Field Study News

Traditional or Dynamic SoundField

Which one gives better speech understanding in noise?

Abstract

Unlike traditional sound field systems with fixed-gain settings, Dynamic SoundField automatically varies the gain of the loudspeaker with changes in the ambient noise level. Goal of this dynamic behaviour is to improve speech intelligibility of the teacher's voice especially when noise levels increase in class, but at the same time to offer a comfortable volume during more quiet moments. To quantify the benefits, speech intelligibility measurements were carried out with 20 normally hearing students in a classroom in different noise levels. Speech understanding improved significantly with the Dynamic SoundField system switched on for all noise levels. Performance with Dynamic SoundField was also better than with one of two other popular (traditional, non-dynamic) sound field systems.

Introduction

Large numbers of studies have documented measurable results in student achievement and attentiveness in classrooms that use sound field (MARRS, 2005; Flexer, 2002; Long, 2001). A study comparing the standardized test scores of first, third, fourth, and fifth grade students in unamplified and amplified classrooms in Oregon (Chelius, 2004) found that:
1) First grade students in the amplified classroom scored an average of 35 percent higher on the Dynamic Indicators of Basic Early Literacy Skills – DIBELS than students in the unamplified classroom
2) The same group scored an average of 21 percent higher on the Developmental Reading Assessment – DRA
3) Fourth and fifth graders in amplified classrooms averaged 35 percent higher in words per minute on a reading fluency test than students in unamplified classrooms.

It is generally accepted that sound field systems for children give the following benefits:

- Improved sentence recognition ability
- Increased student attention, interaction and participation
- Quicker acquisition of reading, writing and numeracy skills
- Easier deciphering of language in early learning years
- Better understanding of teacher for non-native speakers
- Expanded seating options for students with attention deficit issues

There are also considerable benefits for teachers (e.g. less vocal strain and fatigue), but these will not be discussed here.

Recently a new sound field technology was released: Dynamic SoundField. One of its features is an automatic (dynamic) volume control that increases the volume when the noise level in the classroom increases. Noise levels inside classrooms can be high (Bess et al, 1984; Finitzo-Heiber, 1981; Houtgast, 1981; Knecht et al, 2002; Larsen et al, 2008; Markides, 1986; Mendel et al, 2003; Nober et al, 1975; Rosenberg et al, 1999; Sanders, 1965; sato et al, 2008), and they vary from school to school, from one classroom to another. Rosenberg found noise average noise levels in occupied classrooms ranging from 47 to 73,3 dB(A), with a mean of 62,6 dB(A). Most importantly, background noise levels vary considerably during a typical school day (Sisto et al, 2007). In quiet situations, less amplification is required, to avoid unnatural loudness. A high gain setting in quiet conditions can also be quite tiring for listeners. In noise, the gain should be higher without generating any feedback. A traditional sound field system does not automatically track ambient noise levels, which means its volume will only be correct some of the time during the day. At certain moments the system's gain will be too low, resulting in insufficient speech understanding by students, or too high, resulting in loud amplified speech which may sound unnaturally. It is not likely that teachers will adjust the volume control of a sound field system each time the background noise level varies in a classroom. The Dynamic SoundField technology continuously monitors the background noise level in the classroom and adapts its gain accordingly and automatically. This surrounding noise compensation is set in such a way as to produce an STI (Speech Transmission Index) of 0,5 to 0,6 at different noise levels at 3 m distance, ensuring good intelligibility of the teacher's voice. Ambient noise levels are measured using the microphone of the wireless transmitter microphone. In quiet conditions, below 54 dB SPL classroom noise, the

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gain is kept at a value of 6 dB ("gain" refers here to a standard listening situation in a standard classroom and it is defined as the acoustic gain at the ear). This will result in a Speech to Noise Ratio (SNR) of at least 12 dB. At lower noise levels the SNR will be even higher. For instance, at 44 dB(SPL) noise level the SNR will be +20 dB. Intelligibility will be degraded significantly when the SNR drops below +10 dB. Between 54 and 66 dB(SPL) classroom noise level the gain of Dynamic SoundField is automatically increased to maintain a SNR of +10 dB in a normal classroom with a RT_{60} of 0,9 s (Figure 1).

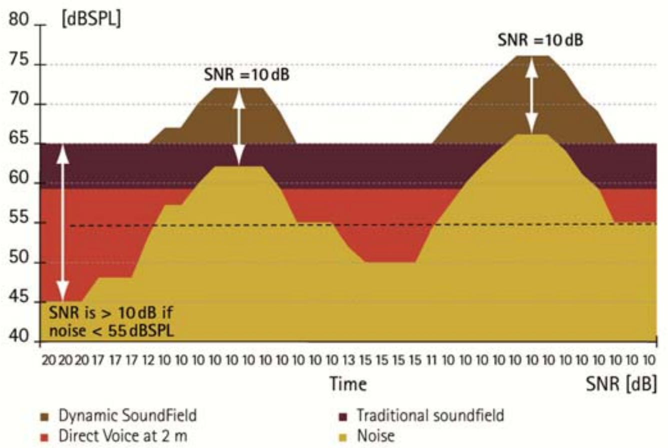

Figure 1. Dynamic SoundField tracks the ambient noise level, giving optimal SNR's during the whole school day.

