The “Hearwig“ as hearing protector for musicians – a practical investigation

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ABSTRACT

The “Hearwig” is a new approach to hearing protection for orchestral musicians. The standing device is placed behind the sitting musician. By leaning backwards into the sound absorbing shell of the “Hearwig”, the musician’s ears and the back of the head are covered. Thus, the device can predominantly be used inbetween entries of the musician. The musician can remove the head quickly and easily from the shell in order to play the instrument unhindered by the device.

So far, very few investigations on the sound absorbing properties of the “Hearwig” exist. We present results of our own measurements in the laboratory and in the field. In the laboratory measurements the angle-dependent sound attentuation was measured with the help of an artificial head. Additionally, sound attenuation was determined using trained test persons and the experimental setup for testing of hearing protection following ISO 4869-1. Afterwards, field measurements during rehearsals of a classical orchestra in a concert hall were performed. We discuss the results of our investigation and the consequences for the usability of the “Hearwig” in the field.

INTRODUCTION

The “Hearwig” is a special product for musicians “[…] protecting the ears from those hazardous sound frequencies produced by loud instruments […]” [1]. Optimal protection is promised to be given for “[…] detrimental frequencies originating from behind the head […]” [2].

The “Hearwig” consists of a U-shaped shell made of plastic which is lined with a soft and fibrous material of several centimeters thickness on the inner side. That material is covered by a fabric which is elongated at the back to blanket also the neck of a user. Figure 1 shows the device as presented by the manufacturer.

Figure 1: Internet presentation of the “Hearwig” [3].

The shell is mounted on an adjustable and self supporting metal construction and surrounds the head of a sitting musician from behind. The head piece can be moved backwards and forwards and can also be locked in place in the back position using only the head and body weight.

The manufacturer also shows sound attentuation values of the “Hearwig” [3], cf. Figure 2. Though, no information on the testing method and test environment is given there.

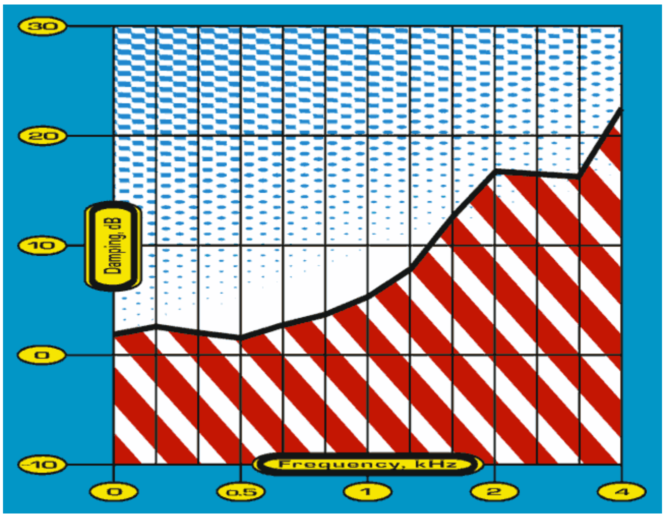

Figure 2: Sound attenuation of the “Hearwig” as presented on the internet page of the manufacturer [3].

ATTENUATION MEASUREMENTS

The “Hearwig” is not a certified hearing protector and thus the sound attenuation values need not to be determined by a notified body according to a standard like ISO 4869-1 [4]. As the IFA is notified body for testing of hearing protectors, the task of measuring the sound attenuation values of the “Hearwig” was assigned to the IFA. To this task, two laboratory measurements and one in-situ measurement in a classical orchestra were performed. The approach and results are presented in the following sections.

Laboratory measurements I

In a first step, the sound attenuation of the “Hearwig” in a diffuse sound field was determined following ISO 4869-1 [4]. Therefore, the hearing thresholds of eight test persons were measured with their heads being positioned in the “Hearwig” as well as without the “Hearwig”. The differences between the two hearing thresholds of each test person give the sound attenuation values for each third-octave band tested. For the test signal third-octave band pink noise at all octave band center frequencies between 63 Hz and 8 kHz was employed, as specified by ISO 4869-1. The results are displayed in Figure 3. For the octave band with center frequencies betwenn 4 kHz and 8 kHz we find attenuation values between 10,8 dB and 13,8 dB. For all measured frequencies lower than 4 kHz attenuation values are not noteworthy.

