AIRCRAFT NOISE AND ITS EFFECT ON PRIMARY SCHOOL TEACHING AND LEARNING: IS THERE A LONGITUDINAL EFFECT OR ARE CHILDREN MORE RESILIENT THAN WE THINK?

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Aircraft noise from flight operations in the landing and takeoff phase near airports is a well recognised environmental stressor. Children enrolled at primary schools near aircraft flight paths are often exposed to noise levels which are believed to hinder teaching and learning. A recent South African study has yielded interesting findings which shed light on how children cope in noisy situations, and has implications for the relative location of schools and airport flight paths.

1. Introduction

Exposure to aircraft noise in communities around airports is frequently linked to concerns about public health. Modern airliner aircraft are substantially quieter than earlier models designed and built in the 70’s and 80’s, resulting in much smaller individual noise footprints. However, as the noise footprints have decreased, the numbers of flights are on the increase, meaning that significant numbers of city inhabitants remain exposed to aircraft noise. Research has been conducted in first world countries investigating the effects of aircraft noise exposure on children’s cognitive performance. Exposure to chronic aircraft noise was found to be associated with a six-month delay in the reading ability of 8-11 year old children. Consistent findings were made during the RANCH project in London (Heathrow Airport), Madrid (Barajas Airport) and Amsterdam (Schiphol) in an epidemiological study, which showed that exposure to aircraft noise at school was related to poorer reading comprehension and the association was maintained even after adjustment for socio-economic variables, episodic memory (conceptual recall and information recall), working memory and sustained attention. Whilst there have been a number of studies demonstrating an association between exposure to chronic noise, and annoyance, memory, reading comprehension and attention, recent studies have suggested otherwise, and that children may be more resilient to noise than expected.

Of interest in this study is whether the effects of exposure to chronic noise are permanent, whether children develop coping mechanisms, making them more resilient to the effects of aircraft noise or whether chronic exposure to aircraft noise impairs children’s performance only on more difficult items of cognitive performance tests. This interest had its origin in studies which have suggested that the effects of chronic noise exposure are reversible, but evolved into a curiosity as to
whether children develop resilience to otherwise disturbing sounds, and consequently manage to cope in noisy environments.

This paper considers a follow-up of a cross-sectional study\textsuperscript{14} conducted in South Africa by Joseph Seabi, Kate Cockcroft and Paul Goldschagg in 2009, nine months before the closure of Durban International Airport (DIA), and the recent work of Charlotte Clark, Jenny Head and Stephen Stansfeld\textsuperscript{10} who conducted a follow-up of the UK cohort of the RANCH study in which they investigated the longitudinal effects of aircraft noise on children’s health and cognition.

In the 2009 DIA study, the authors compared the performance of 437 (52\%) learners who were exposed to chronic aircraft noise with 337 (48\%) children from relatively quiet environments on reading comprehension in a cross-sectional study. The results demonstrated significant differences in favour of those from quieter areas. Following the closure of Durban International Airport in June 2010, measurements were conducted on the same cohort of learners in 2010 and 2011 in a longitudinal study, which will be discussed in the following section. In the RANCH study, in which 2844 children participated, exposure-effect associations were found between aircraft noise exposure at school, and children’s reading comprehension, recognition memory, noise annoyance, and hyperactivity scores\textsuperscript{10}. In the follow-up RANCH study, the responses of 461 children were considered\textsuperscript{10}, which are discussed later in this paper. Therefore, the intention of this paper is to determine whether the effects of aircraft noise on reading comprehension remained after the relocation of the airport or whether they disappeared.

2. Longitudinal effects

2.1 What are longitudinal effects?

Learning under noisy conditions requires more effort since children must use increased cognitive capacity to process information. When noise disturbs teaching and learning, cognitive processing may be impaired, and academic potential in the long term may be compromised\textsuperscript{11-13}. Learning occurs through the mechanisms of memory, and so studies investigate whether children’s long-term and working memory are affected by exposure to aircraft noise during the school day\textsuperscript{9}. The purpose of ongoing research is to determine whether these effects are still manifest later in life, and establish whether aircraft noise exposure interferes with children’s activities, but also if such interferences are found, whether they persist despite relocation of the airport, become worse, or whether children are able to adapt and catch-up with their counterparts in non-noise affected areas.

2.2 How are these assessed?

The DIA and RANCH follow up studies adopted a longitudinal epidemiological field study design, whereby repeated observations of the same variables over a three-year period (2009-2011) for DIA, and six years for RANCH were made between learners located within the vicinity of the noisy flight path and those in relatively quieter areas. Longitudinal studies that explore the associations between exposure to noise, and reading comprehension are required not only to provide understanding of causal pathways between these variables, but also to assist in the designing of preventive interventions.

DIA data were collected over three waves. The analyses is based on the follow-up of the 2009 (Wave 1) cross-sectional study, with a focus on the 2010 (Wave 2) and 2011 (Wave 3) cohorts. Wave 1 involved pre-test measurements of attention, working memory, annoyance, health, and reading comprehension of learners prior to the relocation of the airport. Wave 2 (August 2010) and Wave 3 (August 2011) comprised tracking of the same learners and assessing the aforementioned
areas of functioning after Durban International Airport relocated on the 1st May 2010 to the new site.

Schools were identified for the DIA study based on noise measurements made in the school grounds. The baseline $L_{Aeq}$ noise measurements for the high-noise groups at the DIA noise exposed schools near the flight path (Wave 1) varied from 63.5 to 69.9 $L_{Aeq}$. Maximum noise levels varied from 89.8 to 96.5dBA $L_{Amax}$. In the case of the low-noise groups at schools in relatively quieter areas, noise measurements during Wave 1 testing yielded results of 54.4 to 55.3 $L_{Aeq}$ and 73.2-74.3 $L_{Amax}$. Noise measurements during Waves 2 and 3 when aircraft were absent produced results at the formerly noise exposed schools of 55.2 $L_{Aeq}$ and maximum noise levels of 60.8 to 71.2 $L_{Amax}$. Levels at the quieter schools were averages of 50.5 to 57.9 $L_{Aeq}$ and 60.6 to 70.5 $L_{Amax}$.

