Teachers' reactions to environmental noise at school in the RANCH project: a potential mechanism for noise effects on children's cognition?

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ABSTRACT

Mechanisms hypothesised to account for environmental noise effects on children's cognition include communication difficulties, and teacher stress responses, noise annoyance and frustration. This paper reports on questionnaire data collected from 270 primary-school teachers, from 89 schools near Amsterdam-Schiphol, Madrid-Barajas, and London-Heathrow airports, as part of the RANCH project. Associations of aircraft and road traffic noise exposure at school on teachers' noise annoyance, perceived stress, and perceptions about how noise interferes with children's learning were examined. Aircraft noise estimates for the schools were based on 16-hour outdoor LAeq contours. Road traffic noise estimates were from modeled data, traffic flow data and measurements. Data was pooled across the countries for regression analysis, which adjusted for gender, time at the school, and country. Teachers exposed to aircraft noise at school were significantly more likely to report aircraft noise annoyance than teachers not exposed to aircraft noise (OR=1.14, 95%CI 1.10-1.19, p<0.001). A similar association was found for road traffic noise (OR=1.13, 95%CI 1.06-1.20, p<0.001). Aircraft noise and road traffic noise exposure at school were not significantly associated with self-reported perceived stress (B=0.034, 95%CI -0.23-0.092, p=0.243; B=0.098, 95%CI -0.07-0.202 p=0.066, respectively). Teachers exposed to aircraft noise at school felt it significantly interfered with pupil's communication, concentration, performance, and quality of work (p<0.01): similar associations were observed for road traffic noise (p<0.001). Noise exposure at school was associated with increased teacher annoyance but not self-reported stress. Future analyses will examine the role of teacher perceptions of interference with pupil's learning on the noise effects observed with children's cognition in the RANCH project.

INTRODUCTION

Overall, evidence for the effects of road traffic and aircraft noise on children's cognition and learning has strengthened in recent years, with many studies demonstrating that children exposed to chronic noise exposure at school have poorer reading comprehension and memory than children who are not exposed (Evans and Hygge, 2007, Stansfeld *et al.*, 2005). Similarly, studies have shown that children who

are exposed to chronic aircraft noise at school perform more poorly than their non-noise exposed counterparts on nationally standardised tests (Shield and Dockrell, 2008).

Overall, several plausible pathways and mechanisms for the effects of environmental noise on children's cognition have been put forward, including teacher and pupil frustration (Evans and Lepore, 1993), learned helplessness (Evans and Stecker, 2004) and impaired attention (Cohen *et al.*, 1973, Evans and Lepore, 1993).

In general evidence for mechanisms is fairly sparse; in particular, the role of the teacher in noise effects on children's cognition and learning has not received much research attention. Teacher frustration and interruptions in communication between teachers and children could be a mechanism for cognitive effects (Evans *et al.*, 1991). In the noisiest schools teachers may have to stop teaching while aircraft fly over or loud vehicles pass by and if this is frequent it may contribute to interruptions in communication, as well as to fatigue, stress and reduced motivation in teachers. Noise also causes annoyance, especially if an individual feels their activities are being disturbed or if it causes difficulties with communication. In some individuals, this annoyance may lead to stress responses. Noise annoyance in teachers has received little attention both as a behavioural response to noise, and also as a potential explanatory variable in the relationship between noise exposure at school and children's learning outcomes.

This paper focuses on teacher's annoyance and self-reported stress responses to noise exposure at school. The paper also examines teacher reports of how they think noise exposure at school impacts upon teacher-student communication and children's learning.

METHODS

Participants

Between April and October 2002, we enrolled children aged 9–10 years from primary schools near Schiphol, Barajas, and Heathrow—airports in the Netherlands, Spain, and the UK—to the cross-sectional RANCH (Road traffic and Aircraft Noise exposure and children's Cognition and Health) project(Stansfeld *et al.*, 2005). Schools were selected on the basis of increasing levels of exposure to aircraft and road traffic noise, using the same method in each country, so as to examine exposure-effect relations. We matched chosen schools by the socioeconomic status of the pupils; in the UK and Spain this was measured by eligibility for free school meals and by main language spoken at home; in the Netherlands, we used a neighbourhood-level indicator of property value and the proportion of non-Europeans living in the area and attending the school to match schools. We excluded schools at which noise surveys indicated the presence of a dominant noise other than aircraft or road traffic noise. In the UK and Spain, we selected two classes of children of mixed sex from each school, and in the Netherlands one class. If there were more than two classes in the year, then we randomly selected the classes.

