Senate Rural and Regional Affairs and Transport References Committee

Questions on Notice – 10 June 2010
CANBERRA

Inquiry into the effectiveness of Airservices Australia's management of aircraft noise

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*** A copy of the '*Rehbein report*' tabled by Curfew4Canberra on 10 June 2010 was provided in response to these questions asked. This attachment can be found in the tabled documents from 10 June 2010.**

SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT REFERENCES COMMITTEE

Inquiry into the effectiveness of Airservices Australia's management of aircraft noise

Public Hearing Thursday, 10 June 2010

Questions Taken on Notice - Airservices Australia

HANSARD, RRAT 3

CHAIR—When we have been discussing the noise inquiry line before, some of the witnesses have indicated that they cannot log more than one disturbance through one call, so someone cannot call and say that in the last week they have been disturbed x number of times—each call can only log one instance. Is that correct?

Mr Russell—It is.

CHAIR—Would that not then flow into these figures, where people who were being continually disturbed were having to continually call to log each of those flight disturbances?

Mr Russell—It does have a very minor impact, yes. We do it for reasons of collection of this information. I can assure you it has a minor impact. I can provide you with some further analysis of some of those figures if you would like it.

CHAIR—That would be really useful. I want to make sure that we look at it in context. Thank you for breaking this down for us. But if somebody say at the end of the month wanted to call once and say that they were disturbed 200 times in the last month, they could not do that—they would have to call 200 times to have Airservices note that there were 200 disturbances?

ANSWER:

Airservices Australia's Noise Enquiry Unit has applied the principle of 'one contact = one complaint' to its complaints handling practices for the past 15 years. We are most interested in the issues that are complained about and the number of people that lodge complaints, rather than the number of complaints that are received or the number of flights being complained about. In any contact with the NEU, the operator will try to discern from the complaint / enquiry what the issues of concern are and ensure that all issues are recorded. As such, the practice of 'one contact = one complaint' is regarded as the most effective means of discerning the issues and the extent of the impact.

Web Trak enables complaints to be lodged about individual aircraft movements and each complaint is counted individually. The simplicity of complaints lodgement through Web Trak means that complainants can easily distort the complaint numbers regardless of the legitimacy of the disturbance i.e. complaints could be lodged about movements that occurred when the complainant was not at home.

Not all complaints received by the NEU are valid e.g. in some cases complainants have lodged complaints about aircraft movements that have not occurred or are due to occur in the future. In our view, the NEU database provides an accurate reflection of the issues of concern and extent of the impact for those people that have chosen to contact us.

From 1 July 2010, Airservices is making a database modification to include a field for 'multiple aircraft, same issues' to address those that store up complaints before contacting the NEU and those that complain about being overflown for lengthy periods of time.

HANSARD, RRAT 10 - 11

Senator BACK—So in Brisbane, where it has been undertaken for some period of time, are you able to report to us a change in community perception or acceptance from the initial consultation before it was implemented through to now, when it has been underway for some time? Perhaps you could take this on notice and advise us what change there has been, if any, in community attitudes and what the process of consultation has been in Brisbane. That may give us a better clue about the future airports.

Mr Russell—Okay. I would just make the point that the trial in Brisbane was in fact a trial. While I could give you a view of the outcome from a community viewpoint, I would like to check it before I gave it. I do not recall there being any major shift in public opinion on the issue, but I would like to take it on notice and confirm it.

ANSWER:

Community feedback is primarily obtained through airport consultative committees. Brisbane had a period without such a forum until the Brisbane Airport Community Aviation Consultation Group was recently launched.

While there was no active airport forum from which to obtain community feedback during the Brisbane Green trial, the project report indicated the aircraft noise impact would be significantly reduced. Airservices is not aware, however, of any change in community attitudes at Brisbane resulting from the trial of RNP technology.

HANSARD, RRAT 11

Senator STERLE—Mr Russell, could you take this on notice, please. I am aware of the five suburbs where we have the major complaints because of the changes following on from WARRP, but would you have the number of complaints from suburbs like Guildford, Belmont, and Queens Park that are around the airport, and the number of complainants?

Mr Russell—Senator, I will take that on notice. I think we do. We certainly do in Sydney—we break it down by suburb. Again, it is part of that evenness issue we were just talking about. I will take it on notice and come back to you on it.

ANSWER:

Perth Airport Recorded Complaints vs Complainants, by Suburb for the period 1st January to 31st December 2009.

Suburb	Complaints	Complainants
Not Specified	31	24
Applecross	5	4
Ardross	1	1
Armadale	2	2
Ascot	4	4
Balga	1	1
Ballajura	27	15
Banjup	6	2
Banksia Grove	1	1
Baskerville	1	1
Bassendean	5	4
Bateman	1	1
Bayswater	4	3
Beckenham	4	3
Bedford	1	1
Bedfordale	6	3
Beechboro	302	55
Beldon	1	1
Bellevue	1	1
Belmont	47	21
Bentley	3	3
Bickley	36	14
Booragoon	1	1
Boya	2	2
Bullsbrook	1	1
Byford	1	1
Canning Vale	6	4
Cannington	11	9
Carlisle	7	5
Carmel	7	5
Caversham	4	2
Chidlow	3930	22
Cloverdale	8	6
Como	2	2
Copley	1	1
Cottesloe	1	1
Dalkeith	8	3
Darling Downs	2	2
Darlington	34	22
Duncraig	10	5
East Victoria Park	5	1
Edgewater	1	1
Ellenbrook	3	2
Ferndale	14	13
Forrestdale	3	2
Forrestfield	2	1
Gidgegannup	4	1
Girrawheen	7	4
Glen Forrest	261	60
Gooseberry Hill	3	2

Greenmount	94	8
Greenwood	1	1
Guildford	67	28
Hazelmere	1	1
Helena Valley	6	6
Henley Brook	5	2
High Wycombe	110	13
Highgate	3	1
Hilton	1	1
Hovea	4	3
Jane Brook	8	2
Kalamunda	34	14
Karnup	1	1
Karrinyup	1	1
Kelmscott	5	5
Kensington	12	6
Kenwick	2	2
Kewdale	9	7
Kingsley	1	1
Langford	41	11
Lathlain	3	3
Leeming	1	1
Lesmurdie	8	5
Lower Chittering	54	4
Maddington	3	3
Mahogany Creek	9	2
Maida Vale	4	3
Manning	6	2
Marangaroo	2	1
Maylands	1	1
Middle Swan	1	1
Midland	1	1
Mirrabooka	2	2
Morley	6	1
Mosman Park	1	1
Mount Helena	8	7
Mount Lawley	1	1
Mount Pleasant	1	1
Mullaloo	1	1
Mundaring	4	2
Nedlands	1	1
Noranda	2	2
Padbury	2	2
Parkerville	27	14
Parkwood	5	5
Paulls Valley	19	6
Perth	2	2
Pickering Brook	9	1
Queens Park	17	15
Redcliffe	9	7
Riverton	18	10
Rivervale	12	7

Roleystone	25	15
Rossmoyne	1	1
Salter Point	9	5
Sawyers Valley	2	2
Scarborough	1	1
Shelley	8	4
Sorrento	1	1
South Guildford	20	11
South Perth	5	4
St James	1	1
Stoneville	275	12
Subiaco	1	1
Swan View	13	5
The Vines	7	2
Thornlie	7	3
Trigg	2	1
Upper Swan	1	1
Victoria Park	4	3
Viveash	11	2
Walliston	5	4
Wandi	1	1
Warwick	1	1
Waterford	10	1
Watermans Bay	1	1
Wembley Downs	1	1
West Leederville	1	1
Westminster	1	1
Willetton	4	4
Wilson	26	7
Wooroloo	1	1
TOTAL	**5921**	**673**

Perth Airport Recorded Complaints vs Complainants, by Suburb for the period 1st April to 14th April 2010 **(during AECOM aircraft noise monitoring report).**

Suburb	**Complaints**	**Complainants**
Not Specified	1	1
Applecross	2	1
Ardross	1	1
Ballajura	6	1
Bedfordale	1	1
Beechboro	2	2
Belmont	1	1
Bickley	1	1
Canning Vale	3	1
Carlisle	2	1
Carmel	2	1
Chidlow	67	7
Como	1	1
Darlington	1	1
Ellenbrook	1	1

Gidgegannup	2	2
Glen Forrest	6	2
High Wycombe	5	1
Kalamunda	1	1
Karrinyup	5	1
Langford	50	2
Lesmurdie	1	1
Maddington	1	1
Mount Helena	2	1
North Beach	1	1
Paulls Valley	1	1
Queens Park	3	3
Riverton	1	1
Roleystone	5	4
Shelley	1	1
South Guildford	1	1
Stoneville	35	2
Wilson	2	2
Wooroloo	1	1
Total	**216**	**51**

FURTHER WRITTEN QUESTIONS ON NOTICE

The committee notes answers to written questions on notice from the Perth hearing. The Committee would appreciate any additional information you could provide to further clarify the follow matters.

1. What are the main differences between the RNAV and the RNP-AR technologies?
2. Are they in fact, different generations of the same technology?
3. What has been the experience with the introduction of RNAV technology into Sydney, specifically the Boree Four Standard Terminal Arrival Route? Has there been concentration of aircraft movements as a consequence of introducing the new technology into airline fleets and pilot training?
4. Has Airservices Australia's Noise Enquiry Unit received complaints from residents affected by aircraft movements using the Boree Four Standard Arrival Route? Were these level of complaints anticipated?
5. How many complaints have been received?
6. What actions is Airservices Australia taking to investigate the impacts of the Boree Four upon affected residents?
7. Was an environmental assessment undertaken by Airservices Australia to analyse the impact of the operation of Boree Four STAR?
8. What was the outcome of the environmental assessment undertaken by Airservices into Boree Four STAR?
9. Has the actual impact of the use of Boree Four STAR been measured against the predictions contained in the environmental assessment? If not, why not?

10. When was the *'Communication and Consultation Protocol'* released and what public consultation process led to its formulation?

Q1-2 ANSWER:

Performance Based Navigation (PBN) is a term used to describe the broad range of technologies that use satellite navigation sources and reduce aircraft reliance on conventional, ground-based radio-navigation infrastructure. An aircraft flying a PBN path uses onboard equipment and procedures to follow a defined trajectory.

Area Navigation (RNAV) is a more basic form of PBN in which equipment onboard the aircraft calculates and follows a direct navigation path between two points, without the aircraft having to overfly intermediate, ground-based navigation aids. While RNAV paths are typically limited to straight lines, they represent an improvement over conventional, ground-based navigation in the sense they facilitate an aircraft flying a direct, straight route between two points.

Required Navigation Performance (RNP) is a more advanced form of PBN with the aircraft's onboard navigation system, combined with satellite navigation, as opposed to ground-based navigation, providing enhanced safety through performance monitoring and alerting.

A key feature of RNP is that it allows aircraft to follow precise, curved paths, eliminating the need to build routes out of straight-line flight segments. The ability to design curved paths is particularly important to airspace designers who are trying to design routes in congested airspace, around noise-sensitive areas, or through geographically challenging terrain.

RNP-Approval Required (RNP-AR) is the highest performing type of PBN procedure. It offers the most benefit to users by allowing for predetermined, precise, curved flight paths that optimally navigate within an airspace to reduce track miles, conserve fuel, preserve the environment, and increase airspace capacity. These procedures require specific aircraft functionality and pilot crew training in order to be used.

The International Civil Aviation Organisation (ICAO) is the United Nations entity that determines the standards under which civil aviation is regulated and administered. Australia is a signatory. Australia has agreed to ICAO Resolution 36-23 for introducing PBN and Approaches with Vertical Guidance.

The Civil Aviation Safety Authority (CASA) published Australia's implementation plan in March 2010, with RNP one element of this plan. The CASA plan says RNP standards are the more capable of the two PBN specifications and is recognised worldwide as the navigation standard that should be adopted in the medium to long term to support improvements in safety, efficiency and the environment.

Q 3 ANSWER:

The first RNAV used in the Sydney Terminal Area was a departure procedure introduced in 2000 to address recommendation 28 of the Sydney Airport Long Term Operating Plan (LTOP). This procedure provided a flight path to the south of the airport over water, reducing noise exposure to areas surrounding Cronulla. The only aircraft initially able to use this procedure were aircraft equipped with modern (for their time) flight management systems.

Establishing runway specific STARs at Sydney was proposed in 2001 and considered approaches to Runways 34L and 34R. Prior to this time, aircraft were 'radar vectored' to these runways from points to the north of the city. Radar vectoring requires ongoing intervention by an air traffic controller to provide the pilot with a series of turns and radar headings rather than having the aircraft following a prescribed path to the runway. A system of runway STARs reduces controller and pilot workload, and an orderly flow of traffic along agreed and predetermined flight paths is the outcome of good design and enables safety and efficiency to be optimised.

A trial of connected STARs to Runways 34L and 34R was conducted for some Qantas aircraft from March 2002 to June 2003; Boree was one of the waypoints used. These STARs were designed to copy existing airspace agreements with the use of the left circuit to Runway 34L via Boree i.e. facilitating the use of SODPROPS and Mode 9 including the Precision Runway Monitor.

Airservices' environment assessment of the trial noted a reduction in the lateral spread of tracks as a result of the implementation of runway specific STARs, however the precise extent of this concentration was unable to be determined. Nonetheless the assessment noted it would be reasonable to expect the lateral spread of tracks for arrivals from the north travelling on the western side of the airport to reduce from approximately 6 km wide (where all aircraft were previously radar vectored) to approximately 0.6 km. However, it was further noted this concentration of flight tracks over residential areas occurred where aircraft are flying at or above 6,000 feet above sea level.

