

Environmental noise impact on school students' academic achievements

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The aim of this paper is to investigate the relationships between environmental noise levels of schools and a set of academic achievement factors and also, to determine the noise exposure of schools. Secondary schools in Greater London were studied. Four academic achievement indicators were considered and five noise indicators were obtained after processing noise map data. The results show that in the studied schools, the environmental noise levels have almost no significant relationships with those academic achievement indicators. As expected, the secondary schools in Inner London are noisier than those in Outer London, with an average difference of 2dBA.

1. INTRODUCTION

About 10 million people in Europe are exposed to the excessive traffic noise, which may cause stress, illness and even fatal impact. In the UK, according to the national noise survey, people indicated that the road traffic noise around their home had got worse over the last five years, and the majority of the UK population were affected by the noise levels above those suggested by the WHO Guidelines for Community Noise [1].

There have been some studies on the detrimental influence of chronic external noise upon the academic performance and attainments of school children. A number of findings have indicated that chronic noise exposure would impair concentration, general cognitive functioning, and particularly reading skills [2-8]. However, previous evidence was normally based on subjective or field surveys with sampled school sites, and the results were often limited to a restricted range of areas and in particular, the research on the secondary schools has been limited. A key study relating to this research was conducted by Shield and Dockrell [2], to examine the impact of external and internal noise on the academic attainments of London primary school children, although it only considered a number of schools situated in 3 London boroughs. It was found that external noise has a significant negative impact upon performance, the effect being greater for the older children.

Recently large-scale urban strategic noise mapping has become an essential requirement, particularly in European countries [9-12], although there have been various attempts to improve the accuracy [13-15]. The socio-acoustic research approach has been widely applied, for instance on the relationship between human reactions to noise and non-acoustic variables, like income and occupational status [11,17-22].

The aim of this study is to investigate the relationships between environmental noise levels of secondary schools from noise mapping calculations and a set of academic achievement factors, as well as to determine the noise exposure of secondary schools. For that the Greater London is considered as a case study city.

2. METHODOLOGY

In the UK pupils aged 14 to 16 years old normally enrol in Key Stage 4 and at the end of this stage there is a range of exams typically of the General Certificate of Secondary Education (GCSE) level. The average total point score provides a fuller picture of the achievements of pupils of all abilities at Key Stage 4. The Achievement and Attainment Tables for all the secondary schools in England are published every year by the Department of Children, Schools and Families (DCSF). As previous research suggests that environmental noise has a negative impact upon pupils' performance [2, 6, 8], four major achievement indicators were considered for this study, including the average total point score per pupil of Key Stage 4, Contextual Value Added (CVA) score, overall and persistent absence. CVA score measures the progress made by pupils from the end of Key Stage 2 (KS2) to the end of Key Stage 4 (KS4), using their test and exam results. CVA takes into account the varying starting point of each pupil's KS2 test results, therefore provides a fairer indication of a school's overall effectiveness [23]. The overall absence is the percentage of possible half-days recorded under any combination of the authorised and unauthorised absences for schools which do not report absence by reason, while persistent absence is the percentage of pupil enrolments equalling or exceeding the threshold number of half-day absences over the Autumn and Spring terms combined [23].

The administrative area of Greater London is generally divided into Inner and Outer London. Inner London forms the interior part of Greater London with a land area of 319 km² and the population is 3 million. Occupying 1253 km² for 4.57 million residents, outer London forms a ring around Inner London [24]. Over 500 secondary schools are listed in Greater London in the DCSF Achievement and Attainment Table. Regarding the initial selection, the schools without applicable academic achievement factors were automatically excluded from the selection. The schools in the areas where aircrafts are dominant noise sources were excluded due to their special features. According to the official airport noise maps [25], the schools located within 60dB zone were deleted from the above list. Based on random number generation, 96 secondary schools in Greater London were identified and verified in accordance with relevant noise maps. Data in both academic achievement and noise aspects were then obtained from corresponding databases.

The original data calculated for the noise levels of secondary schools in Greater London were obtained from an open database called London Noise Maps [10]. It considers road traffic as the predominant noise source in London. The maps represent the average noise levels at a height of 4m above the local ground level. The published colour noise maps were processed to obtain a series of digital numbers for the following analysis. The average noise levels of London Noise Maps are expressed in L_{den} , which is a logarithmic composite of the day, evening and night levels [16]. After being smoothed for display, each pixel in the noise map indicates a 1m \times 1m square in reality.

