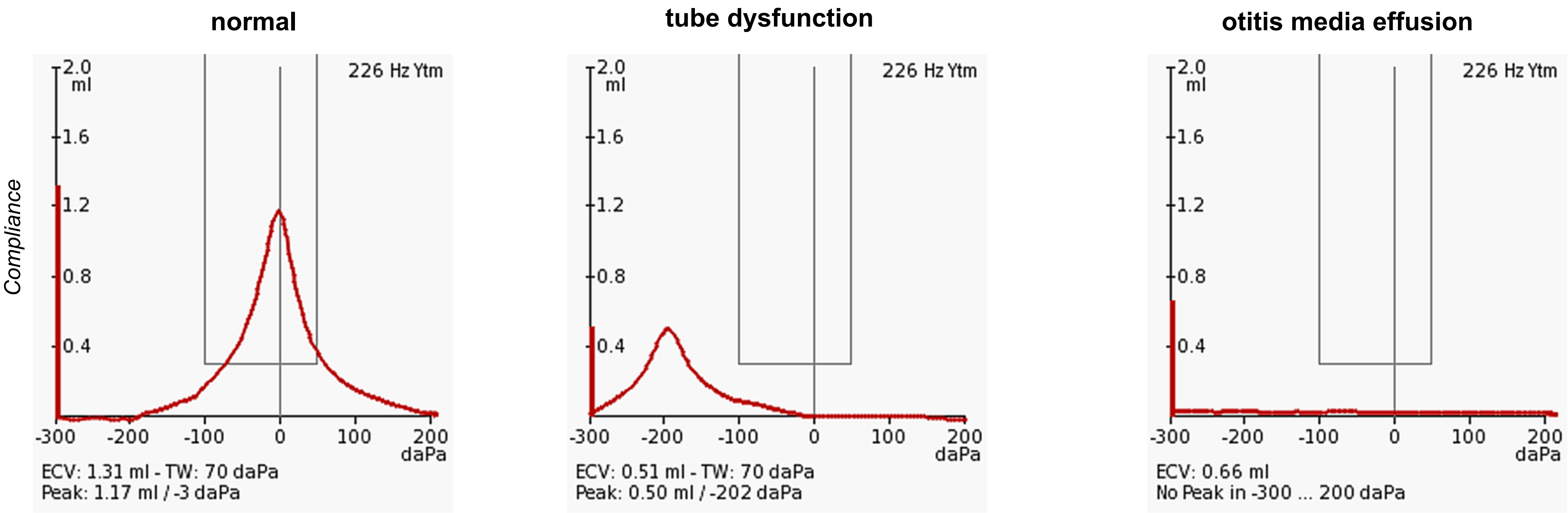
# Tympanometry



The function of the middle ear is to minimize the loss of acoustic energy that appears when sound is transferred from air in the outer ear canal (low density) to fluid in the inner ear (high density). Without the specific middle ear features, approximately 99.9 % of the sound energy would be reflected at the fluid due to the different densities. The middle ear helps to improve the energy balance by increasing sound pressure and force. The increase of sound pressure is simply due to the fact that the tympanic membrane area is seventeen times larger than the area of the footplate of the stapes which is the connecting link between middle and inner ear. The increase of sound pressure becomes clear when looking at the physical equation, which defines pressure as force divided by area ($p = F / A$). Thus, with reduced area and same force the pressure increases. The increase of force is due to the different length of the malleus and the incus providing a lever action of the ossicular chain (malleus, incus, stapes). Both mechanisms yield an impedance matching which allows for a transmission of 60% of the sound energy to the inner ear.