The trial also highlighted there was insufficient airspace on the western downwind leg to ensure a longer intercept onto the Runway 34L final approach (needed to stabilise the aircraft) and that redesign was necessary to ensure airspace capacity was not unnecessarily restricted. Between 2003 and 2005 further work was conducted to re-design (vertically and laterally) the arrival tracks to the parallel runways. Environmental assessment of data gathered during the trial was also used to influence future designs.

In 2004, a revised environmental assessment by Airservices on the introduction of linked STAR procedures for Runway 34 arrivals was presented to the Sydney Airport Community Forum (SACF) and LTOP Implementation Monitoring Committee (IMC). SACF supported the introduction of the Runway 34 arrival STAR (i.e. Boree) and it was published in August 2005.

In 2007, some changes were made to the Boree STAR with further waypoints added and the STAR terminated at a point late on the downwind legs. Radar vectors were provided from these points onto final approach. Whilst the location of the Boree STAR flight path has not changed, aircraft are increasingly able to fly this route with a greater level of precision due to the advent and fitment of improved navigational equipment within the cockpit.

RNAV technology has achieved safety and efficiency benefits through designing flight paths that provide aircraft separation 'by design' so that the system is less reliant on tactical separation performed by the air traffic controllers (and pilots) during the daily surveillance duties. Boree 4 and its earlier iterations were designed to maximise the design separation between arriving and departing aircraft for the sake of safety and efficiency. Boree 4 was not influenced by whether or not RNAV capable aircraft are predominant in the fleet mix or absent.

Q 4-5 ANSWER:

Some complainants have referred to the Boree Four STAR in their complaint but this is not consistently done so we are not able to reliably determine the number of complaints that specifically relate to the STAR.

Q 6 ANSWER:

As with all aspects of the implementation of the LTOP, the IMC is monitoring the situation. Most recently a report was provided to the May 2010 meeting of IMC on the post-Runway End Safety Area (RESA) use of the STAR.

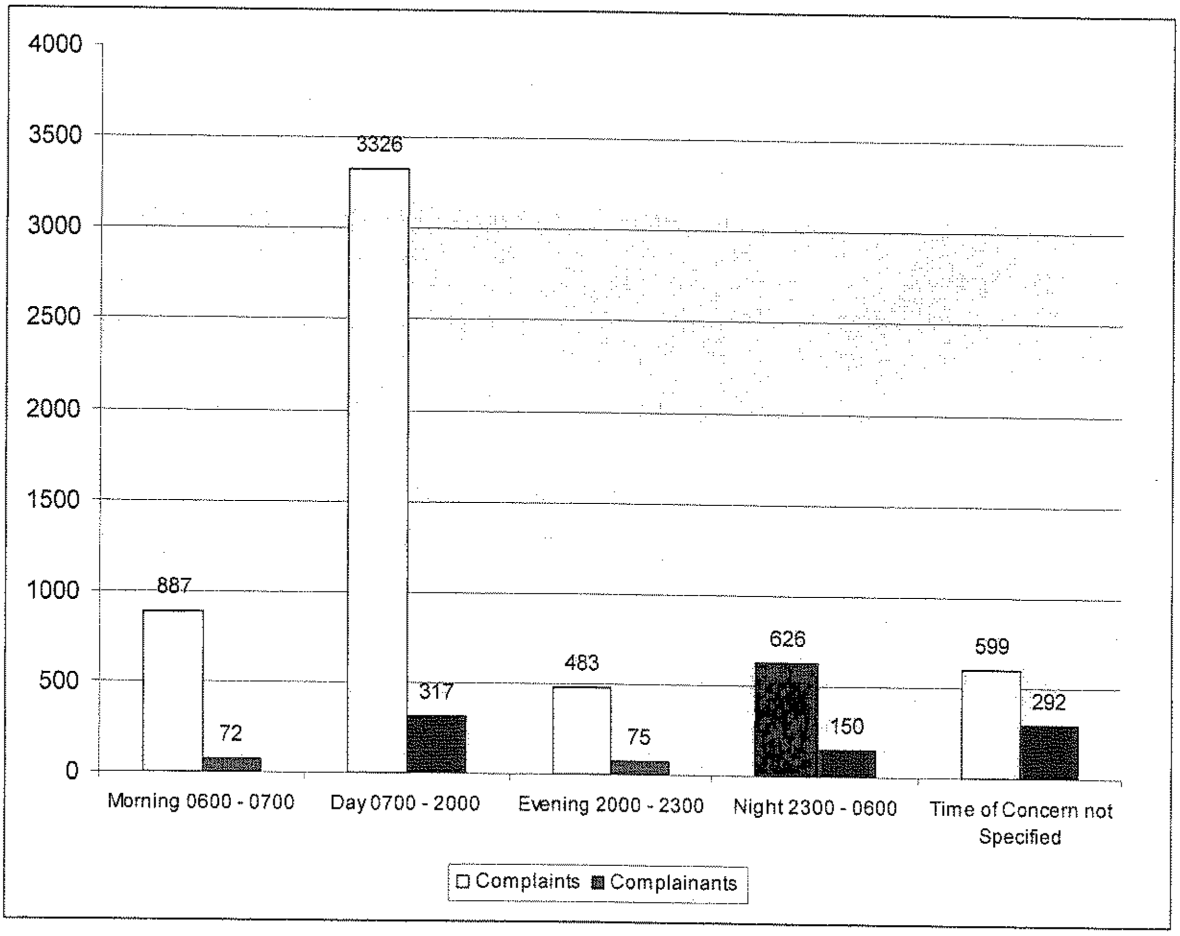
Q 7-9 ANSWER:

The environmental assessment concluded that the implementation of the STAR was not likely to be significant in terms of *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requirements because there was no expected change to traffic mix, noise levels or altitude (> or = 6,000ft). In addition, the change had been discussed at the Sydney Airport Community Forum (SACF) and IMC without issue. Since the original assessment was undertaken in 2003, minor changes have occurred to this and other related STARs. These changes have been assessed but as no new areas would be overflown and the original findings remained valid (no expected change to traffic mix, noise levels or altitude) it was concluded as being unlikely to have a major impact. Consequently a post implementation review was not required as there was no substantial difference.

Q 10 ANSWER:

Airservices Australia's *Communication and Consultation Protocol* was released in May 2010. The Protocol was the product of consistent feedback received through airport forums and public representations seeking clarity and transparency for our community consultation and communication processes.

Perth Airport
Complaints Received by Time of Concern
January to December 2009



SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT REFERENCES COMMITTEE

Inquiry into the effectiveness of Airservices Australia's management of aircraft noise

Public Hearing Thursday, 10 June 2010

Questions Taken on Notice - Jerrabomberra Resident's Association

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HANSARD, RRAT 28-29

Senator STERLE—I am just trying to test the validity of the assumption that in 20 years there will be 20 to 25 large freight jets and international flights. Where has that information come from?

Ms Sachse—That was released in the information that went alongside the Ultimate Practical Capacity ANEF data when that went out for public comment. That was detailed in that document, where they proposed the types of planes and the times of night that those flights will take place.

Senator STERLE—That is in the master plan; is that what you are telling me? The whole lot?

Ms Sachse—It is not in the master plan; it is in the documentation that accompanied the data that went into the Ultimate Practical Capacity ANEF.

Senator STERLE—Do you have that information?

Ms Sachse—I am sorry; I have to take that notice. I will supply that information to you.

Jerrabomberra Residents Association Inc.

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Effectiveness of Airservices Australia's management of aircraft noise
Question on Notice

Dear Ms Radcliffe

Thank you once again for the opportunity to appear before the committee on 10th June 2010. The Jerrabomberra Residents' Association (JRA) took one question on notice and that was to provide a copy of the report REHBEIN AOS report Canberra International Airport Practical Ultimate Capacity ANEF for the Capital Airport Group. This report contains the data that underpins the current ANEF for Canberra Airport. A copy of this report is attached.

Evidence given by Airservices and the Department at the Hearing on 10th June confirms the JRA's concern that the assumptions behind ANEF contours are not checked for feasibility or achievability by any Commonwealth government agency prior to endorsement and inclusion in an airport master plan.

At the Hearing, Mr Doherty said "when the initial master plan was lodged it did include proposals, quite open-ended at that stage, in relation to an overnight freight hub. The minister rejected the initial plan, and one of the factors there was the lack of detailed information about noise. The revised plan that came back included a much more specific proposal about the extent of operations envisaged in the foreseeable future in relation to overnight freight, and it was a handful of movements rather than many more. On that basis the minister was able to make a decision on the master plan, including initiating some work through Airservices for a review of noise abatement procedures to try to control noise."

Senator Nash asked Mr Doherty about the mismatch between the handful of movements in the master plan and the 23,846 movements that forms the basis of the endorsed ANEF.

Mr Doherty said, "As I understand it from what you are saying, it is part of the ANEF process, which goes to articulating the ultimate potential for noise at the airport, if you like—so it is looking forward beyond 30 years to 50 years."

Mr Stone said, "I think the handful of movements that Mr Doherty was referring to are what Canberra Airport detailed in its master plan as the short-term phase-in of this, which I think was about five movements, doubling to something like 10 or 12 over the next five to six years. But the difference in the ANEF is that it has aspirations of what that operation might look like in 20 years."

These statements by Mr Doherty and Mr Stone indicate that the Master Plan has been amended to indicate low rates of growth of freight operations in conflict with the ANEF which has been manipulated to inflate the contours by adopting an unachievable high rate of growth of freight operations.

The JRA is concerned that the ANEF for Canberra Airport has been manipulated to artificially prevent the building of the Jerrabomberra Secondary School on the site preferred by the JRA.

In view of this new evidence from the Department, the JRA would like to make a new recommendation to this Committee:

The ANEF for Canberra Airport should be independently reviewed for feasibility, achievability and compliance with the legal requirements for the airport master plan.

Yours sincerely

Kim Howatson
President
16 June 2010

SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT REFERENCES COMMITTEE

Inquiry into the effectiveness of Airservices Australia's management of aircraft noise

Public Hearing Thursday, 10 June 2010

Questions Taken on Notice - Department of Infrastructure

HANSARD, RRAT 55

CHAIR—Thank you. Can I just ask you to take on notice, in the interests of time: I am interested in the powers of local government when it comes to noise and how those powers are utilised or can be administered. If you could take that on notice; I think that is fairly straightforward. We are due to report very soon, so if you could have that back to us perhaps by earlier next week, that would be very useful. Thank you very much, gentlemen. We do appreciate your giving us your time today.

ANSWER -

State and territory governments give effect to their responsibilities for planning and environmental management through various legislative instruments including:

- Environmental Planning and Assessment Act 1979 (New South Wales)
- Planning and Environment Act 1987 (Victoria);
- Environmental Protection Act 1994 (Queensland);
- Environment Protection Act 1993 (South Australia);
- Environmental Protection Act 1986 (Western Australia);
- Environmental Management and Pollution Control Act 1994 (Tasmania);
- Environment Protection Act 1997 (Australian Capital Territory); and
- Environmental Assessment Act 1982 (Northern Territory).

and through supporting regulations and policy guidelines.

Responsibility for individual planning decisions is normally delegated to local government authorities under these state and territory-based provisions.

Local councils are frequently also owners and/or operators of local airports and in these cases are well-placed to balance the transport needs of their communities with the environmental impact of airport operations.

Any proposals by local councils to manage the impact of aircraft noise by seeking to impose specific conditions on aircraft operators would need to be consistent with the relevant regulatory responsibilities of the Commonwealth overseen by the Civil Aviation Safety Authority and Airservices Australia.

State and territory law does not apply at the 21 airports subject to the Commonwealth Airports Act 1996.

SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT REFERENCES COMMITTEE

Inquiry into the effectiveness of Airservices Australia's management of aircraft noise

Public Hearing Thursday, 10 June 2010

Questions Taken on Notice – Village Building Company

HANSARD, RRAT 70

Mr Winnel—No, but we can provide the committee with similar developments in every other city in Australia where they do not have curfews and where there is not significant impact.

Senator O'BRIEN—You might, but I am taking issue with Double Bay. Indeed, I think Airservices would take issue and say that Double Bay is not appropriate because they do not get night flights.

Mr Winnel—What we might do is come back to the committee with evidence of other similar areas.

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15 June 2010

Jeanette Radcliffe
Committee Secretary
Senate Standing Committee on Rural Regional Affairs and Transport.
Jeanette.Radcliffe@aph.gov.au

The Village Building Co.

Dear Ms Radcliffe,

Senate Inquiry into the Effectiveness of Airservices Australia's Management of Aircraft Noise. Response to Question on Notice

At the Hearing held on 10th June, Senator O'Brien asked The Village Building Co for examples of areas around non-curfewed airports with similar noise to Tralee.

Acoustics consultant, Wilkinson Murray has identified the following residential areas as having similar noise levels from individual over-flights to Tralee during the day and night, but at two to four times the frequency of Tralee:

- Virginia and Geebung, which are near to and less noisy than Chermside in Brisbane.
- Plumpton, further out from Melbourne Airport than Sydenham and Hillside.

Residential development in any area with noise similar to Tralee has never resulted in a curfew or noise sharing. Dr Rob Bullen of Wilkinson Murray advises that the chance that noise sharing will result from the residential development of Tralee is virtually nil.

Residential developments complying with the ANEF system but with far more noise than Tralee have recently been approved in many areas around all major airports including curfew-free airports. Some of these were identified in a report by Wilkinson Murray attached to our written submission. The Department and Airservices have publicly opposed Tralee, but have not opposed any other development that complies with the ANEF system. Airservices should uniformly adopt the ANEF system as per its otherwise universal practice for over 30 years. For just one development in the whole of Australia it is ignoring the ANEF system in favour of ill-defined objections from The Capital Airport Group with no precedent under similar circumstances.

Late Proposal by the Capital Airport Group to abandon AS 2021

At the request of The Capital Airport Group the order appearance at the Hearing in Canberra was altered to put The Capital Airport Group last. They then presented evidence entirely different to their written submission and we did not have an opportunity to respond at the hearing.