The approximate boundary of a sampled school was firstly approached from the noise map database in accordance with its unique postcode. As the initially obtained noise maps may contain other unwanted buildings or areas surrounding the schools but are actually not a part of the selected schools, essential boundary information was double checked through GoogleMap and StreetMap to ensure every building of the studied school was not excluded.

A MATLAB program was developed for the further processing of the identified noise map data. Figure 1a illustrates a typical noise map of a secondary school in Greater London, where each colour represents a 5dBA scale, which is the highest

available resolution from the published noise maps. Since the noise levels range from 35 to 85dBA, this resolution is acceptable for this study. Firstly a noise map is loaded into MATLAB program, and all the colours of that map will be automatically transformed to corresponding noise values in a 2D grid system. Two sets of matrix are subsequently generated, as illustrated in Figure 1b and 1c. In Matrix A (see Figure 1b), 0 represents the location of building blocks and other values refer to the actual noise levels in dBA at grid points where applicable. Based on Matrix A, Matrix B (see Figure 1c) is produced to demonstrate the noise environment around the school buildings, where only the noise levels at the grid points indicating the 1m external locations outside the facades of selected school buildings are retained, while all the other values are assigned to 0. It is noted that Figure 1b and 1c correspond to the area highlighted with dotted lines in Figure 1a.

Five indicators were introduced to this research, including the average spatial noise level L_{s-ave} (dBA), maximum spatial noise level L_{s-max} (dBA), minimum spatial noise level L_{s-min} (dBA), intrusive spatial noise level L_{s-10} (dBA) and background spatial noise level L_{s-90} (dBA), respectively. It is noted that L_n generally represents the level of noise exceeded for n% of the specified measurement period, whereas in this study they were to represent spatial rather than temporal distribution. In other words, if N noise levels are obtained for a school from Matrix B and they are sorted in an descending order, then L_n is the $(100n/N)$ th noise levels in the order.

3. RESULTS AND DISCUSSIONS

Table 1 demonstrates the comparison of five noise indicators, namely the average, maximum, minimum, spatial background and intrusive noise levels between secondary schools located in Inner and Outer London. As expected, the latter is generally lower than the former, although the mean differences are small in magnitude ranging from 0.6 to 3.6dBA, and not statistically significant for most noise indicators, except the intrusive noise level L_{s-10} ($p < 0.05$). L_{s-10} is normally related to the direct sounds towards the buildings. Previous findings also suggested that the noise climate of Inner London is different from that of Outer London in terms of noise levels, noises heard and attitudes to noise [1]. It is also noticed that L_{s-max} in Table 1 is relatively low compared to the conventional temporal indicator of L_{max} , which is because L_{s-max} only indicates the spatial maximum value of average external noise levels outside the selected school buildings.

The Building Research Establishment (BRE) completed a national noise incidence study in 2001 [1] and a specific London noise survey in 2004 [26]. The actual noise level, based on the site measurements covering seven Outer London boroughs where the population is greater and four Inner London boroughs, is relatively higher than that of the average noise level of London secondary schools, with a considerable difference of approximate 7dBA. The large number of internal space and facades within the school premises is likely to be the reason.

In Table 2 the correlations between five environmental noise indicators of secondary schools and four academic achievement indicators are shown. It is shown that all the environmental noise levels have no significant correlations with the academic achievement indicators of the sampled schools, and the correlation coefficients are very low. This suggests that external noise levels may not be a good indicator of internal and overall noise levels, for which previous studies have shown a significant impact on academic achievement [2]. Clearly the airborne sound insulation of building envelopes could play an important role [27]. There are also differences in terms of noise types, education stage of schools and external activities.