The maximum gain the Dynamic SoundField system delivers is 20 dB. To achieve such a high gain advanced feedback cancellation algorithms have been implemented in Dynamic SoundField. These operate in the background both in the time and in the frequency domain, and eliminate all possible feedback, even if the microphone and loudspeaker are very close to each other.

To measure the effect of the dynamic behaviour on speech intelligibility, measurements were carried out under controlled but classroom like conditions. These measurements were performed at different noise levels which are quite common in classrooms.

Test subjects and devices

20 normally hearing students aged 13 to 14 years enrolled in the study. All subjects had German has their mother tongue. There were 7 boys and 13 girls in the study.

Speech understanding in noise was measured in 4 different technology conditions: no sound field, Dynamic SoundField, a traditional sound field system from manufacturer A, a traditional sound field system from manufacturer B. All products were systems with one loudspeaker unit. All students were first tested in the no sound field condition. After that, the order of sound field type conditions was randomized across all subjects.

The tests were carried out blind for the students, they could not read the brand of the loudspeaker unit as the brand names and logos were covered.

For all 4 amplification conditions measurements were carried out at increasing classroom noise levels: 50, 60, 65 and 70 dB(A).

Speech in noise measurements were performed in a classroom in the school. The dimensions of the classroom were 8,35 m by 8,35 m. The measured average reverberation time of the classroom was 1,0 s.

Speech was presented through a B&K manikin from the front of the classroom. The manikin was wearing the wireless microphones of the different sound field systems like a teacher would be wearing them. For the Dynamic SoundField and for Competitor B these were boom microphones at about 2 cm from the 'mouth' of the manikin, for Competitor A this was a kind of lapel microphone, 20 cm from the 'mouth'.

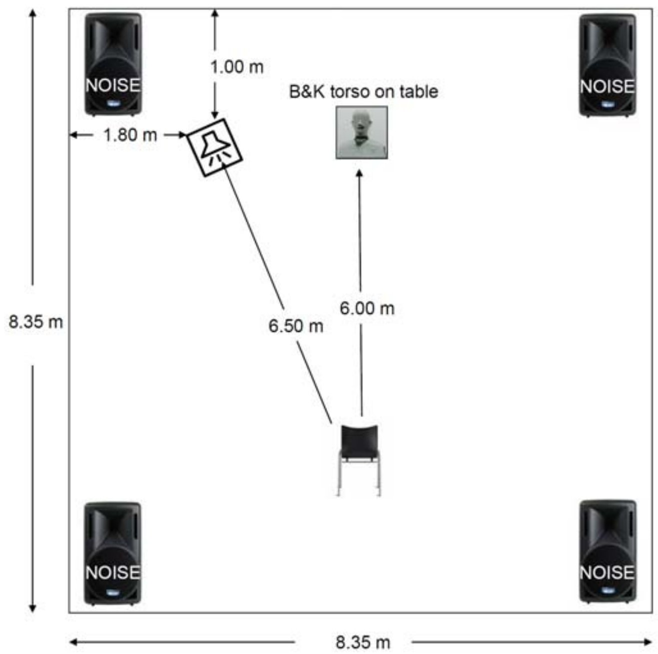

Figure 2. Schematic lay-out of the test set-up.

Speech understanding was measured with the OLSA test (Oldenburger Satz Test), a German Sentence Test for speech understanding in noise. The level of the speech produced by the loudspeaker in the B&K manikin was set fixed during all tests at 65 dB(A) at 1 meter distance (without any sound field amplification). 48 different sets of OLSA sentences were randomized across all listening conditions and across all students.

Classroom-like noise was presented from 4 loudspeakers in the corners of the classroom.

In order to minimize effects of different volume settings between the three sound field systems the following procedure was applied: through the B&K manikin the International Speech test Signal (ISTS) was played in quiet. At 6 meters distance from the manikin at the position where the students would sit to perform the speech in noise test, the sound level was measured for the direct sound plus the Dynamic SoundField in its default volume setting. This was found to be 66 dB(A). The volume setting for competitor B was selected to generate a sound pressure level of 66 dB(A) as well at the same location. For competitor A (with the lapel microphone) the same volume setting could not be reached because of feedback. Its maximum attainable volume setting resulted in a sound pressure level of 65 dB(A). The distance between the B&K manikin and the loudspeaker was about 2,30 m.

Results

Average speech recognition scores in the no sound field condition was clearly affected by increasing noise levels, starting from 95,2% at 50 dB(A) ambient noise level down to 7,6% at 70 dB(A) noise. All sound field systems improved speech understanding by this group of students in all noise conditions, but performance varied considerably between systems, with performance difference increasing at higher noise levels. Figure 3 shows the overall average speech understanding scores for the different noise levels and the different listening conditions.