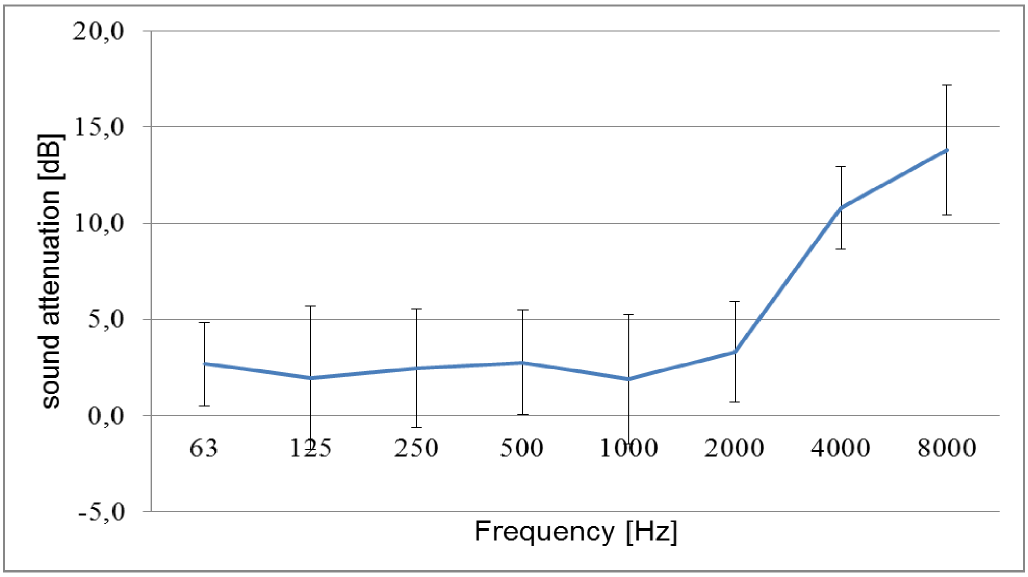

Figure 3: Sound attenuation of the “Hearwig” obtained from measurements in a diffuse field. Shown are mean values and standard deviations obtained from eight trained test persons following ISO 4869-1.

From the measurement values, the Single Number Rating (SNR) and HML-values characterising the overall sound attenuation as well as the sound attenuation for high, middle and low frequency sounds can be calculated following [5]. For the “Hearwig” we obtain a SNR of 3 dB. The corresponding HML-values for sound attenuation in the high, middle and low frequency regime are determined to H=3 dB, M=0 dB und L=0 dB. A closer look on the individual attenuation values leads to the assumption that the attenuation is higher when the fitting of head and “Hearwig”, which is determined only by the head dimensions, is tighter.

Furthermore, sound attentuation values were measured for a free sound field with incidence from behind. The loudspeaker was positioned exactly behind the test persons at a distance of 2 meters and in the height of the test persons heads. Here again, employing third-octave band pink noise as test sound, the hearing thresholds with and without sitting in the “Hearwig” were determined at all octave band center frequencies between 63 Hz and 8 kHz. The sound attenuation values were calculated from the individual hearing threshold differences of the test persons. The results are shown in figure 4. Overall, the measurement values obtained in this experiment are higher than for the diffuse sound field, but the standard deviation is larger, too. An important factor for this high standard deviation could be the fact that the test persons involved in the measurements are trained to hearing threshold measurements in diffuse sound fields only, as specified in [4]. Especially in the middle frequency regime (200 Hz to 2000 Hz) the sound attenuation values are significantly larger than for the diffuse sound field. We calculate a value of 6 dB for the SNR and HML-values of H=5 dB, M=4 dB and L=2 dB. Since the standard deviation of the sound attenuation value distribution among the test persons enters the calculation of the HML-values, especially the H-value reaches only a low value.