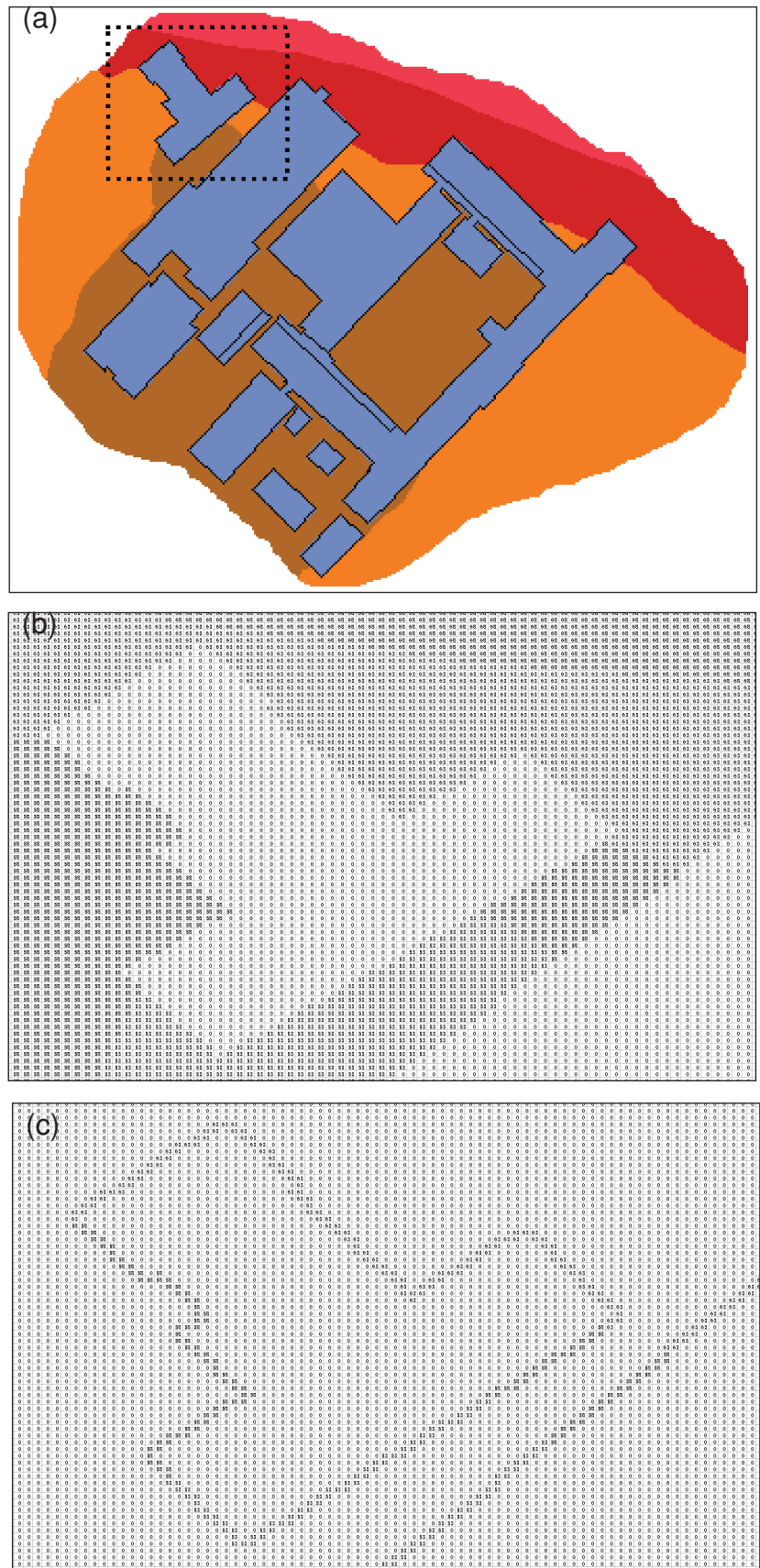


Figure 1. An example representing the standard data processing of a school noise map: (a) A typical noise map of a London secondary school [10]; (b) Matrix A, showing the noise distribution in the area marked with dotted lines in Figure 1a; (c) Matrix B, showing the environmental noise levels around the school buildings in the area marked with dotted lines in Figure 1a.

There are marked variations between secondary school sites within Greater London, in terms of environmental noise levels and distance to the main roads. As shown in Table 3, the difference between the maximum and minimum noise levels of selected schools is more than 20dBA. Therefore, all the schools were sorted by the noise levels in a descending order. The first 25 schools with greater levels were then selected as a sub-group, called road-side school group for the sake of convenience, representing those more influenced by the direct sound of traffic noise and more likely to be close to the main roads. For these road-side schools, all the indicators were normally distributed, except the noise indicator L_{s-min} and L_{s-90} .