# Tympanometry





# Tympanometry

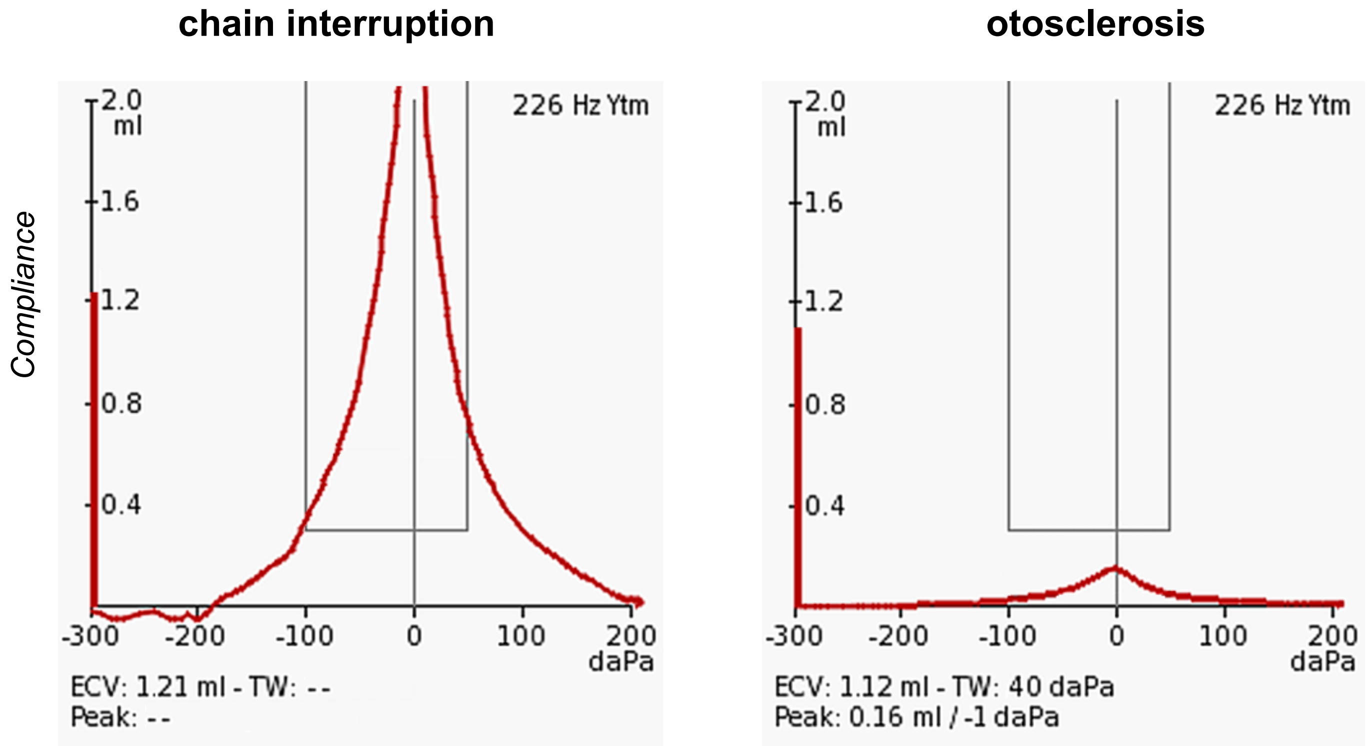


In middle ear diagnostics, typically the admittance is evaluated. Admittance is determined by compliance (= 1/stiffness, spring load), mass, and friction or resistance. Mathematically, the admittance Y is a complex value consisting of conductance G (real part) and susceptance B (imaginary part), i.e. $Y = G + jB$. Friction influences conductance, whereas compliance and mass influence susceptance. Conductance (friction) is independent of frequency, whereas susceptance (compliance, mass) is dependent on frequency with compliant susceptance being inversely proportional to frequency and mass susceptance being directly proportional to frequency. With increasing frequency, the total susceptance progresses from positive values (stiffness controlled) towards 0 mmho (resonance) to negative values (mass controlled). The resonance frequency is directly proportional to the stiffness of the middle ear, i.e. with increasing stiffness the resonance frequency increases (e.g. at otosclerosis), and inversely proportional to the mass of the middle ear, i.e., with increasing mass the resonance frequency decreases.

