BNAM2012
Joint Baltic-Nordic Acoustics Meeting
June 18th - 20th 2012 Odense, Denmark

Minimizing speech contribution using different microphone noise dosimeter positions

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Use of noise dosimeter recordings in low sound level environments is often problematic due to the voice contribution from the carrier. The aim of the study was to find a microphone position with low speech contribution while still providing an accurate sound level recording. An experiment with different microphone positions was conducted in a low sound reverberation room. Two types of noise dosimeters were used (Brüel & Kjaer 4445 and Larson Davis Spark 706-Atex). In repeated measurements the carrier was instructed to read a text chapter during 60 seconds and at a speech of level about 60 dB(A), acquired by practice, with different background noise and noise levels. White noise and preschool noise was used at sound levels 50, 60, 70 and 80 dB(A). The voice contribution to the background noise level was then measured. Three microphone positions were tested; on the shoulder, above the ear and on the back of the head. The position with the microphone placed behind the head of the carrier had the lowest speech contribution, less than 2 dB(A) to the background noise at 70 dB(A). This compared to positions right above the ear 6 dB(A and on the shoulder 12 dB(A).

1 Introduction

The use of noise dosimeters is most common in industrial environments where the equivalent sound pressure level often reaches levels of 80 dBA or higher. However the amount of complaints regarding noise is rising from workplaces with lower equivalent sound pressure levels[1, 2]. In work environments with equivalent sound pressure levels below 80dBA and where speech communication is common, the use of personnel carried noise dosimeters are problematic. The standard position for the microphone is on the shoulder, a position that works well as long as the carrier does not speak or the background noise is loud enough to mask the carrier's voice. Non industrial workplaces such as healthcare and pedagogical workplaces differ regarding the characteristics of the noise, since the noise emanates from many different noise sources. In periods of low sound levels the carrier's own voice there is a risk that the measurement is affected. Previous studies in a day-care center has shown that the carriers voice in average add about 11 dBA to the equivalent sound level measurement[3]. However the method used in that study excluded sound level registered when the carrier was speaking, thus loosing data. In a pedagogical environment where the voice is one of the most important tools for the teachers, a better position of the microphone needs to be found to reduce the contribution of the carrier's voice without excluding data.

2 Aim

The aim of this explorative study was to find a microphone position with a low speech contribution, while still providing an accurate sound level measurement.

3 Method

3.1 Equipment

All sound recording equipment was calibrated before use, using a Brüel & Kjaer Sound Calibrator – Type 4231. A Brüel & Kjaer 2260 Observer was used to calibrate the background sound levels. Two types of noise dosimeters were tested, Brüel & Kjaer 4445 and Larson Davis Spark 706-Atex. The background sound was produced using 360 Systems Instant Replay 2.0 with a Yamaha monitor speaker model MS60S.

3.2 Setup

3.2.1 Premises

This study was conducted in a silent low reverberation room (see Figure 1) with a background sound level not exceeding 20 dB(A).