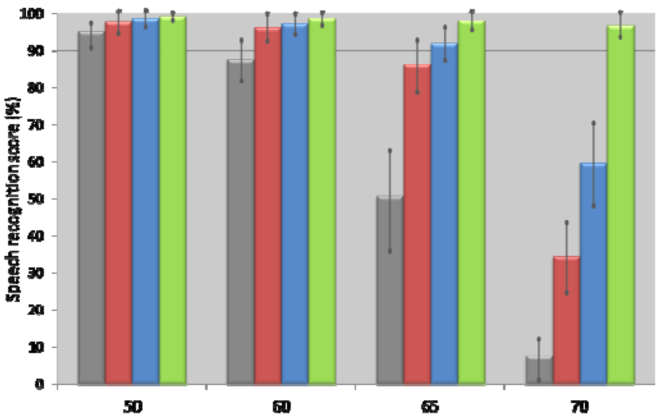

Figure 3. Average (N=20) speech recognition in noise for all technology and all noise level conditions. On the horizontal axis the classroom noise level in dB(A) is indicated. Grey bars: no sound field; red bars: competitor A; blue bars: competitor B; green bars: Dynamic SoundField. Error bars indicate plus or minus one standard deviation.

In Table 1 the median, best and worst scores for 65 dB(A) and 70 dB(A) classroom noise levels for each listening condition are shown. With Dynamic SoundField 4 students reached 100% speech recognition at 65 and at 70 dB(A) noise level and no student performed below 88%. Without sound field the lowest performance at 65 dB(A) was 28% and at 70 dB(A) 0%, and with the competitive products the lowest performance at 65 dB(A) was 76, respectively 84% and at 70 dB(A) it was 14 respectively 34%.

dB(A)		No sound field	Comp. A	Comp. B	Dynamic SoundField
65	Best	86	98	100	100
	Median	49	89	92	98
	Worst	28	76	84	88
70	Best	24	54	78	100
	Median	6	36	58	97
	Worst	0	14	34	90

Table 1. Best, median and worst speech recognition scores (%) for all listening conditions at 65 and at 70 dB(A) classroom noise level.

Conclusion

The results indicate that the participants achieved significantly better speech recognition in noise with Dynamic SoundField as compared to their performance with traditional sound field systems. The benefits of Dynamic SoundField tended to increase with increasing noise levels. At 70 dB(A) noise level, which is not uncommon in classrooms, with Dynamic SoundField a minimum speech recognition score of 90% was found, where popular competitive products dropped as low as 14% and 34%.

References

Bess, F., Sinclair, J.S., & Riggs, D. (1984). Group amplification in schools for the hearing impaired. Ear & Hearing, 5, 138-144.

Chelius, L. (2004). Trost Amplification Study. Canby, Oregon: Canby School District. Unpublished manuscript.

Finitzo-Heiber, T. (1981). Classroom acoustics. In R. Roeser, M. Downs (Eds.). Auditory Disorders in School Children: The Law, Identification, Remediation (pp. 250-262). New York: Thieme-Stratton.

Flexer, Carol. Rationale and use of sound field systems: An update. The Hearing Journal, Vol. 55, No 8, 10-18, 2002.

Long, Amy Bennett. The Effects of Soundfield Amplification on Reading Achievement. 2001.

Houtgast, T. (1981). The effect of ambient noise on speech intelligibility in classrooms. Applied Acoustics, 14, 15-25.

Knecht, H., Nelson, P., Whitelaw, G., & Feth, L. (2002). Backround noise levels and reverberation times in unoccupied classrooms: Predictions and measurements. AJA, 11, 65-71.

Larsen, J.B., & Blair, J.C. (2008). The effect of classroom amplification on the signal-to-noise ratio in classrooms while class is in session. LSHSS, 39, 451-460.

Markides, A. (1986). Speech levels and speech-to-noise ratios. British Journal of Audiology, 20, 115-120.

MARRS. The Use of Sound Field Amplification of the Teacher's Voice In the Regular Education Classroom – A Summary of Studies. 2005

Mendel, L., Roberts, R., & Walton, J. (2003). Speech perception benefits from sound field FM amplification. AJA, 12, 114-124.

Nober, L., & Nober, E. (1975). Auditory discrimination of learning disabled children in quiet and classroom noise. Journal of Learning Disabilities, 8, 656-773.

Rosenberg, G., Blake-Rahter, P., Heavner, J., Allen, L., Redmond, B., Phillips, J., & Stigers, K. (1999). Improving classroom acoustics (ICA): A three-year FM sound field classroom amplification study. JEA, 7, 8-28.

Sanders, D. (1965). Noise conditions in normal school classrooms. Exceptional Children, 31, 344-353.

Sato, H., & Bradley, J. (2008). Evaluation of acoustical conditions for speech communication in working elementary school classrooms. JASA, 123(4), 2064-2077.

Sisto, R., Pieroni, A., Delucis, C. (2007). Noise exposure and speech intelligibility in elementary schools in Tuscany. 19th International Congress on Acoustics, Madrid.

For more information, please contact Hans Mülder at hans.mulder@phonak.com