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THE FM ADVANTAGE IN THE REAL CLASSROOM

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I. Introduction

Classrooms are auditory-verbal environments, where instruction is presented to the students by the teacher's spoken communication. Listening is the cornerstone of education as children are required to listen and understand what is communicated by the teacher. Children spend as much as 75% of their day in a listening situation. Therefore, in order for children to learn, they need optimal access to the target speech signal in classrooms. A barrier to accessing this auditory information is background noise (Flexer, 1997). Background noise affects speech recognition, academic performance, reading and spelling skills, concentration, attention, and behaviour in all children, whether they have normal hearing or a profound hearing impairment (Crandell & Smaldino, 2000). For children with hearing impairment, personal FM systems combined with a hearing aid give the optimal access to the target speech signal.

Typically, the ambient noise of a classroom in the United Kingdom averages 72 dBA L_{Aeq} (Shield, et al. 2001), compared with internationally recommended standards of 30-35 dBA (ASHA, 1997). The important factor for speech understanding is the signal-to-noise ratio (SNR), which is the relationship of the intensity of the speaker's voice and the intensity of the background noise. Unfortunately, the signal-to-noise ratio in classrooms ranges between +1 to +3 dB, compared with international recommendations of +15 dB. Therefore, children are not receiving adequate access to the target signal, the teacher's voice. This is a critical aspect to consider when investigating the impact of background noise. Classrooms are also reverberant environments with reverberation times that are often greater than 1.2 seconds, which is significantly greater than the recommended standard of 0.4 seconds (Crandall & Smaldino, 2000). However, reverberation rarely occurs alone in the classroom. It is combined with distance. As distance increases the ratio of direct sound to reverberant sound decreases, and there is more reverberant noise.

It is clear that classrooms are not reaching these international standards, and children are denied the optimal acoustic environment in which to access information to learn. In order to create a favourable SNR within a classroom, the teacher's voice must be enhanced, background noise needs to be reduced, and the listening distance decreased. Since decreasing background noise is not always possible, enhancing the teacher's voice and decreasing the distance are the only options. The use of personal FM is one way to enhance the teacher's voice and to increase the SNR. With a personal FM system, the child wears the receiver and there is a direct input into the hearing aids. Therefore, the negative effects of background noise and distance are lessened by utilizing a microphone that is fifteen centimeters from a teacher's mouth and transmitting the signal to a receiver via radio waves (Berg, Blair, & Benson, 1996).

The use of personal FM systems has been investigated through a number of studies; however, these studies have been in laboratory or simulated classrooms. Two studies have been completed in classrooms: one with children with normal hearing in a "real" classroom using a personal FM system (Arnold & Canning, 1999) and one study with children with severe-to-profound hearing impairment in a classroom designed for children with hearing impairment using a personal FM system (Boothroyd & Inglehart, 1998). In both studies the use of FM amplification was statistically significant and students demonstrated improved oral comprehension and speech understanding.

The present study advances the current body of research and provides insight to the benefits of utilising a personal FM system in the classroom and at home while extending the findings of previous studies of FM benefit to the "real" classroom. This is accomplished by documenting the benefit of FM through the use of assessment of oral language comprehension rather than speech understanding at a word or sentence level. This measure provides greater ecological validity, as children need to perceive and comprehend language presented orally to them.

Research questions

- 1. Does a personal FM system provide an improvement for the students in terms of oral comprehension as compared to hearing aids alone in the actual classroom learning conditions?*
- 2. What benefits do the children, families, and classroom teachers perceive from the use of the personal FM system at school and at home?*

2. Method

Participants

- 11 students in the United Kingdom, aged 5;11-15;2 years old (mean age: 11;0), participated in the current study. All students were;
- Users of hearing instruments (binaurally fit) for at least six months;
 - Oral language users;
 - Attending mainstream schools;
 - Able to complete open-set speech recognition in aided auditory alone conditions.