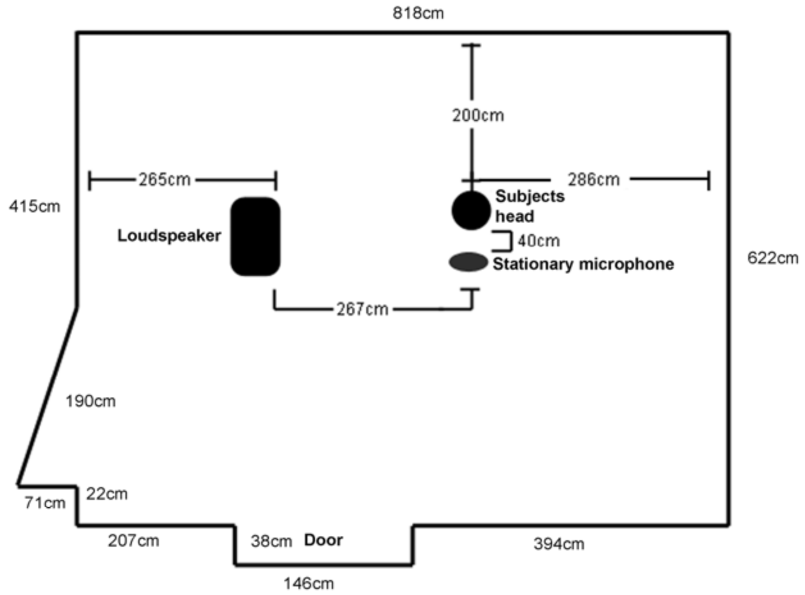

Figure 1: The silent low reverberation room where the study was conducted

3.2.2 Microphone placements

The carrier of the noise dosimeter microphone faced the loudspeaker at a distance of 267 cm. Next to the carrier's head, at the same height of the ear, with a distance of 40 cm the Brüel & Kjaer 2260 Observer microphone was placed, used to calibrate the background noise level.

Three different noise dosimeter microphone positions were evaluated, se Figure 2 below.

1. Placed on the shoulder, about 10 cm from the ear, with the microphone facing forward as recommended by manufacturer.
2. Above the ear, about 5cm from the ear, with the microphone facing forwards.
3. On the back of the head, with the tip of the microphone pointing out on the side of the head, at the same level as the ear.

All measurements were conducted using the three microphone positions simultaneously for all tested conditions.

Figure 2: The different tested microphone positions, 1 = on the shoulder, 2 = above the ear, 3 = on the back of the head

3.2.3 Speech contribution and background noise

The carrier was instructed to read a text out loud with a sound pressure level about 60 dBA without any background noise. The speech sound level was measured using the Brüel & Kjaer 2260 Observer. The procedure was repeated until the sound level of the speech was close to 60 dBA during repeated recordings. Data from the voice training session is presented in Table 1.

Table 1: Data from the voice training

	Mean	Minimum	Maximum	SD
Voice training	61,5	59,4	63,0	1,4

Two different background noises were used in the setup, white noise and recorded preschool noise. Each background noise was presented at four different sound pressure levels, 50, 60, 70 and 80 dB(A), calibrated using the Brüel & Kjaer 2260 Observer. The presented background noise sound pressure level was first measured with the noise dosimeter mounted at position 1, on the shoulder, without the carrier reading the text out loud. This measurement was then followed by a new session with the same background noise, but with the carrier reading the text out loud with same sound pressure level acquired through practice. This procedure was repeated for all different microphone positions giving the following test setup, see Table 2 below. The entire test setup up was repeated one time. The mean values of the two test values for each condition are presented in the results section.

Table 2: Test setup regarding used microphone positions

Microphone placement	Preschool noise (dBA)	White noise (dBA)
On the shoulder *Background noise*	50, 60, 70, 80	50, 60, 70, 80
On the shoulder *Background noise + speech*	50, 60, 70, 80	50, 60, 70, 80
Above the ear *Background noise*	50, 60, 70, 80	50, 60, 70, 80
Above the ear *Background noise + speech*	50, 60, 70, 80	50, 60, 70, 80
On the back of the head *Background noise*	50, 60, 70, 80	50, 60, 70, 80
On the back of the head *Background noise + speech*	50, 60, 70, 80	50, 60, 70, 80

4 Results

As can be seen from Figure 2 below all three microphone positions gave results close to the reference measurement with a deviation not larger than about 3 dBA for the shoulder placement at 70dBA when using white noise as a background noise. The placement with the microphone on the back of the head underestimated the sound pressure level consequently at about 1 dBA, except when measuring the background noise at about 70 dBA.

