Lerning objectives:

EAR

- Sound: Pa, dB (SPL), phone, sone
- Mechanism of sound transmission (air conduction versus bone conduction)
- Directional hearing
- Testing of hearing threshold

NYSTAGMUS

- Sense of balance
- Disorders of the vestibular system (sense of turning, vertigo)

VISION

- Physiological abberations
- Dark adaption
- Picture genesis
- Blind spot

EAR and NYSTAGMUS

EAR

- Exploration of sound conduction and sound sensation
- **Threshold audiometry:** Test of pure tone sensation and its dependance on frequency and amplitude of sound pressure**.**

Note: Keep noise during measurements as low as possible!!!

1. Binaural hearing: Localizing sound sources

1.1. Detection of interaural time and intensity differences

A 1m long tube which is connected to head phones is scaled at its middle. The tube lies on the back of the test person carrying the head phones. The experimenter positions the midth of the tube on one or two of his/her finger tips. With the other hand he/she slightly knocks the tube with a ruler (Try to produce equally loud sounds). The test person indicates whether he/she sensed the sound at the left or right side. The experimenter searches for the minimal distance left ($\mathbf{a_L}$) and right ($\mathbf{a_R}$) from midline, which allows to distinguish the direction of the evoked sound. Calculate the minimal time difference $\mathbf{\Delta t_{min}}$ of the sound wave arrival at both ears according to

temporal discrimination Δt_{min} [s] = s/v_L = $\dfrac{\mathbf{a_L} + \mathbf{a_R}\ [\,m\,]}{330\ m/s}$ = (1)

For simplification: the sound velocity in air is $\mathbf{v_L} \approx 330$ m/s. Use the difference in running distance $\mathbf{s = a_L + a_R \approx 2\,a}$ and the distance between left and right ear **d** . Calculate the minimal **angle ß** necessary to differenciate the direction of the sound.

spacial discrimination β [°] = arcsin (s/d) = (2)

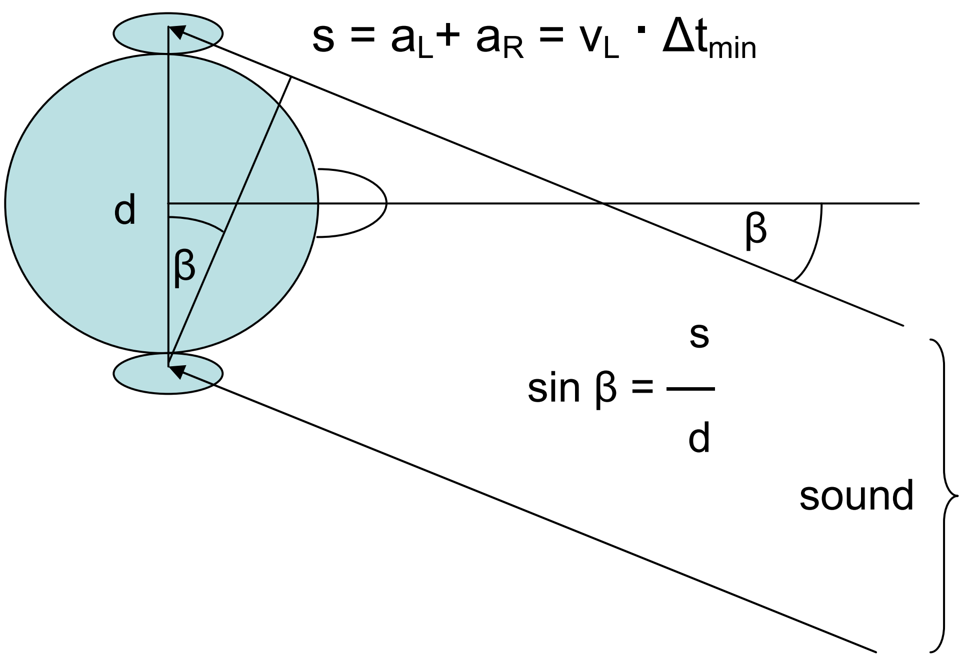


Fig. 1: Construction of angle $\boldsymbol{\beta}$

1.2. Audiometry – registration of hearing thresolds with an audiometer

a) **Preparation of the audiometer**
Select the operation mode: TONE and AIR CONDUCTION. Set the sound pressure level to −10 dB SPL to avoid sounds before the testing. Test tones can be applied by moving the level to more than 0 dB SPL. Chose the left or right ear and put the corresponding side of the protocol sheet on the audiometer.