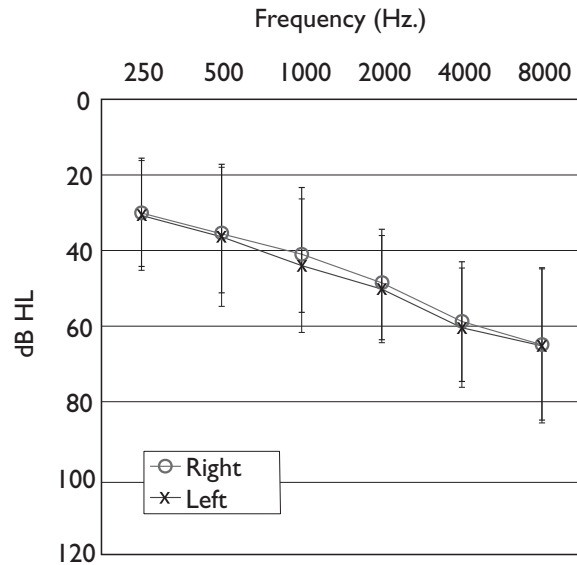


Figure 1: Mean audiogram for each ear with standard deviations for the 11 participants.

The hearing losses of the children ranged from moderate to profound sensorineural hearing loss. In the right ear, the mean unaided pure-tone average (500, 1000, and 2000 Hz) was 66.1 dB HL and in the left ear, the mean unaided pure tone average was 59.2 dB HL (Figure 1). This range of hearing loss is consistent with the guidelines for the National Deaf Children’s Society (NDCS) in the UK for fitting FM systems. Children with left corner or reverse sloping hearing losses were not included in the study. Eight of the 11 students had experience with FM.

Speech perception, speech production and receptive vocabulary were assessed before the trial with the FM system. The speech perception test (Manchester Junior Words) is an open set word identification test. The words were read aloud to the child by their Teacher of the Deaf using live voice at 60 dBA in quiet. A phonological analysis at the word level was completed by the child’s speech and language therapist. The speech and

language therapist also administered a receptive vocabulary test (British Vocabulary Picture Test, BPVT). Results of the test are below (Table 1).

Participant	Speech Perception	Speech Production	Receptive Vocabulary
1	93 %	All correct	119
2	93 %	All correct	92
3	100 %	All correct	89
4	93 %	All correct	46
5	100 %	All correct	86
6	100 %	All correct	104
7	79 %	All correct	116
8	100 %	All correct	117
9	100 %	All correct	111
10	50 %	Unintelligible	50
11	100 %	All correct	85

Table 1: Results for speech perception, speech production, and receptive vocabulary tests for all participants.

Equipment

The students used a personal FM system binaurally with their own hearing instruments for 3 months in their everyday lives. The FM system used was the Oticon Lexis system, consisting of:

- Lexis ear level receivers (with adjustable gain trimmers)
- Lexis handheld directional transmitter

The FM system was fitted to each ear following the Modernising Children's Hearing Aid Services (MCHAS) guidelines. The MCHAS's fitting protocol was used FM (Evans, 2002). It is an "equal output" method which ensures maintenance of the FM advantage. The resulting output from an input signal of 80 dB into the FM was balanced to equal the output from an input signal of 65 dB into the hearing instrument. Fitting was verified with electroacoustical measurements of the hearing aid and the hearing aid coupled to the FM system.

Procedure

FM benefit was assessed objectively and subjectively by a reading comprehension test (Neale Analysis of Reading Ability-Revised, NARA II) and questionnaires. The questionnaires included the Children's Home Inventory for Listening Difficulties (CHILD) (Anderson & Smaldino, 2000) and the Children's Outcome Worksheet (COW) (Williams, 2003).

The benefit of FM use was assessed objectively and subjectively through the use of reading comprehension and questionnaires. During the three month period, the students used the FM system at school and at home. Parents, teachers, and students all commented on the use of the FM system and its benefits.

In the second month of use, a modified version of a reading comprehension test, the Neale Analysis of Reading Ability (Neale, 1988), was administered in the classroom by the Teacher of the Deaf. It was completed on the side of the classroom while the class was engaged in quiet table work.

The level of noise in the test classroom varied between 55 and 80 dBA during “quiet” work time with students. The reverberation time ranged between 0.3 to 0.5s (mean: 0.4s) (Broughton, 2001).

The Neale Analysis of Reading Ability was read aloud with the student sitting two metres from the Teacher of the Deaf. Two forms of the test were used, one for FM and hearing aid and the other form for the hearing aid alone. The teacher’s voice (direct signal) was 55 dBA at the student’s desk. In addition, the use of FM was also assessed subjectively through standardised questionnaires. These questionnaires included the Children’s Home Inventory for Listening Difficulties (CHILD) (Anderson & Smaldino, 2000) and the Children’s Outcome Worksheet (COW) (Williams, 2003). The students completed their questionnaires with the assistance of their parents or the teacher of the deaf. Each questionnaire was completed before FM use began and after the three months of FM use. The first administration of the questionnaires focused on hearing aid benefit while the second administration was focused on the benefit from the FM system and hearing aid.

