

NORAH in context: responses to the Child Study

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ICANA Health Conference 2015

Frankfurt, Germany, November 12-13th 2015



Overview of the talk

- Earlier studies on aircraft noise and children's learning
- Comparison of RANCH and NORAH Study findings
- Recent studies informing RANCH and NORAH findings
- Implications and future research



Environmental noise and Children's Cognitive Performance

Why might children be susceptible to noise and other environmental stressors?

- Critical periods in relation to learning
- Lack of developed coping repertoires
- Vulnerable tasks
- Vulnerable settings (schools, home)



Los Angeles Airport Studies

- Comparison 4 noise exposed (peak 95dBA) and 3 quiet schools
- Higher blood pressure in noisy schools
- Noise exposed more likely to fail on a cognitive task and give up on a difficult task
- Noise exposed children more distractible than children from quiet schools.

(Cohen et al, 1980, 1986)



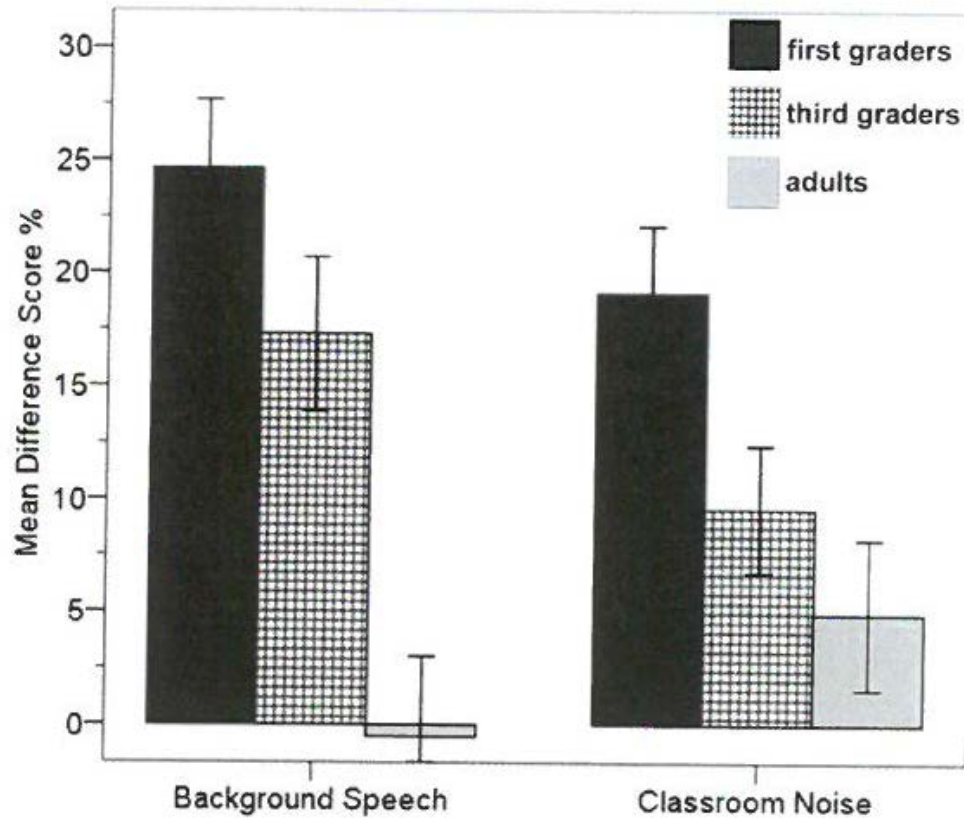
Chronic Noise exposure and Reading

- 116 first/second grade children from 2 elementary schools
- Noisy school exposed to 65 dB Leq Aircraft noise - matched to quiet school
- Noise exposed children showed significant deficits on standardised reading test
- Impairments partially mediated by impaired speech perception

(Evans & Maxwell, 1997)



Percentage drop in listening comprehension in the presence of background speech and classroom noise by age (Klatte et al, 2010)



Schools Health and Environment Study, Heathrow

- Children aged 8 to 11 years
 - Cross sectional, classroom testing
 - Aircraft noise
 - >66dB Leq 16 hours (4 schools)
 - <57 dB Leq 16 hours (4 schools)
 - Tested for cognitive performance and stress responses
 - Higher aircraft noise annoyance levels in noise exposed children
 - 6 month delay in reading comprehension in noise exposed children
- (Haines et al, 2001)