The Capital Airport Group made unsubstantiated claims to undermine the perceived effectiveness of AS 2021 and the ANEF system as a land use planning tool. The airport's last minute, unsupported verbal assertions, require a proper examination. Any forensic examination of these airport assertions about noise levels at Tralee (which conforms to AS 2021) will demonstrate them to be completely false.

AS 2021 is endorsed at a Federal, State and Local level in legislation, regulations, cross-border agreements and planning policies and has successfully protected both airports and residents of new developments alike for over 30 years.

We now wish to comment on just a few specific assertions made in evidence by The Capital Airport Group. We would however, like to address all of their last minute unanswered claims in detail if these claims are to be seriously considered and we would invite the Committee for a site inspection of Tralee during the peak travel period.

We also request the opportunity to comment on any additional documents that the airport might provide to this Inquiry.

Misleading claims about noise levels at Tralee

On page 78 of the Proof Hansard, in response to a question from the Chair about the noise over Tralee from departures, Mr. Byron said, "Between 68 and 73 or 74 decibels for a 737". **This is untrue.**

We do not believe that Mr. Byron has undertaken any measurements to support this assertion. The extract in attachment 1 from a report by Wilkinson Murray, indicates that the measurement of noise from a 737 at the closest proposed house in Tralee to the departure flight path is between 56 to 70 dB. (Each three dB increase in noise represents a doubling of the power or intensity of the noise.)

Mr Byron also said "the landing aircraft that are on that curved flight path are a couple of decibels higher than that". **This is untrue.** Wilkinson Murray measured the noise over South Tralee from arriving aircraft at less than 60 dB. This is a fraction of the noise level wrongly claimed by Mr. Byron.

Misleading claims about alternative development areas and flight paths.

On page 79 of the Proof Hansard, Mr Byron said, "...there are also alternate locations for the development of housing around Queanbeyan, including the development of Googong, which will supply in the order of 25 years worth of development for Queanbeyan..." **This is untrue.**

In 2008, the Capital Airport Group lodged a report to the NSW Minister for Planning suggested a number of alternative residential development areas to Tralee. Attachment 2 is a copy of a plan tabled by Mr Byron at this Inquiry marked by hand with three of the locations proposed by The Capital Airport Group for residential development. These have **similar or more aircraft noise than South Tralee and more over-flights.**

The Capital Airport Group's opposition to Tralee is inconsistent with its support for these nearby areas. It should be noted that The Capital Airport Group is the largest property developer in the region and a competitor of VBC.

In 2008, Queanbeyan Council and the NSW government advised The Capital Airport that the alternative development areas it had proposed were rejected for numerous reasons including the high cost to provide infrastructure. Suitable land is in scarce supply and the Queanbeyan Residential and Economic Strategy 2031 requires the development of both Googong and Tralee and surrounding lands to meet its needs to the year 2031.

Misleading claims about the Commonwealth's policy on the ANEF system

On page 83 of the Proof Hansard, Mr. Byron said, "In simple terms, we agree with the Commonwealth government that the ANEF is not the right tool to sort out the land use planning around airports". This is not a correct statement of Commonwealth policy and was contradicted in the following statements made by Mr Stone of the Department on page 51 of the Proof Transcript.

Mr. Stone— "Another process flowing from the government's white paper is for the Commonwealth to lead a group of state and Commonwealth planning and transport agencies to improve the state and local government planning processes around airports. While in its white paper the government said that it supports using ANEFs as the primary mechanism for land transport planning at the moment, part of that is because not all jurisdictions currently do that. We think the **ANEF is a tested measure that is worth keeping.** But there is nothing to stop states in their oversight of land use planning to have other mechanisms for noise **description** if they choose. We are working with them to assess how some of that might work in a planning context. So the ANEF and the master planning process do not put a legal requirement on states to use that as the only **source of information** for its planning regime."

(Description or **information** about aircraft noise is **different in concept to the regulatory requirements** of AS 2021 and the ANEF system.)

Senator BACK—"But a local government is pretty well obliged, is it not, to use the ANEF for its actual planning programs?"

Mr. Stone—"**It is certainly the best measure and a tested measure that has been around since the 1980s that has proved fairly successful in helping local governments to plan around the vicinity of airports. Nobody has ever said that it is perfect, and that is why we have started this work going forward. However, it is not the view of the department that having more conservative ANEFs would in any way assist to improve that process.**"

Misleading claims about the Inquiry into Queanbeyan Land Release

On page 77 of the Proof Hansard, Mr Byron gave evidence in relation to the so-called "independent" committee of Inquiry into Queanbeyan Land Release. This Inquiry was flawed from the outset by a profound conflict of interest of Mr Ken Matthews, one of the committee members. Mr Matthews was a former Secretary of the Commonwealth Department of Transport and Regional Services and he supported The Capital Airport Group's opposition to Tralee. Mr Matthews had an obligation to declare his conflict and remove himself from any "independent" Inquiry. He failed to do this and this profoundly and irreversibly tainted the credibility of the so called "independent" Inquiry. The NSW Department of Planning found many flaws in the final report of the Queanbeyan Inquiry and subsequently endorsed residential development at South Tralee in the Queanbeyan Residential and Economic Strategy.

Conclusion

The Federal Department of Infrastructure and Transport and Airservices in submissions to this inquiry, identify the ANEF system as the best and the only available proven tool to govern land use planning around airports.

Attempts by The Capital Airport Group to create one exception in one location to the ANEF system, after 30 years of successful operation of that system would seem to be very clearly outside of the terms of reference of this committee.

Evidence to this Inquiry has however, identified that the process for reviewing ANEFs is totally inadequate. A new process is needed, totally independent from Airports, Airservices and the Department. Unlike an airport master plan, the ANEF is not a business plan which properly remains a product of the airport. It needs to be based on an objective forecast of future traffic that provides confidence and certainty for land use planning.

Recommendations

In the light of evidence to the Inquiry, we would like to reshape our recommendations to this inquiry:
(1) The regulation governing the approval of ANEFs should be amended to include an independent body to produce ANEFs based on feasible, achievable and reasonable assumptions;
(2) The process for endorsing ANEFs should be incorporated into the process for approving master plans, so that the two are consistent;
(3) The process for the review of master plans, including ANEFs should be open and transparent;
(4) The proposed Aircraft Noise Ombudsman should have the power to review the processes of the Department and Airservices in relation to airport master plans and ANEFs as well as noise complaints, and should report directly to parliament; and
(5) Government policy frameworks on aircraft noise and land use planning should be uniformly applied and an individual development should not be singled out for inconsistent treatment at the behest of a Council, a developer or an airport. The ANEF system should continue to be defended and not opened to subversion by a particular interest in a particular instance.

Yours sincerely,

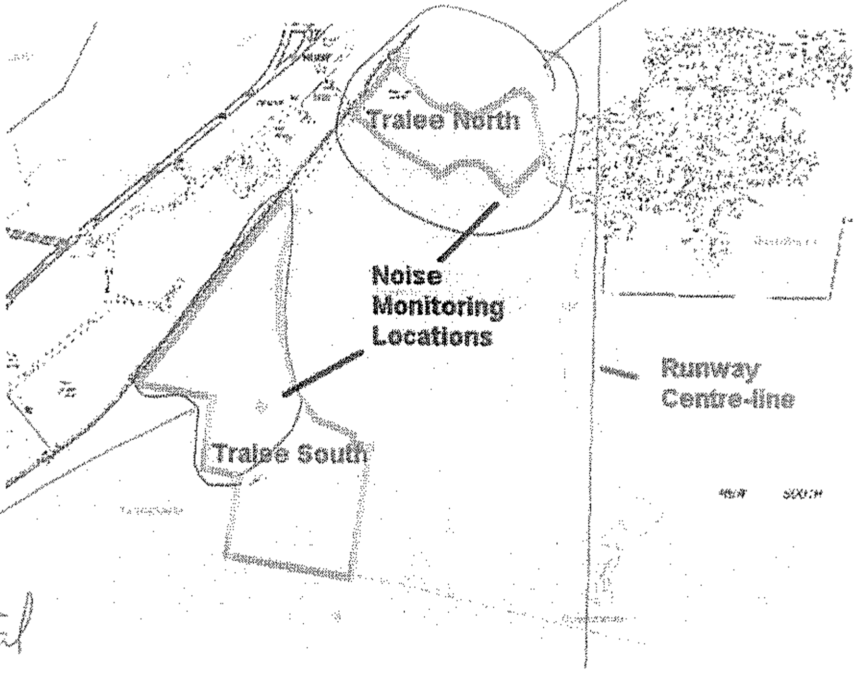
Ken Ineson

General Manager, Special Projects and Feasibilities.

Attachment 1

Industrial *

Figure 2-18 Locations of Attended Noise Monitors



Residential

Table 2-4 Measured Noise Levels from Aircraft Departures Over Tralee

Aircraft Group	Measured Noise Level (dBA) Mean	Measured Noise Level (dBA) Range	Number Recorded	Predicted Noise Level (dBA) (1)
Tralee North				
737	69	61 – 74	16	71
BAe146	69	66-70	4	70
DHC8	61	53-65	8	60
SF340	58	54-61	2	68
Tralee South				
737	66	56-70	11	69
Bae146	54	-	1	68
DHC8	61	-	1	60
SF340	58	51-68	3	66

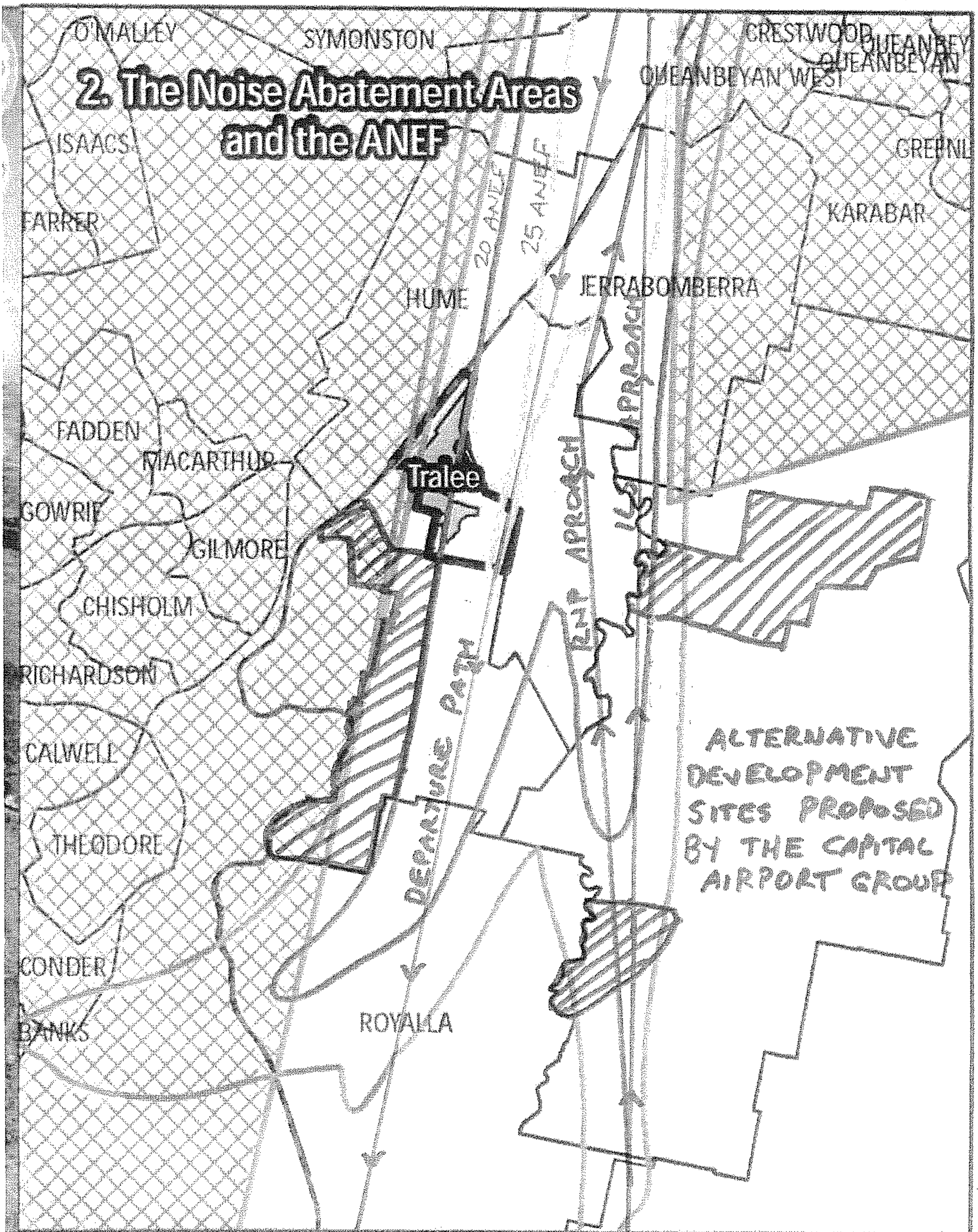
Note: 1) For an aircraft tracking directly over the monitoring location

Industrial * (Tralee North)

Residential (Tralee South)

Attachment 2.

Markup of Map tabled by The Capital Airport Group.



SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT REFERENCES COMMITTEE

Inquiry into the effectiveness of Airservices Australia's management of aircraft noise

Public Hearing Thursday, 10 June 2010

Questions Taken on Notice - Canberra Airport

HANSARD, RRAT 81

CHAIR—We have been provided with a table from Rehbein AOS on potential aircraft movements. There has been a lot of discussion through the course of the inquiry around the assumptions that go into the forecasting from airports—and I am not particularly talking about Canberra; we had this in Sydney and across the board. Will it look at the aircraft movements that have been shown in the table as potentially being the ones in place? Are you able to provide the committee with the assumptions that you used to arrive at these figures?

