Phoneme Perception Test 2.0

October 2013

The Phoneme Perception Test is a NOAH-compatible software, designed for assessing your clients' hearing abilities. The Phoneme Perception Test is a new language independent speech test that works similar to typical free field speech audiometry. However, unlike usual speech audiometry principles, the Phoneme Perception Test is capable of delivering fitting advice on how to improve a hearing aid's setting for gain and frequency lowering. The goal is to improve your client's speech intelligibility while evaluating high frequency audibility and distinction by directly targeting hearing aid settings. A properly calibrated free-field-sound-system is an essential prerequisite for conducting this test.

The software provides a routine that will support the calibration of your computerized sound system. The use of the external input of your audiometer in your sound booth is also possible, if your fitting computer does not contain a calibrated stereo or surround sound system. For details on how to setup and calibrate the sound system, please refer to the "Calibration guideline" chapter of this document.

Content

PHONAK
life is on

Calibration reminder

The Phoneme Perception Test will start with a calibration-reminder. Calibration is an essential part of a reproducible test. You should be aware that the recorded test results are not valid without a proper calibration. Always make sure that your sound system is properly calibrated. It is recommended to run the calibration whenever you are not sure whether a preceding calibration is still valid or when some components of your sound system have been changed or moved. Please consult the Calibration guideline on how to run a calibration Click [Continue] in the right lower corner of the screen to proceed with the Phoneme Perception test, when you have confirmed that your sound system is properly calibrated.

Session management

With every client you can review or create sessions for the assessment of your client's abilities in detecting, recognizing and distinguishing high frequency speech sounds.

At the beginning of a new session, you will be asked, whether the test will be done with your client wearing hearing instruments (aided) or not (unaided). In case of an aided session, select the session with the hearing instrument fitting that you want to test. Select the according audiogram session in case of an unaided session.

View sessions and explore results

Clicking [View sessions] will guide you to the results screen, showing a detailed overview of the test result of the currently selected session (1).

Tick the box [Display expected threshold] (2) and select the appropriate combo box entry (3) (with this example: Moderate) for your clients hearing loss to display hatched overlays (7) on the result screen. This will enable you to judge whether the results are within or far off the expected result ranges for your client – for the detection results (solid bars) (4) as well as for recognition scores (spheres) (5). The lower the results are in the hatched areas indicates better results. Clicking on the pictogram (6) of another session on the vertical list on the left side of the screen will display the current session's results and the previous session's results side-by-side.

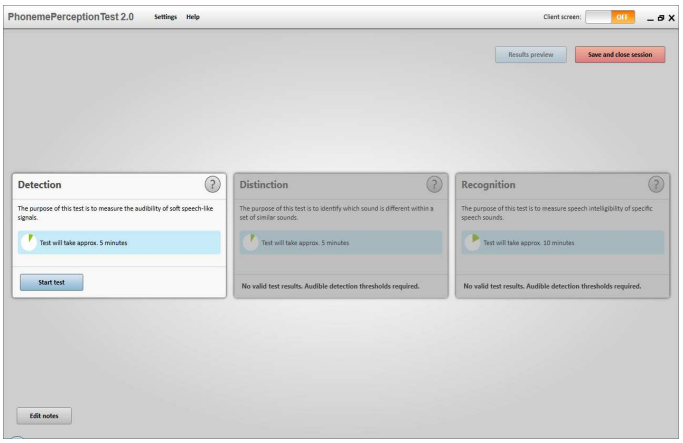
Test overview screen

The test overview screen displays all upcoming tests that are needed to run a complete Phoneme Perception Test session. Depending on the outcome of every test following tests might not be necessary.

Every test displays its purpose and the expected duration to complete. Clicking [?] in the right upper corner of each test-tile will provide some helpful background information about purpose and test execution.

Whenever a part of the Phoneme Perception Test is done, the according results can be shown by clicking [Preview results] in the test overview.

Once having entered this screen you can close the test sequence from within this screen by clicking
[Save and close session] in the right upper corner.



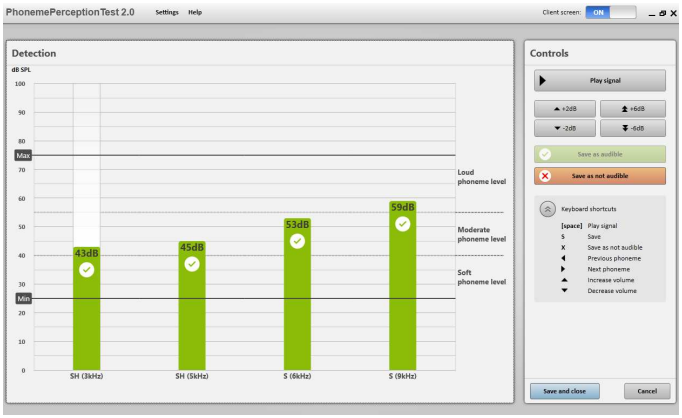
Detection test

The Detection test works like a free field audiogram.

Use the cursor keys or the according buttons to change the level of the presented speech-like sounds.

Press the SPACE bar or click [Play signal] to present the sound to the client.

Depending on whether your client hears or doesn't hear the sound, click [Save as audible] or [Save as not audible] or press the keyboard shortcuts [S] or [X] to store the detection threshold values of your client.



Distinction test

Use the distinction test to assess your clients' ability of to distinguish high frequency speech sounds */sh/ and /s/*. The Phoneme Perception Test will suggest running up to 3 distinction tests, depending on the results of the preceding detection test. Give your client the mouse and tell her/him to listen to the presented sounds and to click the button which was highlighted when the differing sound was heard.

We highly recommend to exclusively use a cable free mouse for doing this test, when passing the mouse to your client.

If you do not want to pass the mouse to your client, please detach the answer-sheet at the end of this document and preferably laminate it. Hand over this sheet to your client to let her/him point at the correct answers, and click the according answers yourself. Or – just simply let your client repeat what he has heard confirming the position-number of the differing sound.