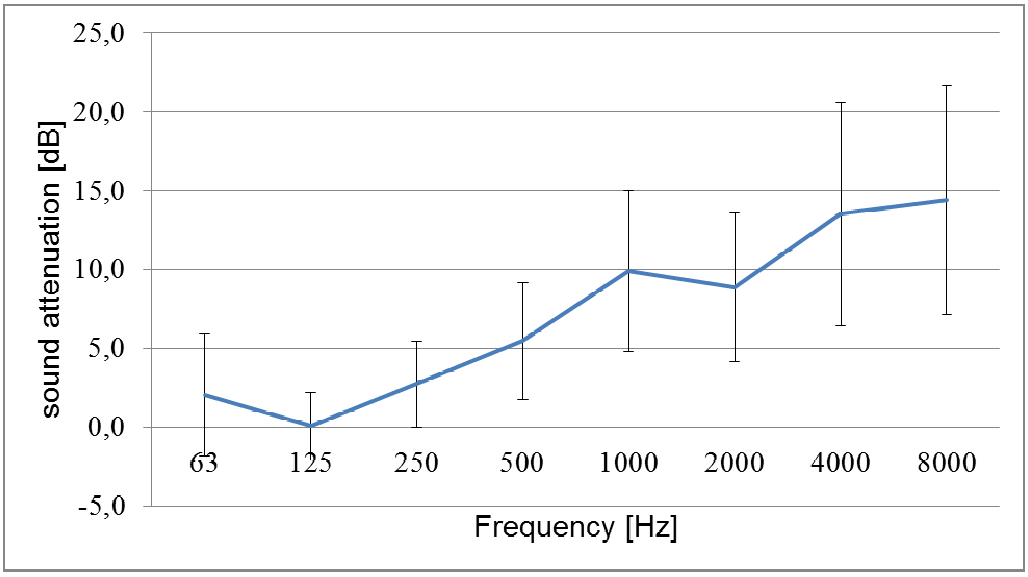

Figure 4: Sound attenuation of the "Hearwig" obtained from measurements in a free field incidenting from behind. Shown are mean values and standard deviations obtained from eight trained test persons.

Laboratory measurements II

To determine the angle dependency of the sound attenuation on the incidenting sound, another series of measurements was conducted. An artificial head was used to obtain the sound attenuation at different incidence angles of a free sound field of pink noise. An angle of 0° corresponds to the position of the loudspeaker in the line of sight. An angle of 180° corresponds to the position of the loudspeaker behind the artificial head, accordingly. This position was already used in the former setup employing test persons. To determine the angle dependency, the sound pressure level was measured at both ears of the artificial head while being positioned in the "Hearwig" and without the "Hearwig". As test signal broadband pink noise was used with a free field sound pressure level of 85 dB in a distance of 2 m to the loudspeaker membrane. The axis of rotation of the artificial head was placed at this point.

Figure 5 shows the attenuation value of the "Hearwig" for different incidence angels and for both ears separately. The values are determined from measurements of the A-rated equivalent sound pressure level L_{Aeq} with the method just described. To simulate different head positions and shapes, the artificial head was placed asymmetrically inside the "Hearwig", leading to slightly different attenuation values for the left and right ear. Graphically this fact manifests itself in the asymmetry of the left and right ear's sound attenuation curve with respect to the line of vision.

In Figure 6 the frequency-dependent sound attenuation is shown for an incident angle of 180°, as was also tested in the first setup with test persons. From the measurement with the artificial head we find lower attenuation values in the middle frequency regime. Also the values given on the manufacturer's homepage (cf. figure 2 [3]) are not reached for the frequencies between 2 kHz and 4 kHz. The manufacturer does not supply an attenuation value for 8 kHz. From the data obtained by measurements with the artificial head we calculate an SNR-value of 8 dB for sound incidence from behind (180°) and HML-values of H=10 dB, M=4 dB and L=2 dB. The values for M and L are in accordance with the values obtained from the subjective testing method while the H-value of the artificial head measurement is much higher due to the significantly smaller standard deviation.