Mr Byron—We would be pleased to do that. We will take them from the extracts that we gave to the Federal Court.

HANSARD, RRAT 86

CHAIR—Finally, before I pass over to Senator O'Brien, I refer to the table of aircraft movements with freight operations. I think five different aircraft listed there. They are all designated freight aircraft, is that correct?

Mr McCann—Not all.

CHAIR—So they are not?

Mr McCann—We can come back to you with the numbers where you asked us for the assumptions. We will answer that at the time.

CHAIR—Okay, that is great. I would like to know what percentage of those is underbelly freight and passenger aircraft and what percentage is designated freight aircraft.

Mr Byron—That information is available as part of the assumptions on the ANEF.

CANBERRA AIRPORT

AL:mm
Our ref: LEG:GOVR

18 June 2010

The Senate Rural and Regional Affairs and
Transport References Committee

Via email: RRAT.Sen@aph.gov.au

Dear Committee Members

As discussed in our appearance at the hearings in Canberra on 10 June 2010, we attach for the Committee's consideration some further material in relation to aircraft noise and the development of the Canberra Airport Ultimate Practical Capacity ANEF:

- The Rehbein AOS "Canberra International Airport Practical Ultimate Capacity ANEF" – this document contains both a report on the ANEF as well as the capacity analysis produced to support the ANEF. This document refers to, and contains, the relevant basis upon which the ANEF was developed.
- The report referred to above contains information concerning the freight aircraft, their number and frequency as requested by the Committee.
- A document from Airservices Australia showing the types of questions and issues that they considered when reviewing the Canberra Airport Practical Ultimate Capacity (PUC) ANEF.
- Letters from the Housing Industry Association and the Master Builders Association – both of these confirm that the Tralee development should not occur given its position under flight paths.
- A number of articles concerning the effect that aircraft noise has on the cognitive functions of young children.
- A copy of our consultation report that we produced and provided to Airservices Australia in relation to the development of the PUC ANEF for Canberra Airport.

If the Committee requires any further material, or wishes to discuss the matter any further, we would of course be happy to assist in any way.

Yours sincerely

Andrew Leece
General Counsel

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Mr Noel McCann
Director, Capital Airport Group
2 Brindabella Crt
Brindabella Business Park
CANBERRA AIRPORT ACT 2609

Dear Noel,

RE Mitigating Aircraft Noise

The HIA has reviewed your document, which sets out the proposal to minimise the impact of aircraft noise on residential areas of Canberra and Queanbeyan.

The HIA sees the Canberra International Airport playing an increasingly important role in the growth and development of Canberra and the South East Region. Your proposed modification to the southern flight path will ensure that the Airport can develop its role while maintaining the amenity of the existing residential areas near the flight path.

The vacant land holdings to the west of Jerrabomberra will obviously not be suitable for residential development, but commercial and industrial uses could be considered for this area. The HIA also understands that other long-term potential residential development areas exist outside Queanbeyan and Canberra. These areas to the north and north-west of Canberra, and south of Queanbeyan are large and can take-up the future growth demands for the Region.

Thank you for the opportunity to comment on your proposal.

Yours sincerely

J. Futer

John Futer
Executive Director
ACT/Southern NSW
16 July 2001

Master Builders
Association of the ACT

Building Excellence

30 July 2001

Mr Noel McCann
Capital Airport Group Pty Ltd
Brindabella Complex
Canberra International Airport
PIALLIGO ACT 2609

By facsimile: 6275 2244

Dear Noel

Quarantine of Excessive Aircraft Noise – Canberra / Queanbeyan Residential Areas

The Association recognises and supports the status held by Canberra International Airport as a major transport hub for the ACT and region. It is an integral part of the viability and on-going development of the area.

The Association supports the Capital Airport Group's approach to the ACT Government and Queanbeyan City Council to define designated flight paths for the Airport.

As Canberra is a planned city and the Airport has been located at Pialligo since 1927, all Canberrans are fully aware of its existence and the fact that the flight paths run north / south.

We believe that it is not good planning practice to allow the development of residential estates under the flight paths. It is important that the ACT and surrounding region does not make the same mistake that we have seen occur in Sydney and other parts of Australia, in allowing such developments.

However, there is no reason why some of the land in close proximity could not be used for other purposes such as light industrial. We also recognise that there is an opportunity for the Airport to allow for international traffic, given the expansion that is currently being undertaken to the runway.

Yours sincerely

David Dawes
Executive Director

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Aircraft and road traffic noise and children's cognition and health: a cross-national study

S A Stansfeld, B Berglund, C Clark, I Lopez-Barrio, P Fischer, E Öhrström, M M Haines, J Head, S Hygge, I van Kamp, B F Berry, on behalf of the RANCH study team*

Lancet 2005; 365: 1942–49

See Comment page 1908

*Study team listed at end of article

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Correspondence to: Prof Stephen Stansfeld S.A.Stansfeld@qmul.ac.uk

Summary

Background Exposure to environmental stressors can impair children's health and their cognitive development. The effects of air pollution, lead, and chemicals have been studied, but there has been less emphasis on the effects of noise. Our aim, therefore, was to assess the effect of exposure to aircraft and road traffic noise on cognitive performance and health in children.

Methods We did a cross-national, cross-sectional study in which we assessed 2844 of 3207 children aged 9–10 years who were attending 89 schools of 77 approached in the Netherlands, 27 in Spain, and 30 in the UK located in local authority areas around three major airports. We selected children by extent of exposure to external aircraft and road traffic noise at school as predicted from noise contour maps, modelling, and on-site measurements, and matched schools within countries for socioeconomic status. We measured cognitive and health outcomes with standardised tests and questionnaires administered in the classroom. We also used a questionnaire to obtain information from parents about socioeconomic status, their education, and ethnic origin.

Findings We identified linear exposure-effect associations between exposure to chronic aircraft noise and impairment of reading comprehension ($p=0\cdot0097$) and recognition memory ($p=0\cdot0141$), and a non-linear association with annoyance ($p<0\cdot0001$) maintained after adjustment for mother's education, socioeconomic status, longstanding illness, and extent of classroom insulation against noise. Exposure to road traffic noise was linearly associated with increases in episodic memory (conceptual recall: $p=0\cdot0066$; information recall: $p=0\cdot0489$), but also with annoyance ($p=0\cdot0047$). Neither aircraft noise nor traffic noise affected sustained attention, self-reported health, or overall mental health.

Interpretation Our findings indicate that a chronic environmental stressor—aircraft noise—could impair cognitive development in children, specifically reading comprehension. Schools exposed to high levels of aircraft noise are not healthy educational environments.

Introduction

An understanding of the way the environment affects children's health and development is central to sustainable living and to the prevention of illness.[1] The effects of air pollution and lead are well known, but less attention has been paid to environmental noise.[2,3] Noise, an ubiquitous environmental pollutant, is a public-health issue because it leads to annoyance, reduces environmental quality, and might affect health and cognition.[4] Children could be particularly vulnerable to the effects of noise because of its potential to interfere with learning at a critical developmental stage, and because they have less capacity than adults do to anticipate, understand, and cope with stressors.[5]

Attention, memory, and reading are all involved in cognitive development at primary school age (5–11 years). Children attend to information that is then encoded in memory through processes of rehearsal, organisation, and elaboration.[6] Strategies for retrieval of information from memory develop gradually. Reading depends on perception and memory and, at an early stage, awareness of speech sounds, which could be distorted by ambient noise.[7] Environmental stressors can have a great effect on the degree to which information is processed, retained, and recalled.[8]

We set up the RANCH project (road traffic and aircraft noise exposure and children's cognition and health: exposure-effect relationships and combined effects) to investigate the relation between exposure to aircraft and road traffic noise and cognitive and health outcomes. We postulated that exposure to these types of noise would be associated with impaired cognitive function and health, including annoyance in children.

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 a cross-sectional study. We selected schools on the basis of increasing levels of exposure to aircraft and road traffic noise with the same systematic method in every country so as to examine exposure-effect relations. We classified schools in a four-by-four grid of noise exposure in every country. We randomly selected two schools within every cell so as to examine the effects of increasing aircraft noise within low road traffic noise, increasing road traffic noise within low aircraft noise, and the effects of combinations of aircraft noise and road traffic noise. We matched chosen schools by the socioeconomic status of the pupils, which we measured by eligibility for free school meals, and by main language spoken at home. We selected those schools exposed to the highest amounts of aircraft noise first. 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 from our study non-state schools in the UK and Spain, but included them in the Netherlands where degrees of achievement do not differ appreciably between school type. We also excluded schools at which noise surveys indicated either the presence of a dominant noise other than aircraft or road traffic noise, or at which insulation against noise was above a certain threshold (double or triple-glazed classroom windows) as identified with a predefined protocol with categories of likely internal-to-external noise level differences for every classroom, although some highly insulated schools were included in the Netherlands. In every noise exposure cell, in every country, we selected two schools according to a protocol. In the UK and Spain, we selected two classes of children of mixed sex from each school, and in the Netherlands one class (most Dutch schools only had one class in this age group). If there were more than two classes in the year, then we randomly selected two or one, dependent on the country. We did not exclude any children from the selected classes.

We obtained written consent from the children and their parents. 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.

Procedures

To assess exposure to noise, we used external noise measurements (dB[A]) as the independent variable (dB[A] is the unit of A-weighted sound pressure level, where A-weighted means that the sound pressure levels in various frequency bands across the audible range have been weighted in accordance with differences in hearing sensitivity at different frequencies). In the UK, we based aircraft noise assessments external to the schools on the 16-h 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 h to 2300 h 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.[9] 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. In all three countries, we also took acute measurements of noise exposure in the classroom and outdoors at the time of testing of cognitive function, to identify any unexpected sources of noise apart from aircraft or road traffic noise that might interfere in the test situation and to assess exposure to acute aircraft and road traffic noise. The measures of acute noise exposure, using microphones, provided level differences. For aircraft noise events this measurement could be taken, in some schools, using the highest intensity points in the noise events, where interior aircraft noise levels were detectable against ambient interior noise levels.

With respect to cognitive outcomes, we measured reading comprehension with nationally standardised and normed tests—Suffolk reading scale,[10] CITO (Centraal Instituute Toets Ontwikkeling) readability index for elementary and special education,[11] and the ECL-2 (Evaluación de la Compresión Lectora, nivel 2).[12] We assessed episodic memory (recognition and recall) by a task adapted from the child memory scale.[13] This task assessed time delayed cued recall and delayed recognition of two stories presented on compact disc. Sustained attention was measured by adapting the Toulouse Pieron test for classroom use.[14] We used a modified version of the search and memory task[15,16] to measure working memory, and assessed prospective memory by asking children to write their initials in the margin when they reached two predefined points in two of the tests.

To assess health outcomes, we gave children a questionnaire that included questions on perceived health, and perceptions of noise and annoyance based on standard adult questions.[17] We also sent a questionnaire home for the parents to complete, which included questions on the perceived health of their child, and which we used to ascertain their children's mental health as measured by the parental version of the strengths and difficulties questionnaire[18]—a well validated measure of child psychological distress, sociodemographic context variables, environmental attitudes, and noise annoyance.

We assessed sociodemographic factors as potential confounding factors and included socioeconomic position (employment status, housing tenure, crowding—an objective measure of the number of people per room at home (1·5 people per room in Spain and the UK, 1 person per room in the Netherlands]), maternal education, ethnic origin, and main language spoken at home, developing comparable measures across countries.

We did pilot studies to assess the feasibility of the cognitive tests in the Netherlands, Spain, and the UK, and, separately, the reliability, validity, and psychometric properties of the tests used against comparison tests. We translated tests and instructions from English into Dutch and Spanish, and back translated to ensure accurate conceptual translation. After piloting, we made minor alterations to the cognitive tests and environment questionnaires, mainly to improve the language and to make them more user friendly. The results of the cognitive tests were normally distributed with no floor or ceiling effects.

We did group testing in 2-h slots under close supervision to a standardised protocol (available from authors) that governed the administration of the tests across countries. In all countries, we did the tests in classrooms in the morning in the second quarter of the year. We ensured strict adherence to the protocol via cross-country quality control visits. We administered tests in a fixed order. We measured the internal and external noise levels at the schools under the supervision of local noise measurement specialists, working to a standardised noise protocol (available from authors).