The distinction test will – by default – start with training, allowing your client to adapt to the sounds and the way the test works. You can skip the training by un-checking the according option in the test overview screen.

You can control the flow of the test via keyboard, while your client is operating the test with the mouse. Pressing the space bar will open a small window, showing the currently played signals together with your client's responses.

Recognition test

Use the Recognition test to assess your clients' ability in recognizing high frequency speech sounds like */sh/ or /s/*. The speech sounds are embedded in a pair of vowels, forming non-sense words like */a-sh-a/*. Give your client the mouse and tell her/him to listen to the presented words and to click the button with the letter which is in the middle of a presented word.

We highly recommend to exclusively use a cable free mouse for doing this test, when passing the mouse to your client.

The Recognition test will – by default – start with training, allowing your client to adapt to the sounds and the way the test works. You can skip the training by un-checking the according option in the test overview screen
You can control the flow of the test via keyboard, while your client is operating the test with the mouse. Pressing the space bar will open a small window, showing the currently played signals together with your client's responses.

Calibration guideline

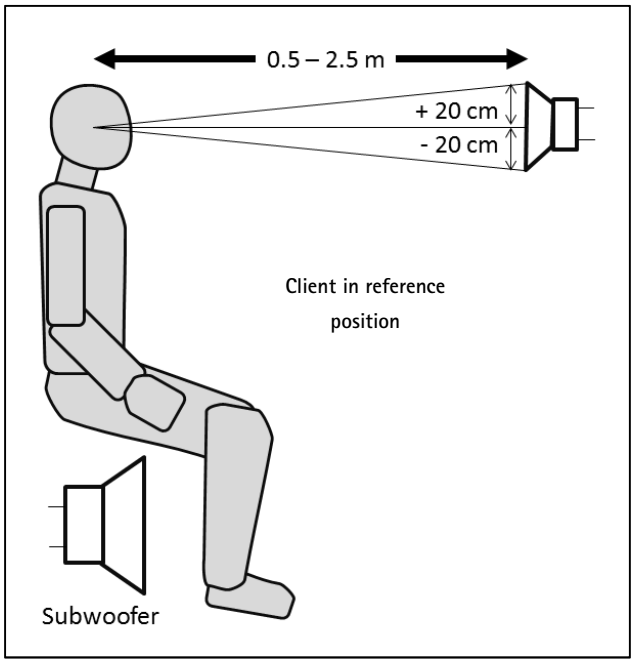
This chapter will guide you through the process of manually calibrating your sound system for the Phoneme perception test.

Definitions

A-Weighting:	A frequency-dependent energy weighting of spectral signals used in the context of measuring the level of sound signals. The weighting has most sensitivity within the range between 1 kHz and 5 kHz. Abbreviation is dB (A)
C-Weighting:	A frequency-dependent energy weighting of spectral signals used in the context of measuring the level of sound signals. The weighting shows a flat response (3 dB corner frequencies) between 250 Hz and 8 kHz. Abbreviation is dB (C)
Sound level meter:	Equipment designed to capture sound in a sound field and calculate the sound pressure level in decibels – a commercially available sound level meter (class 2, IEC 61672-1:2003). The Sound level meter must be capable of report the sound pressure level (dB SPL) within an accuracy of ± 2 dB and must provide the capability of displaying sound levels in dB (A).
Calibration Components:	Overall level calibration is calibration with a broad band sound. Spectral calibration is the dB (A) calibration of narrow band sounds.

Reference position:

Point in the sound field where sound levels are measured or sounds are made accessible for a client. The reference position is defined by height, angle and distance towards the sound source.



Sound equipment: The hardware used to produce sound examples to clients. This includes the computer, sound card, amplifier, and speakers.

Room: The room which contains the sound equipment.

Noah standard speaker configuration
The number of speakers, how they are arranged and the method of assigning segments of the recording to different speakers may vary.

Examples include two speaker system (front-back) (see figure 1), and surround 5.1 sound (see figure 2).