In the UK, Spain and the Netherlands, the class teacher of each class selected was invited to take part in the Teacher sub-study of the RANCH project. In Spain, other class teachers within the school were additionally invited to take part in the Teacher sub-study of the RANCH project by the research team. In the UK, ethical approval for

the study was provided by the East London and the City Local Research Ethics Committee, East Berkshire Local Research Ethics Committee, Hillingdon Local Research Ethics Committee, and Hounslow District Research Ethics Committee. In the Netherlands, ethical approval was given by the Medical Ethics Committee of The Netherlands, Organisation for Applied Scientific Research, Leiden. In Spain, ethical approval was given by the Consejo Superior De Investigaciones Cientificas (CSIC) Bioethical Commission, Madrid.

The brief teacher questionnaire was designed to be self-completed by the teachers in 10-15 minutes, and assessed self-reported stress, noise annoyance, as well as the teacher's perception of how aircraft and road traffic noise exposure interferes with communication and student learning. To ensure accurate conceptual translation, all questionnaires were translated from English into Dutch and Spanish and subsequently back-translated.

Noise Exposure Assessment

In the UK, we based aircraft noise assessments external to the schools on the 16-hour outdoor LAeq contours provided by the Civil Aviation Authority. These contours give the average continuous equivalent sound level of aircraft noise within an area from 0700 hours to 2300 hours within a specified period. We initially defined road traffic noise by use of a simplified form of the UK standard calculation of road traffic noise (CRTN) prediction method, using a combination of information including proximity to motorways, major roads, minor roads, and traffic flow data. We confirmed external traffic noise levels by visits and noise measurements. In the Netherlands, noise assessments were provided by modelled data on road and aircraft noise exposure linked to school locations with geographical information systems. In Spain, we visited all 96 preselected schools and made direct external measurements of road traffic noise. Aircraft noise assessment in Spain was based on predicted contours. Aircraft noise exposure and road traffic noise exposure at the schools are analysed as continuous variables.

Teacher questionnaire

Teachers completed a questionnaire containing standardised measures of noise annoyance and perceived stress, as well as questions designed to assess perceptions of how teacher's felt noise interfered with children's learning and performance. Aircraft noise annoyance at school and road traffic noise annoyance at school were assessed using the ISO annoyance question "Thinking about the last 12 months, when you are at school, how much does noise from [aircraft] [road traffic] noise bother, disturb, or annoy you?" (ISO/TS, 2003). Answers were reported using a five-point category scale ("not at all, slightly, moderately, very, and extremely"). Teachers were also asked how frequently they heard the noise from road traffic or aircraft when they were at school: "Do you hear noise from [aircraft] [road traffic] when at school?" Answers were reported using a four-point scale ("never, sometimes, often, and always"). If teachers reported never hearing noise while reporting being 'slightly', 'moderately', 'very', or 'extremely' annoyed, their answer on the question measuring annoyance was recoded to 'not at all annoyed'. For analyses, annoyance scores were dichotomized into 'not at all & slightly' versus 'moderately, very & extremely'.

The questionnaire included the 10-item 'Perceived Stress Scale' (Cohen *et al.*, 1983), which assesses self-reported stress levels over the past month (e.g. How often have you been able to control irritations in your life?; How often have you found that you could not cope with all the things that you had to do?; How often have you felt difficulties were piling up so high that you could not overcome them?). Items are scored on a 5-point scale - never, seldom, sometimes, often, very often. Positive items are reversed and the 10 items added together to get a total perceived stress score, with high scores indicating higher stress. Cronbach's alpha for the scale in the sample was high ($\alpha=0.862$).

Teachers also reported the extent to which aircraft and road traffic noise exposure at school interferes with communication between student and teacher; student attention; student concentration; student performance; and the quality of the students' work. These items were scored using a 4 point scale – never, sometimes, often, and always, and were dichotomized 'never & sometimes' versus 'often & always' for analyses.

The questionnaire also collected self-reported sociodemographic information including age, gender, and the number of years that the teacher had been a) working at the school and b) qualified as a teacher.

Statistical Analysis

The data were pooled across the countries for analysis. Multilevel regression analyses taking school and individual level variation into account were conducted in SPSS (Version 22) to examine associations between aircraft and road traffic noise on teacher's annoyance, perceived stress, and perceptions of noise interfering with children's learning. The regression analyses adjusted for age, gender, the number of years that the teacher had been working at the school, and country.