Statistical analysis

We dealt with the potential confounding effects of sociodemographic factors through-the-study design (eg, by exclusion or matching) and by statistical adjustment of findings. We did analyses of the pooled data from the UK, the Netherlands, and Spain with multilevel modelling, including exposure to aircraft noise and road traffic noise as continuous variables. The advantage of multilevel modelling is its ability to

	Pooled sample	UK	Netherlands	Spain
Pupil level data				
Response rate				
Child	2844 (89%)	1174 (87%)	762 (92%)	908 (88%)
Parent	2276 (80%)	960 (82%)	658 (86%)	658 (72%)
Median age (range)	10 y 6 m (8 y 10 m–12 y 10 m)	10 y 3 m (8 y 10 m–11 y 11 m)	10 y 5 m (8 y 10 m–12 y 10 m)	10 y 11 m (9 y 5 m–12 y 4 m)
Sex				
Boys	1064/2261 (47%)	433/960 (45%)	321/643 (50%)	310/658 (47%)
Girls	1197/2261 (53%)	527/960 (55%)	322/643 (50%)	348/658 (53%)
Employed				
No	337/2256 (15%)	217/952 (23%)	48/651 (7%)	72/653 (11%)
Yes	1919/2256 (85%)	735/952 (77%)	603/651 (93%)	581/653 (89%)
Crowding				
No	1745/2218 (79%)	717/928 (77%)	444/645 (69%)	584/645 (91%)
Yes	473/2218 (21%)	211/928 (23%)	201/645 (31%)	61/645 (9%)
Home owner				
No	619/2232 (28%)	398/944 (42%)	123/652 (19%)	98/636 (15%)
Yes	1613/2232 (72%)	546/944 (58%)	529/652 (81%)	538/636 (85%)
Mean mother's education (SD)*	0·50 (0·28)	0·50 (0·28)	0·50 (0·28)	0·50 (0·28)
Long standing illness				
No	1724/2280 (76%)	703/953 (74%)	481/657 (73%)	540/670 (81%)
Yes	556/2280 (24%)	250/953 (26%)	176/657 (27%)	130/670 (19%)
Main language spoken at school				
No	269/2253 (12%)	211/960 (22%)	42/637 (7%)	16/656 (2%)
Yes	1984/2253 (88%)	749/960 (78%)	595/637 (93%)	640/656 (98%)
Mean parental support scale (SD)†	10·1 (2·0)	10·1 (1·9)	8·8 (1·9)	11·1 (1·5)
School level data				
Number of schools	89	29	33	27
Median noise exposure, dB(A) (range)				
Aircraft	52 (30–77)	52 (34–68)	54 (41–68)	43 (30–77)
Road traffic	51 (32–71)	48 (37–67)	53 (32–66)	53 (43–71)
Classroom insulation				
Single glazing	50 (56·2%)	17 (58·6%)	15 (45·5%)	18 (66·7%)
Double glazing	35 (39·3%)	12 (41·4%)	14 (42·2%)	9 (33·3%)
Triple glazing	4 (4·5%)	0	4 (12·1%)	0

Data are number (%) unless otherwise indicated. y=years. m=months. *Ranked index of standard qualification in every country. †Ordinal scale, range 3–12. Missing values: age 5%, sex <1%, employment 5%, crowding 7%, home ownership 6%, mother's education 7%, long standing illness 4%, main language 5%, parental support 6%, classroom insulation 0%.

Table 1: Sociodemographic characteristics of participants

	Reading comprehension (n=2010)				Recognition (n=1998)			
	Model 1		Model 2		Model 1		Model 2	
	β (SE)	p	β (SE)	p	β (SE)	p	β (SE)	p
Fixed coefficients								
Intercept	0·248 (0·625)		−1·36 (0·625)		26·68 (1·51)		22·96 (1·55)	
Aircraft noise	−0·009 (0·003)	0·0089	−0·008 (0·003)	0·0097	−0·021 (0·008)	0·0082	−0·018 (0·007)	0·0141
Road noise			0·002 (0·004)	0·5413			0·005 (0·009)	0·6737
Spain	Ref		Ref		Ref		Ref	
UK	0·051 (0·089)	0·5657	0·272 (0·082)	0·0010	−0·066 (0·210)	0·7529	0·427 (0·206)	0·0383
Netherlands	0·067 (0·087)	0·4403	0·320 (0·085)	0·0002	0·213 (0·206)	0·3025	0·560 (0·211)	0·0080
Age	0·043 (0·154)	0·7800	0·162 (0·147)	0·2708	−0·085 (0·368)	0·8206	0·037 (0·361)	0·9191
Sex (female)	−0·015 (0·044)	0·7319	−0·056 (0·042)	0·1804	−0·076 (0·106)	0·4772	−0·134 (0·104)	0·1967
Employed			0·080 (0·065)	0·2159			0·350 (0·159)	0·0281
Crowded			−0·073 (0·055)	0·1797			−0·123 (0·134)	0·3584
Home owner			0·206 (0·053)	<0·0001			0·579 (0·132)	<0·0001
Mother's education			−0·713 (0·078)	<0·0001			−0·691 (0·191)	0·0003
Long standing illness			−0·148 (0·049)	0·0028			−0·045 (0·121)	0·7089
Speak main language at home			0·183 (0·076)	0·0163			0·962 (0·190)	<0·0001
Parental support			0·085 (0·012)	<0·0001			0·131 (0·029)	<0·0001
Classroom glazing			0·002 (0·028)	0·9522			0·064 (0·070)	0·3650
Random parameters (↓)								
Level 2: school	0·041 (0·013)		0·023 (0·010)		0·221 (0·071)		0·163 (0·060)	
Level 1: pupil	0·952 (0·031)		0·865 (0·028)		5·51 (0·178)		5·20 (0·168)	

Table 2: Multilevel models for aircraft noise and reading comprehension and recognition

take into account effects at the level of the school and the pupil simultaneously. We initially adjusted all pooled analyses for age, sex, country, and noise (model 1), and subsequently for socioeconomic status and mother's education. The final model also adjusted for children's longstanding illness, main language spoken at home, parental support for schoolwork, and the type of glazing in the windows of the child's classroom (model 2). Separately we tested whether the results of the final model changed after adjustment for acute noise exposure during testing. We also examined interactions between noise level, sociodemographic factors, and the outcomes. We tested for significance by comparing the goodness of fit of different models with a χ^2 test of deviance.

We investigated the possibility of a curvilinear exposure-effect relation between noise (either aircraft or road traffic) and every cognitive and health outcome with fractional polynomial models.[19] We chose the best fitting model from a set of two degree fractional polynomials (of the form $\beta_1 aircraft\ noise^{p1} + \beta_2\ aircraft\ noise^{p2}$ where p_1 and p_2 belong to the set −2, −1, −0·5, 0, 0·5, 1, 2, 3), then compared the goodness of fit (deviance) of this model with that of a straight line model to test for departure from a straight line relation.

Role of the funding source

The sponsors of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

2844 children from 89 schools participated (table 1). In the UK, Spain, and the Netherlands, one of 30, none of 27, and 33 of 77 schools, respectively, declined to participate. From the pool of primary schools identified near airports in the UK and Spain, we excluded 26 and 19 non-state schools, respectively. Child response rates were universally high (table 1). Home ownership, parental employment status, and the proportion of children whose main language was not the native language differed across countries and have been adjusted for in analyses.

The range of exposure to noise around the schools varied across countries, reflecting the distribution of noise; nevertheless, there was considerable overlap (table 1). In analysis we have pooled the data from the three airport noise field studies and analysed the exposure-effect relationships across the total sample,

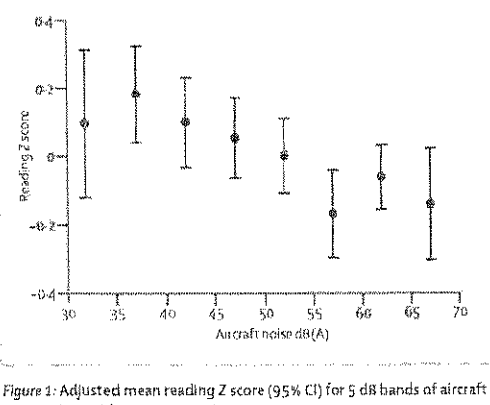

Figure 1: Adjusted mean reading Z score (95% CI) for 5 dB bands of aircraft noise (adjusted for age, sex, and country)

	β (SE)	95% CI	p
Cued recall conceptual (n=1975)			
Model 1	−0·006 (0·005)	−0·015 to 0·003	
Model 2	−0·004 (0·004)	−0·012 to 0·003	0·2684
Cued recall information (n=1974)			
Model 1	−0·030 (0·018)	−0·065 to 0·006	
Model 2	−0·022 (0·016)	−0·053 to 0·008	0·1531
Prospective memory* (n=1958)			
Model 1	−0·015 (0·009)	−0·033 to 0·003	
Model 2	−0·015 (0·009)	−0·033 to 0·003	0·1250
Working memory (n=1938)			
Model 1	−0·024 (0·022)	−0·067 to 0·019	
Model 2	−0·021 (0·021)	−0·064 to 0·022	0·3412
Sustained attention (n=1938)			
Model 1	−0·051 (0·115)	−0·277 to 0·175	
Model 2	−0·037 (0·115)	−0·263 to 0·189	0·7471
Mental health (n=2014)			
Model 1	0·015 (0·014)	−0·012 to 0·042	
Model 2	0·013 (0·013)	−0·012 to 0·038	0·3098
Self-reported health (n=1970)			
Model 1	−0·001 (0·002)	−0·005 to 0·003	
Model 2	−0·002 (0·002)	−0·006 to 0·002	0·4345
Noise annoyance (n=1969)			
Model 1	0·037 (0·004)	0·029 to 0·045	
Model 2†	0·037 (0·004)	0·029 to 0·045	0·0001

*Binomial multilevel modelling done; β therefore indicates success or failure on task. †Adjusted for country, age, sex, socioeconomic status, mother's education, length of enrolment at school, classroom glazing, ethnic origin.

Table 3: Cognitive and health outcomes and aircraft noise exposure

using continuous data for aircraft noise and road traffic noise prediction.

With respect to cognitive effects, in analyses of the pooled data from the UK, the Netherlands, and Spain, exposure to chronic aircraft noise was associated with a significant impairment in reading comprehension that was maintained after full adjustment (table 2). The effect sizes at different exposure levels for aircraft noise for reading across countries were consistent (test for heterogeneity p=0·9 and in the same direction of association). A 5 dB difference in aircraft noise was equivalent to a 2-month reading delay in the UK and a 1-month reading delay in the Netherlands. There are no national data available for Spain. In the Netherlands and Spain, a 20 dB increase in aircraft noise was associated with a decrement of one-eighth of an SD on the reading test; in the UK the decrement was one-fifth of an SD. The size of the effect did not differ by socioeconomic status. Figure 1 shows reading comprehension by 5 dB bands of aircraft noise adjusted for age, sex, and country. There was no significant departure from linearity (p=0·99 for comparison of straight line fit with the best fitting fractional polynomial curve).

We measured episodic memory in terms of recognition and cued recall. Cued recall included assessment of information recall and conceptual recall. Exposure to aircraft noise was linearly associated with a significant impairment in recognition, but not information recall or conceptual recall (table 2 and table 3). For recognition memory, the heterogeneity test was not significant (p=0·104), indicating that the effects did not significantly differ in magnitude across countries. Aircraft noise was also not associated with impairment in working memory, prospective memory, or sustained attention. Road traffic noise was associated with a significant increase in scores for the episodic memory scales of information recall and conceptual recall that were maintained after full adjustment (table 4). The effect sizes for information recall and conceptual recall were not significantly different

	Conceptual recall (n=1975)				Information recall (n=1974)			
	Model 1		Model 2		Model 1		Model 2	
	β (SE)	p	β (SE)	p	β (SE)	p	β (SE)	p
Fixed coefficients								
Intercept	4·07 (0·850)		2·41 (0·834)		17·63 (3·28)		11·68 (3·24)	
Aircraft noise			−0·004 (0·004)	0·2653			−0·022 (0·016)	0·1513
Road noise	0·013 (0·006)	0·0201	0·013 (0·005)	0·0066	0·040 (0·022)	0·0713	0·038 (0·019)	0·0489
Spain	Ref		Ref		Ref		Ref	
UK	0·790 (0·117)	<0·0001	1·10 (0·108)	<0·0001	1·21 (0·462)	0·0082	2·43 (0·438)	<0·0001
Netherlands	0·521 (0·112)	<0·0001	0·806 (0·110)	<0·0001	−1·08 (0·447)	0·0160	−0·025 (0·445)	0·9545
Age	−0·052 (0·204)	0·7998	0·074 (0·197)	0·7079	−0·455 (0·780)	0·5611	0·033 (0·759)	0·9653
Sex (female)	−0·113 (0·059)	0·0554	−0·150 (0·057)	0·0088	−0·236 (0·224)	0·2910	−0·363 (0·218)	0·0956
Employed			0·009 (0·088)	0·9219			0·260 (0·335)	0·4365
Crowded			−0·115 (0·074)	0·1187			−0·420 (0·281)	0·1347
Home owner			0·294 (0·072)	<0·0001			1·24 (0·276)	<0·0001
Mother's education			−0·607 (0·106)	<0·0001			−2·28 (0·403)	<0·0001
Long standing illness			−0·015 (0·067)	0·8207			0·154 (0·253)	0·5426
Speak main language at home			0·535 (0·103)	<0·0001			1·74 (0·399)	<0·0001
Parental support			0·081 (0·016)	<0·0001			0·288 (0·061)	<0·0001
Classroom glazing			0·018 (0·036)	0·6226			0·092 (0·149)	0·5349
Random parameters (↓)								
Level 2: school	0·075 (0·025)		0·032 (0·018)		1·31 (0·406)		0·729 (0·293)	
Level 1: pupil	1·66 (0·054)		1·57 (0·051)		23·98 (0·783)		22·61 (0·738)	

Table 4: Multilevel models for road traffic noise and cued recall

	β (SE)	95% CI	p
Reading comprehension (n=2010)			
Model 1	0·003 (0·004)	–0·005 to 0·012	
Model 2	0·002 (0·004)	–0·005 to 0·009	0·5417
Recognition (n=1998)			
Model 1	0·006 (0·010)	–0·014 to 0·026	
Model 2	0·005 (0·009)	–0·013 to 0·023	0·6240
Prospective memory* (n=1958)			
Model 1	0·007 (0·012)	–0·017 to 0·031	
Model 2	0·007 (0·012)	–0·017 to 0·031	0·1360
Working memory (n=1938)			
Model 1	0·033 (0·027)	–0·020 to 0·087	
Model 2	0·030 (0·027)	–0·023 to 0·083	0·2742
Sustained attention (n=1938)			
Model 1	–0·020 (0·143)	–0·300 to 0·261	
Model 2	–0·046 (0·144)	–0·328 to 0·237	0·7499
Mental health (n=2014)			
Model 1	–0·012 (0·017)	–0·045 to 0·023	
Model 2	–0·018 (0·016)	–0·049 to 0·013	0·2747
Self–reported health (n=1970)			
Model 1	0·005 (0·003)	–0·001 to 0·011	
Model 2	0·005 (0·003)	–0·0004 to 0·010	0·0725
Noise annoyance (n=1969)			
Model 1	0·017 (0·004)	0·009 to 0·025	
Model 2†	0·016 (0·004)	0·008 to 0·024	0·0047