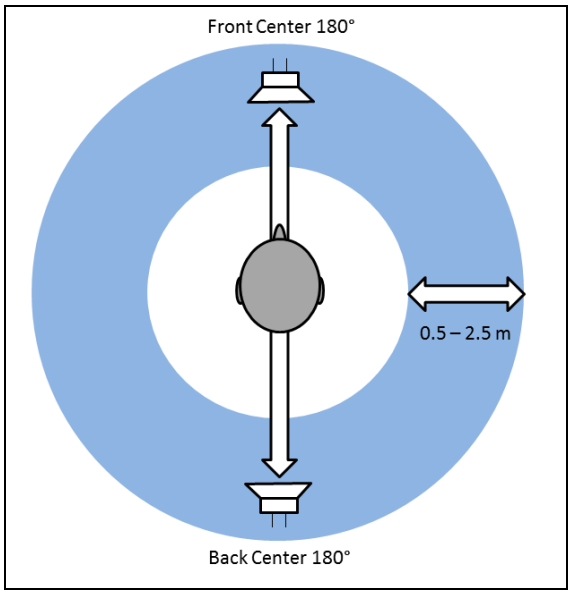


Figure 1

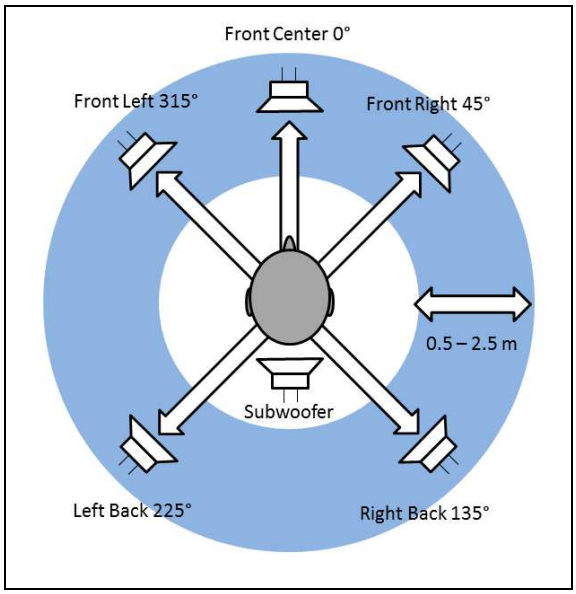


Figure 2

Importance of calibration

The Phoneme Perception Test delivers results which reliably help you assessing the hearing capabilities of your clients. The more precise the results are the better the assessment finally will be. Therefore it is recommended to regularly check whether the used sound equipment provides the correct levels – at least at the relevant frequencies. The phoneme perception test is especially sensitive for high frequencies. Therefore providing proper adjustment of the loudness for high frequencies of your sound equipment is essential for best results. Ideally you should never touch the level settings of your sound equipment or your computer volume (except for the purpose of re-calibration), once a calibration was done successfully.

How often should I calibrate?

The calibration procedure (overall level and separate adjustments of different high frequency signals) must be done prior to the first assessment session with a client. It is highly recommended to repeat the procedure whenever any component of the used sound system (e.g. loud speakers, amplifier, sound card, and computer) had been changed, replaced, or moved. It is also recommended to redo the whole calibration procedure from within the Phoneme perception test every 1-2 month to ensure correct, reproducible, and useful results.

The overall-level (of the broadband signal) should ideally be checked and calibrated every time prior to every test with a client.

How to calibrate

To start the calibration, open the Settings Menu and click [Start Calibration]. This will open the Calibration function of the Phoneme Perception Test. To do a proper calibration follow the steps described below:

1. Setup the audio equipment you are using
    a. Stereo (left speaker)
    b. Surround 5.1 (center speaker)

2. Select your audio equipment from the choices offered in the Phoneme Perception Test calibration screen.
3. Broadband calibration
    a. Click [Play sound] to present the overall calibration signal (broadband noise) via the center loudspeaker of your sound equipment
    b. Measure the level at the client's reference position (see previous page) using a sound level meter (class 2, IEC 61672-1:2003). The presentation level shall be 70 dB (A).
    c. Adjust the sound level of your sound equipment by [Program volume] until it matches 70 dB (A). In addition you can adjust the Windows volume to set the overall level for the Phoneme Perception Test.

4. Spectral calibration
    a. Click every button from [Play 0.5kHz] to [Play 8.0kHz], one after the other to play the frequency specific calibration signals (spectrally shaped noises) via the denoted loudspeaker of your sound equipment
    b. Measure the output at the client's reference position (see previous page) using a sound level meter (class 2, IEC 61672-1:2003). The presentation level shall be 70 dB (A) for each signal.
    If some of the played frequency specific calibration signals do not match 70 dB (A) within ± 2 dB tolerance, adjust your sound equipment amplifier until the levels match 70 dB (A).

    Ideally your sound system should be equipped with a graphic equalizer allowing specifically adjusting the levels around the denoted center frequencies of the frequency specific calibration sounds.

    c. After the adjustment procedure the tolerance for all sounds (broadband signal and separate high frequency signals) will be within this ± 2 dB tolerance for one setting of your sound equipment
    d. Recheck the broadband calibration settings by playing the broadband calibration sound (29) and checking its level.
    e. Click [Save] or [Cancel] to accept or discard the new configuration of your Audio equipment

Background information

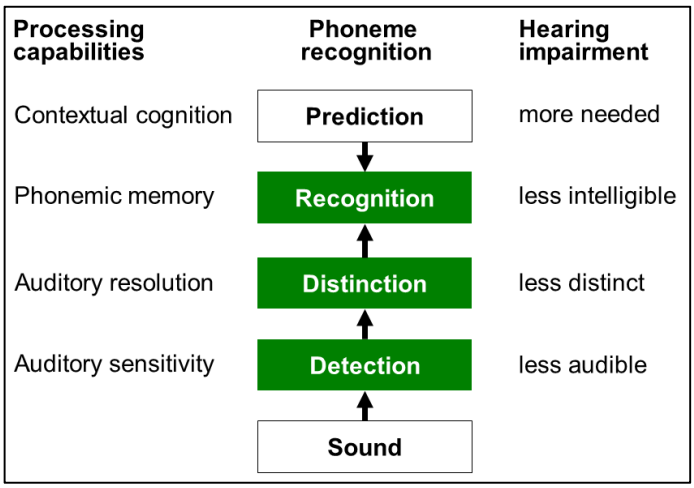
Speech intelligibility in quiet and in noisy situations is most important within the process of fitting hearing instruments. Verification of hearing-instrument-fittings using with available speech tests does not provide precise data on how to change hearing instrument behavior (gain, frequency lowering algorithms, sound cleaning, etc.) in order to optimize audibility and speech recognition for the hearing-impaired person.

What is Speech?

Speech is the vocalized form of human communication. Each spoken word consists of a limited set of vowels and consonants, called phonemes.

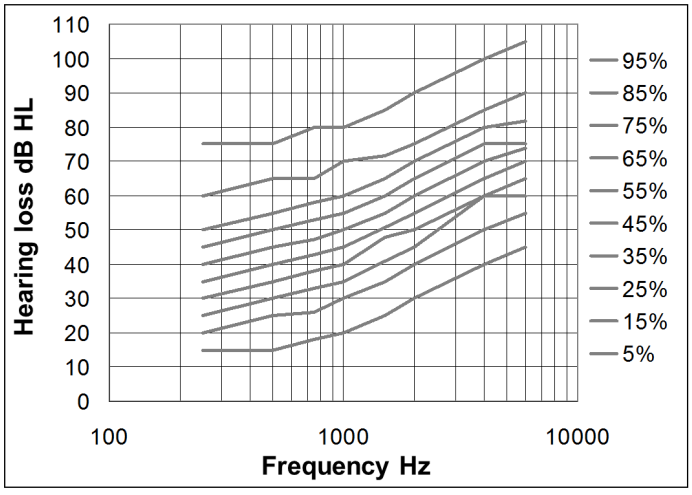
How does phoneme perception work?