West London Schools Study, Heathrow, Haines et al 2001

- Children aged 8 to 11 years, cross sectional, classroom testing
- Aircraft noise
 - >63dB Leq 16 hours (10 schools)
 - <57 dB Leq 16 hours (10 schools)
- Aircraft noise not associated with mean reading score, memory, attention or stress responses
- Higher noise annoyance levels in aircraft noise exposed children
- Higher aircraft noise exposure associated with impaired reading on difficult test items



Problems With Earlier Studies

- Only cross-sectional studies
- Small sample sizes
- Insufficient adjustments for confounding (e.g. SES)
- No assessment of exposure effect relationships



The Munich Airport Study, Hygge et al 2002

- Longitudinal study of the closure of the old airport and the opening of the new airport.
- Aircraft noise
 - Neighbourhood 1 = 68 dB (A) Leq 24 hours
 - Neighbourhood 2 = 59 dB (A) Leq 24 hours
 - Socioeconomically matched
- Mean age 10.7 years
- Tested for blood pressure, attention, long-term memory, working memory, reading, motivation and annoyance



The Munich Airport Study, Hygge et al 2002

- **BASELINE FINDINGS**

- Aircraft noise exposure was associated with deficits in long term memory, reading, motivation, annoyance

- **LONGITUDINAL FINDINGS**

- Impairments found diminished within 2 years of the airport closing
- Same impairments developed in the newly noise exposed group of children within 2 years of the new airport opening
- Suggests reversibility of effects if noise exposure is reduced



New York City, Green et al., 1982

- 8,240 grades of children in grades 2 – 6 from 362 Schools
- Schools geo-coded into 5 aircraft noise contour bands
- Outcome: % reading below reading level for each school
- Result: Dose-response relationship percentage below grade level increased as noise level increased
- Limitations:
 - Dichotomous outcome not as sensitive as continuous outcome
 - aggregate scores for schools not individual level



SATS Study Design

- Multi-level modeling study
- British National Standardised Scores (SATS) for Key Stage 2 were analysed in relation to aircraft noise exposure around Heathrow Airport in West London
- 8 levels of aircraft noise 54-75 dBA 16hrLeq
- 11,000 scores of children aged 11 from 128 schools (SATS exams in 1996, 1997)
- Analyses were at both the school and individual level
Adjustment made for socio-economic and school quality factors



SATS Study

Results Summary

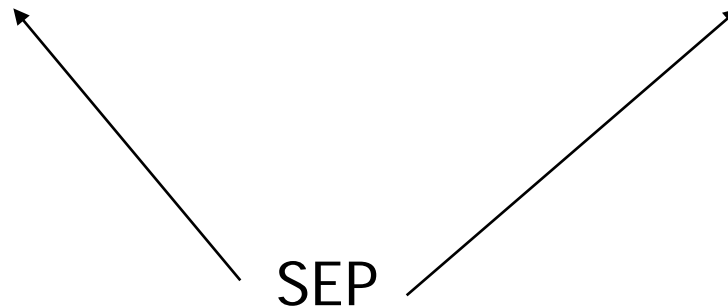
- Aircraft noise was significantly related to poorer **reading performance** and was not associated with the control English performance outcomes, spelling, and handwriting
- Aircraft noise at school was significantly related to poorer performance on a nationally standardised test of **mathematics** after adjustment for school effects
- After adjustment for socioeconomic status, the association between high noise exposure and poorer performance was reduced and no longer statistically significant



Socioeconomic position (SEP) and environmental stressors

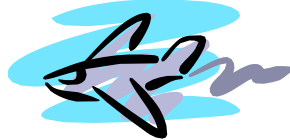
SEP → environmental stressors → health

Environmental stressors → health





Aircraft noise - the international studies



- **Los Angeles Airport Study** (Cohen *et al.*, 1980, 1981)
- **New York Airport City** (Evans & Maxwell, 1997)
- **Munich airport study** (Evans *et al.*, 1995; 1998)
- **Heathrow studies** (Haines *et al.*, 2001 a,b,c; 2002)

Over twenty studies have reported that noise adversely affects children's academic performance



RANCH: Road traffic and aircraft noise exposure and children's cognition and health: exposure-effect relationships and combined effects

To test for an exposure-effect relationship between

chronic exposure to aircraft noise and child health and cognition

chronic exposure to road traffic noise and child health and cognition

To examine...

whether or not chronic exposure at school to road traffic noise has a combined effect with that of aircraft noise on the cognitive function and health of children