*Binomial multilevel modelling done; β therefore indicates success or failure on task.
†Adjusted for country, age, sex, socioeconomic status, mother's education, length of enrolment at school, classroom glazing, ethnic origin

Table 5: Cognitive and health outcomes and exposure to road traffic noise

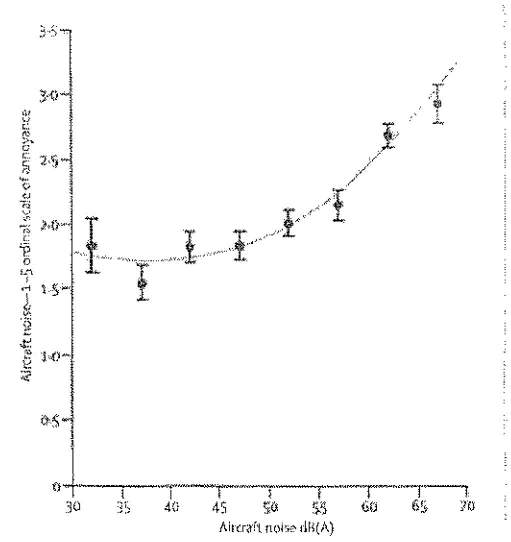

Figure 2: Adjusted mean annoyance (95% CI) for 5 dB bands of aircraft noise (adjusted for age, sex, and country) and fitted curve*
*Fractional polynomial curve fitted to continuous aircraft noise of form $-0{\cdot}188X^2+0{\cdot}107X^2*\log(x)$ (where x=aircraft noise/10).

between countries (p=0·9 for information recall, p=0·7 for conceptual recall) and were consistent in the direction of the association with exposure to road traffic noise. There was no significant departure from linearity for information recall or conceptual recall (p=0·67 and p=0·99 for comparison of straight line fit with the best fitting fractional polynomial curve, respectively). These effects were stronger for children from crowded homes than for those whose homes were not crowded (interaction p=0·01 for both information and conceptual recall). We noted no effects of road traffic noise on reading comprehension, recognition, working memory, prospective memory, and sustained attention (table 5).

With respect to health effects, increasing exposure to both aircraft noise and road traffic noise was associated with increasing annoyance responses in children. This finding was maintained after full adjustment (table 2 and table 5). Figure 2 shows annoyance from aircraft noise by 5 dB bands adjusted for age, sex, and country. The best fitting fractional polynomial curve was non-linear and showed a steeper dose-response gradient at higher levels of aircraft noise (p=0·018, test for departure from straight line fit).

There was a linear association between road traffic noise and annoyance adjusted for age, sex, and country (p=0·11 for comparison of straight line fit with best fitting fractional polynomial curve). We noted no effects of either aircraft noise or road traffic noise on self-reported health or mental health.

Discussion

Our findings indicate a linear exposure-effect association between exposure to aircraft noise and impaired reading comprehension and recognition memory in children, and between exposure to road traffic noise and increased functioning of episodic memory, in terms of information and conceptual recall. Our results also show non-linear and linear exposure-response associations between aircraft and road traffic noise, respectively, and annoyance. Neither aircraft noise nor road traffic noise affected sustained attention, self-reported health, or mental health.

By comparison with previous studies,[20–23] our results are robust because we used data from three countries with different sociodemographic profiles, our questionnaire response rates were high, we made careful and detailed noise assessments and measured the effect of confounding factors, we adjusted for acute noise exposure, and we used standardised outcome measures. Results for aircraft noise and reading comprehension across the three countries were largely similar—ie, we noted cross-cultural replication of findings. The advantage of multilevel modelling is that it can also adjust for variance in cognitive function between schools and between countries. The limitations of our study are: that it was cross-sectional rather than longitudinal; we studied a small age range; we focused largely on exposure to noise in schools, though noise at home might also affect health outcomes; and we used different noise assessment techniques in the three countries. However, using the pooled sample, we were able to combine exposure sites with different associations between noise exposure and socioeconomic position and thus adjust, to some extent, and more so than in previous studies,[10,11,21] for socioeconomic status as a potential confounding factor. Contrary to previous work done in the UK,[40] socioeconomic status did not explain the association between noise and cognitive function in children.

An effect of aircraft noise on reading is consistent with previous findings.[21-25] Exposure to aircraft noise has been related to impairments of children's cognition in terms of reading comprehension, long-term memory, and motivation.[21-26] Tasks that involve central processing and language comprehension, such as reading, attention, problem solving, and memory seem most affected by exposure to noise. With a few exceptions,[20,27] most studies have compared groups exposed to high levels and low levels of noise, and have not examined exposure-effect relations. Moreover, most studies in children have focused on aircraft noise rather than road traffic noise. These exposure-effect associations, in combination with results from earlier studies,[21-25] suggest a causal effect of exposure to aircraft noise on children's reading comprehension. This effect is significant though small in magnitude, but does show a linear exposure-effect relation. In practical terms, aircraft noise might have only a small effect on the development of reading, but the effect of long-term exposure remains unknown.

Aircraft noise, because of its intensity, the location of the source, and its variability and unpredictability, is likely to have a greater effect on children's reading than road traffic noise, which might be of a more constant intensity.[18,28] In adults, sound that shows appreciable variation over time (changing state) impairs cognitive function whereas sound that does not vary (steady state) has little effect.[29,30] The noise of aircraft flyovers has an unpredictable rise time that might attract attention and distract children from learning tasks.

This notion does not explain why exposure to road traffic noise was related to improved episodic memory scores. Road traffic noise is unlikely to increase arousal sufficiently to improve performance on the memory tasks we used, which are difficult and might be impaired by increased arousal. Another explanation is confounding, but the only significant interaction between road traffic noise, sociodemographic status, and episodic memory was for crowding, in which the effects were stronger for those from crowded households. This unexplained finding needs further study. The absence of an association between road traffic noise and reading is inconsistent with previous studies, but the highest noise levels we recorded were 71 dB LAeq, which is lower than in previous work.[11]

Noise exposure is associated with annoyance and impairment of quality of life in children. This association is stronger for aircraft than for road traffic noise, as in adults. We noted no association between aircraft or road traffic noise and self-reported health or mental health, though other studies have shown effects of aircraft noise on blood pressure.[36,37]

Further research is needed to understand the psychological mechanisms of these cognitive effects. Children might adapt to noise interference during activities by filtering out the unwanted noise stimuli. This tuning out strategy might overgeneralise to situations where noise is not present, such that children tune out stimuli indiscriminately.[21,31] This tuning out response is supported by the findings that children exposed to noise have deficits in attention, auditory discrimination,[32] and speech perception.[6] However, our findings indicate that sustained attention is not impaired by aircraft noise, and others[33,34] have shown that noise impairs both attention and recall[33,34] without attention mediating the effect on cued recall. Teacher frustration and interruptions in communication between teachers and children could also be a mechanism for cognitive effects.[35] Similarly, learned helplessness has been proposed as a mechanism to account for deficits in motivation in children exposed to noise.[36]

The effects of exposure to noise at home, as well as at school, the interaction with classroom acoustics, the potential protective effect of classroom insulation against noise, and what children and teachers can do to overcome these effects deserve further inquiry. Our results are relevant to the design and placement of schools in relation to airports, to the formulation of policy on noise and child health, and to a wider consideration of the effect of environmental stressors on children's cognitive development. Greater specification of exposure-effect relations is an important step in confirming a causal role for exposure to environmental noise in impairments of children's cognition.

Contributors

S A Stansfeld, M M Haines, J Head, and B Berglund formulated the study design and interpreted the results. S A Stansfeld wrote the original draft of the manuscript. C Clark did the analyses, interpreted the results, and commented on the manuscript. J Head advised on analyses. B F Berry designed the noise measurements and interpreted noise effects. S Hygge helped on the choice of instruments and interpretation of the cognitive effects; I Lopez-Barrio, P Fischer, and I van Kamp led on data collection in Spain and the Netherlands, and commented on drafts and interpreted results. E Öhrström commented on the instruments, on drafts, and interpreted results.

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Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

We thank all of the pupils, parents, and teachers who participated.

The RANCH study was funded by the European Community (QLRT-2000-00197) in the Vth framework programme under Key Action 1999: /C 361/06 Quality of life and management of living resources. In the UK, cofunding was provided by the Department of Environment, Food and Rural Affairs. In the Netherlands, cofunding was provided by the Dutch Ministry of Public Health, Welfare and Sports, Dutch Ministry of Spatial Planning, Housing and Environment, and the Dutch Ministry of Transport, Public Works and Water Management. In Sweden, cofunding was provided by the Swedish Foundation for International Cooperation in Research and Higher Education.

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A follow-up study of effects of chronic aircraft noise exposure on child stress responses and cognition

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Abstract

Background Children are a high-risk group vulnerable to the effects of chronic aircraft noise exposure. This study examines the effects of aircraft noise exposure on children's health and cognition around London Heathrow airport and tests sustained attention as an underlying mechanism of effects of noise on reading and examines the way children adapt to continued exposure to aircraft noise.

Methods In this repeated measures epidemiological field study, the cognitive performance and health of 275 children aged 8–11 years attending four schools in high aircraft noise areas (16-h outdoor Leq >66 dBA) was compared with children attending four matched control schools exposed to lower levels of aircraft noise (16-h outdoor Leq <57 dBA). The children first examined at baseline were examined again after a period of one year at follow-up. Health questionnaires and cognitive tests were group administered to the children in the schools.

Results and Conclusions At follow-up chronic aircraft noise exposure was associated with higher levels of annoyance and perceived stress, poorer reading comprehension and sustained attention, measured by standardized scales after adjustment for age, social deprivation and main language spoken. These results do not support the sustained attention hypothesis previously used to account for the effects of noise on cognition in children. The reading and annoyance effects do not habituate over a one-year period and do not provide strong evidence of adaptation.

Keywords Chronic aircraft noise exposure, children, cognition and stress responses, adaptation, repeated measures epidemiological field study

Accepted 11 October 2000

Consistent associations between chronic aircraft noise exposure and impaired cognition and stress responses in children have been found in cross-sectional studies around international airports namely: Los Angeles;[1] Munich;[2,3] New York;[4] and London.[5] Important questions remain unanswered about the long-term effects of persistent aircraft noise exposure, underlying causal mechanisms, and the nature of the noise effects. It is still unknown whether prolonged exposure to aircraft noise results in increasing adverse effects, or whether the effects remain constant, or the effects lessen or disappear. Cohen and colleagues[6] reported a one-year follow up of their baseline sample of school children around Los Angeles Airport[1] but unfortunately due to a low response rate in the noisy schools the within-subjects analyses were difficult to interpret.[6] In this repeated measures study we report follow-up data from the same sample of children first examined at baseline where cross-sectional main effects were found on reading and noise annoyance.[5] By following these children up after a period of a year, child adaptation will be examined to provide a preliminary answer to how children are affected by persistent noise exposure in terms of reading and noise annoyance.

Chronic exposure to environmental noise may be a stressor because it decreases expectancies for control and increases susceptibility to helplessness.[7] However, there is little empirical evidence to support the key assumption of this theory that the children exposed to high levels of environmental noise are, in fact, stressed. Furthermore, understanding of the mechanisms underlying child noise effects is limited. Only three studies[4,5,8] have directly tested the mediating role of a hypothesized factor and no study has tested the attention mediation hypothesis. Aircraft noise has a main direct effect on sustained attention,[9–14] however, it is also possible that sustained attention also acts as a mediating factor between noise exposure and cognitive impairments.

It was hypothesized that the effects of aircraft noise exposure found on reading comprehension and noise annoyance at baseline[5] would be replicated in the same sample of school children who were tested at follow-up one year later. It was also hypothesized that: (1) chronic aircraft noise exposure produces an increased delay in reading comprehension over a period of a year compared to pupils not exposed to aircraft noise during that year and (2) that chronic aircraft noise exposure in children would be associated with impairments in sustained attention and high levels of self-reported stress. Sustained attention was tested as a mediating factor in the association between noise exposure and reading impairment.

Methods

Design

The school performance and health of children attending four schools in a high-aircraft noise-impact urban area (16-h outdoor Leq >66 dBA) were compared with those of children from four matched control schools in low-aircraft noise-impact urban areas (16-h outdoor

Leq <57 dBA) around Heathrow Airport in West London (for full details of design and methods[5]). Children first examined in 1996 were examined again one year later in 1997. The schools were initially chosen such that children were matched across high and low aircraft noise as much by: age; sex; sound level at the school from non-aircraft sources; existing noise protection in the schools; and socioeconomic status and ethnicity of the school's electoral wards. The performance and health measures were group administered in the classrooms.

Participants and response rate

At baseline in 1996, 340 pupils participated. At follow-up the overall child response rate was 81% of the baseline sample across the eight schools. Of the original sample of 340, 10% (n = 35) declined to take part in 1997; 6% (n = 19) had moved; and 3% (n = 11) were away at the time of testing. The response rate did not differ between high- and low-noise exposed children. The follow-up participants were 275 fifth (n = 121) and sixth (n = 154) class pupils (mean age = 10 years and 8 months, 52% girls, 48% boys) of the baseline sample. In all, 148 attended schools exposed to high levels of aircraft noise and 127 attended schools exposed to low levels of aircraft noise. The socio-demographic characteristics of the declining sample and the sample that had moved were not significantly different to the participating sample in terms of sex, race, age and social class.

