EUHA Guideline

Wireless remote microphone systems – configuration, verification and measurement of individual benefit

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1. Introduction

In various everyday situations, the wireless transmission of a signal of a remotely positioned microphone can improve speech intelligibility and reduce listening effort. This technology especially helps hearing impaired people in difficult situations, e.g. listening in a classroom or lecture hall.

There are different types of implementation of, and names for, this technology where the signal of a remotely positioned microphone is wirelessly transmitted to the listener, such as classical FM systems, wireless or remote microphones, or systems involving a smartphone. In the following, a system providing this technology is referred to as a wireless remote microphone system (WRMS or WRM system). In addition, the remotely positioned microphone is generally called a remote microphone.

The goal of these Guidelines is to provide a possibility of measuring the individual benefit of a WRM system (see section 3). As reference situation, listening in a classroom or lecture hall is emulated. In that way, it is possible

- to compare performance with and without WRM system,
- and to compare performance of different WRM systems.

Although the measurement setup emulates a real-life situation, it is designed such that it is easy to apply in practice (e.g. for a hearing aid professional, an ENT doctor, a clinic, in schools, in pediatric centres, etc.). Furthermore, the setup allows to test normal and hearing impaired people using hearing aids, cochlear implants, or other devices compensating for a hearing loss.

Before individual benefit can be measured, the WRM system is required to be correctly configured. Therefore, in section 2, we shall describe how to configure the WRM system, and how to verify its configuration. Only when this step has been completed, can a reliable measurement of individual benefit using the procedure be explained in section 3.

Note: All explanations in these Guidelines are given in a general way, without making reference to any manufacturer-specific audiometric equipment. However, manufacturers of audiometric equipment are invited to send a document to the EUHA, providing specific information about an implementation using their equipment. For this purpose, please contact the EUHA by e-mailing to info@euho.org. Before sharing this information, the EUHA will check the document. The EUHA reserves the right to reject documents due to inappropriate content. If the document is accepted, the EUHA will make the information available on its website together with these Guidelines.

2. Configuration and verification of the transfer characteristic

If loudness, or, to be precise, the transfer characteristic of the WRM system is too soft, the sound in close proximity to the listener masks the wirelessly transmitted speech signal. In this case, the benefit of the WRM system is limited, or completely lost. On the other hand, if the transfer characteristic of the WRM system is too loud, the user is isolated and cannot recognise any sounds in close proximity. As a result, no communication with other people such as colleagues, classmates, etc. is possible anymore. Thus, our suggestion is to adjust the transfer characteristic of the WRM system so that the signal of the speaker (e.g. the lecturer or teacher) is dominant, but sounds in the immediate environment (e.g. comments of other people) can still be recognised.

Since the transfer characteristic of the WRMS directly effects the benefit for the user, it is necessary to configure this parameter such that it can be reproduced. Only when this step has been completed, can a reliable measurement of individual benefit using the procedure be explained in section 3. Thus, in the following, different methods to configure and verify the configuration of WRM systems are presented. The basis for these methods is the so-called "10 dB FM advantage", which is described in the Guidelines for Fitting and Monitoring FM Systems written by the ASHA Ad Hoc Committee on FM Systems in 1999 [1]. The 10 dB FM advantage is aimed at making the wirelessly transmitted signal of the remote microphone 10 dB louder than sounds in the immediate environment of the listener. Since direct measurement of the FM advantage is often difficult to perform in practice (see Appendix I - a)), as an alternative, transparency of the WRM system is demanded:

The transfer characteristic of the WRM system is transparent if the International Speech Test Signal (ISTS), provided with 65 dB SPL at the remote microphone, generates an equal output signal for the user to an ISTS with 65 dB SPL without WRMS. In this context, "equal" means that in both cases, the signal recognised by the user differs by not more than ±5 dB in the frequency range from 800 Hz to 3.5 kHz.

2.1 Verification of transparency for hearing aids in a test box

The following procedure allows us to verify transparency for hearing aids in a test box. For reasons of clearness, detailed background information is omitted in this section, but can be found in Appendix I - b).

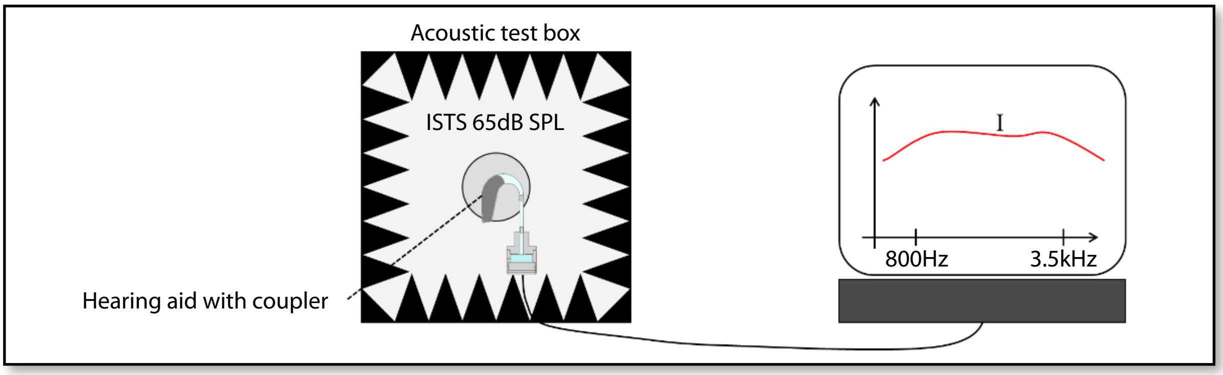

Fig. 1: Transparency measurement for hearing aids – step I - no connection to the WRM system

(I) Apply the regular every day configuration to the hearing aid so that there is no connection to the WRM system. Measure the output characteristic of the hearing aid using an ISTS of 65 dB in a frequency range between 800 Hz and 3.5 kHz.

