THE EFFECTS OF CLASSROOM NOISE ON CHILDREN'S ACADEMIC ATTAINMENTS

PACS REFERENCE: 43.50.Qp

Shield, Bridget [1] and Dockrell, Julie[2]

[1] School of Engineering, South Bank University, Borough Road London SE1 0AA, UK
Tel: 0044 20 7815 7658, Fax: 0044 20 7815 7658 email: shieldbm@sbu.ac.uk

[2] London Institute of Education, 25 Woburn Square, London WC1, UK
Tel: 0044 20 7612 6297, Fax: 0044 20 7684 1051, email: j.dockrell@ioe.ac.uk

ABSTRACT
Noise levels have been measured in 140 classrooms in 16 primary schools in central London. The noise levels have been compared with school data on children's performance in national standardised assessment tests of 7 and 11 year olds. There were significant correlations between background noise levels in occupied classrooms and test results, particularly those of the older children, suggesting that classroom noise has a detrimental effect upon children's academic performance.

INTRODUCTION
Noise surveys have been carried out in and around primary schools, that is schools for 5 to 11 year olds, in London. Internal noise levels were measured in over 200 locations in sixteen schools, including empty and occupied classrooms, assembly halls and corridor spaces. In order to investigate the effects, if any, of classroom noise on children's attainments at school, the measured noise levels were compared with academic performances of the schools as reflected by the results of standard assessment tests (SATs). These are tests which are taken by all children in state primary schools in the UK at the ages of 7 and 11.

RELATION TO PREVIOUS WORK
It is generally accepted that noise has a detrimental effect upon the cognitive development of primary school children, and that older children in this group appear to be more affected than younger children [1,2]. At the beginning of the 1990s two major reviews of previous work in this area [3,4] both concluded that chronic noise exposure of young children has a detrimental effect upon their reading ability.

The majority of previous studies have been concerned with the effects of environmental noise, particularly aircraft noise, upon children's academic attainments [5-11]. However, some recent studies have examined the effect of internal classroom noise on children's performance. It is generally recognised that background noise level in a classroom should not interfere with the ability of the children to hear the teacher. Hetu et al [3] found a significant drop in children's performance, particularly in learning to read, when the background noise level interfered with speech. Berg et al [12] suggest that background noise levels in classrooms should be below 50 dB(A). Mackenzie [13] compared the performance

of children in primary school classrooms that had been acoustically treated, thereby reducing background noise levels, with children in untreated classrooms. Children performed better in word intelligibility tests in the acoustically treated rooms, the improvement being particularly marked when other pupils were talking in the classrooms. Similar results were obtained by Maxwell and Evans [14] in a study of pre-school children who had been exposed to levels in the classroom of 75 dB(A). Following acoustic treatment to reduce the noise the children's performance improved in letter, number and word recognition.

However, no previous studies have examined the effect of classroom noise upon children's performance as measured by SATs results, although Haines et al [15] used SATs results in determining the effects of aircraft noise exposure upon school children.

The present study showed a wide range of noise levels in the classroom. Comparison of these noise levels with SATs data therefore enabled the outcome of varying exposures to noise to be examined. In addition, a comparison of the noise parameters measured with the SATs scores allows an investigation to determine the most important aspect of the noise (for example its background or ambient level) in relation to performance, an aspect that has not been considered in previous studies. Thus in comparing internal levels with SATs results it is possible to investigate not only whether classroom noise has an effect on performance but also what parameter of sound measurement is most closely associated with any effect.

CLASSROOM NOISE SURVEYS

Noise surveys were carried out in 16 schools. In each school, short 2 minute measurements were made during lessons in classrooms and other occupied and unoccupied spaces around the school, such as assembly halls, foyers, stairs and corridors, and empty classrooms. This method of measuring noise has been found to be the most appropriate for primary school surveys, being efficient and reliable and in particular unobtrusive and non-disruptive to teachers and pupils [16].