Stress response and health outcomes measures

Annoyance

Noise annoyance was measured with seven child adapted standard questions.[15] These questions assessed the level of annoyance on a four-point Likert scale (very much, quite a bit, a little, not at all) felt by the child when they heard four sources of environmental noise without a timeframe. The sources of environmental noise were: aircraft noise, train noise, road traffic and neighbours' noise (only at home). Aircraft noise at school was the annoyance item used in the analyses with the higher the score the higher the noise annoyance.

Lewis Child Stress Scale

Child stress was measured with the Lewis child stress scale.[16] The scale consists of 20 stress-provoking circumstances that were generated through interviews with children concerning sources of stress in their lives. The 20 items included situations that would make children feel bad (e.g. not having homework done on time), nervous (e.g. changing schools) or worried (e.g. not getting along with your teacher). The 20 items were repeated in two subscales. The first scale asks the children to rate how bad would they feel if each of the 20 situations happened to them on a five-point scale: 'not bad'–'terrible'. The second scale asks the children to rate how often each of the 20 situations happened to them on a five-point scale: 'never'– 'all the time'. Three scores were used in the analysis: (1) a perceived stress score: an addition of the first scale values, how bad would they feel if an event happened to them, (2) a frequency score: an addition of the second scale values to calculate how often negative life events had occurred, (3) an overall stress score: calculated by individually multiplying each item from the first scale ('how bad they would feel') by the second scale (frequency of occurrence) and summing the total for the 20 items. Normative data from 2480 fifth grade American students found high internal consistency ($\alpha = 0.82$).[16]

Depression

Depression was measured with the short version of the Child Depression Inventory (CDI,[17] modified for an English sample[18]).

Anxiety

Anxiety was measured with the Revised Child Manifest Anxiety Scale (CMAS).[19]

Cognition and performance outcome measures

Reading comprehension

Reading comprehension was measured using the UK standardized Suffolk Reading Scale[20] Level 2.

Sustained attention

This was measured with the Score task taken from Tests of Everyday Attention for Children (TEA-Ch) battery of measures for the assessment of attention in children (version A[21]). In this task the children are asked to imagine that they are keeping score by counting the scoring sounds in a computer game. This test measures ability to count tones with irregular inter-stimulus intervals. The test has good construct validity and test-retest reliability (76.2%) after 6–15 days re-administration.[21] There are 10 trials each scored for correct number of items counted.

Measurement of confounding factors

The household deprivation score was calculated on a scale adapted from Townsend's Scale[22] by incorporating income, crowding, home ownership and unemployment in a single scale (these data were collected from parents). The number of indicators of household deprivation reported out of these four indices were summed and a total deprivation score calculated.[22] Household deprivation was preferred as a confounding factor because social class was not considered to be a satisfactory indicator of social disadvantage.[23] Main language spoken at home was collected from the children, parents and school. Age was collected from school records and the parents.

Procedures

Testing at the schools was conducted the same way as baseline (for full procedural details[5]). The group administered testing was conducted on three days each a week apart, counterbalanced for questionnaire order and time of day across noise exposure in the classrooms. Measurements at individual schools were carried out inside classrooms to assess indoor sound levels of aircraft noise during testing using a sound level meter mounted on a tripod and a portable DAT recorder.

Statistical analysis

Three potential confounding factors were adjusted for in the analyses namely: age, main language spoken at home and household deprivation. Main language spoken at home was reported by parents and children and is a variable with two levels: English and non-English. Analyses of covariance (ANCOVA) adjusting for baseline performance were used to assess the noise-effects over time. The within-subjects unadjusted model adjusts for baseline performance only and the fully adjusted model also adjusts for age, main language spoken at home and household deprivation. A procedural error occurred earlier at baseline, when one control school did not supply a representative sample class but a class of lower ability (for full discussion[5]). Therefore, the results will be presented on all eight schools and on the seven schools excluding the school with the biased sample selection for the significant main effects in the result section text with means, F-test statistics and P-values. All statistical tests are two tailed and the alpha value was set at 0.05.

Results

Descriptive results

The high- and low-noise follow-up sample were well matched across noise levels for class at school and sex (Table 1). The high noise school sample had a higher proportion of non-white pupils and pupils with languages other than English as the main language spoken at home than the low-noise sample. The high-noise sample also had a slightly higher proportion of pupils from manual social class households indicated by the registrar general's classification and pupils from deprived households than the low noise sample (Table 1).

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Table 1 The socio-demographic characteristics of the high- and low-noise child follow-up samples: frequencies and proportions, continuity correction x^2 P-value

Cross-sectional effects at follow-up: stress responses and cognitive performance

All results presented have been adjusted for age, deprivation and main language spoken (Table 2).

View this table:

Table 2 Stress response and cognitive mean scores, difference score at follow-up fully adjusted for age, deprivation and main language spoken [in this window] [in a new window] in the four high-noise schools and the three low-noise schools (excluding the procedural error school)

Annoyance

Chronic exposure to high levels of aircraft noise was associated with higher levels of annoyance in the analyses of the eight schools (high-noise [HN] mean = 1.00, low-noise [LN] mean = 0.58, $F(1,206) = 9.75$, $P = 0.002$) and the seven schools (LN mean = 0.56, $F(1,188) = 8.8$, $P = 0.003$) (Table 2+).

Self-reported stress

Chronic exposure to aircraft noise was associated with higher levels of perceived stress in the analyses of the eight schools (HN mean = 3.5, LN mean = 3.22, $F(1,185) = 9.57$, $P = 0.002$) and in the seven schools (LN mean = 3.19, $F(1,168) = 10.2$, $P = 0.002$, Table 2+). Chronic exposure to aircraft noise was not associated with the prevalence of stressful life events nor with the total stress score (Table 2+).

Anxiety and depression

The two groups did not significantly differ in mean scores of anxiety and depression (Table 2+), nor was aircraft noise exposure related to higher prevalence of depressive and anxiety symptoms as measured by scores above the clinically relevant cut-off points of the CDI and CMAS, respectively.

Reading comprehension

Chronic exposure to aircraft noise had no significant effect on reading comprehension in the analyses of the eight schools. However, in the seven schools, children in the four high-noise exposed schools had poorer reading comprehension than children in the three low-noise schools (HN mean = 100.63, LN mean = 105.21, $F(1,178) = 5.00$, $P = 0.027$, Table 2+).

Sustained attention

Chronic exposure to high levels of aircraft noise was associated with poorer sustained attention in the eight schools (HN mean = 8.44, LN mean = 9.01, $F(1,201) = 8.01$, $P = 0.005$) and in the seven schools (LN mean = 8.91, $F(1,183) = 4.16$, $P = 0.04$, Table 2+).

Within-subjects analyses—the effects of noise over time

Reading comprehension

After adjusting for baseline performance, performance at follow-up was significantly different between the high-noise and low-noise children in the eight (HN mean = 100.1, LN mean = 101.9, $F(1,225) = 4.57$, $P = 0.03$, Table 3+) and seven schools (HN mean = 101.1, LN mean = 103.0, $F(1,204) = 4.8$, $P = 0.03$, Table 3+). However, after further adjustments are made for age, main language spoken and deprivation, the difference in reading comprehension in both the seven and eight schools fails to reach significance (Table 3+).

The inability to find a significant effect after full adjustment might be due to a reduction in statistical power, because of a drop in sample size. Analyses were conducted in reduced samples with scores taken out for children with missing values for both deprivation and main language spoken. The within-subjects reading analysis was conducted in these samples and the results were: reduced sample for main language spoken (difference score = 1.6, $F(1,193) = 3.41$, $P = 0.06$) and the reduced sample for deprivation (difference score = 1.4, $F(1,173) = 2.48$, $P = 0.12$). In the reduced samples the main effect found in the full sample (difference score = 1.9) is of similar magnitude but is no longer significant.

View this table: [in this window] [in a new window] Table 3 Difference score from the within-subjects ANCOVA models (1) adjusting for baseline performance on follow-up reading comprehension and noise annoyance performance and (2) fully adjusted for age, main language spoken and deprivation in the eight and seven schools (excluding the procedural error school)

Noise annoyance

In the analyses of the eight schools after adjusting for baseline noise annoyance, noise annoyance at follow-up was significantly different between the high-noise and low-noise children (HN mean = 0.93, LN mean = 0.67, $F(1,245) = 5.42$, $P = 0.02$, Table 3•). This did not remain significant after further adjustment was made for age, deprivation and main language spoken (Table 3•). There was no significant effect in the seven schools (Table 3•).

Testing the sustained attention hypothesis

To test this hypothesis, sustained attention score was entered as a covariate in an ANCOVA model (independent variable—school noise level: high or low, dependent variable—reading comprehension score). Sustained attention did not explain the significant association between aircraft noise exposure at school and reading comprehension. This is indicated by the fact that the significance level of the main reading effect in the seven schools was not altered by the adjustment for sustained attention ($F(1,203) = 8.51$, $P = 0.004$).

Noise exposure

At follow-up measurements were taken at individual schools to assess indoor sound levels of aircraft noise during testing. Acute levels of aircraft noise at the time of testing were measured in single event noise exposure levels (SEL dBA). The SEL is defined as the total sound energy of an event expressed as a one-second equivalent and is a measure of sound energy which allows for the direct comparison of sound events of differing duration. Acute aircraft noise was only present at the testing of one high noise school over the two testing sessions. School 4 had a mean of 65.7 SEL dBA with 3 aircraft events on day 1 of testing and a mean 64.2 SEL dBA with 41 events on day 2. This indicates that there was very little difference between high and low chronic aircraft noise exposed schools in terms of acute aircraft noise exposure during testing. This is in contrast to the high level of acute interference reported in the high noise schools at baseline.[5]

Discussion

There were five main findings in this study. First, the associations between chronic aircraft noise exposure and reading comprehension, noise annoyance and mental health were replicated at follow-up. Second, the within-subjects analyses indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure. Noise annoyance remained constant over a year with no strong evidence of habituation. The effect of aircraft noise on children's progress in reading over time may be influenced by socio-demographic factors. Third, the association between aircraft noise exposure and reading comprehension could not be accounted for by the sustained attention mediation hypothesis. Fourth, chronic aircraft noise exposure was associated with poorer sustained attention in children. Fifth, chronic aircraft noise exposure was associated with higher levels of self-reported perceived stress in children. These results provide evidence that aircraft noise adversely affects the performance and health of school children and that these effects do not habituate over time.

Adaptation

After adjustment for baseline reading performance a significant noise effect on reading remained at follow-up indicating that further noise exposure over time was associated with an increase in the size of the difference in reading impairments in the high noise exposed group compared with the control sample. However, the within-subjects reading result was not conclusive because socioeconomic factors may influence reading comprehension. After statistical adjustment was made for deprivation and main language spoken at home on the association between noise and reading progress, the size of the effect was reduced and became non-significant. The results of the analyses in the reduced samples suggest that regardless of whether main language spoken or deprivation were, or were not, confounding factors, the sample size was reduced to such an extent that when adjustments were made for language and deprivation the 'noise effect' would be lost. Therefore, it must be concluded that it is still possible that socioeconomic factors may have confounded the relationship because there were insufficient socio-demographic data to test this reliably.

The Los Angeles Study and the present study are limited because the impact of previous experience of exposure to aircraft noise is unknown and a self-selected high-noise sample cannot be ruled out. In the case of this study, it is possible that children with poorer performance tended to remain in the high-noise exposed areas because their parents were less socially advantaged, hence less mobile. If the effects of social disadvantage on reading comprehension were partly mediated through noise exposure, statistically adjusting for social deprivation may constitute an over adjustment. The issue of long-term habituation to environmental stressors has only started to be addressed, and further repeated measures longitudinal research is still required to address these problems.

Sustained attention mediation hypothesis

The results of this study do not support the sustained attention mediation hypothesis because adjustment for sustained attention did not influence the significant association between aircraft noise at school and reading comprehension. Attentional processes have been hypothesized as mediators in noise-related memory impairments more than reading effects. Adult noise studies on memory have been interpreted as indicative of attention narrowing or focusing on dominant stimuli.[24] Greater attention to more central cues could lead to poorer encoding of more peripheral material when greater processing demands are placed on memory than would be expected on a reading task. So it is possible that specific cognitive mechanisms may only apply to specific noise effects on child cognition. Further research should test and refine the other theories to account for these reading effects, especially testing psycholinguistic mechanisms where there is preliminary evidence of mediation by impairment of speech perception[4] and auditory discrimination.[8] Better understanding of the mechanisms by which noise impairs reading may allow for more effective counter measures to the effects of noise.

Annoyance

The annoyance response remained constant over time and there was little evidence that the effect increases over time. The long-term health consequences of chronic annoyance are unknown. This finding that noise annoyance, a stress response, remains persistent is in potential contradiction to the conclusions from the follow-up study around Los Angeles [6] where the data were interpreted to indicate some habituation of physiological stress response. It is indeed possible that the annoyance response may be affected by chronic noise in a different way than a physiological stress response. It is also possible that response style related to coping with environmental stress influences reports of annoyance, more than physiological responses. Future longitudinal research should measure both noise annoyance and physiological stress responses to examine habituation or potentiation as well as the interaction between self-reported stress and biological stress markers. Adaptive behaviours may reduce the immediate stress response in the form of physiological adaptation, but the coping process itself may have adverse health effects that might be measured through self-reported stress.[25]

Perceived stress

Children chronically exposed to high levels of aircraft noise had higher levels of perceived stress even after adjustment for age, deprivation and main language spoken indicating that the high noise children reported they would have felt more stressed than the control children if these stressful life events were to occur in their lives. Interestingly, the children across the two groups did not differ in terms of reporting actual stressful events. This suggests some specificity of effect in relation to perceived stress and that children did not answer according to a trait of general negative affectivity. It is possible that this perceived stress scale also partly measures perceived coping ability or worrying and high scores predict sensitivity to stress.