b) **Preparing the test person** The test person puts on the head set and controls whether the side of the stimulated ear corresponds with the side indicated on the protocol sheet (red marked earphone at the left ear). The test person closes the eyes or turns his/her head away from the audiometer and grips the stick with the indicator button. The test person should press this button as soon as and as long as he/she hears a tone. During pressing the experimenter at the audiometer sees a light signal.

c) **Measurement**
Start with 1 kHz and 40 dB to give the test person a brief impression of what has to be recognized. Then start the test series: Bring the volume to -10 dB SPL and then slowly enhance the volume until the test person signals by pressing the indicator button a hearing sensation. This way the hearing threshold has already been exceeded. The volume is now decreased until the test person does not hear the tone and the light signal is switched off. Explore the exact hearing threshold by repeating this process. It is possible to improve the measurement by briefly switching of the tone (at…) because the discrimination threshold for volume differences is small. The smallest value for the threshold is protocolled on the protocol sheet. Test in the same manner the threshold for all the other frequencies above and below 1 kHz in a randomized series.

d) **Hearing threshold curve**
The audiometer detects the hearing loss of a test peron compared to normal healthy persons in dB. In the audiogram (protocol sheet) the mean hearing threshold curve of persons with healthy ears is shown across all frequencies as a straight line at 0 dB. The base underlying this straight line is shown in Fig. 2. Each line shows tones at different frequencies which are sensed as equally loud (isophones) although the sound pressure level changes. The hearing threshold is shown at 4 phone. Each straight line on the audiometer protocol sheet represents an isophone because the dB SPL level is adjusted to the different frequencies indicated by the audiometer.

e) **Evaluation: individual hearing threshold curve**
1. Take Fig. 2 and inscribe the measured hearing losses of the test person for the left and right ear (curves in diffent colours). Discuss the differences between the measured values and the mean hearing threshold curve. Name possible reasons for a hearing loss (use of music instruments, traumata…).
2. What would an audiogram look like with a general disturbance of the air conduction? Give 3 possible reasons for such a disturbance.
3. A person has a hearing loss of 20dB at 4 kHz at both ears. What would be the necessary sound pressure for this person to have any hearing sensation at 4kHz?

