A guide to research on soundfield systems
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What are soundfield systems?

A growing number of companies are offering portable or fixed soundfield systems to support improvements in learning and behaviour for all children. This document aims to summarise key information to date. The BATOD Foundation is keen to encourage discussion on acoustic interventions and to formulate a UK based study on their effectiveness for deaf children.

Soundfield systems consist of a transmitter and a receiver linked to an amplifier. They use either infrared or FM radio technologies with one or more directional or flat panel loudspeakers to spread the amplified sound around the room. A well-designed system spreads the teacher’s voice uniformly, regardless of teacher or student position, at a comfortable listening level that avoids driving further reverberation. It is important that soundfield systems are installed correctly, in appropriate places in the classroom and with consultation of the teachers who will be using them; training in the use of soundfield systems is essential. A soundfield system will enhance the desired speech signal compared to the ambient soundscape. Used well they can improve listening and learning behaviours and help overcome effects of poor classroom acoustics.

In 2009 BATOD published two previous Association Magazine articles on soundfield systems as part of the Audiology Refreshers series (available on the BATOD website www.batod.org.uk). Audiology Refresher A4 outlines the benefits of soundfield systems in schools and gives representative feedback from children and staff about their use. Audiology Refresher A5 on portable soundfield amplification systems explains that reverberation and background noise are the main contributors to poor acoustic conditions in schools. Standards on acoustics had just become available through Building Bulletin 93 (BB93) Acoustic Design of Schools (DfES 2003) and schools were encouraged to think about the learning environment as part of their Disability Access Strategy planning.

Research on soundfield systems

In June 2010 the free access database PubMed1 was used to search for peer-reviewed articles related to soundfield (sound field or sound-field) amplification systems, classroom acoustics, reverberation and noise. Over two hundred references were sourced and three published literature reviews of relevance were consulted (Millett, 2008; Rosenberg, 2005; Stephenson, 2007).

Findings

Deaf children experience difficulties in learning spaces with excessive noise and reverberation levels (Bess, 1999; Smythe and Bamford, 1997). Early studies in the USA (Finitzo-Hieber and Tillman, 1978; Nabelek and Pickett, 1974; Ross and Giolas, 1971) showed the value of personal FM amplification and established that classroom

Acoustics should be considered a critical variable in the educational achievement of children.

The earliest investigation of soundfield amplification was the Mainstream Amplification Resource Room Study (MARRS) Project (Sarff et al., 1981). The MARRS Project was primarily intended as a means of helping students with mild or minimal fluctuating hearing losses compensate for poor classroom acoustics. Students that failed a 15 dB hearing screen were divided into three groups: a) typical classroom settings, b) regular classroom instruction and withdrawal for supplemental resource room instruction, and c) regular classroom instruction with soundfield amplification of the teacher's voice. Results showed that the academic achievement test gains in the amplified group were obtained faster and reached a higher level with lower costs than those in the unamplified groups.

In a study by Massie and Dillon (2006a; 2006b) teachers reported statistically significant improvement in communication and classroom behaviour in amplified compared to unamplified classrooms.

Soundfield systems are widely used in the USA and Canada. Studies in New Zealand have explored the implication of poor acoustic environments (Whitlock and Dodd, 2002; Wilson et al., 2002). Rosenberg (2005), Stephenson (2007) and Millet (2008) have produced comprehensive summaries of research studies investigating efficacy of soundfield amplification.

Rosenberg (op. cit.) concluded that soundfield amplification efficacy studies have demonstrated positive changes in students’ literacy growth and academic achievement, speech recognition abilities, attending skills, and learning behaviours. However, the rigorous literature search by Stephenson (2007) critically appraised available studies and concluded that "overall, evidence of the effect of sound field amplification on children’s academic or behavioural performance is not strong for two main reasons, these being a lack of published [peer-reviewed] studies and poor study design" (Stephenson, op. cit. iii).

Stephenson (ibid) noted that the best evidence for improved listening and learning behaviours came from two longitudinal studies by Rosenberg et al. (1999) and Heeney (2007). Rosenberg et al. (op. cit.) conducted a three-year study of a large sample of children aged 5 to 8 years in the USA. Teachers rated all the children in their class using a Listening and Learning Observation Schedule which compares students' listening behaviours and academic performance to other students in the class. In this study the 5-year-old children (kindergarten/Reception) appeared to benefit more from soundfield systems than the older children. It was suggested that this might be because the younger children have not developed the cognitive skills to fill in the linguistic gaps when they are unable to hear the teacher.