RESULTS

Sample descriptives

A total of 270 teachers from the RANCH primary schools completed the questionnaire (UK n=45; NL n=35; Spain n=190). 67% of the sample was female; the median age of the respondents was 40 (range 21-68 years), with a median number of years qualified as a teacher of 14 years (range <1-49 years) (See Table 1).

Noise annoyance at school

Table 1 shows that 21.9% of the teachers reported being moderately, very or extremely annoyed by aircraft noise at school. Teachers exposed to aircraft noise at school were significantly more likely to report being moderately, very or extremely annoyed by aircraft noise at school than teachers not exposed to aircraft noise at school (OR=1.14, 95%CI 1.10-1.19, $p<0.001$). A 1dB increase in aircraft noise exposure at school was associated with a 14% increase in the odds for being moderately, very, or extremely annoyed by aircraft noise.

Table 1: Summary of demographics, noise exposure, noise annoyance, and Perceived Stress Scale scores for the overall sample and for each country in the RANCH project teacher sub-sample.

	Total	**UK**	**NL**	**Spain**
	% (N)	*% (N)*	*% (N)*	*% (N)*
No of teachers	270	16.7 (45)	13.0 (35)	70.4 (190)
Gender				
Male	25.2 (68)	26.7 (12)	48.6 (17)	20.5 (39)
Female	67.0 (181)	71.1 (32)	48.6 (17)	69.5 (132)
Missing/unknown	7.7 (21)	2.2 (1)	2.89 (1)	10.0 (19)
Age				
Median	40	30	40	40
Range	21-68	22-58	22-58	24-68
Time teaching in school				
Median	5	2	3	7
Range	<1-30	1-26	<1-30	<1-30
Time teaching in career				
Median	14	4.5	6.5	18
Range	1-49	1-34	1-35	1-49
Aircraft noise exposure at school (LAeq16hours)				
Median	49	52	54	43
Range	30-77	34-68	41-68	30-77
Road traffic noise exposure at school (LAeq16hours)				
Median	53	49	54	53
Range	32-71	37-67	32-66	43-71
Aircraft noise annoyance at school (ISO question)				
% moderately, very or extremely annoyed	21.9 (59)	28.9 (13)	20.0 (7)	20.5 (39)
Road traffic noise annoyance at school (ISO question)				
% moderately, very or extremely annoyed	11.5% (31)	6.7 (3)	0.0 (0)	14.7 (28)
Perceived Social Stress Scale				
Mean (SD)	13.94 (5.6)	16.28 (6.5)	10.58 (4.7)	13.98 (5.2)
Median (range 0-30)	13.00	15.00	11.00	13.50

Table 1 also shows that 11.5% of the teachers reported being moderately, very or extremely annoyed by road traffic noise at school. Teachers exposed to road traffic noise at school were significantly more likely to report being moderately, very, or extremely annoyed by road traffic noise at school than teachers not exposed to road traffic noise at school (OR=1.13, 95%CI 1.06-1.20, $p<0.001$). A 1dB increase in road traffic noise exposure at school was associated with a 13% increase in the odds for being moderately, very, or extremely annoyed by a road traffic noise.

Perceived stress

Table 1 shows that the mean perceived stress score was 13.96 (score range 0-30), with scores being highest in the UK and lowest in the Netherlands. Aircraft noise exposure at school was not significantly associated with self-reported perceived stress ($\beta=0.034$, 95%CI -0.23-0.092, $p=0.243$). Road traffic noise exposure at school showed a trend with self-reported perceived stress: there was a borderline

statistically significant association between road traffic noise exposure at school and self-reported perceived stress(β=0.098, 95%CI -0.07-0.202, p=0.066).

Perceived noise interference with children's learning

Table 2 shows that one-sixth to one-fifth of teachers felt that aircraft noise often or always interfered with communication (20%), student attention (21.1%), student concentration (20.4%), student performance (15.9%) and quality of work (16%). Teachers exposed to aircraft noise at school felt it significantly interfered with student communication, concentration, performance, and quality of work (p<0.01 – see Table 3).