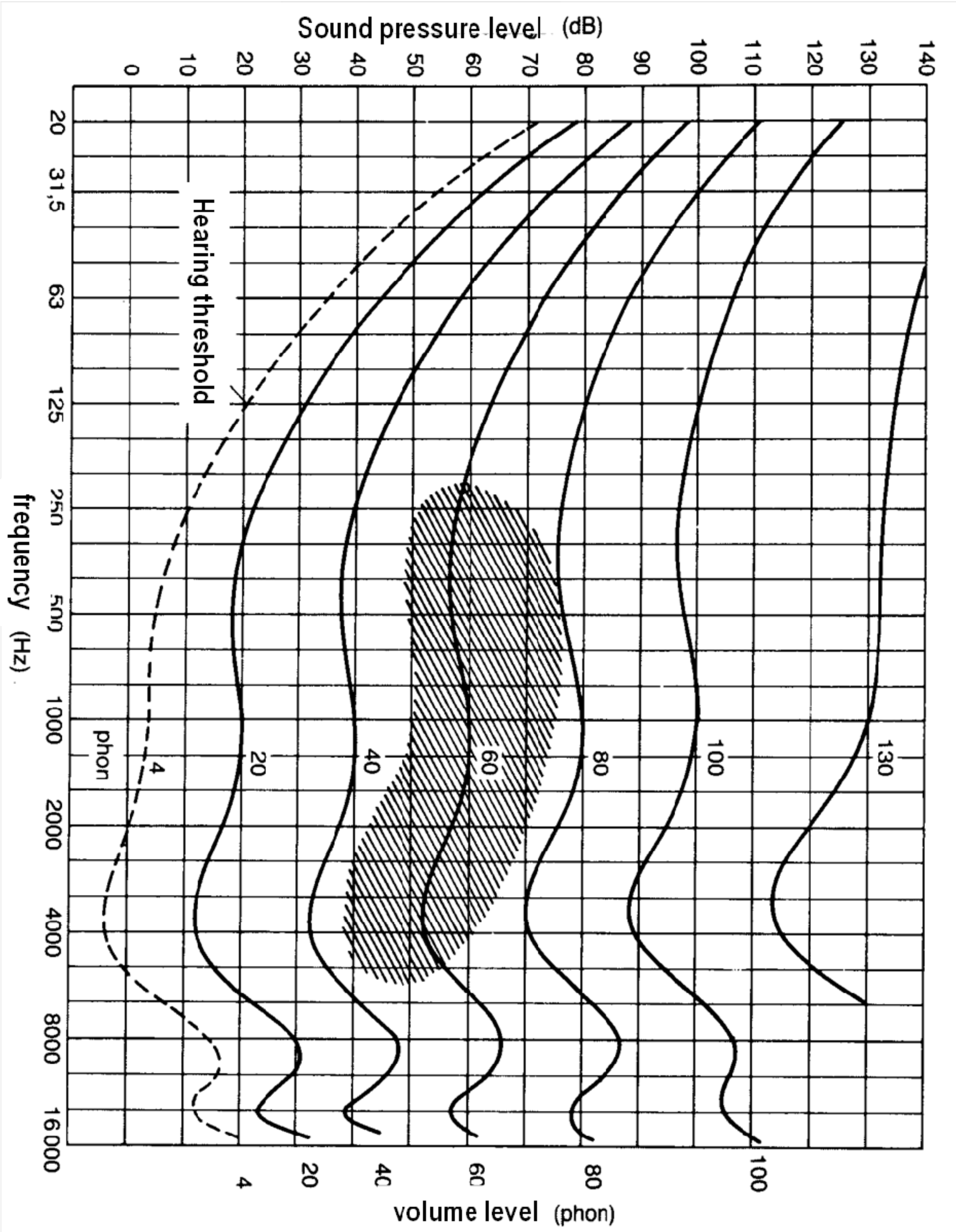


Fig. 2: mean hearing threshold graph and isophones between 4 and 130 Phon

II. Nystagmus

1. Aim

Observation of nystagmus after different ways of nystagmus induction

2. Introduction

Nystagmus is a sudden characteristic horizontal or vertical eye movement following vestibular, visual or caloric stimuli. A nystagmus consists of a slow follow-up component (**deviation**) and a fast switch-back movement of the eye (**saccade**). According to this fast component the direction of the nystagmus is defined.

During a passive circular motion of the body –in our experiment on a swivel chair – a **vestibular** stimulus is caused on the one hand. On the other hand the **visual** environment is shifted – **optokinetic Nystagmus** (e.g. occurring when looking out of a moving train). Thus two stimuli are acting together.

Which is the dominant stimulus?

The **vestibular Nystagmus** is generated as a compensatory movement of the eyes due to an activation of the vestibular system during an angular acceleration of the head. The slow component of the nystagmus supports the eye in fixing a certain point during head or body movements. The quick component (in direction of rotation) is a corrective movement independent of the vestibular corrections. The quick component can be divided into an initial phase (start of rotation) and a post-rotoatory phase (after stopping the rotation). Using special glasses (+20 dpt, by Frenzel) visual influences can be avoided. Wearing these glasses the test peson is especially myop and it is impossible to him/her to fix a point in the environment.

3. Experiment

Note: **Use the swivel chair only in the presence of the advisor!**

3.1. Observation of the optokinetic nystagmus

The test person (without Frenzel glasses) is being spinned on the swivel chair at a constant speed.The eye movement is observed during rotation to the right, the left, and directly after stopping.

Describe the eye movement and the optokinetic nystagmus.

3.2. Observation of the vestibular nystagmus

The test prson is wearing glasses by Frenzel and is spinned on the chair in the direction of the clock with increasing velocity (initial phase – per-rotatory). After a number of free rotations of the chair the movement is suddenly stopped and the eyes of the test person are observed (**post-rotatory** Nystagmus).