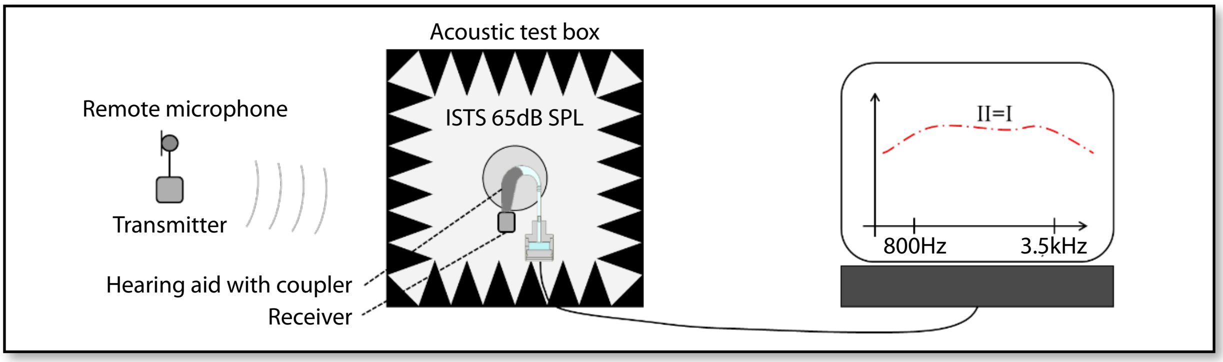

Fig. 2: Transparency measurement for hearing aids – step II – hearing aid inside the test box

(II) Connect the hearing aid to the WRM system and place the remote microphone at a quiet position outside the test box. Measure the output characteristic of the hearing aid using an ISTS of 65 dB in a frequency range between 800 Hz and 3.5 kHz. In this frequency range, the output characteristic has to equal (±5 dB) the characteristic of step I. If necessary, adjust the setting of the hearing aid accordingly.

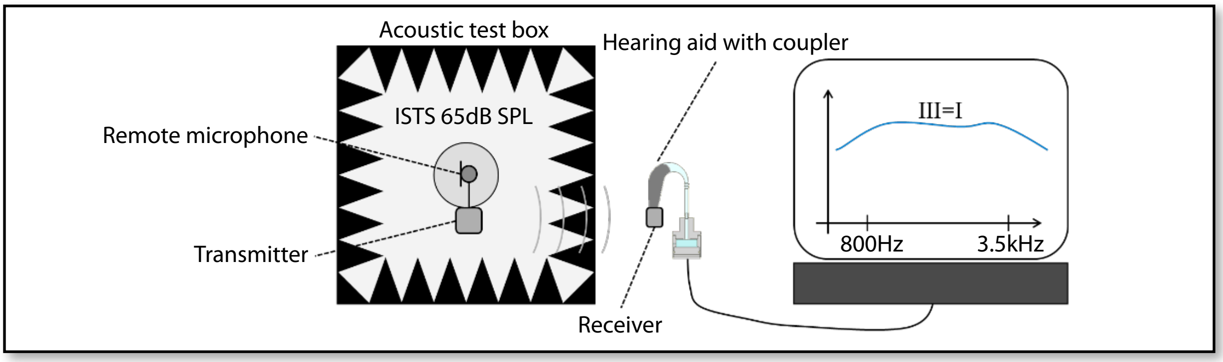

Fig. 3: Transparency measurement for hearing aids – step III – remote microphone inside the test box

(III) Place the remote microphone inside the test box and measure the output characteristic of the hearing aid using an ISTS of 65 dB in a frequency range between 800 Hz and 3.5 kHz. For WRM systems with a directional remote microphone arrange the microphone in the direction of the loudspeaker (see Appendix I - c)). Should there be different settings for the directionality of the remote microphone, choose the setting intended for the real situation. The measurement result is to equal the characteristic measured in step I (±5 dB). If necessary, adjust the setting of the hearing aid and/or of the WRM system accordingly.

Note: If the setting needs to be adjusted, step II must be repeated!

For reliable measurement results in step II and step III, the hearing aid or remote microphone is required to be placed in a "quiet" position. Therefore, using the procedure described below, check each time whether the selected position is sufficiently quiet.

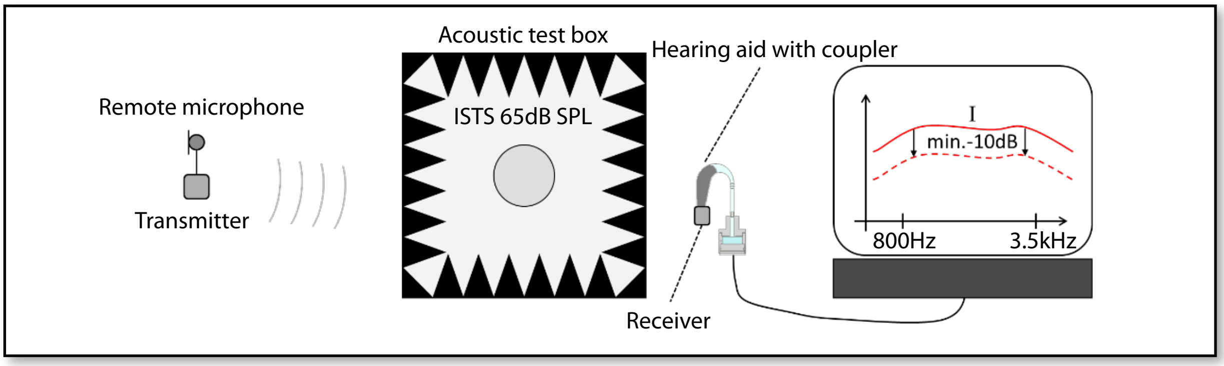

Fig. 4: Verification of the measurement conditions with empty test box

Verification of the measurement conditions: Place both the hearing aid and the remote microphone outside the test box (see Fig. 4). Make sure that there is a connection between the hearing aid and the WRM system, as in step II and step III. Measure the output characteristic of the hearing aid. In a frequency range between 800 Hz and 3.5 kHz, this characteristic needs to be at least 10 dB below the characteristic of step I.

