Using Personal Response Systems in the Classroom as a Means to Evaluate the Efficacy of Soundfield Amplification.

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Factors Affecting Classroom Speech Perception

Talkers (Teacher and Other Students)
- Speech Level
- Clarity

Communication Channel (Classroom)
- Noise Level
- Reverberance
- Signal/Noise Ratio

Listeners (Students)
- Age/Development
- Hearing Status
- English Proficiency
- Other Disorders

• Teachers must adjust voices to be audible above background noise when noise > 40dBA

• Vocal adjustments contribute to increased vocal fatigue/strain

• Teacher’s voice quality and speech signal are compromised; poorer perception for children

• A disproportionate number of teachers experience voice problems
• 28% of schools in the US report that noise is their primary problem

• Noise interferes with speech intelligibility

• One third of the content of lessons can be missed due to poor acoustics

• Typically speech at 65dBA has vowels at 75-80 dB and consonants at 45-50 dB
  – Could be very difficult for children to detect consonants
- **Reverberation** is the persistence of sound after the original sound has stopped.

- **RT60** is the time required for reflections of a direct sound to decay by 60 dB below the level of the direct sound.

**RT60 Measurements**
- Classrooms typically vary from 0.4 to 1.5 seconds.
- High ceilings in old classrooms one of biggest problems.
ANSI Standard S12.60-2002 for classrooms

- Background noise levels should be below 35dBA
- Maximum RT$_{60}$ is 0.6 seconds
- SNR should be +15dB
- Reported in the UK that this increases the cost of building by 1% to meet these requirements
Acoustic survey of 55 classrooms in 25 schools:

18 out of 44 untreated rooms met ISO S12.60-2002
All treated rooms met criterion

How to improve classroom listening?
• Increasing acoustic absorption to reduce reverberation time
• Using amplification/sound field systems in the classroom

Individual Factors – e.g. Developmental Age

- 6-13 year old normal hearing typically developing listeners

- Speech Reception Thresholds (SRT) for Hearing in Noise Test (HINT)

- Adult SRTs shown by filled square

Goal of Sound Field Amplification (SFA)?

Provide a cost-effective way to evenly distribute the teacher’s voice around the classroom to enhance the delivery of the speech signal to all children.
It is difficult to truly determine efficacy of SFA

- Some researchers have used spelling tests
- Some tested speech perception with two children at a time
- Subjective evaluations, questionnaires and monitoring behaviour
Our study Goal

Talkers (Teacher and Other Students)

Communication Channel (Classroom)

Listeners (Students)

Recorded Speech to Simulate a teacher

Assess
- Vocabulary Age
- Hearing Status
- English Proficiency
- Special Educational Needs

Look at individual results

- $\text{RT}_{60}$
- SFA (on or off)
- Background noise (on or off)
Stimuli Screen – Chear Auditory Perception Test (CAPT)

Input – Real Word Monosyllables

1. Bat
2. Fat
3. Mat
4. Cat
Listeners - Group Data Collection Approach

Test set up in a nutshell

- Children trained on vocabulary
- Each child given a Personal Response System (PRS) - voting card
- Cards explained to the children
- Trained with warm up questions
- Speech Stimuli presented and children pressed appropriate option
- All responses stored by handset code
School Information - Rhyll

- Inner City 19th Century London School
- 2 classes:
  - 6-7 year olds (Year 2)
  - 7-8 year olds (Year 3)
- \( RT60 = 1.05s \) (Year 3s) & \( .89s \) (Year 2s)
- 22 children in each class
- In each class only 5 had English as first language
- Assessed expressive vocabulary age
- Otoscopy and tympanometry used with each child
- Testing in quiet and with noise
Classroom Layouts

- Children sat at normal classroom places
- Noises presented from side speakers
  - White noise from window speaker, ISTS noise from hallway side
- Calibrated at 46dBA at centre of room
### Listeners – Responses stored by card id