A)Results– Per-rotatory nystagmus :

	cupula-deviation	receptor-potential	direction of deviation	direction of nystagmus
right labyrinth				
left labyrinth				

B)*Results– post-rotatory nystagmus :*

	cupula-deviation	receptor-potential	direction of deviation	direction of nystagmus
right labyrinth				
left labyrinth				

Interprete the data. Draw a (simple) sheme of the situation in the labyrinth in A and B. (Direction of movement of the endolymph, distortion of stereocilia, polarization of the left and right hair cells)

3.3. **Barany and finger-to-nose test** (without Frenzel glasses)

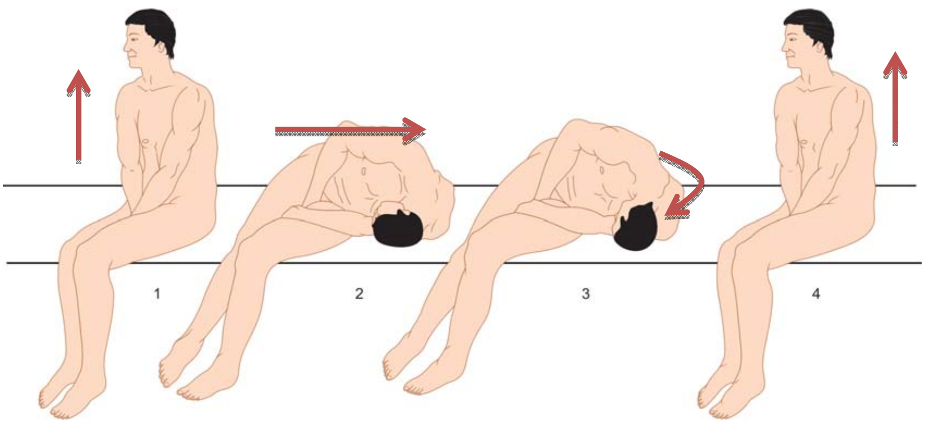
Rotation of the test person like in 3.1. but the eyes are closed.

1. Point directly to the front with a stretched arm after the stop. (Barany)
2. Point to the tip of the own nose

Describe and explain the observations.

3.4. Positional Vertigo

A doctor has diagnosed positional vertigo at the left side. It occurs when otoconia have been detached from the otolithic membrane and fall into the canals of the inner ear where they by changing the body or head position may stimulate the hair cells and cause vertigo. He uses the following procedure:



Why does the vertigo of the patient improve (in about 85%) ?
Make a simple drawing of the direction of the equilibrium organ when changing the body position and of the position of the loosened otoconia.

Vision

Lenses

Take a + lense. Look at a fixed structure (for example the cross of the window). Move the lense directly in front of your eye up and down and describe the movement of the picture.

Repeat the small experiment with a minus lense. Describe what you see

Take a cylintric lense and move it in a circle directly in front of your eye. Describe what you see

Explain what you see. A simple drawing would be helpful.

Measure the lenses with the aid of the optical bench. Move the lense on the bench until the two parallel laser spots concentrate in one focus. Read the distance between the focus point and the lense and calculate the dpt of the lense. There are cylintric lenses whch have two optical lense powers! Lenses which do not meet one focus point have to be corrected with a strong converging lense. Put it in the second slot of the optical bench. The readout in this case is the mean value of both lenses. Subtract the power (in dpt) of the lense you used as an aid.

Number of lense	**D**iverging lense **C**onverging lense C**y**lindrical lense	dpt

1____

2____

3____

4____

5____

6____

7____

8____

9____

10_______________________________________

11_______________________________________

12_______________________________________

Pupillary width

Close one eye with an eye patch.
Bring a text to your eye so that it's exactly in your near point (letters as big and sharp as possible). Measure the distance between eye and text (near point).
Bring a text very close to your eye (closer than the near point) so that the letters cannot be seen sharply. Bring the pinhole direct in front of your eye and look at the text. Measure how far you can reduce the distance between the eye and the text so that the letters are still sharp.

Nearpoint in cm____________________ in dpt________________________ without pinhole.
Nearpoint in cm____________________ in dpt________________________ with pinhole.

Describe and discuss the phenomenon.

Pulfrich effect

Sit about 1 m in front of the steadily moving pendulum. Observe with both eyes the movement. Bring one (or more) grey lenses in front of one eye. Observe the movement with both eyes. Change the grey lenses to the other eye.

What have you seen?

What are the explanations for te observed phenomenon?