2.2 Subjective verification of transparency

The subjective assessment of the transparency can be done for persons with and without hearing impairment, and for persons wearing cochlear implants or other types of hearing devices. As this assessment does not, however, include an objective, frequency-related evaluation of the transmission characteristic, hearing aids should be evaluated using the method described in section 2.1. For children wearing hearing aids, the quantitative assessment as shown in section 2.1 is indispensable.

Preparation: Connect the WRM system and adjust it to the actual user settings. Have the user take a seat in an acoustic test chamber where you can produce an ISTS at 65 dB SPL in the free sound field. Place the wireless microphone in a test box in which you can also produce an ISTS at 65 dB SPL. For WRM systems with directional microphone technology, the remote microphone must point at the speech signal loudspeaker (see Appendix I - c). If the directional characteristic of the microphone can be adjusted, the system should be set to the actual user settings.

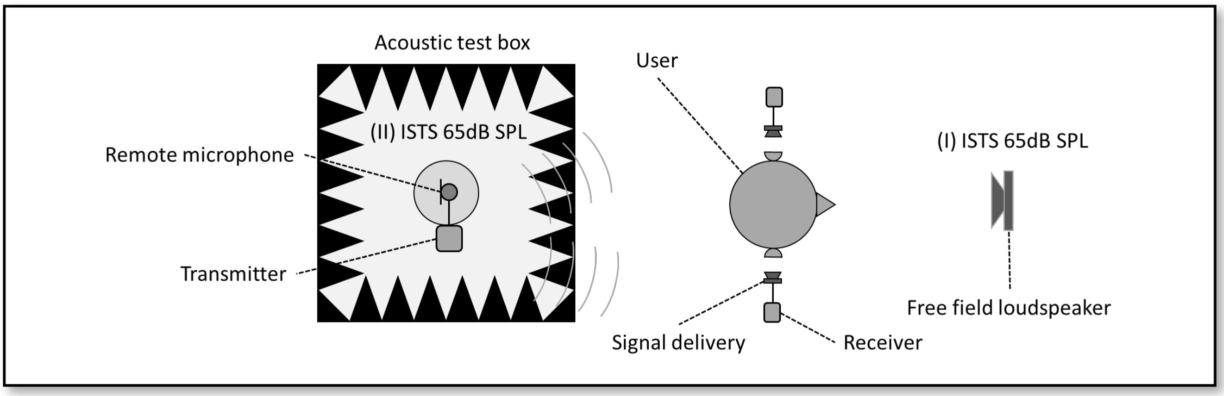

Fig. 5: Subjective evaluation of transparency. The "signal delivery" function block represents hearing aids, cochlea implants, or receiver systems for people without impaired hearing.

(I) *In the free sound field only*, produce an ISTS at 65 dB SPL and ask the user to memorise the volume (and preferably also the transmission characteristic).

(II) *In the acoustic test box only*, produce an ISTS at 65 dB SPL and ask the user whether the volume (and transmission characteristic) is the same as that of the free sound field signal. If this is not the case, adjust the volume (and transmission characteristic) at the WRM system. Repeat steps (I) and (II) until the user is sure that the volume (and transmission characteristic) is the same in both test situations.

2.3 In-situ testing of transparency

If the signal transmitted through the wireless system is also made audible by the receiver unit, as is the case with hearing aids and WRM systems for people without impaired hearing, the transparency can be assessed in situ. To do this, proceed as described in section 2.2. However, rather than relying on user memory and feedback, measure the sound pressure in front of the eardrum, with and without WRM system. This method allows for the quantitative assessment and adjustment of transparency. Please note, however, that most measuring systems used today do not support simultaneous ISTS emission and recording in a test box for in-situ measurement.

3. Electroacoustic evaluation of subjective benefit

3.1 Test arrangement

For this test, a test arrangement as shown in Fig. 6 is used, consisting of the following components:

- dual-channel speech audiometer
- 3 speakers

One channel of the audiometer is used to play useful signals at an angle of 0° to the user, while the second channel is used to play noise through two speakers arranged at right angles to the axis between audiometer and the user.