The noise surveys were combined with classroom observation which showed that the noise inside classrooms was dominated by the noise of the children and dependent upon the particular activity in which they were engaged. External noise was rarely noticeable and did not influence the level of noise in the classroom except in the quietest conditions [16]. However, questionnaire surveys of children and teachers showed that they were aware of and annoyed by external environmental noise [17]. The classroom observation identified six distinct types of classroom activity, as follows:

Activity 1	Children sitting at tables doing silent reading or tests
Activity 2	Children sitting at tables or on the floor, with one person (teacher or child) speaking at any one time
Activity 3	Children sitting at tables working individually, with some talking
Activity 4	Children working individually, moving around the classroom, with some talking
Activity 5	Children working in groups, sitting at tables, with some talking
Activity 6	Children working in groups, some movement, some talking

CLASSROOM NOISE LEVELS

In total, in the 16 schools surveyed, measurements were made in approximately 110 occupied classrooms, 30 empty classrooms, and 50 other locations. These measurements have been averaged according to year group, classroom activity and type of space; the average values of L_{Aeq} and L_{A90} are presented in Tables 1, 2 and 3.

Table 1. Average L_{Aeq} and L_{A90} activity levels

Activity	Average noise level	
	L_{Aeq}	L_{A90}
Activity 1	56.3	42.4
Activity 2	61.2	45.8
Activity 3	64.7	52.1
Activity 4	72.2	59.6
Activity 5	72.9	58.6
Activity 6	76.8	63.9

Table 2. Average L_{Aeq} and L_{A90} location levels

School location	Average noise level	
	L_{Aeq}	L_{A90}
Occupied teaching space	72.1	54.1
Unoccupied classrooms	47.0	36.9
Corridor/foyer/stairs	58.1	44.6
Occupied hall	73.4	55.1
Unoccupied hall	53.2	44.3

Table 3. Average L_{Aeq} and L_{A90} age group levels

Year/age group	Average noise level	
	L_{Aeq}	L_{A90}
Reception (4-5 year olds)	73.9	62.3
Year 1 (5-6 year olds)	74.3	61.0
Year 2 (6-7 year olds)	66.3	51.3
Year 3 (7-8 year olds)	68.9	52.5
Year 4 (8-9 year olds)	69.6	49.8
Year 5 (9-10 year olds)	73.2	53.8
Year 6 (10-11 year olds)	71.2	52.9

STANDARD ASSESSMENT TESTS (SATS)

Children take SATs in Year 2, when they are 7 years old (Key Stage 1 tests) and in Year 6, when they are 11 (Key Stage 2 tests). At Key Stage 1 (KS1) they are tested in reading, writing, spelling and mathematics and at Key Stage 2 (KS2) in English, Mathematics and Science. The Department for Education and Skills publishes results for all schools as the percentages of pupils entered by a school who achieve a certain standard in each subject. Average KS1 and KS2 scores for each school are also published.

The measured noise levels were compared with the SATs results for the year 1999-2000, as this was the academic year in which the majority of the noise levels were measured.

COMPARISON OF TEST RESULTS AND NOISE

Measured internal L_{Aeq} and L_{A90} noise levels have been correlated with average and subject Key Stage 1 and Key Stage 2 SATs results. The internal data used were the Year 2 and Year 6 average levels, as these are the years in which children sit SATs; activity levels for Activities 1 to 6; and the average levels measured in the various school locations.

It is known that social deprivation has a negative effect upon children's performance at school [15,18]. It is therefore necessary in any analysis of noise and school performance to eliminate the confounding effects of social or economic factors which might be related to poor academic achievement. The following data was obtained in relation to the schools: percentage of children receiving free school meals (FSM), percentage of children with English as an additional language (EAL) and percentage of children with special educational needs (SEN). Partial correlation was carried out to eliminate the effects of these three factors on the data.

Correlation with year group levels

No significant correlations were found between Year 2 and Year 6 noise levels and individual or average SATs results.

Correlation with activity levels

The only significant negative correlations between activity levels and SATs results were between the background (L_{A90}) level for Activity 5 and KS1 Reading ($r=-0.725$, $p<0.05$) and Mathematics ($r = -0.726$, $p<0.05$) results.

However, when the effect of FSM was eliminated, there was a significant correlation between Activity 3 L_{A90} and KS2 English ($r = -0.564$, $p<0.05$) and when EAL was accounted for there is significant correlation between Activity 3 L_{A90} and KS2 English ($r = -0.616$, $p<0.05$).

It is not clear why background noise levels during only Activities 3 (children sitting at tables working individually, with some talking) and 5 (children working in groups, sitting at tables, with some talking) were related to SATs results. One possibility is that there was insufficient data to give significant results for the other activities. An alternative explanation is that these two activities represent the most common classroom situation, and hence noise levels measured during these activities are the levels occurring during most learning tasks.

