Original Article

Effects of traffic noise around schools on attention and memory in primary school children

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Abstract

Background and Aim: Noise pollution has been of increasing concern worldwide, particularly in urban areas. Children could be particularly vulnerable to the effects of noise because of its potential to interfere with learning at a critical development stage. Most of the learning occurs at school and thus noise exposure at school is most pertinent to its influences on cognitive performance. Hence, the objective of this study was to evaluate and compare the attention and memory in school children exposed to noise with the school children in relatively noise free area in the city of Bengaluru.

Methods: The study involved two groups, a case group consisting of 80 students learning in a noise environment of 80.4 dB and a control group consisting of 80 students learning in noise environment of 56.28 dB. Both groups were found to be matched for age, gender, intelligence, and socioeconomic status. Attention and memory were assessed using a battery of performance tests. The results were analyzed for statistical significance.

Results: Exposure to high levels of noise during learning significantly reduced scores in attention, working memory with an auditory component, and logical memory. However, there was no significant reduction in working memory with a visual component and visual memory.

Conclusion: The results suggest that high levels of noise is a disadvantage to children's learning capacity and learning environment must not be neglected.

Key words: Attention, children, cognition, memory, noise pollution, traffic noise

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INTRODUCTION

Noise pollution is an increasing concern worldwide, particularly in most urban areas. According to World Health Organization (WHO), traffic noise is one of the main sources of environmental noise exposure in urban communities.[1] With the growing demand for road travel, more people are being exposed to noise and noise exposure have become an increasing and important environmental public health issue.[2] Progressive hearing loss due to exposure to continuous noise of 85–90 dB is a known fact which is due to the direct auditory effect of sound energy on human hearing. However, the less well-established and accepted are the nonauditory effects of noise which acts as a general stressor on cognitive performance.[2,3]

Attention and memory is involved in cognitive development at primary school age.[4] It is a necessary skill within the educational system which defines the way in which we acquire and apply information and skills on a daily basis. Children attend to information that is then encoded in memory through processes of rehearsal, organization, and elaboration.[4] Noise can

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have a greater effect on the degree to which information is processed, retained, and recalled.[5] According to WHO, the permissible noise level in school environment should not exceed 35 dB.[3] School is a microenvironment, important for cognitive development of children.[1] Noise exposure at school which is a critical period of learning could influence cognitive performance and potentially affect child's educational achievements.[2,6]

Most of the current literature in this regard is available on aircraft noise with mixed results. The literature that is available in India is inadequate, especially on road traffic noise. Hence, this study was undertaken to evaluate the extent of cognitive disability of a student exposed to noise with a student in relatively silent area in the city of Bengaluru. Most previous studies have induced artificial noise to know its effects on memory unlike the current study where it is done in natural ambience. All confounding factors have been considered in the present study.

MATERIALS AND METHODS

It was a case–control study carried out in Bengaluru City of Karnataka. Two schools were selected based on noise levels in Karnataka State Pollution Control Board report and noise levels were measured using sound level meter (QUEST technologies, MODEL 1900 integrating logging sound level meter). One was located in a noise polluted area (LEQ - 80.4 dB) and the other in a relatively quiet area (LEQ - 56.28 dB). Both the schools were teaching state board syllabus and had English as the medium of instruction. Two groups of cases and control were made, case group consisting of students learning in a noise environment of 80.4 dB and control group consisting of students learning in noise environment of 56.28 dB.

Students aged between 7 and 11 years of both genders were included in the study. At the beginning of the session, a brief introduction about the project was given. Children were told that information was for the researchers and not for the school and no one else would know their results. Students with history of any organic or psychiatric illness, hearing problem, specific learning difficulty, and noncooperative children were excluded from the study.