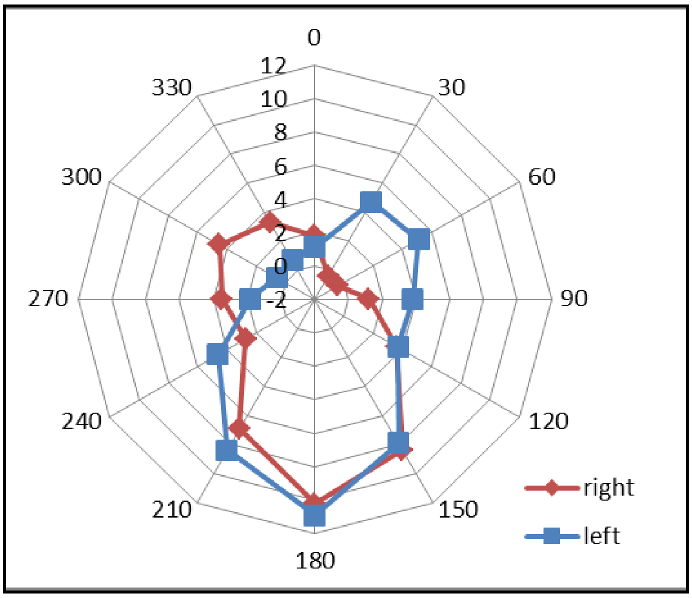

Figure 5: Sound attenuation of the “Hearwig” obtained from measurements in a free field incidenting from behind. Shown are the angle-dependent sound attenuation values measured at left and right ear of an artificial head placed asymmetrically in the shell of the “Hearwig”. The left ear was placed closer to the lining, which is reflected by slightly higher attenuation values compared to the right ear. The measurement was conducted in steps of 30° with the angle of 0° corresponding to the sound source being positioned in the line of sight in front of the artificial head.

When performing an average over all measured incidence angles of the artificial head measurement, the sound attenuation for an approximate diffuse sound field, missing only sound incidence from the vertical direction, is obtained. For this average we calculate attenuation values SNR=4 dB, H=3 dB, M=1 dB and L=0 dB.

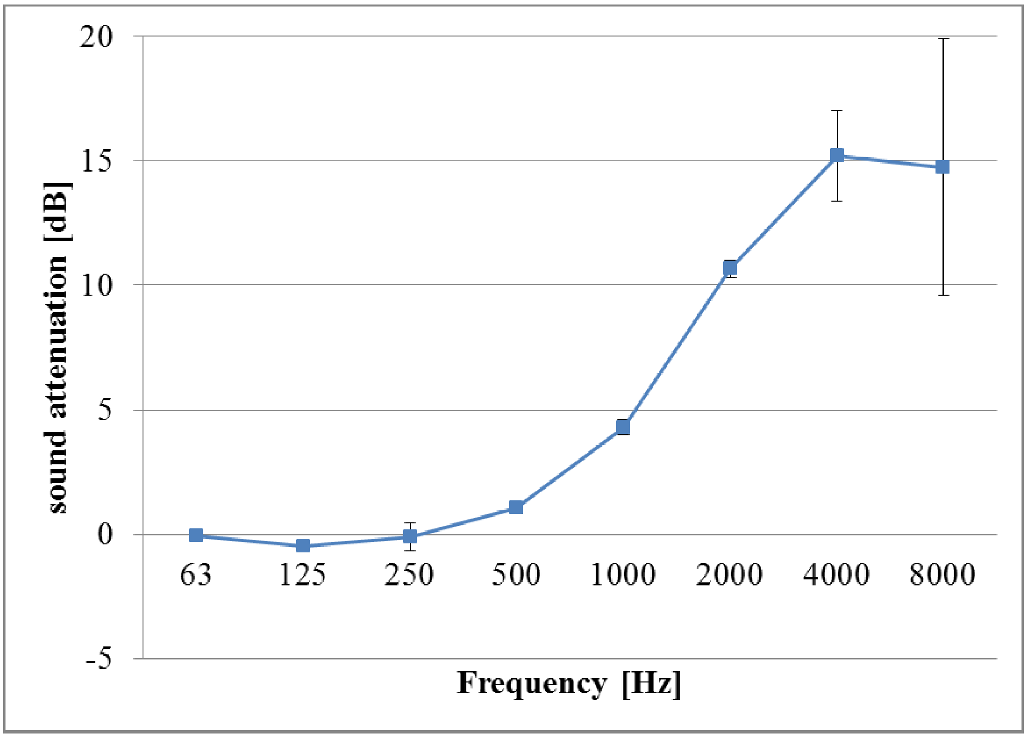

Figure 6: Sound attenuation of the “Hearwig” obtained from measurements in a free field incidenting from behind. Shown are mean values and standard deviations obtained from the measurement with an artificial head. Results of left and right ear are averaged. Like in figure 5, the left ear was placed closer to the lining than the right ear to simulate different head widths.