Correlation with location levels

The greatest number of significant correlations was found between location levels and SATs results. There were no correlations between location levels and the average KS1 scores. However, significant negative correlations were found between the average KS2 scores and background (L_{A90}) levels in occupied classrooms ($r = -0.635$, $p<.01$). This suggests that noise is related to the SATs results of the older rather than the younger children, which is consistent with the results of previous research [5,7]. A scatter diagram illustrating the relationship between classroom L_{A90} levels and average KS2 scores is shown in Figure 1.

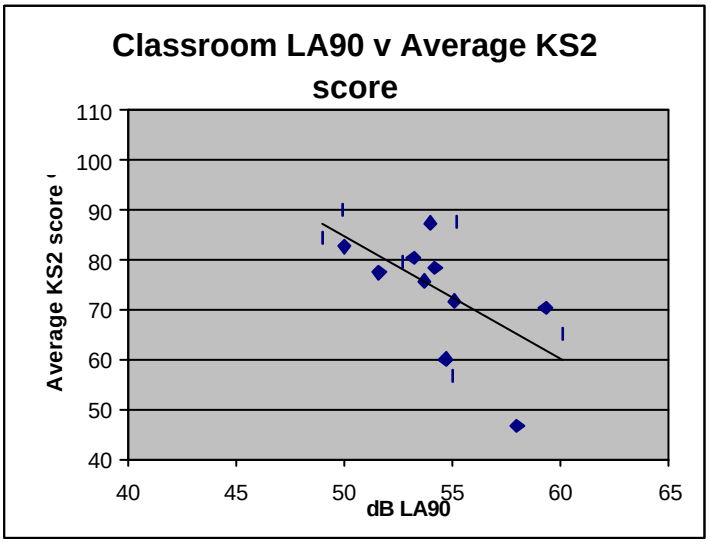

Figure 1. Relationship between L_{A90} in occupied classrooms and average KS2 SATs scores

When considering SATs results for individual subjects the L_{A90} levels for occupied classrooms were significantly negatively correlated with several subjects as shown in Table 4. Background levels in unoccupied classrooms and corridor/foyer areas were also significantly correlated with some subjects as can be seen in Table 4, and the average L_{Aeq} for occupied classrooms was significantly correlated with the KS2 English score.

Table 4 Significant correlation coefficients between SATs results and location levels

	KS1 Reading	KS1 Writing	KS1 Spelling	KS1 Maths	KS2 English	KS2 Maths	KS2 Science
Occ class L_{Aeq}					-.554*		
Occ class L_{A90}	-.599**	-.598**		-.574**	-.765**		-.503*
Unocc class L_{A90}				-.544*			
Corr/foyer L_{A90}					-.623*		

*significant at 5% level ** significant at 1% level

Table 4 shows that the strongest relationships between internal noise levels and SATs scores are given by the background (L_{A90}) levels in classrooms. It can also be seen that KS1 Mathematics and KS2 English are the subjects most affected by noise. There are no significant relationships between noise and KS1 Spelling or KS2 Mathematics.

Correlation with location levels corrected for socio-economic factors

Average school SATs scores

When partial correlation analysis to eliminate the effects of FSM or EAL is carried out, there were no significant correlation coefficients relating internal levels and average SATs results. When correcting for SEN, there were significant relationships between average KS2 results and corridor/foyer L_{Aeq} level ($r = -0.621$, $p<0.05$), and occupied classroom L_{A90} ($r = -0.633$, $p<0.05$) levels.

School subject scores

When individual subject scores were considered there were several significant relationships, even when data was corrected for school characteristics. When the effects of FSM were eliminated KS2 English scores were significantly correlated with corridor/foyer L_{A90} levels ($r = -0.555$, $p<0.05$), and with occupied classroom L_{A90} ($r = -0.663$, $p<0.01$) levels. When the effects of EAL were eliminated KS2 English scores were significantly correlated with corridor/foyer and occupied classroom L_{A90} levels ($r = -0.585$, $p<0.05$ and $r = -0.683$, $p<0.01$ respectively). When correcting for SEN L_{A90} levels in classrooms were significantly correlated with several subjects (KS1 Reading: $r = -.602$, $p<0.05$; KS1 Writing: $r = -.623$, $p<0.05$; KS1 Maths: $r = -.604$, $p<0.05$; KS2 English: $r = -.758$, $p<0.01$).