The figure below shows how phoneme recognition works in principle, which speech-processing capabilities are needed and what are the consequences for hearing impairment. The figure also shows that the phoneme recognition steps "detection" and "distinction" are mainly driven by bottom up processes and "recognition" is strongly driven by top down processes. Hearing aids may help making things audible and due to better audibility, the processed information gets less/equal/more distinguishable. Therefore, recognition could increase immediately. Sometimes the hearing impaired person needs to "recalibrate" his/her phonemic memory first, before being able recognizing phonemes again. We call this process "acclimatization".



Why focus on high frequency speech sounds?

Hearing losses of most hearing impaired people are mainly dominant in high frequency regions (above 1.5 kHz) and less significant towards low frequencies (below 1 kHz). The figure below shows more than 8000 audiograms from Phonak clients divided in percentile clusters. The figure suggests that most hearing-impaired people would need high frequency support from hearing aids rather than low frequency support.



Bad high frequency hearing – consequences for speech intelligibility

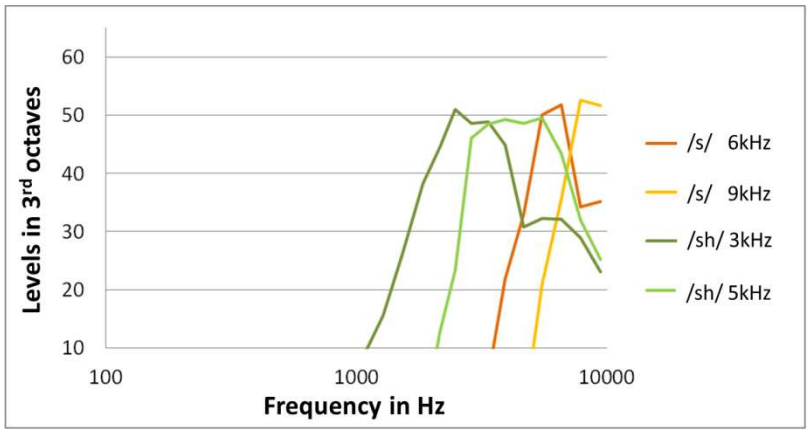
Unknown names, abbreviations, in noisy or reverberant conditions may lead to uncertainties, misunderstandings or lack of speech intelligibility. In situations with good phoneme predictability, e.g. conversation on familiar topics, reduced audibility for high frequencies may result in reduced redundancy, increased hearing effort, and early fatigue.

Why should a phoneme based speech test be useful?

Many languages share a couple of phonemes. It makes sence to create a test, which is useful for several languages. Phonemes may be pronounced differently for different languages and phonemes are used differently in words and sentences. Nevertheless, frequency, amplitude, duration and temporal structure are almost the same.

Why focus on /s/ and /sh/ sounds?

Many phonemes cover a broad frequency range. Unvoiced fricatives /s/ and /sh/ have unique cues in high frequencies as shown in the figure below. The spectral shapes of /s/ and /sh/ are almost equal. But the center frequencies can vary amongst speakers – male or female. Therefore, the test provides two /s/-sounds and two /sh/-sounds – one representing male the other one representing female speakers. Whenever additional frequency information is provided with the denoted phoneme (e.g. /s/ high (9 kHz)) the additional information addresses the center frequency of the phoneme.



Purpose of different sub-tests within the Phoneme Perception Test

As shown in the figures below, the *detection* test detects the level at which a hearing-impaired person begins to hear phonemes.

The *recognition* test measures the recognition performance for audible phonemes. In aided tests (persons are wearing hearing instruments), systematic confusions between two similar phonemes (e.g. /asha/ and /asa/) can originate from two reasons.