In three European countries:

the Netherlands, Spain and the United Kingdom



School Selection in RANCH and **NORAH**

- State-funded primary schools around each airport

Heathrow airport, London, United Kingdom

Schiphol airport, Amsterdam, the Netherlands

Barajas airport, Madrid, Spain

High aircraft noise schools selected first, remaining schools matched on child SES, migration background and German language proficiency

- RANCH: Schools matched for socioeconomic status and main language spoken





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School Noise Exposure Prediction

- School aircraft noise exposure based on 16 hour aircraft outdoor L_{Aeq} contours (7-23hrs) in NORAH 8-14hrs during work days
- Road and Rail noise measured as potential confounding factor in NORAH
- 16 hour aircraft outdoor L_{Aeq} contours also used to predict home aircraft noise from the child's postcode
- In NORAH Aircraft noise at home 6-18hrs and 20-6hrs



RANCH and **NORAH** Procedures

- RANCH Children aged 9-10 years, **NORAH 7-10 years (mean 8y 4mths)**
- Classroom based testing
- Standardised test procedures and instructions
- Acute noise measurement during testing/ **Use of headphones**
- Parents completed questionnaire about socioeconomic status



Measures

- **Reading Comprehension** Suffolk Reading Scale (UK)
- **Episodic Memory** Child Memory Scale
- **Working Memory** Search and Memory Task
- **Sustained Attention** Toulouse Pieron Test
- **Noise Annoyance** ISO questions
- **Mental Health** Strengths & Difficulties Questionnaire
- **Sociodemographic** Child & Parent questionnaires





Measures in NORAH

- **Reading Comprehension** Standardised reading test - reading speed, accuracy for single words, sentences and short paragraphs
- **Episodic memory** Includes recognition memory test
- **Non-verbal abilities** Short form of coloured progressive matrices
- **Long-term memory** Rapid retrieval from long term memory
- **Short term memory** Same/different judgements of spoken words
- **Speech Perception** Word-picture matching of noise masked words
- **Mental Health** KINDL-R 'mental wellbeing'





The noise exposure characteristics of RANCH & NORAH

Sociodemographic Characteristic	Pooled RANCH Sample	NORAH
Number of Schools	89	29
Number of Classes	129	85
Response rate %	89.0	77.3
Range of noise Exposure Aircraft dB(A)	30 – 77	39-59

NORAH Study 100% double glazing in classrooms, RANCH Study double/triple glazing 43.8%



Adjustment for confounding factors

- RANCH: Multi-level Models adjusted for centre, age, gender & employment status, crowding, home ownership, mother's education & long standing illness, main language spoken at home, parental support, classroom glazing
- NORAH: Multilevel models adjusted for age, gender, non-verbal abilities, SES, migration background, number of children's books at home, German language proficiency, % of children with migration background in class, mean SES, class size, parental involvement, classroom insulation, road traffic and railway noise