A cohort of 732 learners with a mean age of 11.1 participated at baseline measurement at Wave 1. At Wave 2, a sample of 650 learners with a mean age of 12.3 were reassessed. At Wave 3, the sample comprised 178 learners with a mean age of 13.1. The loss of participants due to attrition was because permission to follow-up some learners in Grade 8 at their new high schools was not granted by some school principals, and unseasonably bad weather during the assessment day which resulted in many learners being absent from school.

3. Resilience

Under noisy conditions, listening is more effortful, requiring more cognitive resources to decode verbal information which may be misheard, misunderstood or not heard at all\(^9\). Noise removes attention from the target task, and when it occurs at the same time as learning, it has a negative effect on how information is processed, stored and retrieved\(^12\). Children may be more susceptible to noise than adults, because children’s understanding of speech in a noisy environment only reaches adult levels in the late teens\(^3\). Thus, children may have a reduced capacity to anticipate the impact of noise, as well as a lack of well-developed coping repertoires for dealing with noisy environments, relative to adults. When the noise occurs during learning time, it may significantly impair cognitive processing and have long-term effects on the achievement of academic potential.

Resilience develops when children find ways of coping in the learning situation – called cognitive coping\(^17\) – so that noise is dealt with by tuning it out. Shield and Dockrell\(^17\) argue that this should result in generalised poor attention, which implies that a full range of cognitive tasks would be affected, but does not appear to happen.

4. Findings

The noise exposed children performed better than children at the quieter schools on the cued recall measure of episodic memory and working memory. However, noise exposed children performed significantly worse than their peers at the quieter schools on prospective memory. The groups did not differ on free recall of episodic memory or attention. Neither noise annoyance nor sensitivity mediated the effects of noise on episodic or working memory. The conclusion reached is that children in noisy environments may develop coping mechanisms, including increased control mechanisms such as working memory. This supports models of cognitive arousal which propose that noise enhances attention and performance via stochastic resonance. While children’s memory capabilities may be more resilient than anticipated, chronic noise may impair aspects of memory vital for learning, such as prospective memory.

Two interesting findings emerged from this study. Firstly, background noise appears less detrimental to memory for verbal material than may be thought. The results suggest that aircraft noise has little effect on children’s episodic memory recall and recognition, or on visio-spatial working
memory and attention. A negative effect of aircraft noise was found on prospective memory, suggesting that such noise may tax different memory systems in different ways. It is possible that the memory systems of the children in the noisy group were working harder than those in the quiet group in order to yield a non-significant result. Working memory is particularly implicated in making inferences based on incomplete information as a result of competing background noise. More cognitive processing resources may need to be allocated in such situations in order to ignore the irrelevant background noise. The noisy environment may also produce a general increase in arousal that counteracts boredom via stochastic resonance. According to the Moderate Brain Arousal Model\textsuperscript{15}, noise in the environment introduces internal, neural noise, thus raising the individual’s level of arousal. Prolonged exposure to noise may actually result in working and episodic memory functioning effectively through mechanisms such as habituation and stochastic resonance. Since participants had lived in the area for two years or more, it is unclear how long it would take for such coping mechanisms to develop. This suggests that noise abatement interventions should not only include concrete amenities, such as insulation and soundproofing, but also cognitive strategies to improve memory.

The second finding was the negative effect of aircraft noise on prospective memory. Prospective memory is one of the most important memory systems for children in a classroom context. Children are often asked by their teacher to do something after they have finished with a task or at a specific time. It is difficult to explain why prospective memory was the only memory system to be negatively affected by aircraft noise. Episodic, working and prospective memories share many common processes, yet also have unique processing requirements. It is possible that an overtaxed attention resource system may only have sufficient processing capacity to deal with the immediate tasks. The processes of sustained attention and attentional switching, which are fundamental to optimal prospective memory, are sensitive to interference\textsuperscript{16}. The noise may distract these processes from operating efficiently, impairing the complex, transient attentional processes inherent in monitoring the environment for target cues. Since prospective memory is vital for learning, this has implications for the placement of schools, formulation of acoustic standards and how best to allocate limited noise abatement resources.

In their six-year follow-up of the UK RANCH cohort Clark et al.\textsuperscript{10} report a non-significant decrease in reading comprehension. This suggests that there are similarities in the findings of the present study and the RANCH follow-up, and that children may develop resilience. A limitation of the DIA study is that no information was collected on children’s noise exposure at home, or on internal classroom noise levels. Further studies which incorporate more detailed noise information are needed before definite conclusions can be drawn.

Impairment of learning in classrooms should be regarded as a process, based on the total number of noise events, the loudness of these events, and the length of time pupils are exposed. More attention needs to be paid to multiple causal links. For example, establishing noise exposure at home is difficult without researchers being resourced. Some children in noisy environments grow and prosper, whilst others follow the path of vulnerability research (alcohol and drug abuse, delinquency, violent behaviour). More research is needed to look at children who are resilient to noise, and develop an understanding of what causes resilience.

In conclusion, in those areas where noise is intense, there is a wide body of research which shows that noise-exposed environments are not healthy when measured against sleep disturbance, cardiovascular health, and mental health. It would not, as a precautionary measure be remiss to implement land use planning policies which keep sensitive land users, including schools, away from places where aircraft noise is encountered.

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REFERENCES