In this case the results obtained were similar to those for the uncorrected data. As before KS2 English is the subject most affected by noise, and occupied classroom background (L_{A90}) level was the parameter most closely associated with SATs results.

CONCLUSIONS

The results of correlation analysis between measured noise levels in schools and the results of standardised assessment tests suggest that internal classroom noise is related to children's performance, having a detrimental effect on SATs scores. This relationship exists when the data is corrected to allow for socio-economic factors. The noise parameter most closely associated with SATs scores is the background noise level (L_{A90}) in occupied classrooms. In some cases there are significant correlations with background and underlying levels in unoccupied classrooms and corridor/foyer areas; these areas may give an indication of the general noise environment in a school. The test most affected by noise is KS2 English which is consistent with previous studies which have found reading to be the task most affected by noise, particularly for older children. The results are also consistent with the

findings of a parallel experimental study [19] which examined the effects of classroom noise on children's processing of verbal and non-verbal tasks.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Health and Department of the Environment, Food and Regional Affairs for financing this project, and the schools, children and teachers who took part in this research. Thanks are also due to Rebecca Asker and Ioannis Tachmatzidis for collection of the noise and school data.

REFERENCES

1. Berglund B and Lindvall T. Community Noise. Document prepared for World Health Organisation. Archives of the Center for Sensory Research 2(1), Stockholm University and Karolinska Institute, Sweden, 1995.

2. Institute for Environment and Health. The non-auditory effects of noise. 1997.

3. Hetu R, Truchon-Gagnon C, Bilodeau SA. Problems of noise in school settings: a review of literature and the results of an exploratory study, J. Speech, Language Pathology and Audiology, 14 (3), 31-38, 1990.

4. Evans G and Lepore S. Non-auditory effects of noise on children: a critical review. Children's Environments 10, 31-51, 1993

5. Bronzaft AL and McCarthy D P. The effect of elevated train noise on reading ability. Environment and Behaviour 7, 517-527, 1975

6. Cohen S, Evans G W, Krantz D S, Stokols D and Kelly S. Aircraft noise and children, longitudinal and cross sectional evidence on adaptation to noise and the effectiveness of noise abatement. J Personality & Soc Psychology 40, 331-345, 1981

7. Green, K B, Pasternack B S and Shore R E. Effects of aircraft noise on reading ability of school-age children. Archives of Environmental Health 37, 24-31, 1982.

8. Haines M M, Stansfeld S A, Job R F S, Berglund B and Head J. Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children, Psychological Medicine 31 (2), 265-277, 2001

9. Hygge S, Evans GW and Bullinger M. The Munich Airport noise study: Cognitive effects on children from before to after the change over of airports. Proc. Internoise '96, Liverpool, 2189-2192, 1996.

10. Sanz S, Garcia AM, Garcia A. Road traffic noise around schools: a risk for pupils' performance? International Archives of Occupational and Environmental Health 65, 205-207, 1993.

11. Lundquist P, Holmberg K and Landstrom U. Annoyance and effects on work from environmental noise at school. Noise and Health 2(8), 39-46, 2000

12. Berg F, Blair J and Benson P. Classroom acoustics: the problem, impact and solution. Language, Speech and Hearing Services in Schools 27, 16-20, 1996.

13. Mackenzie D J. Noise sources and levels in UK schools. Proc. International symposium on Noise Control and Acoustics for Educational Buildings, Proc Turkish Acoustical Society, 97-106, Istanbul, May 2000.

14. Maxwell L and Evans G. The effects of noise on pre-school children's pre-reading skills. J. Environmental Psychology. 20, 91-97, 2000

15. Haines M M, Stansfeld S A, Head J and Job R F S. Multi-level modelling of aircraft noise on performance tests in schools around Heathrow Airport London. J. Epidemiology and Community Health (in press 2002)

16. B M Shield and R L Asker. The measurement of classroom noise, submitted for publication, 2002.

17. J Dockrell and B Shield. Children's perceptions of environmental noise in classrooms. Proc. Institute of Acoustics Spring Conference, 2002

18. Higgs,G,Bellin W and Farrell S. Educational attainments and social disadvantage: contextualising school league tables. Regional Studies 31, 775-789, 1997

19 J Dockrell and B Shield. The effects of noise on children's processing of verbal and non-verbal tasks. Forum Acusticum Seville, 2002