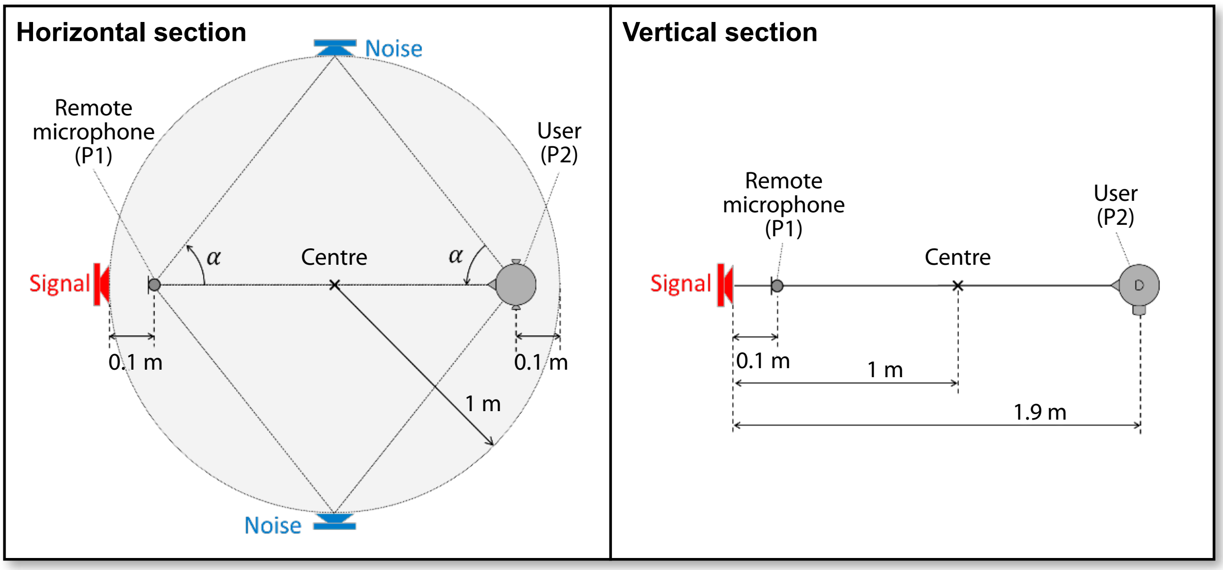

Fig. 6: Diagram of test arrangement. P1 indicates the position of the remote microphone. P2 indicates the position of the user.

The test setup should always be implemented in cooperation with the audiometer manufacturer. For more information regarding the implementation of the test setup, see Appendix I. Please note that the actual test arrangement might deviate within certain limits from the recommended arrangement shown in Fig. 6. In such a case, the limits specified in Appendix II - d) must be strictly adhered to. In addition, the fact that the test arrangement deviated from the recommended one must be noted in the test reports (e.g. in the form given in Appendix IV).

3.2 Test procedure

Ensure that the remote microphone is at the correct distance and angle to the speech signal speaker. For more information, refer to Appendix II - b). In WRM systems with directional microphone technology, the remote microphone must point at the speech signal speaker. If the directional characteristic of the microphone can be adjusted, the system should be set to the actual user settings.

Speech intelligibility is assessed both *with* and *without* the WRM system. The test arrangement simulates a typical lecture hall where the listener is at a distance of 4 m from the speaker. For more information, see Appendix III - a). The tests are performed with a background noise of 60 dB SPL and/or 70 dB SPL. To perform the tests, proceed as follows:

Speech intelligibility test without WRM system

- Set the speech signal at the user to 58 dB SPL.
- Set the background noise at the user and at the directional microphone to 60 dB SPL.
- Perform a speech intelligibility test, e.g. Freiburg word test.
- If speech intelligibility is greater than 50%, repeat the test with a background noise of 70 dB SPL.

Speech intelligibility test with WRM system

- Ensure that the volume of the WRM system is set correctly (see section 2).
- At the remote microphone, set the speech signal level as follows:
  - to 80 dB SPL for microphones worn around the neck
  - to 85 dB SPL for microphones positioned in front of the mouth
- Set the background noise at the user and at the remote microphone to 60 dB SPL.
- Perform the speech intelligibility test as described above.
- When the test without WRM system is performed with a background noise of 70 dB SPL, the test with WRM system must also be performed with 70 dB SPL.

The signal-to-noise ratio for lecture situations with low and/or medium background noise (60 dB SPL and 70 dB SPL, respectively) is determined from the speech intelligibility tests with and without WRM system. Possible results are illustrated and discussed in Appendix III - b), using three examples. Appendix IV includes a form for the documentation of the tests and results.

References

[1] ASHA Ad Hoc Committee on FM Systems, *Guidelines for Fitting and Monitoring FM Systems*, 1999.

[2] Holube, Inga; Fredelake, Stefan; Vlaming, Marcel; Kollmeier, Birger. Development and analysis of an International Speech Test Signal (ISTS). Int J Audiol 49(12): 891-903, 2010.

[3] Hagerman, Björn; Olofsson, Åke. A method to measure the effect of noise reduction algorithms using simultaneous speech in noise. Acta Acustica united with Acustica 90(2): 356-361, 2004.

[4] Husstedt, Hendrik; Steinhauer, Julia. Practicability study of a setup for the evaluation of wireless remote microphone technology. AudiologyNow!, April 2016.

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Appendix

Appendix I **Explanations and instructions for transparency assessments**

Appendix II **Instructions on the implementation of the test setup for subjective benefit assessment**

Appendix III **Comments on the test setup for subjective benefit assessment**

Appendix IV **Test report for wireless remote microphone systems according to the EUHA Guideline "Wireless remote microphone systems"**

Appendix I Explanations and instructions for transparency assessment

a) Relationship between 10-dB FM gain and acoustic transparency

As signal processing is not linear, it is often not possible to accurately measure the 10-dB FM gain. Non-linear signal processing such as volume compression normally takes place in both the WRM system and the hearing aids. To examine this in more detail, let us have a look at hearing aid coupling. The 10-dB FM gain can only be accurately assessed with a simultaneous signal at both the remote microphone and the hearing aid microphone. Sequential measurements normally return incorrect results, as signal processing is not linear. The sound pressure levels must be chosen in line with the envisaged application, e.g. 80 dB SPL at the remote microphone and 65 dB SPL at the hearing aid microphones, as both signals must be recorded at the output of the hearing aid. In order to show that the signal coupled through the remote microphone is 10 dB louder than that coupled through the hearing aid microphone, the two signals need to be separated. This can, for example, be done with the method developed by Hagerman and Olofsson [3]. As this method is not readily available to practitioners, a substitute method based on transparency has been developed (see section 2). According to this substitute method, the output signal generated with an ISTS of 65 dB at the remote microphone is the same as that generated with an ISTS of 65 dB at the hearing aid microphone. As the same input level is used, the application point is also more or less the same so that sequential measurement is possible, despite non-linear signal processing. If the transparency criterion is met at 65 dB, it is most likely that an FM gain of approximately 10 dB can be achieved in the actual application. This is primarily due to the fact that the remote microphone is placed close to the mouth of the speaker so that there is a significantly higher sound pressure level of around 80 dB. If signal processing were perfectly linear, the transparency requirement would thus result in an FM gain of 15 dB. As an input level of 80 dB normally results in volume compression, the FM gain is more likely to be around 10 dB. We also wish to state that the extent of the FM gain due to the transparency criterion cannot be accurately predicted or assessed.

b) Assessment of transparency of hearing aids in acoustic test box

The procedure for the assessment and adjustment of the transparency of hearing aids in the acoustic test box consists of three steps (see section 2.1).