I. Measuring pupillary distance

Measurement of the pupillary distance according to Scheiner during accommodation for near and far objects. The rangefinder for pupils (Scheiners' ruler) is positioned close to the eyes and adjusted to achieve binocular vision through the two small holes. Then the slide is shifted as far as only one hole is seen because the visual fields of both eyes are totally overlapping to form one concentric field. The distance between the holes on the rangefinder correlates to the distance of the pupils. Repeat the measurement three times for accommodation for far objects and for the maximal accommodation for near objects (physiologically about 10 cm).

Fill in the following table:

	pupillary distance focus on distant objects [mm]	*pupillary distance focus on near objects [mm]*
1. measurement		
3. measurement		
4. measurement		
mean		

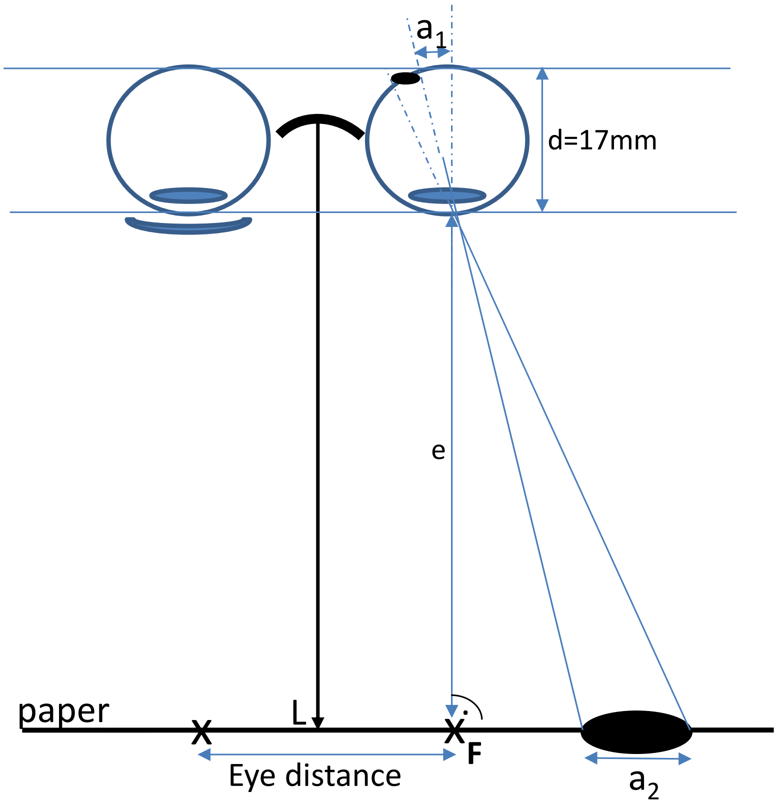
Explain what happens if the focus axis of the left and right eye are diverging.

II. Size and position of the blind spot

Detection of the blind spot of the left and right eye with a simple stand.

The stand is put on a paper where a reference line is drawn on which the crossing point of the lead hanging from the stand is marked (L). On each side of this point the distance to the pupil (during accommodation to far point) of the left and right eye is marked (detection of eye distance see II). The test person positions the root of his/her nose on the support of the stand. One eye is covered by an eye patch, the other is focussing F. The experimenter moves a pinhead from the side of the coverd eye along the reference line and marks the beginning and the end of the section on the line where the test person claims that he/she cannot see the pinhead.

The intercept theorem (e.g. $a_1/a_2 = d/e$) is used to detect position and size of the blind spot.



Give the following values for the blind spot left and right:

- *First nasal appearace in [mm] and [°]*
- *Temporal disappearance in [mm] and [°]*
- *Diameter in [mm] and [°]*

Explain why we do not have “black holes” in our visual perception..

Tips for your protocol:

Aim is to have one protocol in the end ! (not some filled-in instruction sheets and additional protocol sheets)
Give a **few** sentences of introduction to each topic.
Repeat experimental procedures only in brief (principle) and as far as they are necessary for the interpretation of the data.

Respond **thoroughly** to the tasks (usually written in **red**) in the manuscript and copy tables and graphs from the instruction sheets to your protocol.
Use simple drawings (by hand will do) if helpful.
Do not forget to interprete your individual data (compare them to physiological values, explain possible technical problems if necessary).