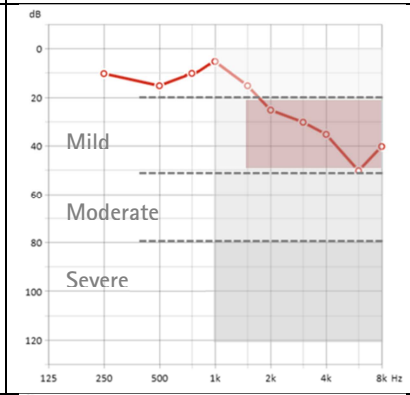
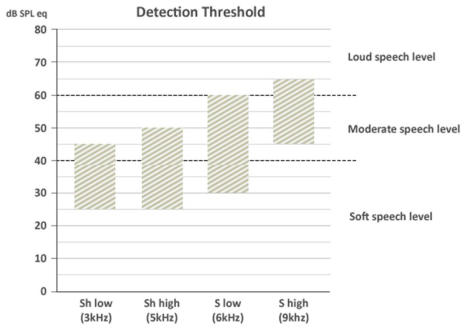
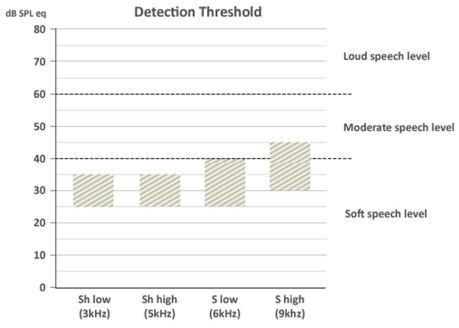
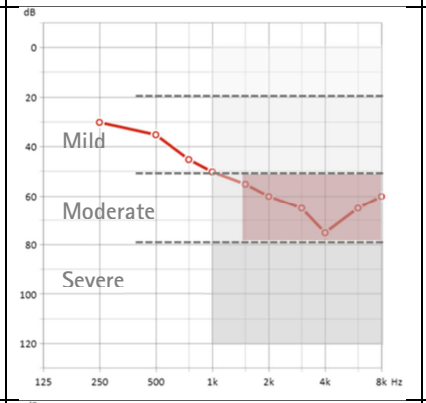
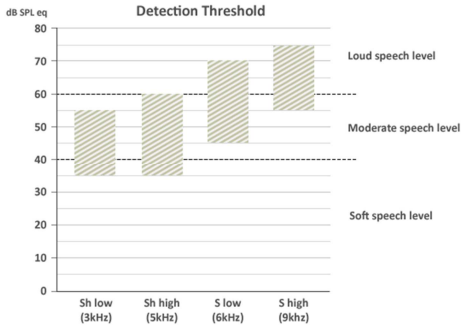
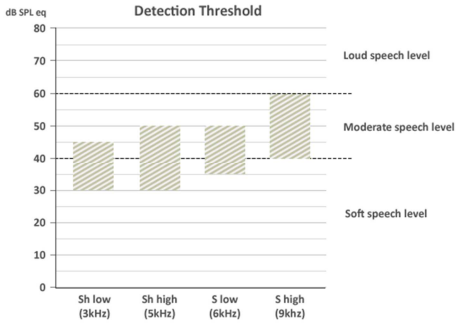
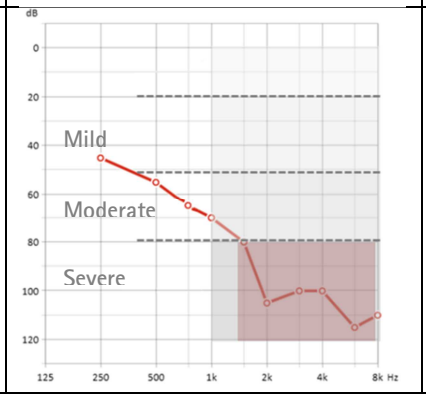
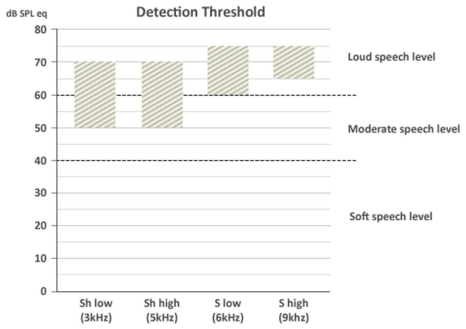
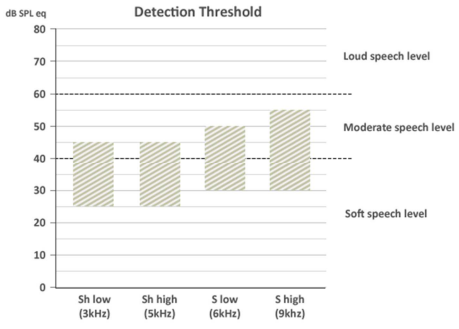
1. The hearing-impaired person is not used to the sound of the phonemes via hearing aids, yet and needs to acclimatize to the sound
2. Two phonemes are not distinguishable due to reduced frequency resolution or from frequency lowering settings being set too aggressively.

The distinction test can reveal the root cause of phoneme confusion

a) lack of acclimatization to the hearing instrument settings
b) reduced distinction capabilities of the wearer of the hearing aid

Using this test with different degrees of hearing losses

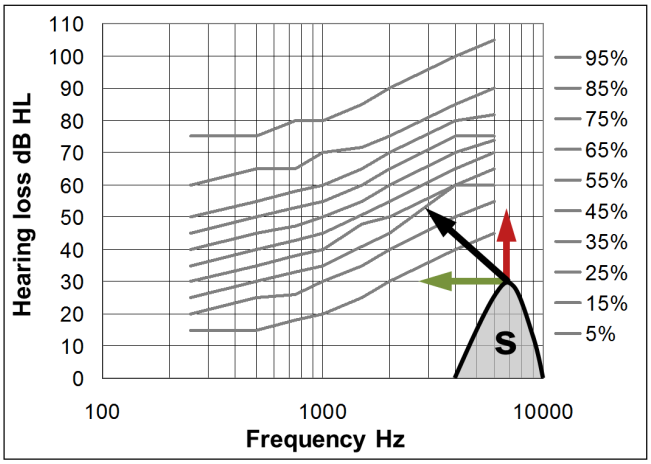
The phoneme perception test is applicable for all degrees of hearing losses – with and without hearing aids. However, the test outcome and the expectations where the detection thresholds are situated strongly depend on the degree of hearing loss. The table below shows the expected detection thresholds for three different classes of hearing loss – with and without hearing aids.

	Degree of hearing loss (with example audiogram)	Expected detection threshold without hearing instruments (unaided)	Expected detection threshold with hearing instruments (aided)
Mild			
Moderate			
Severe			

How to use the Phoneme Perception Test results to improve fitting

The Phoneme Perception Test delivers results which show hearing abilities and deficits of your client together with the strengths and weaknesses of fitted hearing aids – both in a comprehensive way.
Positive results of the test can be used as indication that further optimizations are no longer necessary, whereas negative results show the weaknesses of the current hearing aid fitting. You can tell positive results from negative, when all bars and spheres are within the hatched areas. These areas indicate the recommended range for results with a certain type of hearing loss. Whenever values are out of the denoted ranges, please, read the chapters below on how to deal with these situations.

How much gain and how much frequency lowering (e.g. SoundRecover) should I add?
Gain/amplification is the most effective parameter to increase audibility for high frequencies if the hearing loss within this frequency range is below 60 dB HL. For hearing losses above 60 dB or for hearing losses with very little dynamic range (residual range between thresholds of audibility and discomfort), frequency lowering or a combination of frequency lowering and increased amplification may be the right approach. But, how much of each component you can or you should add, this strongly depends on the hearing loss and the hearing instrument used and – of course – on the gain you can apply before feedback occurs.