3. Results

Most students used the FM system between 4 and 8 hours per day in a variety of situations at school and home. The FM was used by all students at school during the day. Outside of school, watching TV and/or listening to music were the most common uses of the FM system (Figure 2).

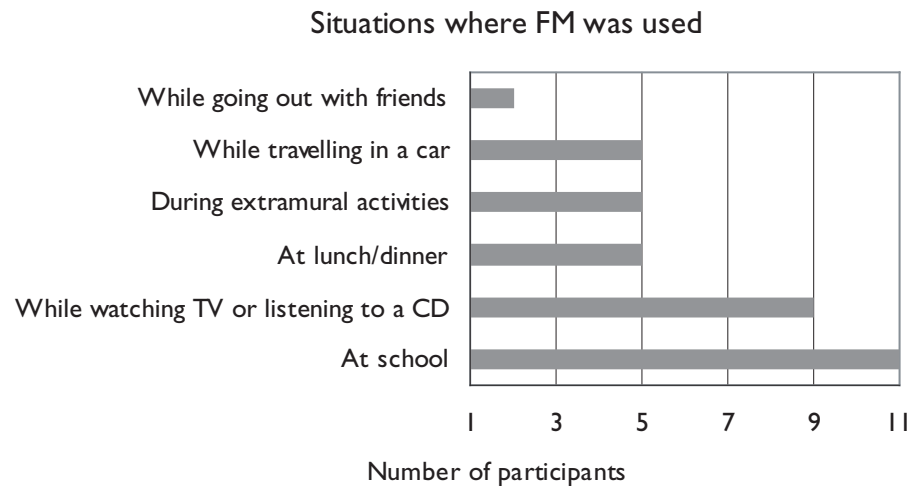


Figure 2. Situations in which the participants used the FM.

Results indicated that all students benefited from the use of the FM system in the classroom. The difference in benefit was statistically significant ($t= 4.59$, $df=10$, $p<.001$), with a mean for “HA” of 10.1 and a mean for “FM+HA” of 17.1. The standard error was 2.0 for “HA” and 2.6 for “FM+HA” (Figure 3).

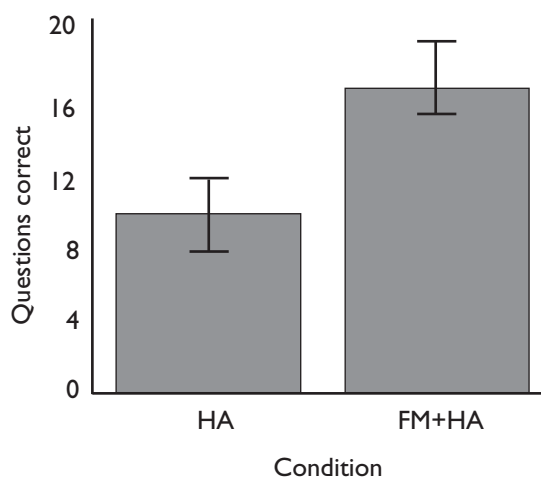


Figure 3. Neale mean scores and standard error for FM+HA and HA.

Listening Situational Benefit

A. Children’s Home Inventory for Listening Difficulties (CHILD)

The CHILD is a checklist of common daily situations that occur in a child’s home environment. Each checklist is completed separately by the parent and child. Fifteen situations are described and then each one is rated on the ability of the child’s understanding in each situation. The ability to understand is related to the “Understand-O-Meter” and ranges from 8 (“Great”) to 1 (“Huh”). The outcome of the checklist is identifying areas where there may be concern about the child’s ability to understand speech in the identified situations, and where the child therefore benefit from amplification. The CHILD can be re-administered to evaluate the benefit of amplification within the home environment.

Results from the CHILD demonstrated benefit from using the FM system in the home environment. The children’s average scores were statistically significant ($t= -2.43$, $df=10$, $p<.05$). The standard error was 0.3 for “HA” and 0.5 for “FM+HA” (Figure 4).