RANCH & NORAH: Exposure-effect relationships for cognition

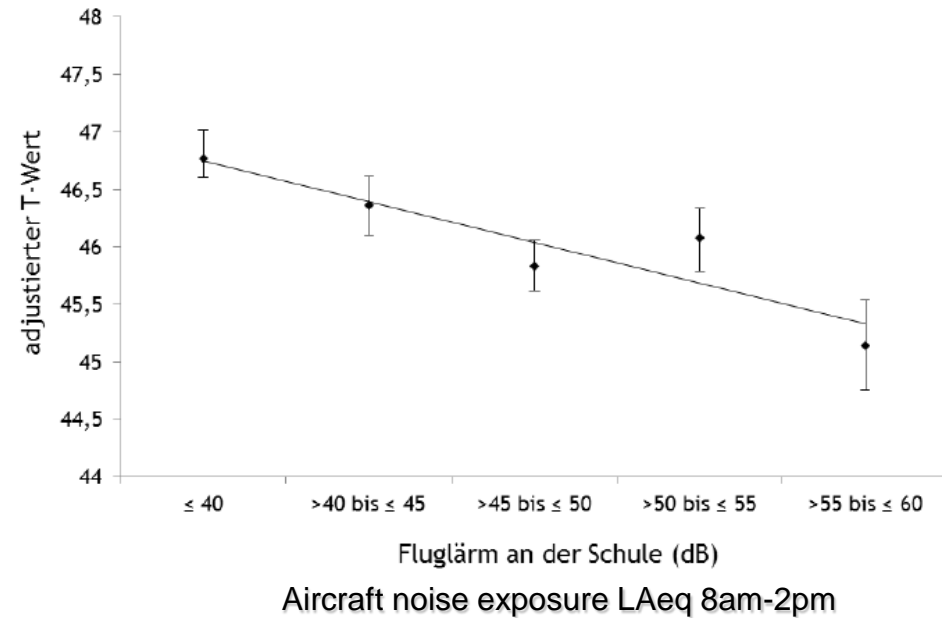
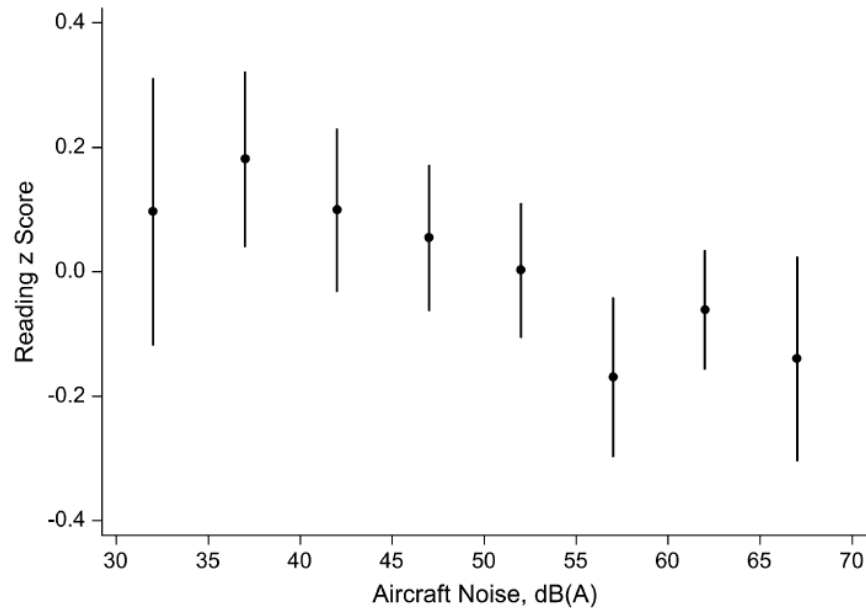
Outcome	RANCH : Aircraft Noise B, CI, p value	NORAH: Aircraft Noise B, (SE), p value
Reading comprehension	Significant -0.008, -0.014 to -0.002, p 0.001	Significant -0.327 (0.172), p 0.027
Recognition	Significant -0.018, -0.032 to -0.004, p=0.016	Not significant
Episodic memory	Not significant	Not significant
Working memory	Not significant	
Speech Perception		Not significant
Sustained attention	Not significant	

B = change in outcome score associated with 1db change in noise





Exposure-effect between aircraft noise at school & reading comprehension



The RANCH Project:

Stansfeld et al 2005; Clark et al, 2006

The NORAH Study:

Klatte et al, 2014

Size of the effect of aircraft noise on reading

- In RANCH: a 5dB increase in aircraft noise exposure was equivalent to a 2 month reading delay in the UK and a 1 month reading delay in the Netherlands. A 20dB increase in aircraft noise was associated with a decrement of one-eighth of a standard deviation on the reading test in the Netherlands and Spain and one-fifth of a standard deviation in the UK
- In NORAH: a 10dB increase in aircraft noise was associated with a decrement on the reading test of one tenth of a standard deviation corresponding to one month reading delay