Percentile levels of over 8000 audiograms

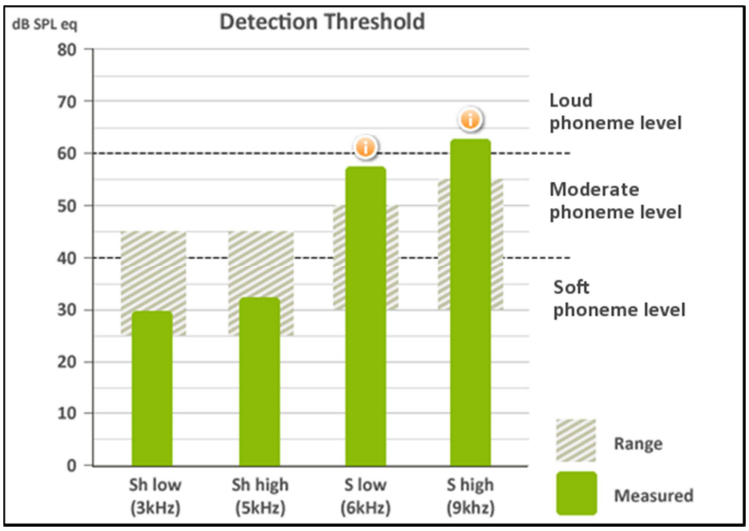
Amplification
Frequency lowering
Combination of amplification and frequency lowering

Applicable gain

Applying more gain in the high frequency regions of the hearing instrument often is the most appropriate means to regain audibility in these frequency ranges. As the phonemes are always displayed with their center frequency (e.g. /sh/ 5 kHz), it is easy to identify the frequencies with performance deficit.

The example shows an obvious lack of amplification at 6 kHz and at 9 kHz. This clearly suggests increasing the gain for speech sounds between 6 kHz and 9 kHz to reach the targeted perception thresholds (hatched areas).

These hatched target-areas, which depend on the client's hearing loss, can be displayed by selecting the according entry in the shown drop-down box within the session overview



However, take care not to over amplify denoted gain ranges, since this will lead to adverse effects like increased feedback tendency and poor clients' acceptance tothe adapted hearing aids.

Since the available additional gain in the hearing aids depends on the feedback threshold that is set within the hearing aid, it might be a good idea to go to more occluded fittings whenever available gain headroom does not suffice to restore clients' high frequency audibility.

Applicable frequency lowering

If the worn hearing aids are equipped with a frequency lowering functionality (e.g. Spectral iQ™, Audibility Extender, SoundRecover™) these functions are alternative or supporting methods to restore the clients' audibility for high frequency fricative sounds (/s/, /sh/). Frequency-lowering techniques offer means to map inaudible sounds back into your client's residual hearing, when your client has a hearing loss which is sloping to higher frequencies.

Applying frequency lowering – when available – provides two advantages:

1. The high-frequency fricatives are shifted/transposed/compressed into a frequency area, where clients' hearing usually is much better than in the original frequency area of the according speech sounds
2. The hearing instruments usually provide much more gain in the shifted/ transposed/compressed area than in the original areas of high-frequency speech sounds which adds extra gain advantage

Though this may suggest that the more lowering you apply the better, there are drawback.

- Applying too much of frequency lowering will make the sound of the hearing aids strange and adverse for your client.

Clients with high-frequency sloping hearing losses also suffer from bad frequency resolution capabilities. Increasing the strength of frequency-lowering settings in frequency regions with reduced resolution may even worsen this handicap. This may result in reduced distinguishability of similarly sounding fricatives as e.g. /s/ and /sh/.

Regarding the distinction – be careful

The Phoneme Perception Test proposes to pursue a distinction test whenever there is clear indication, that reduced distinguishability might be the root cause for reducedrecognition scores. The outcome of the distinction test will indicate whether

a) lack of acclimatization to a hearing instrument setting
b) Reduced distinguishability is the reason for reducedrecognition scores of your client.

The traffic light indicators show whether distinction capabilities are generally good while acclimatization is missing, or whether wrong hearing instrument settings and/or physiological reasons of your client are the root cause for reduced distinction capabilities

.

= distinction good, maybe lack of acclimatization (give client some time to acclimatize to instruments)

= distinction OK (hearing instrument, client's hearing loss)