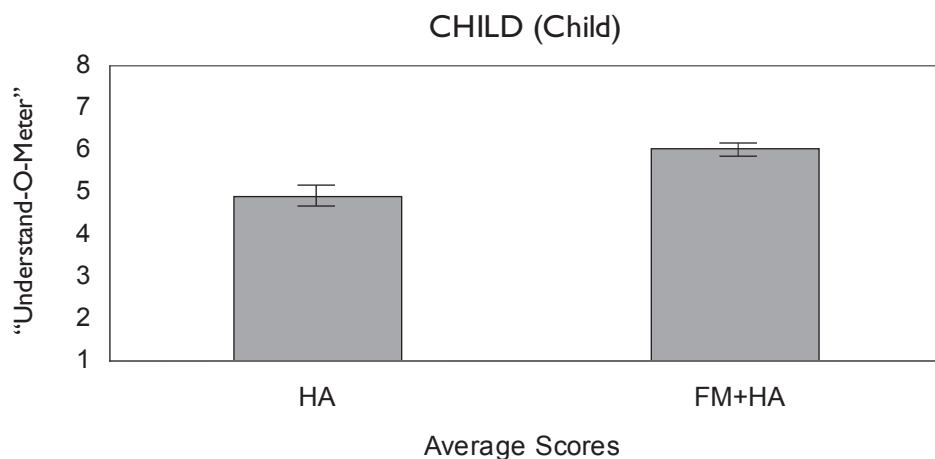


Figure 4. Children’s average scores with the FM+HA and the HA on the CHILD.

The parents average scores were statistically significant ($t= -2.48$, $df=10$, $p<.05$) and demonstrated benefit from using the FM system. The standard error was 0.4 for “HA” and “FM+HA” (Figure 5).

Seven situations were statistically significant ($p<.05$). Five of them were identified by the children and six by the parents, with four overlapping situations. Parents perceived the benefit of increased speech understanding while the “child and parent were at the dinner table” and when “they spoke to the child from behind in a noisy environment”. Benefit was perceived by the children when the FM system was used while “playing inside with a group of children”. Parents and children jointly reported benefit from using the FM when “the child was spoken to from behind when watching TV or playing with a noisy toy”, when “the child was in a quiet room and was spoken to without the person getting the student’s attention first”, when “the child was being called from another room”, or when “the child was listening from the backseat of a car”.

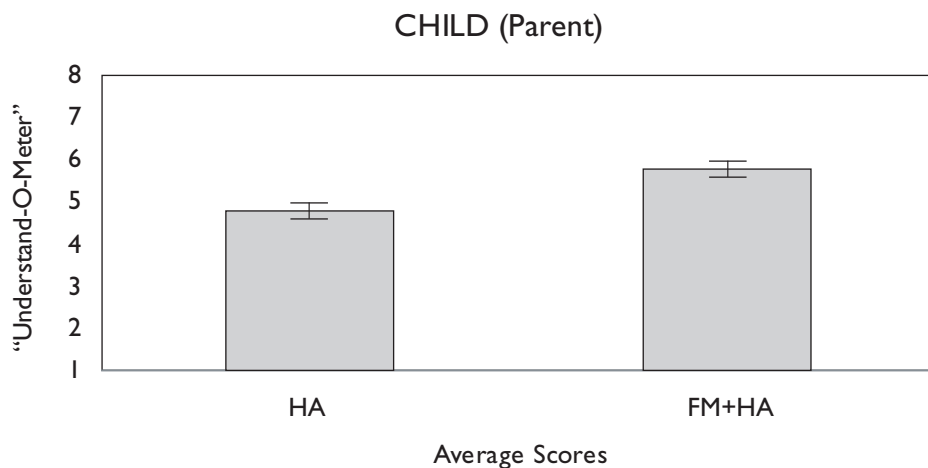


Figure 5. Parents’ average scores with the FM+HA and the HA on the CHILD.

Four of the fifteen situations are not applicable to the use of FM in the CHILD. These situations included “sitting side by side in a quiet room”, “the child using a clock radio or alarm to wake up”, “speaking on the telephone”, and “talking to the child in a quiet room”. Parents and children identified these as situations where FM is not needed and did not respond to them for the FM+HA condition.

B. Children’s Outcome Worksheet (COW)

The COW identifies the specific needs of parents, students, and teachers, and they establish situations where there is a need to hear better. After identifying the situations, they are rated in order of importance. The situations identified by five or more of the parents, students, or teachers focused on situations in the school setting.