Children do not have the same auditory perception abilities as adults (Nelson and Soli, 2000). Children develop their sensitivity to the small differences in acoustic cues as their attending and listening skills mature (Johnson, 2000). Speech perception abilities within conditions of noise and reverberation may not reach adult-like levels of performance until the mid to late teenage years (Johnson, op. cit.).

Heeney (2007) showed that children who studied in classrooms with soundfield amplification improved to a greater extent than children in unamplified classrooms in

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2 Defined by the MARRS study as 15-40 dB
standardised tests of listening comprehension, reading comprehension and mathematics.

Millett’s literature review (2008) documented three main rationales for the use of soundfield amplification: a) the higher incidence of ear infections, and related hearing loss, in young children, b) greater difficulty understanding speech in the presence of noise, and c) immature listening skills related to neuro-maturation of the auditory system well into adolescence.

UK based studies have looked at the effects of noise and reverberation within the classroom. The South Bank University and the Institute of Education took part in the EPSRC EQUAL Research Initiative. They considered the effect of aspects of the design of school classrooms on the learning of integrated classes so as to develop better acoustic guidelines and teaching strategies. Between 2002 and 2005 learning conditions in 39 mainstream and special school classrooms for hearing and hearing-impaired children were surveyed in Berkshire, Hampshire, Hertfordshire, and London. Their studies in Primary schools have shown the negative relationship between performance and noise levels (Dockrell and Shield, 2006; Shield and Dockrell, 2008). David Canning’s recent interim report on changing the acoustic environment of Essex schools presents a considered evidence-based approach to the classroom refurbishment process (Canning, 2010).

The challenge of listening

Our listening skills develop with time and experience; we learn to use different levels of attention. Active listening involves a conscious search for environmental cues and requires the ability to focus on one sound to the exclusion of others. This ‘tuned in’ analytical listening may be associated with ‘left-brain’ type processes, the dominant hemisphere used in language processing. We also use an intermediate kind of listening in which the brain is ready to receive information and evaluate its potential significance, but attention is probably directed elsewhere. Truax (2000:22) suggests that listening skills depend “on association being built up over time, so that the sounds are familiar and can readily be indentified even by ‘background’ processing in the brain.” Background listening is an important part of the listening process but noise levels compete against this skill. When background noise levels increase there is a greater information load on the brain. Studies have shown generally high noise levels in UK mainstream schools (Dockrell and Shield, 2004; Moodley, 1989; Shield and Dockrell, 2004; Smythe and Bamford, 1997).

Sound waves travel through the air until they hit a surface; the sound waves are then partly absorbed by the surface and partly reflected off, back into the room. When we listen to sound in a room we perceive not only an original direct sound source, but also its many complex multi-source overlapping reflections. These reflections from reverberant surfaces quickly increase in number while their magnitude decreases approximately exponentially. The acoustic properties of a room change the character of direct sound, there are tonal alterations as reflections ‘colour’ the direct sound. Studies suggest that lower levels of reverberation allow for better speech perception (Bistafa and Bradley, 2000; George et al., 2008; Harris and Swenson, 1990; Hodgson and Nosal, 2002; Yacullo and Hawkins, 1987).

Speech is a modulating signal but the ‘shape’ or ‘pattern’ of this signal provides essential information; for good speech intelligibility modulation needs to be preserved (Davies, 2010). Reverberation causes the listener to receive multiple copies of the
original signal, all slightly delayed. Early reflections support speech intelligibility (Davies, 2010) but late reflections and background noise degrades speech modulation, the ‘shape’ of the sound is added to and filled in. The level of the desired signal compared to everything else (noise) is described as the signal-to-noise ratio. The brain is adept at pattern detection, but a minimum signal-to-noise ratio is required so that the desired signal may be separated from any competing noise (Truax, 2000).

A child with a sensori-neural hearing loss has the added challenges of reduced audibility, dynamic range, frequency resolution and temporal resolution (Dillon, 2001). It has often been stated that “the problem with hearing loss is that you do not hear so well, so you hear what you think you hear, and you do not hear what you do not hear” (Flexer, 2005). The complex nature of deaf children’s learning has been explored (Powers et al., 1999). With these factors in mind it is important to encourage discussion on acoustic interventions and to promote further UK based studies on their effectiveness for deaf children. Stephenson (2007) recommended randomised controlled trials to investigate the effect of both soundfield amplification and classroom acoustic augmentation on the academic and behavioural performance of children of different age groups.

The BATOD Foundation would welcome discussion on acoustic interventions with a view to formulating a UK based study on their effectiveness for deaf children.

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References