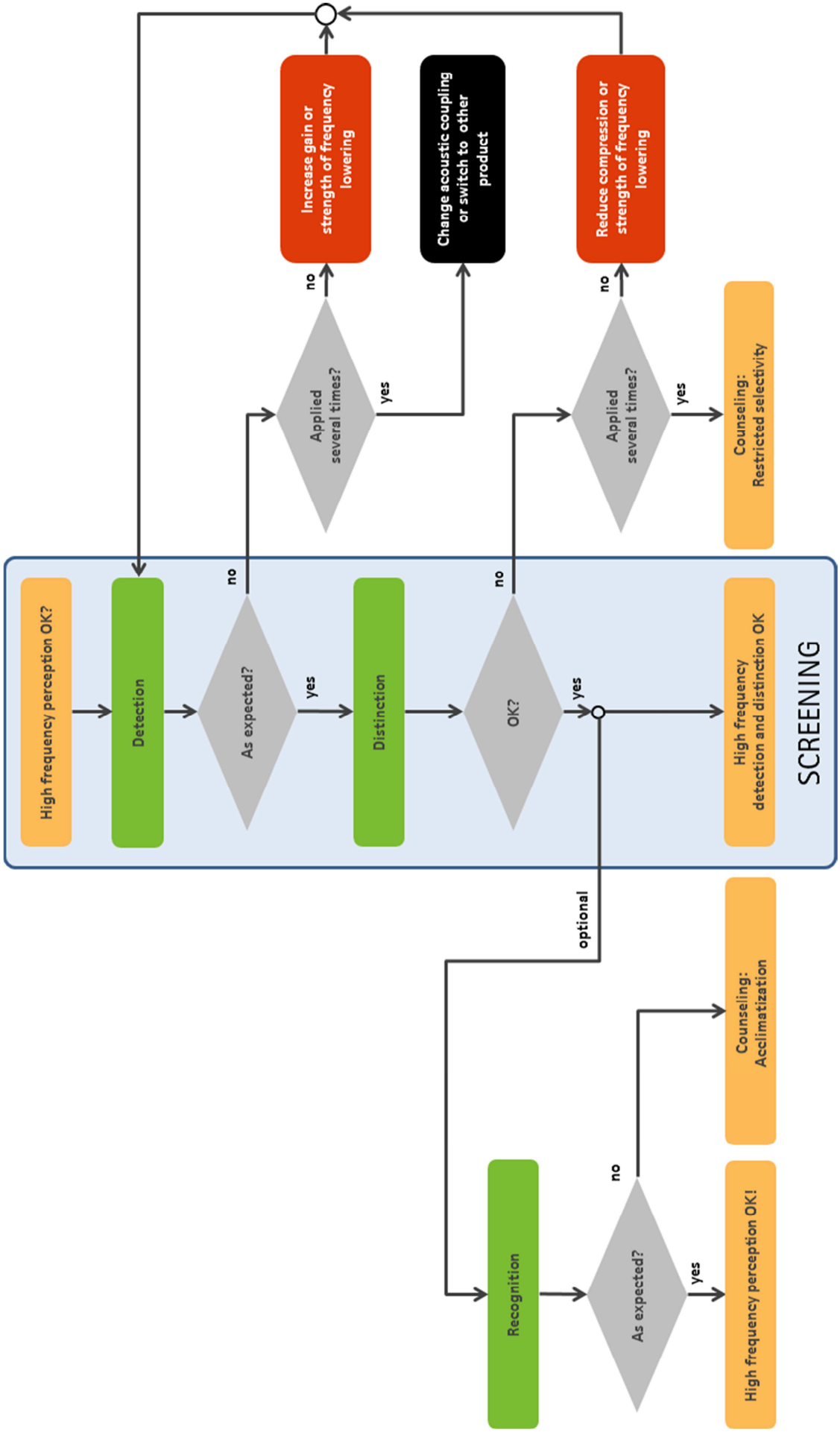
= distinction reduced (hearing instrument, client's hearing loss)

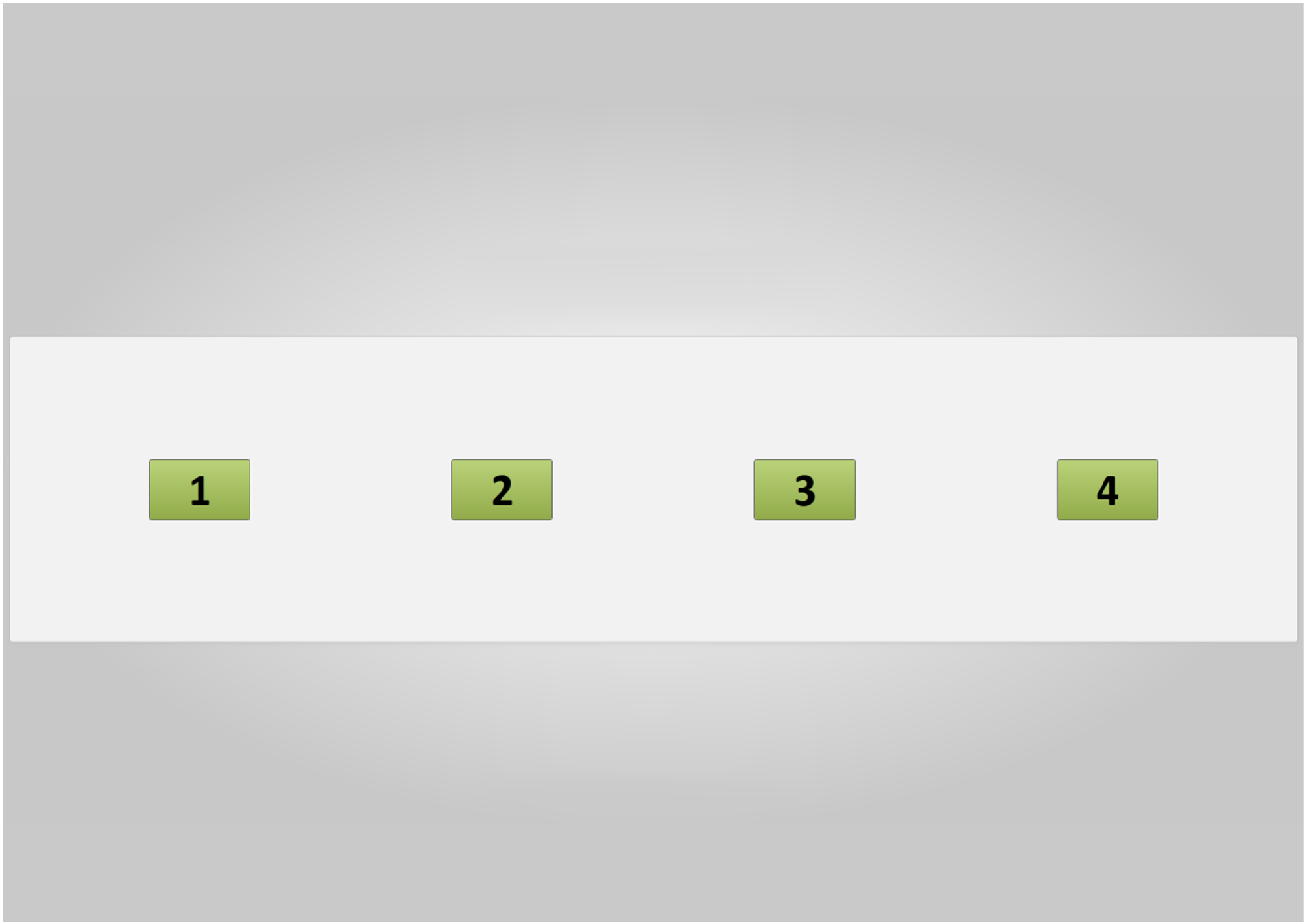
In the case of OK or reduced distinction there is no use in trying to apply stronger frequency-lowering settings, since this would worsen the recognition score as well as the distinction score. In this case, you even may consider reducing the strength of frequency lowering of the hearing instruments to provide better phoneme distinction capabilities for your client.