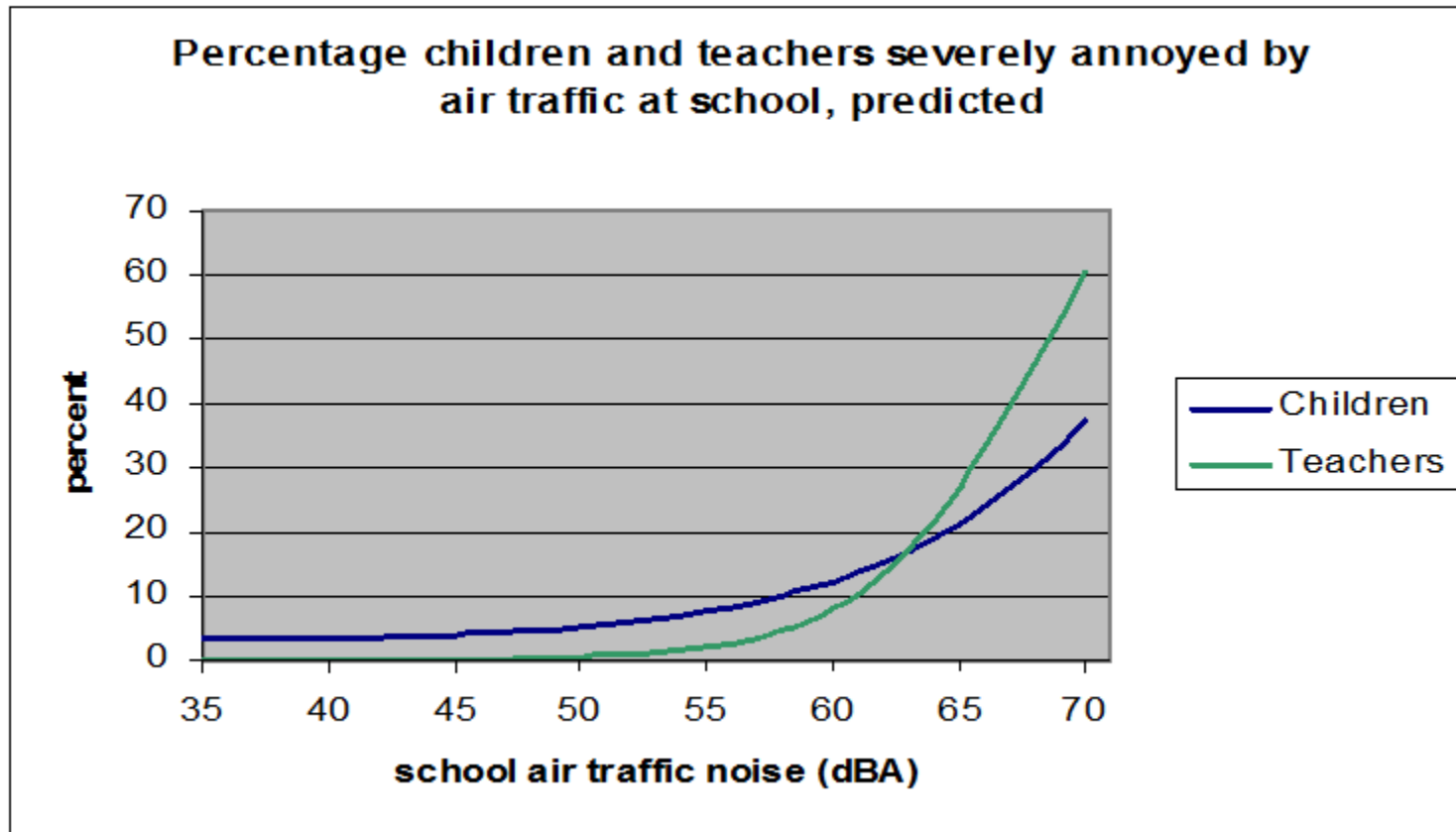
Exposure-effect relationships for health

Outcome	RANCH: Aircraft Noise (n=2100) B, CI, p value	NORAH : Aircraft noise (n=1058) B, (SE), p value
Annoyance	Significant .037, 0.029 to 0.045, p=0.0001	Significant
Self-rated health	Not significant	Significant -0.101 (0.042) p0.016
Overall mental health (SDQ)	Not significant	
Hyperactivity	Significant 0.013, 0.001 to 0.025, p=0.03	
Wellbeing	Not significant	Significant -0.299 (0.139) p0.031

B = change in outcome score associated with 1db change in noise



Air traffic at school (RANCH NL DATA)