# Tympanometry







# Tympanometry

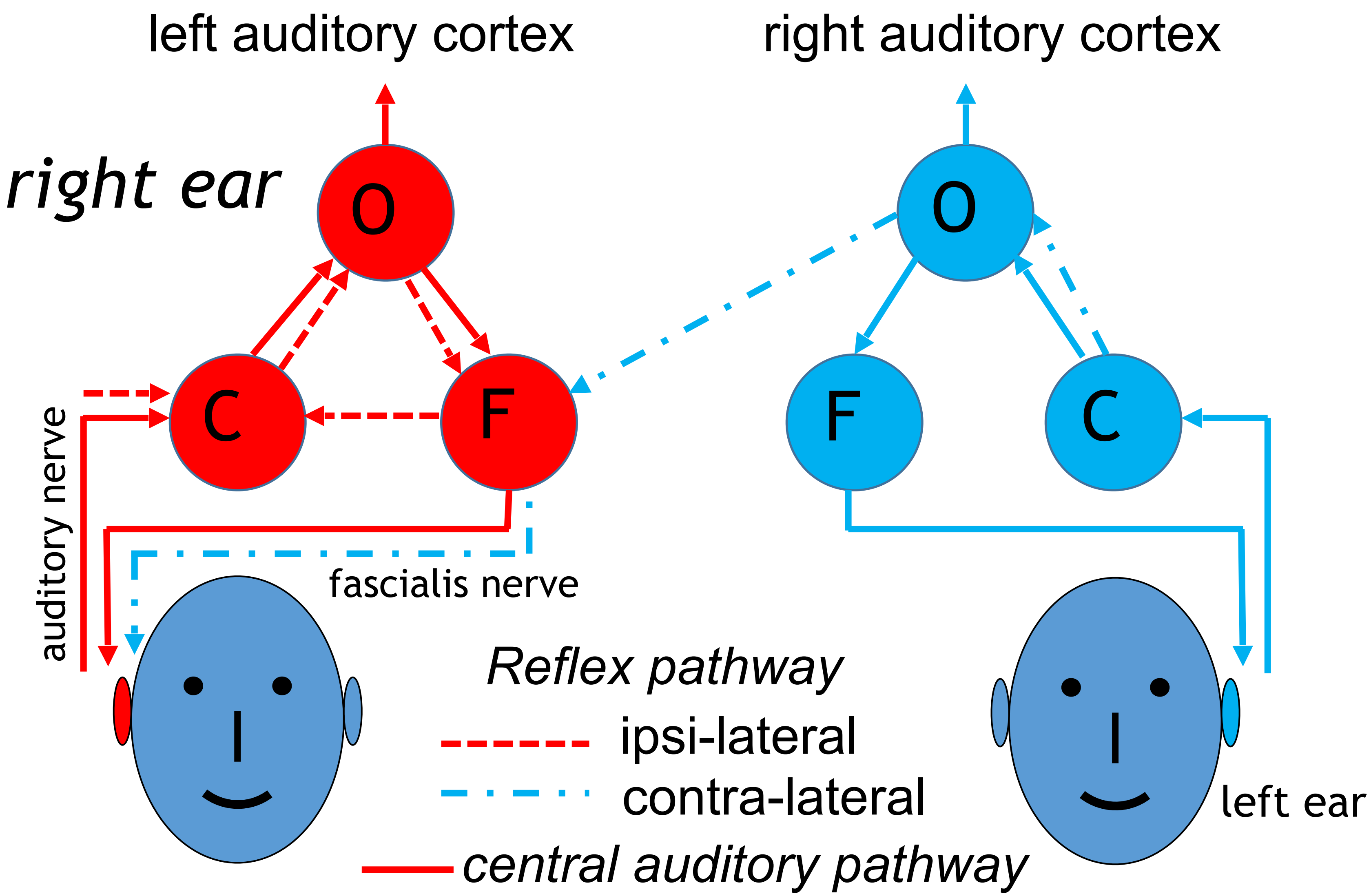


Tympanometry is usually performed at low test-tone frequency (220 or 226 Hz). At low frequencies, the normal-middle ear system is stiffness-controlled and susceptance (stiffness element) contributes more to overall admittance than conductance (frictional element). Typically, static air pressure varied from +200 daPa to -200 daPa. The result is a graphic display called a tympanogram which plots middle ear admittance over static air pressure.

Different middle-ear pathologies exhibit different tympanogram shapes. In case of normal middle-ear function the tympanogram shape corresponds to a Gaussian bell curve with its maximum being around zero static pressure, i.e., maximum energy is transferred into the cochlea. In case of Eustachian-tube dysfunction the peak of the Gaussian bell curve is shifted towards negative pressure. In case of otosclerosis, the peak of the Gaussian bell curve is small (due to decreased mobility), however located within the zero static pressure range. In case of an interruption of the ossicular chain (due to increased motility) there is a open curve.