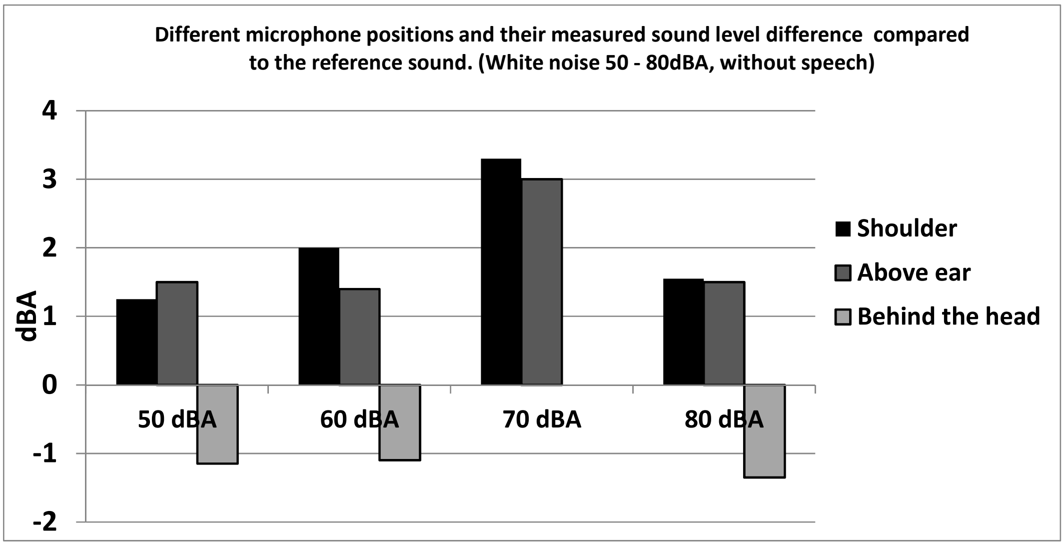

Figure 2: Background noise measurements using white noise compared to reference measurement

Using the same background noise as shown in Figure 2, but adding speech from the carrier, the following result presented in Figure 3 below was obtained. The placement of the microphone on the shoulder gave the highest speech contribution compared to placement above the ear and on the back of the head. The placement with the microphone on the back of the head generally gave the smallest speech contribution thereof the tested microphone positions.

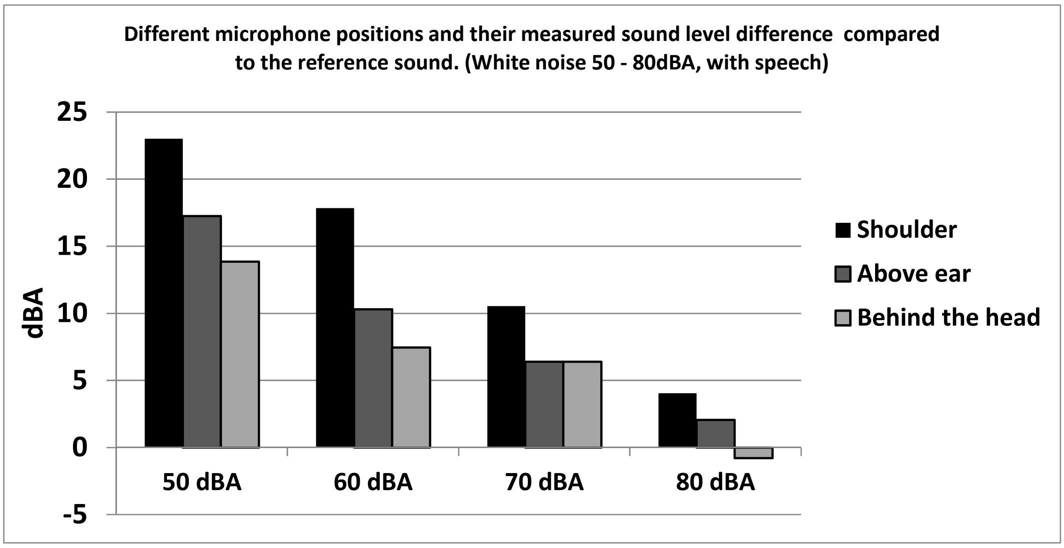

Figure 3: Background noise measurements using white noise with speech contribution from the microphone carrier compared to reference measurement

As can be seen in Figure 4 the placements on the shoulder deviated mostly from the reference measurement when measuring preschool noise at 50, 60, 70 and 80 dBA. The measured equivalent sound level was about 3 to 4.5 dBA higher than the reference value. Placing the microphone on the back of the head gave the most accurate measurement compared to the reference measurement with a deviation about 0.5 dBA to 2 dBA.