In step I, the reference characteristic at the hearing aid output with actual user settings and without WRM system is measured and recorded with an ISTS of 65 dB SPL.

In step II, the WRM system is connected to the hearing aid, and the output is measured again with an ISTS of 65 dB SPL at the input of the hearing aid. As the remote microphone is located at a quiet location outside the acoustic test box, the output signal is generated solely by the input signal of the hearing aid microphones. Therefore, the characteristic should correspond to that determined in step I, with some allowance for minor measuring deviations. With certain hearing aids, the transmission characteristic for input through the hearing aid microphones might, however, change when the device is coupled to a WRM system. The above measurement is performed to evaluate whether this is the case.

In step III, the transmission characteristic of the WRM system is evaluated in order to determine whether it is transparent with regard to transmission through hearing aid microphones. According to the definition in section 2, an ISTS of 65 dB transmitted by a remote microphone results in the same output signal at the user device as an ISTS of 65 dB transmitted by the hearing aid microphones.

For the accuracy and validity of the characteristics recorded in steps I and II, it is important that the remote microphone and the hearing aid with coupler are in a "quiet position" when the measurements are performed. Prior to performing the above measurements, the test technician should examine whether such a quiet position actually exists. To do this, the hearing aid with coupler and the remote microphone must be positioned outside the acoustic test box. As in steps II and III, a connection must be established between the hearing aid and the WRM system. For the recording of a characteristic under these conditions, the curve within the frequency range of between 800 Hz and 3.5 kHz should be at least 10 dB below the reference characteristic from step I. This ensures that all noise signals are at least 10 dB below the curves recorded in steps II and III so that the effect of such noise signals on the characteristics can be ignored.

c) Positioning of remote microphone in acoustic test box

In WRM systems with directional microphone technology, the remote microphone must be positioned exactly in front of the speech signal speaker. It is therefore necessary to carefully examine the alignment of the remote microphone as well as the position and alignment of the speaker in the acoustic test box.

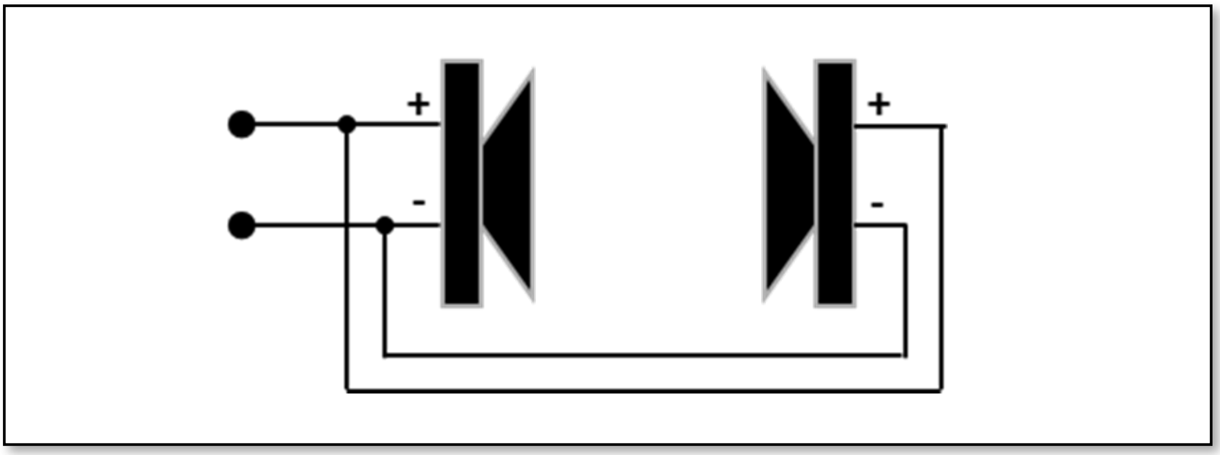
In certain cases, the dimensions of the remote microphone and those of the acoustic test box might make it impossible to point the microphone at the speaker. In such cases, the directional characteristic of the remote microphone can be set to omnidirectional so that a different microphone alignment can be chosen for the acoustic test box. Should the remote microphone not fit into the test box, the measurement might be performed while the test box is open. Before resorting to this approach, consult the acoustic test box manufacturer. When measuring with an open test box, it must still be possible to place the coupler with the hearing aid at a distance from the speech signal speaker so as to achieve a volume reduction of 10 dB (see section 2.1).

Appendix II Instructions on the implementation of the test setup for subjective benefit assessment

The information in this section is provided to assist you in setting up the testing equipment for assessing subjective benefit. The actual test setup should always be designed in cooperation with the audiometer manufacturer.

a) Playing the noise signal from one audiometer channel through two speakers

In order to play the noise signal from one audiometer channel through two speakers, the two speakers may be connected in parallel. This is, however, only possible if the amplifier of the audiometer caters for the parallel connection of speakers (see also [4]).