# Tympanometry, acoustic reflex





# Tympanometry, acoustic reflex



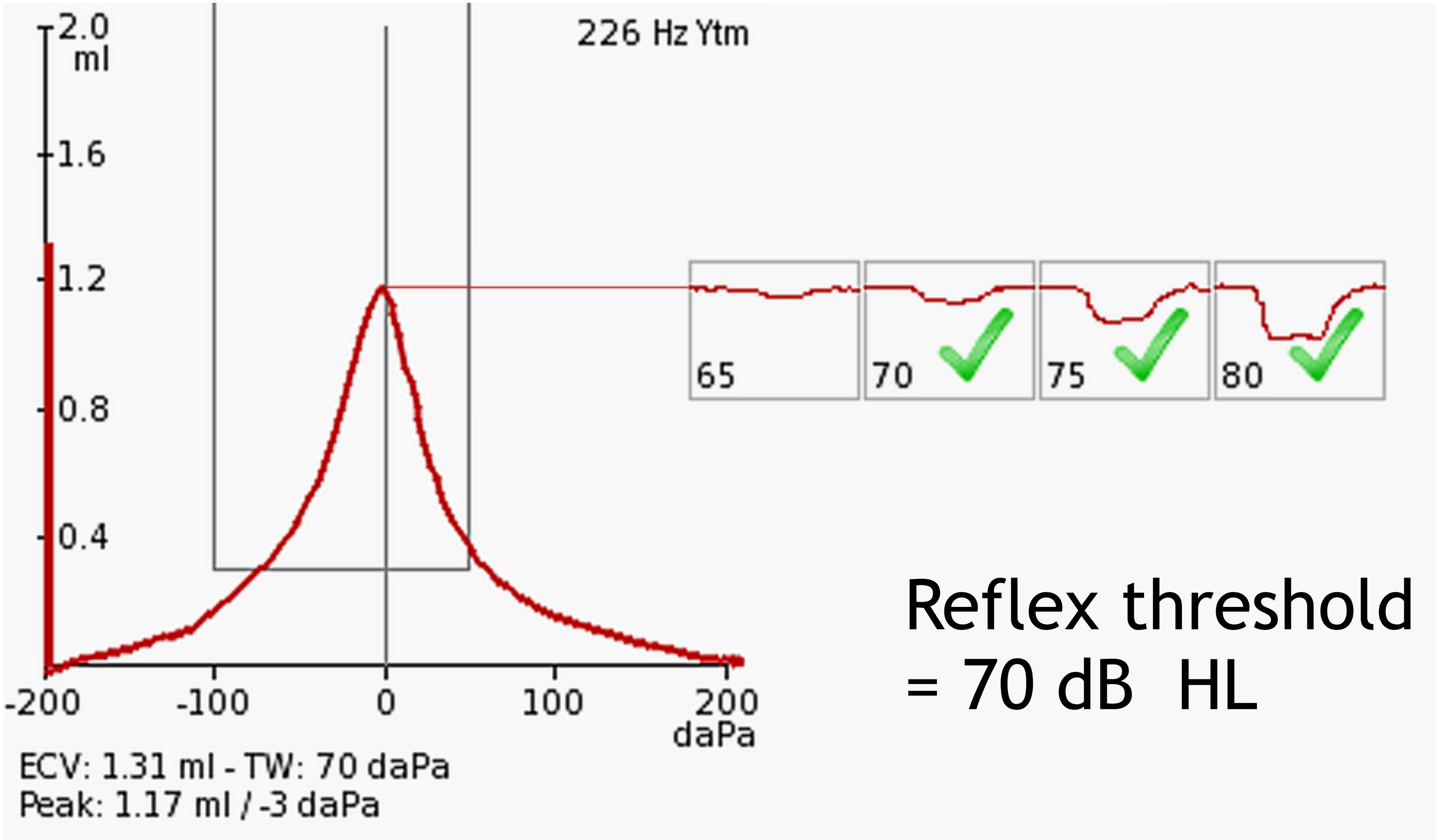
The middle ear is able to increase its impedance for providing protection against loud sounds. In case of a sound higher than about 80 dB HL, the middle ear muscles (stapedius muscle and tensor tympani muscle) are activated resulting in an increased stiffness of the middle ear. As a consequence, the energy transmitted to the inner ear is lower.

The acoustic reflex (or stapedius reflex, attenuation reflex, auditory reflex) is an involuntary muscle contraction. This includes contraction of the stapedius and tensor tympani muscle. The stapedius muscle stiffens the ossicular chain by pulling the stapes away from the oval window of the cochlea and the tensor tympani muscle stiffens the ossicular chain by loading the eardrum when it pulls the malleus in toward the middle ear. As a consequence the transmission of vibrational energy to the cochlea is decreased. The pathway involved in the acoustic reflex is complex and can involve the ossicular chain itself, the cochlea, the auditory nerve and the brainstem. Acoustic reflex is elicited at different test-frequencies: 500, 1, 2, 3, and 4 kHz.

# Tympanometry, acoustic reflex



tympanogram acoustic reflex




Reflex threshold
= 70 dB HL

# Tympanometry, acoustic reflex

## Reflex at different test-frequencies