Otherwise –stronger frequency lowering may help in restoring the audibility of /s/ and /sh/ sounds, as long as your client is capable of distinguishing similarly sounding fricatives while wearing hearing instruments.

Frequency-lowering features can change the perception of sounds more than expected and could require your client to acclimatize to these new frequency-lowering settings.

Flow chart for actions and decisions

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3
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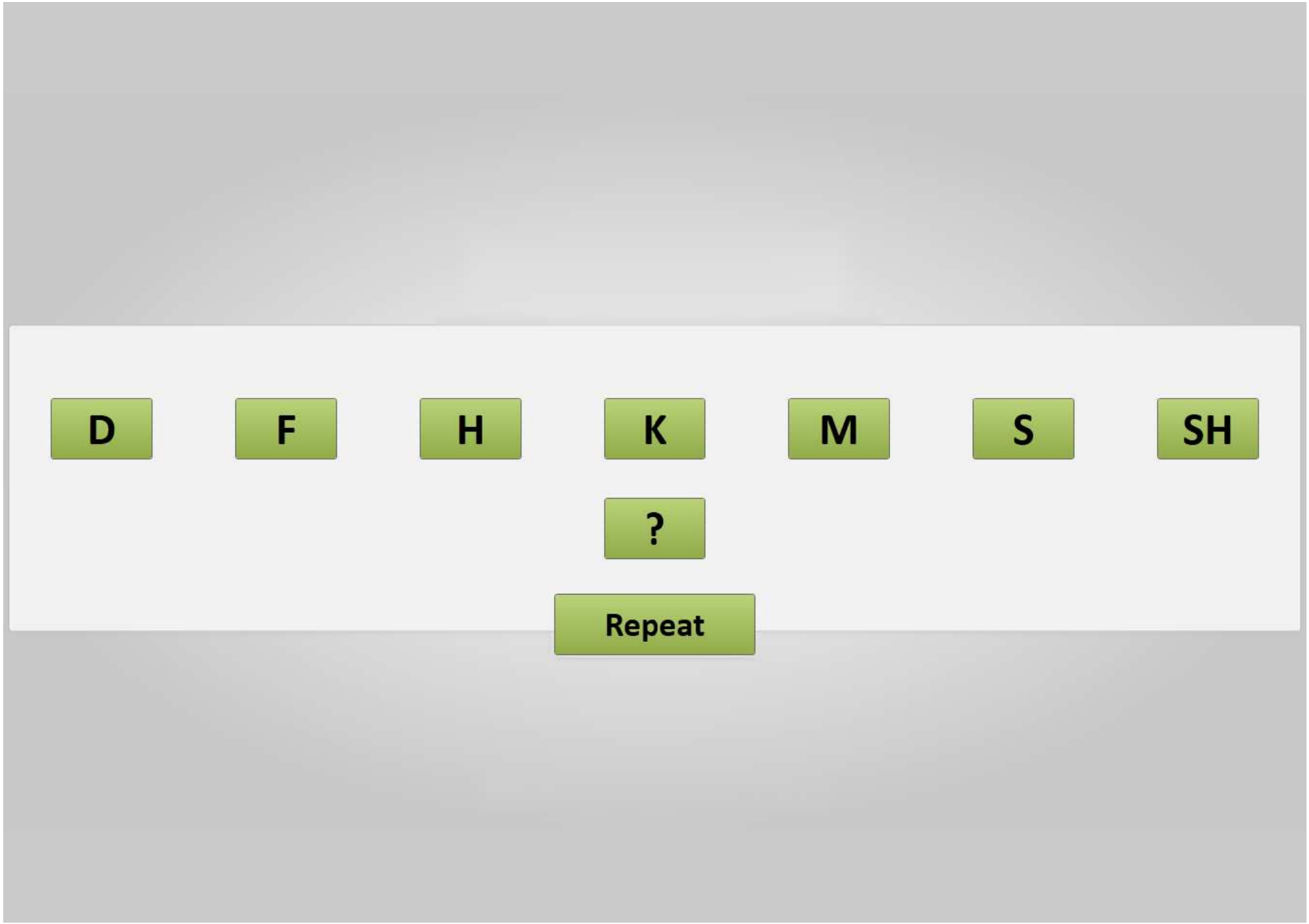
D
F
H
K
M
S
SH
?
Repeat

System requirements

Software	Phoneme Perception Test
Processor	Pentium IV, 2 GHz or faster
RAM	2 GB or more
Hard disk space	200 MB or more
Operating system	• MS Windows XP, 32 bit, SP2 and later • MS Windows Vista, 32 bit / 64 bit, latest SP • MS Windows 7, 32 bit / 64 bit
Screen resolution	1280 x 1024 pixels or more
Graphic card	• 16 Million (24bit) screen colors or more • DirectX 9 capable / Premium Ready PC
Drive	DVD-Rom or CD-Rom
Browser	Internet Browser
Sound card	Surround 5.1 or stereo
Playback system	200 Hz – 10 kHz (± 2 dB), 93 dB 50 Hz – 14kHz (± 5dB)

Manufacturer:
Phonak AG
Laubisrütistrasse 28
CH-8712 Stäfa
Switzerland