Parents identified the following needs:

- “Hearing instructions in school”
- “Hearing when playing with a group of family or friends”

Parents and students jointly identified the following needs:

- “Understanding conversations during a meal”

Students identified the following needs:

- “Hearing other answers and comments”
- “Understanding the teacher’s lectures when he/she was moving around the classroom or in a large classroom”

Students and teachers jointly identified the following needs:

- “Understanding others during group work”
- “Understanding the speaker during assemblies”
- “Understanding the teacher during general instruction”
- “Understanding others during social activities”

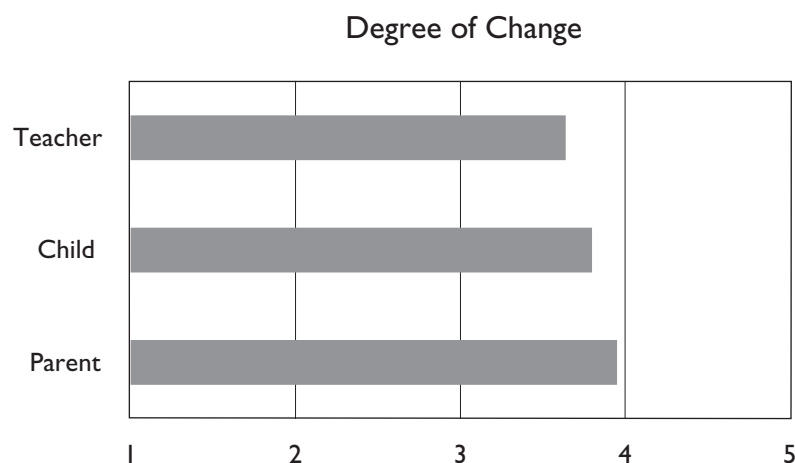


Figure 6. Degree of change perceived from using the FM system, as measured by the COW. 1= Worse, 2= No difference, 3= Slightly better, 4= Better, 5= Much better.

After a period of use with the new amplification (in this case FM use), the degree of change in each situation is rated on a 5 point scale from “worse” (1) to “much better” (5) by the parent, student, and teacher. Parents, students, and teachers rated the degree of change to be between “Slightly better” and “Much better” (Figure 6).

The ability or how often the student can hear satisfactorily is also rated on a scale from (1) “hardly ever” to (5) “almost always”. Parents, students, and teachers rated this satisfactorily level “Most of the time” when using the FM system.

4. Summary

The current study clearly demonstrates the benefit of using FM in a “real” classroom for students with hearing impairment ranging in degree from moderate to profound. The students were assessed in their own classroom after using the FM system for four to eight hours a day over a three month period. FM benefit was demonstrated using objective and subjective measures.

The study focused on the following two questions.

1. *Does a personal FM system provide an improvement for the students in terms of oral comprehension as compared to hearing aids alone in actual classroom learning conditions?*

A significant improvement ($p < .001$) was observed with the use of a personal FM system in the child’s “real” classroom. By using a personal FM system, each child responded accurately to more questions on the oral comprehension test than with hearing aids alone. When the children used only their hearing aid, the average number of questions answered correctly was 10; however, when the FM system was used, the average number of questions answered correctly was 17. This demonstrates that children are able to understand more information when an FM system is utilised in their classroom.

2. *What benefits do the children, families, and classroom teachers perceive from the use of the personal FM system at school and at home?*

Two questionnaires were administered to address this question. The responses from the children, families, and classroom teachers on the Children’s Home Inventory for Listening Difficulties (CHILD) and the Children’s Outcome Worksheet (COW) demonstrated a significant benefit was perceived through the use of a personal FM system. The main benefit, as compared to hearing aid alone, was an increase in speech understanding by the children which was perceived by the children, parents, and teachers.

The Children's Home Inventory for Listening Difficulties (CHILD) demonstrated the benefit of FM outside of the classroom. The average scores of the parents and children demonstrate significant benefit from the use of an FM system. Using the FM system improved the understanding of the children significantly in seven crucial situations. These situations included the child "playing inside with a group of children" and "listening from the backseat of a car". These situations often occur at home.

The Children's Outcome Worksheet (COW) showed the degree of change experienced when using FM. For the parent, student, and teacher, the degree of change was rated as "Slightly better" to "Much better". The ability with use of FM (Student "can hear satisfactorily...") was rated as "Half of the time" to "Most of the time". Situations identified include group work in class, listening to lectures, assembly during school, during mealtimes (lunch and dinner), and listening while in the car.

The data presented demonstrates benefits from the use of an FM system coupled to hearing aids in a child's daily life. The use of FM systems increases students' ability to understand information in the classroom. FM systems are used at school during lectures, group work and in assembly. At home, the use of FM systems also is beneficial while eating dinner and listening in a car.

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