One-tenth of teachers felt that road traffic noise often or always interfered with communication (11.1%), student attention (11.1%), student concentration (11.9%), student performance (8.9%), and quality of work (8.6%). Teachers exposed to road traffic noise at school felt it significantly interfered with student communication, concentration, performance, and quality of work (p<0.001 – see Table 3).

Table 2: reports of how teachers perceive noise influences communication in the classroom and student learning.

	Never	Sometimes	Often	Always
	% (N)	*% (N)*	*% (N)*	*% (N)*
Aircraft noise				
Communication between students and teachers	36.7 (99)	38.5 (104)	13.3 (36)	6.7 (18)
Student attention	33.0 (89)	40.7 (110)	14.8 (40)	6.3 (17)
Student concentration	35.6 (96)	38.9 (105)	14.8 (40)	5.6 (15)
Student performance	43.3 (117)	35.2 (95)	10.7 (29)	5.2 (14)
Quality of work	45.9 (124)	32.6 (88)	11.9 (32)	4.1 (11)
Road traffic noise				
Communication between students and teachers	50.4 (136)	34.1 (92)	8.1 (22)	3.0 (8)
Student attention	45.2 (122)	37.8 (102)	8.1 (22)	3.0 (8)
Student concentration	48.5 (131)	34.1 (92)	9.3 (25)	2.6 (7)
Student performance	56.7 (153)	28.9 (78)	6.3 (17)	2.6 (7)
Quality of work	56.7 (153)	29.6 (80)	5.6 (15)	3.0 (8)
NB: these items were dichotomised never/sometimes versus often/always for analyses				

Table 3: Associations between aircraft and road traffic noise exposure at school and teacher perceived impact on communication and student's learning: adjusted for country (UK, NL, Spain), age, gender and length of time teaching in the school.

	Odds ratio*	95% CI	p-value
Aircraft noise			
Communication between students and teachers	1.05	1.02-1.08	0.001
Students attention	1.03	1.01-1.06	0.007
Students concentration	1.04	1.01-1.07	0.002
Students performance	1.03	1.00-1.06	0.015
Students quality of work	1.03	1.00-1.06	0.014
Road traffic noise			
Communication between students and teachers	1.13	1.06-1.21	0.001
Students attention	1.11	1.04-1.18	0.001
Students concentration	1.11	1.05-1.18	0.001
Students performance	1.13	1.05-1.20	0.001
Students quality of work	1.13	1.05-1.21	0.001

* odds ratio for binomial regression analyses and reflects the increase in the variable score given a 1dB increase in aircraft noise exposure at school.

CONCLUSIONS

The aim of this paper was to examine how exposure to aircraft and road traffic noise at school was related teacher's annoyance and self-reported stress responses, and to how teachers perceive noise exposure at school impacts upon communication and children's learning. In summary, the analyses show that aircraft noise and road traffic noise at school were associated with increased noise annoyance responses. Evidence for noise effects on teacher's self-reported stress was mixed, with no association observed for aircraft noise exposure and a trend observed for road traffic noise exposure at school. Teachers exposed to aircraft noise at school or road traffic noise at school felt it significantly interfered with student communication, concentration, performance, and quality of work.

Noise annoyance has been put forward as a potential mechanism for noise effects on children's cognitive performance and learning outcomes, with the focus being on the annoyance experienced by the child as a learner, rather than the annoyance experienced by the teacher. Previous analyses of the RANCH project child cognitive data found that the association between aircraft noise exposure at school and reading comprehension was diminished after adjustment for child aircraft noise annoyance but remained statistically significant (Clark *et al.*, 2006), highlighting the role that annoyance may play in noise effects. Teacher annoyance represents another potential pathway for the association of aircraft noise exposure on children's cognitive performance: a pathway that has been under-researched to date. Further secondary analyses of the RANCH project datasets will be carried out, exploring the role of teacher annoyance on the association between aircraft noise exposure at school and children's reading and memory.

The findings relating to teacher self-reported stress need replicating in larger datasets. It would also be useful to explore biological markers of stress such as cortisol, as well as standardized measures of depression and anxiety in future studies. Teacher stress could be a fruitful pathway to explore in relation to noise

effects on children's learning: noise is established as impacting children's performance and may therefore be likely to be having a similar impact upon teaching performance.

Teachers exposed to higher levels of aircraft noise or road traffic noise at school clearly perceive noise exposure to impact upon communication and students' learning in the classroom. Further exploration of these data as mechanisms for noise effects on children's cognition will be carried out with the RANCH project cognitive performance data.

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