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Repeatability measure shows that 17.6% indicates a significant difference on an individual level i.e. 3 or 4 out of 20
Rhyll results

Significant effect of Age, SFA and presence/absence of noise

% Correct

Quiet no SFA
Quiet with SFA
46dB noise no SFA
46dB noise with SFA

Group 7-8 year olds 6-7 year olds
Rhyll results

Significant relationship between Vocab Age and CAPT in quiet and noise without SFA, BUT not with SFA
Rhyll results

Significant correlation between score without SFA and the benefit obtained from SFA

**Quiet without SFA**

R-square = .46, p<.001

**Noise (46dBA) without SFA**

R-square = .37, p<.001
School Information - Meadowbrook

- Bristol suburban new build
- 2 classes:
  - 5-6 year olds (Year 1)
- RT60 = .33s well within .6s recommendation
- 30 in first class and 29 in second class
- In each class 5 didn’t have English as first language
- Assessed expressive vocabulary age
- Otoscopy and tympanometry used with each child
- Testing in quiet and with noise
More children at Meadowbrook with lower vocab ages accessed speech.
Both schools greater improvement for poorer performers.

Meadowbrook – Good Acoustics

Rhyll – Poor Acoustics
Benefit greater for school with poorer acoustics

Small number of children got worse with SFA at Meadowbrook

Could Acute Testing be the problem – Rhyll were older children
School Information - Selwyn

- Inner City London School – New build
- 2 classes:
  - 5-6 year olds (Year 1)
- RT60 = 1.05s (Year 3s) & .89s (Year 2s)
- 22 children in each class
- In each class only 5 had English as first language
- Assessed expressive vocabulary age
- Otoscopy and tympanometry used with each child
- Testing in quiet and with noise
Little group effect with SFA

No child got significantly worse
Small number of children did improve
Benefit for different schools

![Graph showing the percent correct scores for Meadowbrook and Rhyll schools without Single Faculty Assignment (SFA).]
Selwyn have poorer scores but younger than Rhyll and majority have EAL
Children don’t get worse with SFA
Selwyn have poorer scores but younger than Rhyll and majority have EAL
Children don’t get worse with SFA
Some children improve with SFA

Benefit for different schools
Selwyn have poorer scores, but younger than Rhyll
Children don’t get worse with SFA
Some children improve with SFA
Meadowbrook some children got worse in acute testing
The way forward

- Conduct a large scale study to follow children in schools with different acoustic characteristics, different socio-economic regions to determine if SFA improves access to speech
- Assess hearing status, speech in noise perception
- Compare scores to educational outcomes
  - Spelling
  - Numeracy
  - Phonics screen
- Group testing of British Picture Vocabulary Scale
- Incorporate Nonsense syllables into test battery
Stimuli Screen – Nonsense Syllable Test

1. slub
2. lub
3. wubs
4. slun

Input – Nonsense Word Monosyllables
Test re-test for Nonsense syllables

\[ R^2 = 0.72 \]
Conclusions – Testing Approach

- Good test re-test reliability for speech tests (CAPT and Nonsense syllables) using PRS

- Children enjoy the task and it allows observation within a group setting

- Other applications:
  - Testing efficacy of FM systems within a classroom
  - Speech perception testing in freefield
    - Individual or group
  - Observe perception of children with dyslexia, APD and other special educational needs
Conclusions – SFA

- SFAs provide improvements for speech perception in poor acoustic environments

- In general the poorer performers gain the most

- In good acoustic environments some children gain benefit but majority are unaffected

- Some children deteriorated in good acoustic environments with the SFA – most likely due to acute testing

- Need large scale study to explore individual factors
Vickers, D. et al. (in press). *Using personal response systems to assess speech perception within the classroom: an approach to determine the efficacy of sound field amplification in primary school classrooms*. Ear and Hearing

Please contact me for further details

Thank you

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