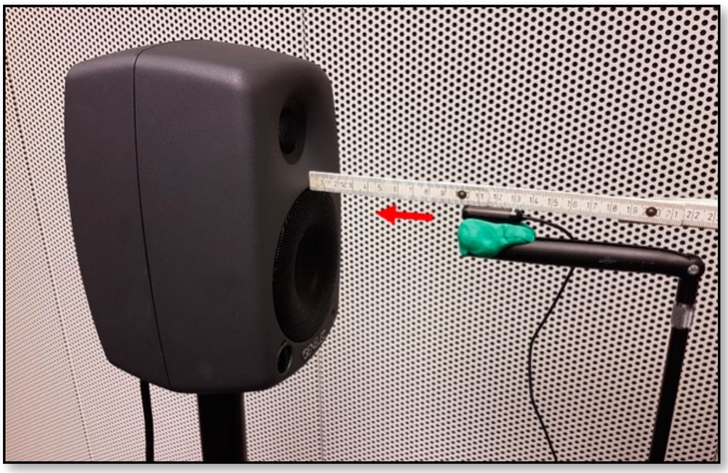


Appendix II - Fig. 1: Diagram of two speakers connected in parallel

If the audiometer amplifier does not support the parallel connection of speakers, you can use two active speakers to produce the background noise.

b) Positioning of remote microphone

To position the remote microphone, we recommend using a microphone stand to which the microphone is attached with kneadable rubber (see Appendix II - Fig. 2.). Ensure that



Appendix II - Fig. 2: Positioning remote microphone at a distance of 10 cm to the speaker, using a microphone stand and kneadable rubber the remote microphone is at the correct distance and angle to the speech signal speaker. In WRM systems with directional microphone technology, the remote microphone must point at the speech signal speaker. If the directional characteristic of the microphone can be adjusted, the system should be set to the actual user settings.

c) Adjustment of sound pressure level

For the above measurements, the speech signal sound pressure level must be set with high accuracy to the required value at the position of the remote microphone (P1), and also at the position of the system user (P2) (see Fig. 2). The background noise pressure level at these two positions P1 and P2 must also be set with high accuracy. This can, for instance, be done by applying the correction values defined below. For the purpose of the descriptions below, the audiometer channel connected to the speech signal speakers is referred to as channel A, while the audiometer channel connected to the background noise speakers is referred to as channel B (see Appendix II - Table 1).

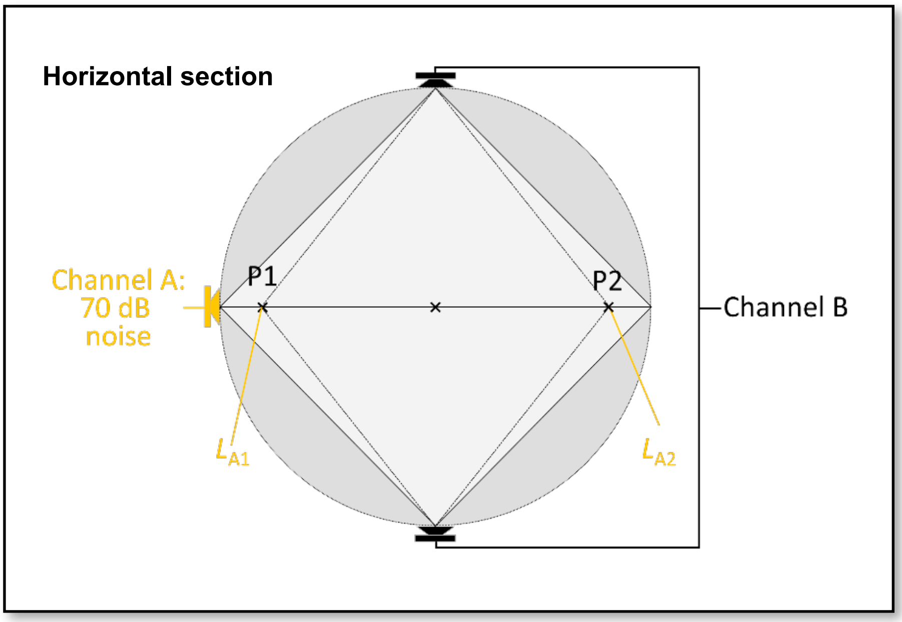
	Position P1	**Position P2**
Speech signal speaker (channel A)	K_{A1}	K_{A2}
Noise signal speaker (channel B)	K_B	

Appendix II - Table 1: Correction values to be determined

The correction values indicate by how much the value of the respective audiometer channel must be increased or reduced in order to achieve the desired sound pressure level at the respective position. In order to achieve a sound pressure level of 58 dB from the speech signal speaker at the position of the system user, the output level of the audiometer channel A must be set to 58 dB + K_{A2}.

The applicable correction values K_{A1} and K_{A2} can be determined as follows:

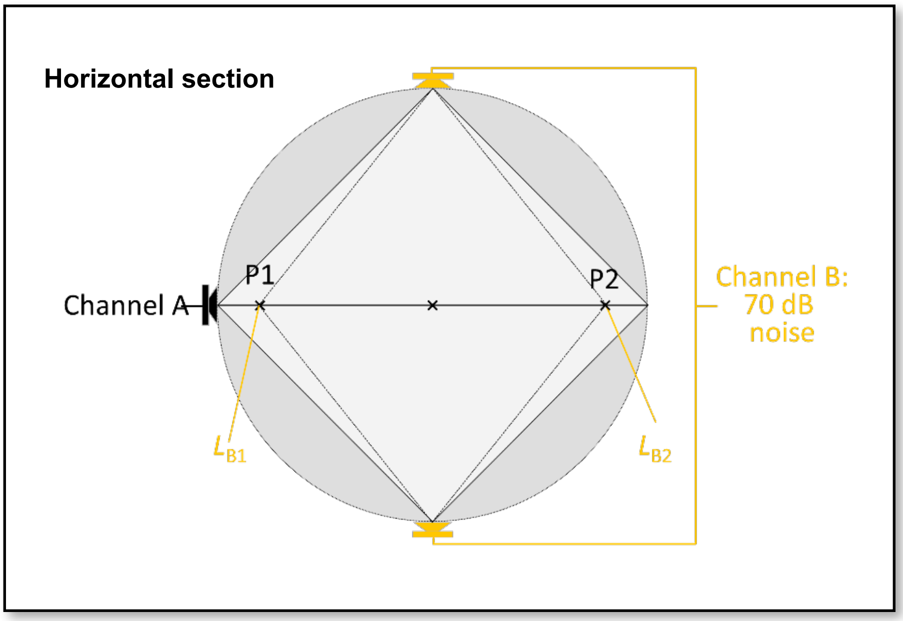
- In channel A, generate a calibration noise signal at 70 dB SPL through the speech signal speaker.
- Measure the sound pressure level L_{A1} at position P1 and the sound pressure level L_{A2} at position P2.
- Calculation of correction values:
  - K_{A1}=70 dB – L_{A1},
  - K_{A2}=70 dB – L_{A2},



Appendix II - Fig. 3: Sound pressure levels for calculation of correction values K_{A1} and K_{A2}

Proceed accordingly to determine correction value K_B.