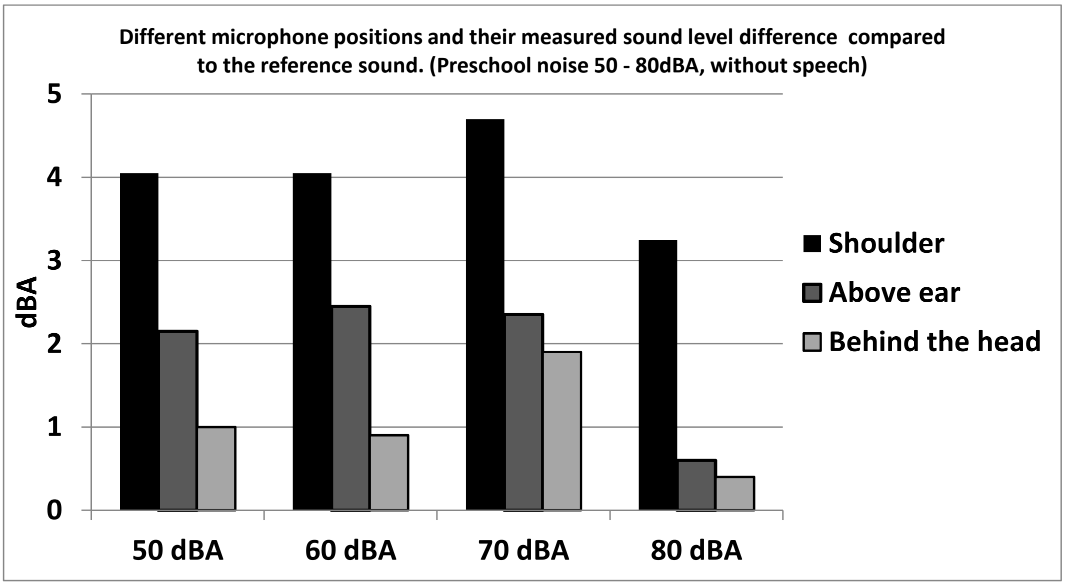

Figure 4: Background noise measurements using preschool noise compared to reference measurement

Using the same background noise (preschool) as shown in Figure 4, but adding speech from the carrier gave the following result presented in Figure 5 below. Again, placing the microphone on the shoulder showed the highest sound pressure level compared to the other placements. The microphone placement with the lowest speech contribution was on the back of the head.