Field measurements performed in a classical orchestra

To estimate the validity of the laboratory measurement concerning the field use of the “Hearwig”, additional measurements with an artificial head in a classical orchestra were conducted. During orchestra rehearsals in a concert hall the sound pressure level with and without the “Hearwig” was measured at the ears of the artificial head while several classical compositions were practised. The artificial head was placed at the position of a clarinet at the front of the brass. For the calculation of the practical attenuation values of the “Hearwig” two complete classical pieces with durations of 15 minutes and 45 minutes and a series of short samples were evaluated. From both complete pieces attenuation values of SNR=4 dB, H=4 dB and M=1 dB were retrieved. The values for L were calculated to 0 dB and 1 dB, respectively. As for each piece only one measurement with and one without the “Hearwig” could be recorded, no standard deviation is incoorporated into the calculation of SNR and HML-values.

Furthermore, we could measure a sample with the whole orchestra involved (a so-called “tutti”) with a duration of 11 seconds. We could retrieve six samples in total, three with the artificial head being positioned in the “Hearwig” and three without the “Hearwig”. From these measurements we get attenuation values SNR=4 dB with HML-values of H=3 dB, M=1 dB and L=1 dB.

The results of these field measurements are in agreement with the laboratory measurements for the approximate diffuse sound field.

CONCLUSIONS

The sound attenuation of the “Hearwig” was investigated in several laboratory and field measurements. The single number rating (SNR) for all measurements with an artificial head involving sound fields of diffuse character was calculated to a value of 4 dB. The main contribution to the SNR is provided by the high-frequency attenuation values at 2 kHz, 4 kHz and 8 kHz. These values are confirmed by the results of the subjective test procedure in the diffuse sound field following [4]. Naturally, the standard deviation of the subjective testing is higher than for measurements with an artificial head. From the subjective measurements we can possibly defer that a tight fitting of head and “Hearwig” leads to higher individual attentuation values. All results are summarised in the Tables 1 and 2. We were not able to reproduce the attenuation values provided by the manufacturer.

The sound attenuation values presented in the preceding sections are reached only in case the musician’s head rests in the shell of the “Hearwig” for the whole time of sound exposure. Once the head is removed from the “Hearwig”, either by leaning forward or by locking the “Hearwig” in the back position, no attenuation effect is observed at all. Most likely, the musician will not sit with the head in the “Hearwig during “tutti” sections of a composition, when the overall sound pressure level is highest. Unfortunately, these passages typically give dominant contributions to an individual’s sound exposure level. Accordingly, the effective sound attenuation value has to be calculated individually for each musician and each composition, depending on individual entries and overall behaviour. It is highly likely, that this effective value will be much lower than the measured values. Additionally, the sound exposition by the own instrument could not be considered in the measurements.

The “Hearwig” shows high sound attenuation values only for high frequencies, i.e. 4 kHz and 8 kHz. Although the suitability of the “Hearwig” as a hearing protector is questionable, this high frequency attenuation could for example help musicians suffering from hyperacusis.

Table 1: Overview of sound attenuation values obtained in the laboratory measurements

Measurement method	Sound incidence	Type of sound	SNR	H	M	L
Subjective	Diffuse	Third-octave band pink noise	3	3	0	0
	From behind	Third-octave band pink noise	6	5	4	2
Artificial head	Nearly diffuse	Pink noise	4	3	1	0
	From behind	Pink noise	8	10	4	2

Table 2: Overview of sound attenuation values obtained in the field measurement

Measurement method	Sound incidence	Type of sound	SNR	H	M	L
Artificial head	Diffuse	sample	4	3	1	1
	Diffuse	15 minutes (whole piece)	4	4	1	0
	Diffuse	45 minutes (whole piece)	4	4	1	1

REFERENCES

[1] (03/2017) www.hearwig.com/argorch.html

[2] (03/2017) www.hearwig.com/argknock.html

[3] (03/2017) www.hearwig.com

[4] ISO 4869-1 (1990). Acoustics; hearing protectors; subjective method for the measurement of sound attenuation

[5] ISO 4869-2 (1995). Acoustics; hearing protectors; estimation of effective A-weighted sound pressure levels when hearing protectors are worn