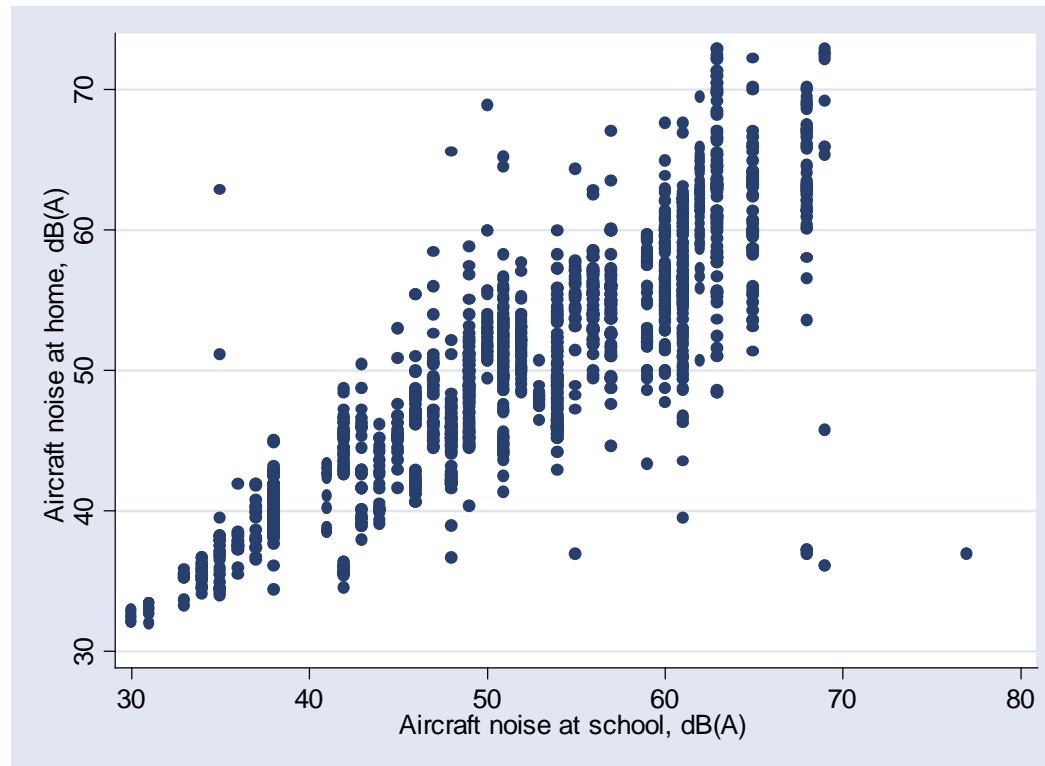
Home aircraft noise exposure and reading comprehension



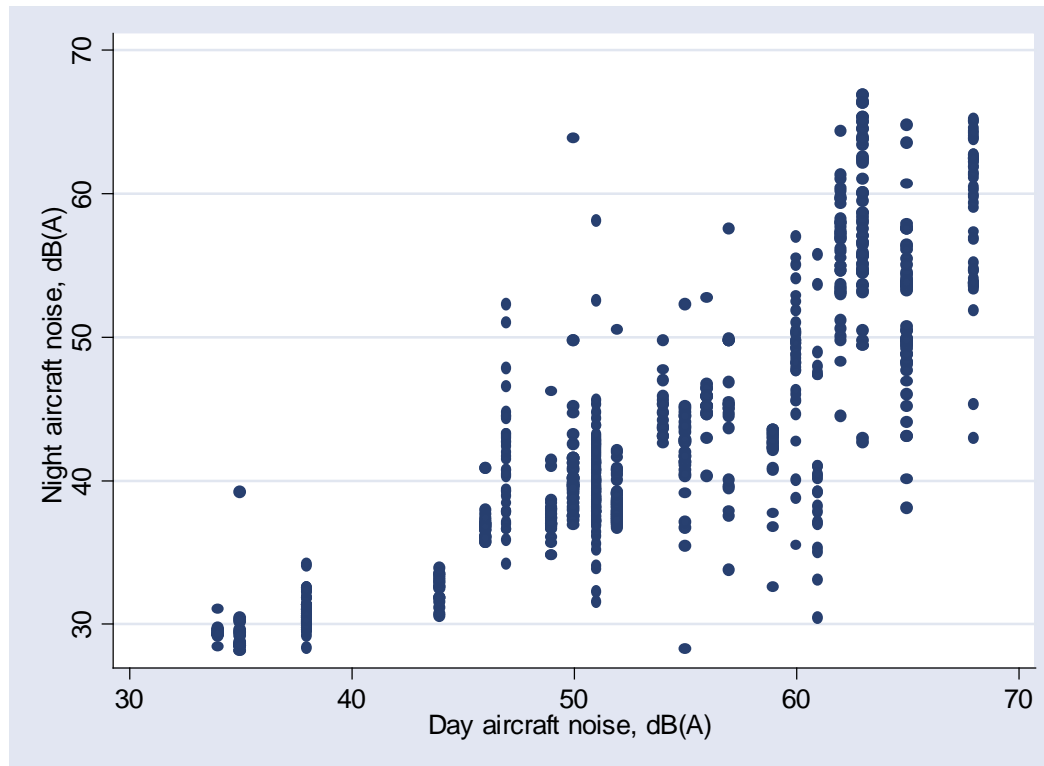
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Correlation between aircraft noise exposure at home and school (LAeq₁₆) in the UK



Correlation between daytime (school) and night-time (home) aircraft noise exposure ($LAeq_{16}$) in the UK



Effects of noise and reading in migrants



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Aircraft noise and reading comprehension in South Africa (Seabi et al, 2012; Seabi et al, 2013)