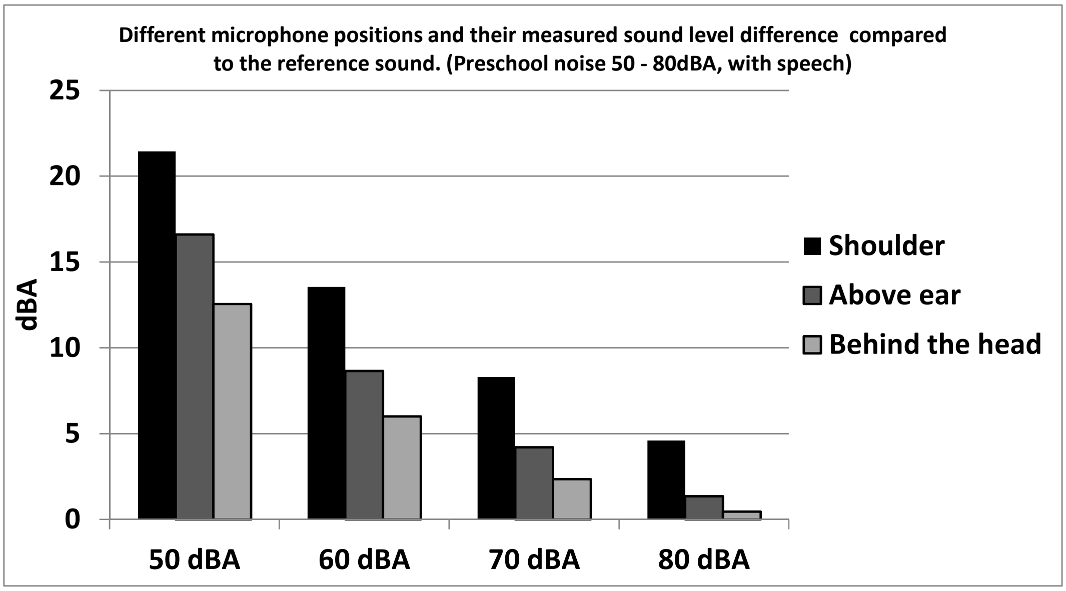

Figure 5: Background noise measurements using preschool noise with speech contribution from the microphone carrier compared to reference measurement

5 Discussion

New work places are gradually emerging with middle high noise levels and complex exposure characteristics. The sound environment at these work places differ from the traditional industrial workplaces since the noise often is not isolated to a few dominating sound sources. Instead the noise often derives from several different noise sources such as alarms, technical equipment, human voices, doors closing and human activities. As an example of these new work places are preschools. In this study we have evaluated how different positions of the noise dosimeter affect the sound measurement. The study was carried out at different backgrounds levels and different characteristics (white noise and preschool noise). The results showed that both the background noise characteristics and sound pressure level in conjunction with the placement have a large impact on the measurement.

When only measuring background noise, all positions of the microphone overestimated the equivalent sound pressure level when using preschool noise. The difference in the overestimation was also rather large depending on the position of the microphone. Placing the microphone on the shoulder, recommended by the manufacturer gave the highest overestimation when measuring a background noise of 70 dBA compared to the reference measurement, whereas the placement on the back of head hardly overestimated at all. When measuring white noise all microphone positions gave more accurate measurement with less overestimation. However, when using white noise as background noise the placement of the microphone on the back of the head instead slightly underestimated the sound level, with about 1 dBA.

The results showed that irrespective of what background noise was used, the speech contribution from the carrier's voice is rather high with background sound levels of 60 dBA or lower. When reaching background sound levels at 70 dBA, the speech contribution is lower, but there are still large differences in the measured sound level depending on the microphone position.

With a background sound level of a 70dBA white noise placing the microphone on the shoulder gave about 10 dBA addition to the measured sound value when the carrier is speaking with voice strength of about 60 dBA. This compared to a 6 dBA addition when positioning the microphone above the ear or at the back of the head.

Interestingly, when using preschool noise instead of white noise, a larger difference between the microphone positions was shown. With background values around 70 dBA and the carrier is speaking out loud with a voice strength of about 60 dBA, the position at the back of the head only gave an addition of about 2 dBA to the measurement, whereas the position above the ear gave an addition of about 4 dBA and the position on the shoulder give an addition of about 8 dBA.

Noteworthy is that this speech addition is measured when the speaker is speaking continuously during the whole measurement, a situation rather unlikely in real exposure measurements at the work places. The speech addition with the microphone behind the head is in real life is therefore most probably even smaller.

An objection might be the fact that the position of the microphone behind the head can be shadowed by the head, thus underestimating the noise exposure. Nevertheless the results when measuring the background noise without speech showed that this position also gave the most accurate measurement of all three positions compared to the reference measurement.

Consequently the results indicate that a position of the microphone behind the head is to prefer when measuring equivalent sound pressure levels at work places where speech contributes to the sound level and where the background noise levels is about 70 dBA or lower. Further research is needed to achieve a higher statistical power regarding the difference between the microphone positions.

References

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