Selection of students was done based on multistage screening. Stage one screening involved screening for behavioral problems and it was done using pediatric symptom checklist.[7] Eligible candidates were selected and stage two screening was done. The stage two screening involved general physical examination, systemic examination, and pure tone audiometry (ARPHI [500 MK I]) to rule out hearing defects was done. Ravens Colored Progressive Matrices was administered to assess the intelligence.[8] Eighty students from case group and 80 students from control group satisfying the inclusion and exclusion criteria were selected by simple random method.

Ethical clearance was taken from the Institutional Ethical Board and written consent from the participant's parents/guardian was obtained. Tests for assessment of attention and memory were administered. Tests for attention was digit span forward, test for working memory were digit span backward,[9-11] word recall meaningful, word recall nonmeaningful,[12] and tests for logical memory were story recall immediate and story recall delayed,[13] and picture recall was used for visual memory.[14] Before each test, the method of answering was explained and the children were trained. Any problem with tests was solved during training. Information regarding socioeconomic status was obtained from parents using modified Kuppuswamy's socioeconomic status classification.[15] Results were compiled and statistically analyzed.

Statistical analysis of data

Descriptive statistical analysis has been carried out on the data obtained in the present study. The statistical software SPSS (Statistical Package for Social Sciences), version 15 was used for data entry and analysis. Results on continuous measurements are presented on mean ± standard deviation (SD) and results on categorical measurements are presented in number (%). Chi-square test and analysis of variance have been used to find the significance of study parameters on categorical scale between two groups and more than two groups, respectively. Student's *t*-test (two-tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups. Spearman's correlation has been used to study correlation between study variables. $P < 0.05$ was considered significant. Microsoft word and excel have been used to generate graphs and tables.

RESULTS

The present work is a comparative study involving 80 cases and 80 controls. The mean age (±SD) of students in years was 9.44 (±0.81) and 9.47 (±0.83) for cases and control, respectively. With regard to gender, the proportion of males was 53.8% for cases and 51.2% for controls. The two groups were found to be well matched for age ($P = 0.843$) [Table 1], intelligence ($P = 0.727$) [Table 2], gender ($P = 0.874$), and socioeconomic status ($P = 0.704$). Six parameters were evaluated in the two groups [Table 3].

Students from the noisy areas (i.e., cases) performed poorly in digit span forward, digit span backward, logical

memory immediate and logical memory delayed when compared to students from less noisy area (i.e., controls). There was no significant difference in performance in the two groups in word recall meaningful, word recall nonmeaningful, and picture recall. Spearman's correlation revealed significant negative correlation of traffic noise around schools with digit span forward, digit span backward, logical memory immediate, and logical memory of the study population [Table 4].

DISCUSSION

The pattern of results from current study to examine and compare the performance on attention and memory tasks in children aged 7–11 years attending schools exposed to road traffic noise above acceptable levels with those attending schools in a relatively noise free area were as follows: Attention, working memory (digit span backward), and logical memory were affected in the case group. The reduced performance in attention in the case group is consistent with the results found by van Kempen *et al*. and Haines *et al*.[16,17] This effect is because there is a competition for attentional resources between the distracter and the target stimuli.[18]

Performance was reduced in working memory in digit span backward recall task which is in accordance with the study done by Haines *et al*. and Ljung *et al*.[17,19] It is a complex task requiring storage and manipulation of the information prior to recall which is thought to tax working memory. When the number of inputs one must attend increases, task performance deteriorates. Noise increases demands on the working memory which has a limited capacity reducing the information processing resources available for the memory tasks disrupting the performance of complex task.[18] Processing the speech in unfavorable conditions such as traffic noise puts higher demands on the working memory.[20] This could be the possible reason for reduced performance in the cases.