437 learners (9-14 yrs) exposed to aircraft noise ($>69\text{dBA}$) around Durban International Airport in 2009 – completed Suffolk reading Scale

337 in control group not exposed to aircraft noise ($<40\text{dBA}$)

49% have English as first language (EFL)

At baseline significant association of aircraft noise with poorer reading comprehension in EFL group but not ESL group

Airport relocated May 2010

At follow up in 2010, 2011 high noise level had fallen to 55dBA and no difference between noise exposed and control groups in reading



South Africa Study: Interaction between aircraft noise and language on reading comprehension

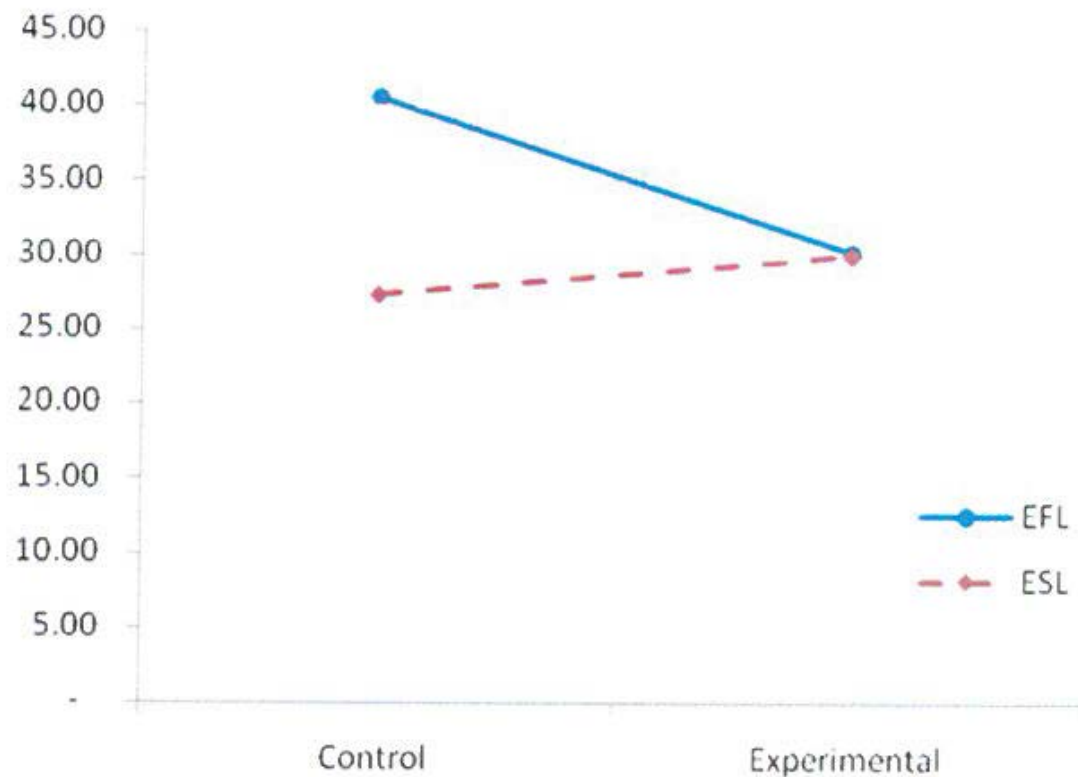
Groups Language	N	Mean (SD)
Experimental EFL	151	30.16 (13.76)
Experimental ESL	162	29.48 (14.69)
Control EFL	191	40.95 (14.06)
Control ESL	156	27.69 (12.14)

EFL= English first language; ESL=English second language

(Seabi et al, 2012)



Aircraft noise and language interaction for reading comprehension (Seabi et al, 2012)



Lack of noise effects in ethnic minorities?

- Lack of noise effect on reading in migrants in NORAH and lack of effect those with English as a second language in South Africa
- In NORAH 60% had a non-German born parent, 12% in RANCH
- Potential explanations: SEP effects, language proficiency, lower maternal education, longstanding illness or lack of power?