Further correlations between the five environmental noise indicators of those 25 secondary schools and the four academic achievement indicators are analysed, as shown in Table 4. It can be seen that the only significant correlation was found between the intrusive environment noise and persistent absence ($p < 0.05$). It is interesting to note that past studies have revealed that both socio-economic issues and classroom environment quality are related to student absence [28-30]. It is possible that similar to the effect of classroom CO₂ concentrations on attendance rate [30], excessive external noise level might also be associated with student absence.

Table 1. Comparison of environmental noise levels (dBA) of secondary schools between Inner London (30 sampled schools) and Outer London (66 sampled schools), where the significance level (2-tailed) are also shown, with ** indicates $p < 0.01$ and * indicate $p < 0.05$.

	Mean		Standard deviation		Mean difference
	Inner London	Outer London	Inner London	Outer London	
L_{s-ave}	51.6	49.8	4.67	5.02	1.8
L_{s-max}	59.0	56.1	8.92	8.21	2.9
L_{s-min}	47.2	46.3	2.92	3.73	0.9
L_{s-90}	48.0	47.4	3.31	4.43	0.6
L_{s-10}	57.3	53.7	8.25	7.50	3.6 (*)

Table 2. Pearson and Spearman correlation coefficients between environmental noise levels of all secondary schools and academic achievement indicators, where the significance levels (2-tailed) are also shown (** indicates $p < 0.01$ and * indicate $p < 0.05$).

		Key Stage 4 score	CVA score	Overall absence	Persistent absence
Pearson	L_{s-ave}	0.056		-0.029	-0.078
Spearman	L_{s-ave}		0.106		
	L_{s-max}	0.064	0.147	0.080	0.046
	L_{s-min}	0.066	0.028	-0.106	-0.118
	L_{s-90}	0.056	0.013	-0.034	-0.071
	L_{s-10}	0.085	0.160	0.050	0.014

Table 3. Descriptive Statistics of environmental noise levels (dBA) of all the secondary schools and the road-side school group (25 sampled schools with greater noise levels).

		Number of sampled schools	Minimum	Maximum	Mean	Standard deviation
Road-side school group	L_{s-ave}	25	54.0	60.8	56.7	1.92
	L_{s-max}	25	57.5	72.5	65.7	5.38
	L_{s-min}	25	47.5	52.5	49.7	2.53
	L_{s-90}	25	47.5	57.5	52.3	3.06
	L_{s-10}	25	57.5	72.5	63.7	4.85
All schools	L_{s-ave}	96	37.5	60.8	50.4	4.96
	L_{s-max}	96	37.5	72.5	57.0	8.49
	L_{s-min}	96	37.5	52.5	46.6	3.50
	L_{s-90}	96	37.5	57.5	47.6	4.10
	L_{s-10}	96	37.5	72.5	54.8	7.88

Table 4. Pearson and Spearman correlation coefficients between environmental noise levels of road-side school group and academic achievement, where the significance levels (2-tailed) are also shown (** indicates $p < 0.01$ and * indicate $p < 0.05$).

		Key Stage 4 score	CVA score	Overall absence	Persistent absence
Pearson	L_{s-ave}	-0.172	-0.267	0.169	0.193
	L_{s-max}	-0.144	0.054	0.229	0.335
	L_{s-10}	-0.215	-0.002	0.298	0.417(*)
Spearman	L_{s-min}	0.123	-0.073	-0.129	-0.157
	L_{s-90}	-0.053	-0.343	-0.132	-0.254

4. CONCLUSIONS

Through the use of noise map database, the analysis shows that the secondary schools in Inner London are noisier than those in Outer London, with an average difference of 2dBA. It has been shown that the environmental noise levels of secondary schools in Greater London have almost no significant relationships with the academic achievement indicators [31].

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PUPILS: WHISPER PLEASE

Children were told to whisper during lunchtime at a Portsmouth school – because the noise they made was giving staff headaches. Headteacher Iain Gilmour said too many children were shouting and that if they continued to be loud they would have to sit in silence. One mother, whose nine-year-old daughter attends the school, said: 'I asked the headteacher and he said he asked the children to whisper. When I asked why he said he gets a headache. Mr Gilmour said: 'In our lunch hall we had 110 children shouting. It was breaking the health and safety laws in terms of decibels. We said to them "please talk quietly and if you can't talk quietly then don't talk at all".'