- In channel B, generate a calibration noise signal at 70 dB SPL through the noise speakers.
- Measure the sound pressure level L_{B1} at position P1 and the sound pressure level L_{B2} at position P2. The two values should not deviate from each other by more than 2 dB.
- Calculation of correction value:
  - $K_B = 70\text{ dB} - \frac{1}{2} L_{B1} - \frac{1}{2} L_{B2}$.

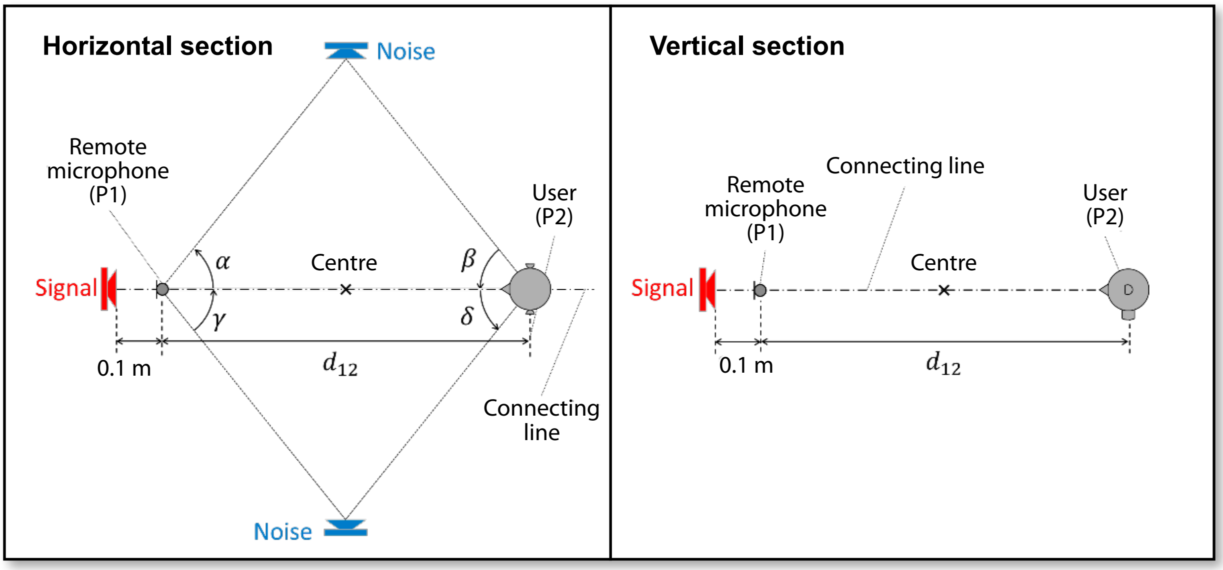


Appendix II - Fig. 4: Sound pressure levels for calculation of correction value K_B

d) Modification of test setup

If the test arrangement described in section 3.1 cannot be implemented, it can be modified within the following limits:

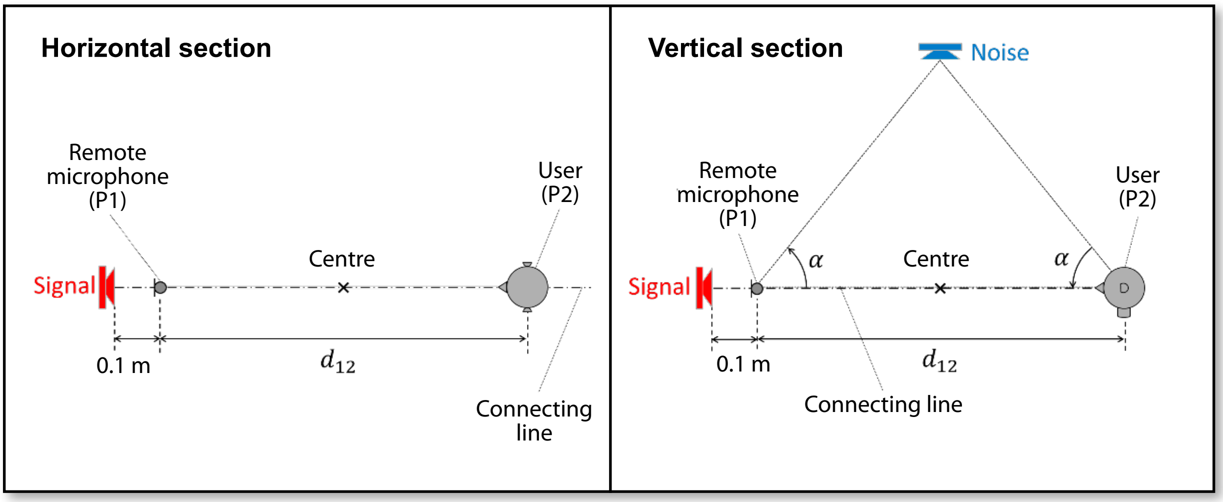
- The sound pressure levels of the signals from the speech signal speaker and the noise signal speaker at the left and right ears of the user must not differ by more than 2 dB.
- The background noise level at the position of the remote microphone (P1) must not deviate by more than 2 dB from the background noise level at the position of the user (P2).
- The speech signal speaker, the remote microphone, and the head of the user must be in a straight line (see dot-dash line in Appendix II - Fig. 5).
- At the positions of the remote microphone and the user, the background noise must be at an angle of 30° to 60° to the above straight line (*α, β, γ* and *δ* in Appendix II - Fig. 5).
- The distance between the remote microphone and the head of the user must be between 1.4 m and 2.2 m (d_{12} in Appendix II - Fig. 5).
- If the speech signal speaker produces 85 dB at the position of the remote microphone (P1), the level at the position of the user (P2) must be ≤ 65 dB. If this cannot be achieved, it is not possible to test remote microphones positioned in front of the mouth. In such a case, it might be useful to check whether, at a level of 80 dB at the remote microphone (P1) from the speech signal speaker, the level at the user position (P2) is ≤ 65 dB. If this is the case, the above test arrangement can be used to test collar microphones.