Logical memory which reflects episodic memory was also found to be affected by traffic noise. Similar results were found by Matsui *et al*. who found chronic exposure to aircraft noise was associated with decreased motivation in school children reflecting in the deficits in episodic memory.[6] Increased exposure to noise leads to learned helplessness which eventually accounts for deficits in motivation in children.[21]

Performance in digit span backward was affected but word recall meaningful and nonmeaningful was not affected, though all these assess the working memory. This difference is attributed to the fact that digit span backward has an auditory component, whereas the other two have visual component. Performance in picture recall task assessing the visual memory was also not affected. It can be observed that visually presented task performance seemed not to be affected by noise. These findings are in line with Saeki *et al*.[22]

Functionally, when compared to vision, sense of hearing has an omnidirectional nature and it has the capacity to receive information at almost all times, even in darkness or during sleep. Hearing also has a capacity to respond to sharp changes in energy, to capture attention even while a person is otherwise engaged, and this feature is an advantage for designing alarms, but it also has a disadvantage that the persons can easily get distracted to irrelevant sounds even when the intention is to concentrate on something else.[23] Hence, significant difference between two groups for digit span forward, digit span backward, logical memory immediate, and delayed was found.

Table 1: Age distribution of cases and controls

Age groups (years)	Cases (*n*=80) (%)	Controls (*n*=80) (%)
8-9	24 (30)	23 (28.8)
9-10	27 (33.8)	29 (36.2)
10-11	29 (36.2)	28 (35)
Mean±SD	9.44±0.81	9.47±0.83

P=0.843 (insignificant). SD: Standard deviation. Statistical analysis of data was done by Students *t* test and Chi-square test. *P*>0.05 was considered significant

Table 2: RCPM distribution of cases and controls

RCPM	Cases (*n*=80) (%)	Controls (*n*=80) (%)
Above intelligence	15 (18.8)	17 (21.2)
Intelligent	47 (58.7)	42 (52.5)
Average	18 (22.5)	21 (26.3)

P=0.727 (insignificant). RCPM: Ravens Colored Progressive Matrices. Statistical analysis of data was done by Chi-square test. *P*>0.05 was considered significant

Table 3: Comparison of study variables in cases and controls

Test	Cases (*n*=80)	Controls (*n*=80)	*t*	df	*P*
Digit span forward	4.11±0.59	4.31±0.56	−2.18	158	0.031*
Digit span backward	2.9±0.56	3.15±0.69	−2.496	158	0.014*
Logical memory immediate recall	6.81±1.87	7.5±1.94	−2.273	158	0.024*
Logical memory delayed recall	5.98±1.57	6.61±1.76	−2.408	158	0.017*
Word recall meaningful	6.06±1.31	6.43±1.37	−1.703	158	0.09
Word recall nonmeaningful	5.23±1.35	5.61±1.31	−1.831	158	0.069
Picture recall	2.49±0.59	2.65±0.67	−1.612	158	0.109

**P*<0.05. Data expressed as Mean±SD. Statistical analysis of data was done by Students *t* test. *P*>0.05 was considered significant

Table 4: Correlation of traffic noise around schools with attention and memory in the entire study population

Parameters	*n*	Traffic noise	
		r	*P*
Digit span forward	160	−0.165	0.037*
Digit span backward	160	−0.197	0.013*
Logical memory immediate recall	160	−0.183	0.021*
Logical memory delayed recall	160	−0.183	0.021*
Word recall meaningful	160	−0.147	0.064
Word recall nonmeaningful	160	−0.135	0.088
Picture recall	160	−0.119	0.135

*P<0.05 was considered significant

These effects could not be accounted by age, gender, intelligence, or socioeconomic factors as the two groups were found to be well matched for the confounding factors which eliminate the possible effect of the confounding factors on the results obtained.

Limitations of the study

The present study focused on exposure to noise in schools, though noise at home might also affect the performance. The study was conducted on a limited sample over a short duration of time. Large scale study is needed so that the effects of traffic noise on attention and memory would be representative of population.

CONCLUSION

Exposure to high levels of traffic noise in learning environment significantly reduces attention, working memory with auditory component, and episodic memory. However, working memory with visual component and visual memory is not affected by noise.

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Conflicts of interest

There are no conflicts of interest.

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