Possible mechanisms for noise effects

- Tuning out of attention
- Impairment of auditory discrimination/speech perception
- Teacher frustration and communication difficulties
- Learned helplessness



Implications for Classroom Acoustics: Studies of London Primary Schools

- Noise levels in classroom dominated by children
- Background noise level, reverberation time most important influences
- Poor acoustic conditions reduce speech intelligibility
- External noise affected classroom noise only when children doing quiet activities such as reading
- Both external (LA_{max}), internal noise(LA₉₀) influence achievement scores adjusting for social deprivation

(Shield & Dockrell, 2004; Dockrell & Shield, 2004)



Application of Results

- NORAH provides methodologically powerful evidence for exposure-effect relationships for aircraft noise and children's cognition and health
- Can influence policy guidance for school location and design
- Work with classroom acoustics in reducing cognitive effects – more sound insulation of classrooms

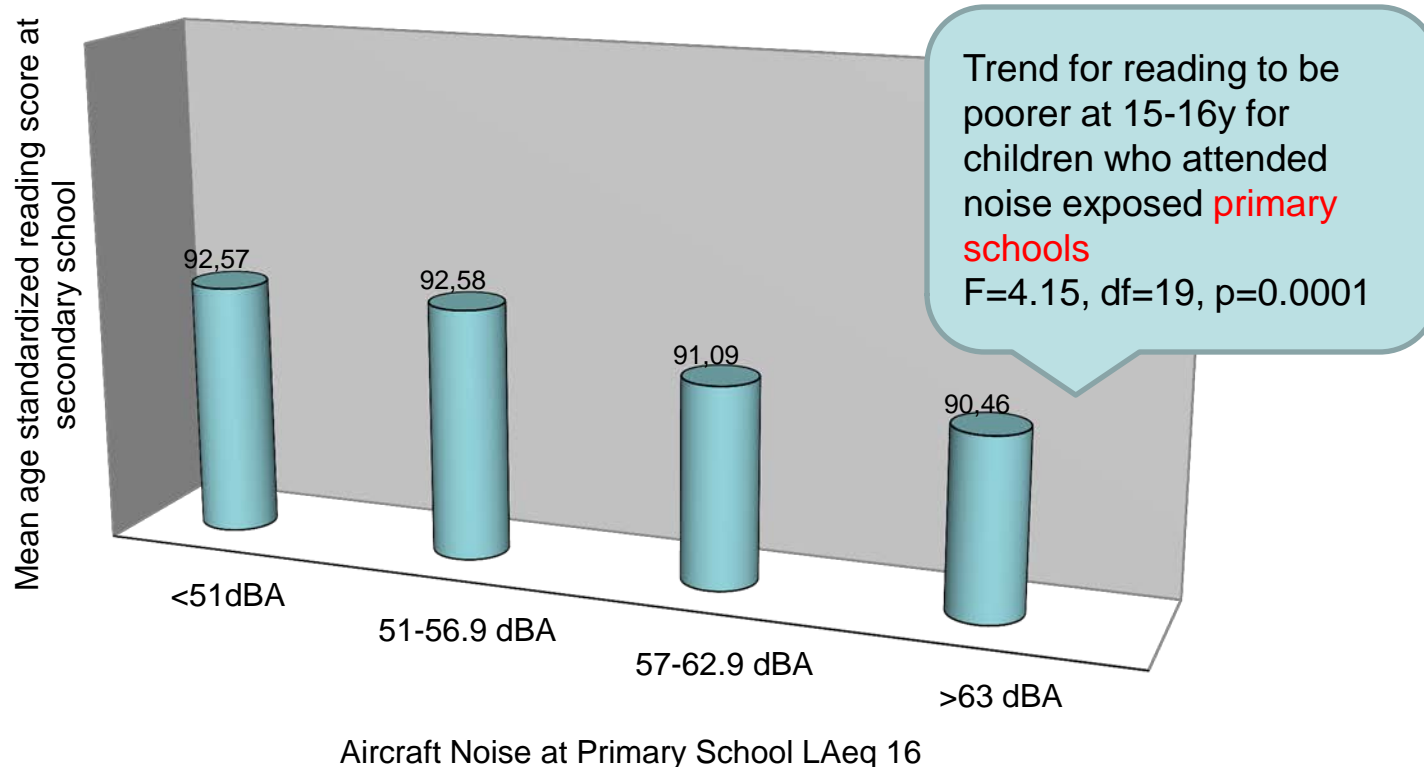


Further research

- Longitudinal follow up studies
- Change of noise exposure studies
- Studies of sound insulation
- Intervention studies



Aircraft noise at primary school and secondary school reading comprehension (Clark et al 2013)



Conclusions

- Both NORAH and RANCH demonstrate linear exposure-effect associations between aircraft noise exposure and reading comprehension in primary school children
- The mechanisms of these effects are still unclear but no support for the hypothesis that effects of reading acquisition are mediated by effects of phonological abilities
- There are implications for interventions to reduce these noise effects and to develop further research