Appendix II - Fig. 5: Diagram of test arrangement in the event of deviations from the recommended geometry

Within the above limits, the test arrangement can be adapted in various ways as required. One modification that is of practical use is the adjustment of the distance between the remote microphone and the head of the user. The recommended distance of 1 m from the centre point (see recommended test arrangement in section 3.1) can be changed to any distance between 0.8 m and 1.2 m.

The test arrangement can also be adjusted to cater for a speaker mounted on the ceiling. In this case, the noise signal can be produced through a single speaker, provided that the above limit requirements are met. A possible arrangement is shown in Appendix II - Fig. 6.



Appendix II - Fig. 6: Possible test arrangement with ceiling-mounted speaker

Appendix III Comments on the test setup for subjective benefit assessment

a) Sound levels

For measurements **without** a WRM system, the required 58 dB SPL for the speech signal at the position of the user corresponds to the typical sound level produced by a lecturer standing 4 m away from the listener and speaking at a normal volume. This is based on the assumption that the sound level at a distance of 1 m from a person speaking at normal volume in an open space is 65 dB SPL. The corresponding sound pressure level in enclosed rooms is determined by approximation, using the Hopkins-Stryker equation. For more information, see [5].

For measurements **with** a WRM system, the sound pressure level at the remote microphone is the key factor. This level depends on whether the remote microphone is positioned in front of the mouth or worn around the neck. For microphones worn around the neck, the sound pressure level is 80 dB. For microphones positioned in front of the mouth, the sound pressure level is 85 dB.

During measurements with a WRM system, the speech signal also reaches the user directly through the air. Provided that the transmission characteristic of the WRM system is set correctly as described in section 2, the air-borne speech signal level is extremely low and can thus be ignored.

b) Sample measurements

The sample measurements below illustrate possible results and their interpretation.

a)	without	with
60 dB	20 %	90 %
70 dB	-	-

b)	without	with
60 dB	80 %	90 %
70 dB	10 %	85 %

c)	without	WRMS1	WRMS2
60 dB	20 %	95 %	95 %
70 dB	0 %	90 %	70 %

Appendix III - Table 1: Sample results of measurements for the benefit assessment of WRM systems. Rows "60 dB" and "70 dB" represent the sound pressure level (SPL) of the background noise. Column "without" shows the results achieved without WRM system, while column "with" shows the results with WRM system. In example c), column "WRMS1" shows the results achieved with WRM system 1, and column "WRMS2" shows the results with WRM system 2.

In example a), without WRM system and with a background noise of 60 dB SPL, the user understands as little as 50% of what is said. Therefore, the test with WRM system is only performed at this background noise level. The results show that, at such a low background noise level, using a WRM system improves speech intelligibility by 70%.

In example b), without WRM system and a background noise level of 60 dB SPL, the user understands more than 50% of what is said. Given this relatively high value, the test is repeated with a background noise of 70 dB SPL. The tests are further repeated with WRM system at background noise levels of 60 dB SPL and 70 dB SPL, respectively. At the lower noise level, there is a slight improvement in speech intelligibility of around 10%. In the test with a medium background noise of 70 dB SPL, the improvement is significantly higher at 75%.

Example c) shows how the method can be used to compare the performance of various WRM systems. At low background noise levels, the differences between the WRM systems might be minor. We therefore recommend always using a background noise of 60 dB SPL and 70 dB SPL, respectively, for such comparisons. If speech intelligibility without WRM system and at a background noise level of 60 dB is below 50% (as is the case in this example), it is not useful to repeat the test with a background noise of 70 dB SPL, and speech intelligibility of 0% can be assumed.

Appendix IV Test report for wireless remote microphone systems according to the EUHA Guideline "Wireless remote microphone systems"

Name of user: ______________________________

Name of test technician: ______________________________ Date: ________________

WRM system 1 (WRMS1): ______________________________

WRM system 2 (WRMS2): ______________________________

WRM system 3 (WRMS3): ______________________________

1) Assessment of transparency

The acoustic transparency of the WRM system has been assessed and adjusted using the following method(s):

- Assessment of transparency of hearing aids in acoustic test box according to section 2.1 of these Guidelines
- Subjective assessment of transparency (see section 2.2. of these Guidelines)
- In-situ testing of transparency (see section 2.3. of these Guidelines)
- ______________________________

2) Test arrangement

Test arrangement used for the electroacoustic evaluation of individual benefit:

- The test arrangement recommended in these Guidelines (see section 3.1) was used.
- The recommended test arrangement was modified. The limit requirements defined in Appendix II – d) of these Guidelines were met. The following modifications were made:

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____

3) Electroacoustic evaluation of subjective benefit

(see section 3.2 of these Guidelines)

	without	WRMS1	WRMS2	WRMS3
60 dB				
70 dB				