Our results show for the first time that children chronically exposed to aircraft noise do have higher levels of self-reported stress, which complements the previous psychophysiological stress data (catecholamine secretion and raised blood pressure).[1-3] This result is important because it lends support to the underlying assumption that chronic exposure to aircraft noise is subjectively stressful. This self-reported stress response needs to be refined by further measures, to ascertain what these children are stressed about—is it their environment? Consistent with the baseline results,[5] levels of depression and anxiety did not differ between the two samples. These affective results taken together suggest that chronic exposure to aircraft noise produces annoyance and general stress responses rather than sub-clinical mental health problems such as depression or anxiety.

Conclusions

The results of this repeated measures study are not conclusive. Nevertheless, they provide stronger evidence than previous studies to suggest that noise exposure affects child cognition and stress responses and that these effects do not habituate over a one-year period. The fact that the main reading effect remained constant between baseline and follow-up, despite marked variation in the acute noise interference at testing, provides further evidence that the cognitive impairments are due to chronic exposure rather an acute interference at the time of testing. These results do not support the sustained attention hypothesis previously used to account for the effects of noise on cognition in children. The within-subjects analyses indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure. Noise annoyance remains constant over a year with no strong evidence of habituation. Further research should look at the long-term implications of these effects and examine further underlying mechanisms.

KEY MESSAGES

- this repeated measures epidemiological field study examines the effects of aircraft noise exposure on primary school children's health and cognition around London Heathrow airport.
- chronic exposure to aircraft noise was associated with impairments in reading and attention and raised annoyance and perceived stress.
- the results provide evidence that aircraft noise adversely affects the performance and health of school children and that these effects do not habituate over time.

Acknowledgments

A sincere thank-you to the children, parents and teachers from the eight schools. We thank Val Beale, Jane Boyd, Robert Gibson, and Patrick Shortt for help in data collection and noise measurement; Sarah Brentnall and Maria Luz Herrero for coding. We also acknowledge the generous support of Professor Staffan Hygge, Colin Cobbing and Terry Gould. This research was funded by a consortium of local authorities and health agencies around Heathrow Airport. We thank them for their support.

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Aircraft noise exposure and resident's stress and hypertension: A public health perspective for airport environmental management

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Available online 25 May 2007.

Abstract

Noise management regulations and policies at commercial airports are reviewed. A cross-sectional study of environmental noise and community health based, on the SF-36, was conducted in residential neighborhoods near Sydney Airport with high exposure to aircraft noise and in a matched control suburb unaffected by aircraft noise. Noise measurements were analysed and a novel noise metric formulated based on background environmental noise levels. After controlling for confounders, subjects who have been chronically exposed to high aircraft noise level are more likely to report stress and hypertension compared with those not exposed to aircraft noise. Policy implications and further research are described.

Environment and Behavior, Vol. 30, No. 1, 101-113 (1998)
DOI: 10.1177/0013916598301005

Aircraft Noise

A Potential Health Hazard

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A questionnaire distributed to two groups, one living within the flight pattern of a major airport and the other in a nonflight area, sought to determine whether these groups would respond differently to questions pertaining to noise, health perception, and quality of life issues. Nearly 70% of the residents living within the flight corridors reported themselves bothered by aircraft noise. Aircraft noise, in contrast to other bothersome noises, interfered more frequently with daily activities. Subjects who were bothered by aircraft noise were more likely to complain of sleep difficulties and more likely to perceive themselves to be in poorer health. The study's finding of a possible relationship between noise and adverse health effects might encourage policy makers to enact pending antinoise legislation and to fund further noise research.

Kids near airports don't read as well because they tune out speech, Cornell study finds

FOR RELEASE: April 28, 1997

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ITHACA, N.Y. -- Children in schools bombarded by frequent aircraft noise don't learn to read as well as children in quiet schools, Cornell University researchers have confirmed. And they have discovered one major reason: kids tune out speech in the racket.

"We've known for a long time that chronic noise is having a devastating effect on the academic performance of children in noisy homes and schools," says Gary Evans, an international expert on environmental stress, such as noise, crowding and air pollution. "This study shows that children don't tune out sound per se, rather they have difficulty acquiring speech recognition skills."

Evans and his collaborator, Lorraine Maxwell, both environmental psychologists, are in the Department of Design and Environmental Analysis in the College of Human Ecology at Cornell.

Evans and Maxwell compared children in a noisy school (in the flight path of a New York international airport) with similar children in a quiet school. Unlike in other studies, both groups of children were tested in quiet conditions. By doing so, the researchers showed that the link between chronic noise and reading scores is the chronic noise exposure -- not noisy episodes that might have occurred during the testing sessions.

Evans and Maxwell, whose study will be published in Environment and Behavior later this year, compared a total of 116 first and second graders from two elementary schools. One school was battered by peaks of up to 90 decibels of noise every 6.6 minutes by low-flying planes passing overhead. The other school, closely matched for ethnicity and percentage of children receiving subsidized school lunches and speaking English as a second language, was in the same urban area but in a quiet neighborhood. Only children for whom English was their first language were included in the study.

Each child was first given an auditory screening test. They were subsequently tested for abilities to read, distinguish words with background noise, distinguish sounds with background noise and distinguish word sounds (phonemes) under quiet conditions. The tests, with the exception of the initial auditory test, were conducted by Elissa Tolle and Pegauy Santil, 1996 Cornell graduates in human ecology, who were both seniors at the time. When the data were analyzed, the researchers controlled for mother's education.

"Interestingly, the findings were only significant for speech perception amidst noise, not sound perception" says Maxwell. "This implies that language acquisition is an underlying, intervening mechanism that accounts for some of the noise-reading deficit link."

Evans and Maxwell also suspect that other factors may be at work in noisy schools and neighborhoods, such as teacher and parent irritability and their reluctance to talk as much, use as many complete sentences and read aloud as often as other teachers and parents.

Both researchers stress the need to reestablish an office of noise abatement within the Environmental Protection Agency; such an office was abolished during the Reagan administration. They point to other health concerns related to chronic noise, including hearing damage, chronic cardiovascular activation, elevated annoyance and irritation, motivation problems such as learned helplessness, and impaired cognitive development and reading achievement.

"These effects have all been well documented," says Evans. "Unfortunately, we're experiencing exponential increases in worldwide, ambient noise levels that are a byproduct of economic development, particularly prevalent among economically underdeveloped countries."

The research was supported by the Cornell College of Human Ecology and the National Heart, Lung and Blood Institute and the U.S. Department of Agriculture.

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Physiological, Motivational, and Cognitive Effects of Aircraft Noise on Children: Moving From the Laboratory to the Field. *American Psychologist*, Vol. 35, March 1980, pp. 231-243 Sheldon Cohen, Gary W. Evans*, David S. Krantz, and Daniel Stokols*
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Noise pollution has been primarily linked to a loss of hearing. Recent studies, however, have suggested a link between noise and physiological processes associated with stress. These processes, including elevated blood pressure and levels of stress hormones, are considered a health hazard. Further, it was suggested that children, the sick, and the elderly are the most susceptible to noise impact, because they lack the ability to develop a coping mechanism. An inability to cope with stress can lead to increased feelings of helplessness that, by themselves, can lead to illness. The authors decided to test this hypothesis by examining the effects of aircraft noise on school children in Los Angeles.

Children were selected from the four noisiest elementary schools in the air corridor of Los Angeles International Airport. Peak noise levels reached 95 decibels (dBA), on the A scale, with one flight every 2.5 minutes. As a control group, children were also selected from three schools in quiet neighborhoods with matching socioeconomic status. A total of 262 children, from third and fourth grades, participated in task performance, on two consecutive days for 45 minutes. Children with existing hearing problems were excluded from the study.

Noise levels were measured for one hour in the two neighborhoods. Mean peaks for noisy schools were 74 dBA, as compared to 56 dBA in the quiet ones. This difference is significant because an increase of 10 dBA is considered to be twice the level of noise.

Perception. Both parents and children from the high noise schools perceived higher levels of noise at home, compared to their counterparts from the quiet schools. Further, the level of noise reported by the parents of the noise-school group increased with the length of living at the same residence.

Physiology. Blood pressures were monitored once per day and averaged. The authors noted a significant change in blood pressure between the two groups, with children from the noisy schools exhibited higher blood pressure than the children from the quiet schools.

Motivation. It has been suggested that exposure to high intensity noise can induce feeling of helplessness, which often occur when an individual cannot control or change a stressful event. This feeling, in turn, can decrease motivation to initiate new tasks and to lack of persistence giving-up. Children were administered a success-failure test where both a response to failure and giving-up are considered as indication of helplessness.

Each child was required to solve a puzzle. Half were given an insoluble (failure) puzzle, while the rest received a soluble (success) one. After the allotted time passed, all the children were required to solve a second, soluble puzzle, of moderate difficulty. The percentage of failure to solve either puzzle, as well as giving-up, was higher among the children from the noisy schools, compared to their counterparts from the quiet ones Further, the differences appeared to increase with the duration of school enrollment, for children with longer exposure to aircraft noise.

Cognitive. It has been suggested that children reared in noisy environments become inattentive to sound, by tuning it out. When this inattention includes speech-relevant sound, it may lead to reading problems. It was hypothesized, therefore, that children using such a selective inattention strategy might be less affected by noise distraction. To test this hypothesis, children were given a six-grade level essay, where, within a time limit, they were required to cross out all the e's on the pages. One test was performed while a recorded story, at a moderate voice, was playing. The second test, using a different essay, was conducted under background noise conditions to provide a baseline. A significant difference in the number of e's found was observed between the noise-school and the quiet-school groups, and it was associated with the length of enrollment in school.

During the first two years of enrollment, the children from the noisy schools did better than their quiet-school counterparts. After four years of exposure to noise, however, their performances deteriorated. The authors concluded that ìthis finding suggests that as the length of noise exposure increases, children are more disturbed by auditory distractions. Further, the authors suggested that, at first, the children attempted to cope with noise by tuning it out. Later, however, they gave up when they realized that this strategy did not work behavior consistent with helplessness data.

Last, the authors looked at 20 children from the quietest homes who were part of the noise-school group. This sub-group was more susceptible to the effects of noise, as was determined by their lower performance in several of the tests and their elevated blood pressure. Thus, living in a quiet neighborhood did not lessen the impact of exposure to noise while at school.

This study, concluded the authors, added weight to a possible impact of aircraft noise on psychological adjustment and on nonauditory aspects of health on children.

http://www.eltoroairport.org/issues/lax_noise.htm

Chronic Noise and Psychological Stress

Chronic Noise and Psychological Stress. *Psychological Sciences,* Vol. 6, November 1995, pp. 333-338 Gary W. Evans*, Staffan Hygge, and Monika Bullinger.
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For many years it has been known that adverse environmental conditions affect human health. This study used measurable body functions to demonstrate how noise levels affect elementary school-aged-children.

The study concentrated on 135 third and fourth graders, living either in a high-noise-impact urban neighborhood, surrounding the Munich International Airport, or in a quiet urban neighborhood. The children from both neighborhoods were matched according to their socioeconomic status. The children were tested for two consecutive days, with a test time of 85 minutes each day.

The study focused on psychophysiological cognitive and motivational measures.

Psychophysiological measures included levels of stress hormones -- epinephrine (adrenaline) and norepinephrine, as well as blood pressure. The study showed that both epinephrine and norepinephrine were elevated among the children from the noisy communities. This same group also showed elevated systolic (higher value) blood pressure and lower reactivity systolic blood pressure. These results confirmed the link between chronic exposure to noise and elevation of stress hormones, elevation of resting blood pressure and differential cardiovascular reactivity. The last observation was interpreted by the authors as suggesting that chronic exposure to noise may deplete the coping capacity of the children; rendering them less able to mobilize fight or flight resources needed when faced with immediate dangers. Such deficiencies can directly affect cardiovascular diseases and indirectly affect the immune system.

Cognitive attributes were measured as follows:

Attention was measured by signal-to-noise. Each child listened to a favorite story at his/her preferred volume, with a background noise, including road, traffic and aircraft. At random intervals the storyteller's voice dropped by 10 dBA, and the child readjusted the volume of the story to his/her comfort level. The children from the noisy neighborhood chose a lower signal-to-noise ratio, indicating an accommodation to noisy distractions.

Memory was measured by the ability to recall, the next day, an interesting story read while intermittent bursts of noise were introduced during the reading. The children from the noisy neighborhood performed less accurately than those from the quieter communities.

Reading abilities were measured, using standardized reading tests. The children from noisy communities had larger numbers of errors, compared to the ones from the quieter neighborhoods.

Motivation was measured by the ability of children to solve two puzzles, after reading a text under noisy conditions. The first puzzle was insoluble, while the second one was soluble. The numbers of attempts made to solve the first puzzle before giving up and moving to the second one were recorded. The children from the noisy neighborhoods were less motivated, giving up sooner. The authors interpreted these observations as exhibiting less persistence in task performance when challenged.

Overall conclusions were that cognitive data indicate selective impairment in cognitive functioning among children from noisy communities. That in young children, more complex, higher order skills, such as reading, problem solving, and comprehension of difficult materials, appear vulnerable to adverse environmental conditions. Further, that children may cope with noise by developing cognitive strategies like tuning out noise, which may have consequences for language acquisition and speech processing.

Michael Bond, in the *New Scientist,* V152, Nov. 16,1996, added that while the authors were summarizing their findings, the old airport was closed, and another one was opened. The team concluded that the affected children recovered their deficiencies in memory and reading, two years after the closing of the airport. They also found that children living near the new airport are developing cognitive problems. One of the authors speculated that if the children were exposed to aircraft noise throughout the time they were growing up, the effects might be permanent.

http://www.eltoroairport.org/issues/munich.htm

Science for Environment Policy
DG Environment News Alert Service
European Commission

18 May, 2006

Aircraft Noise Affects Cognitive Performance in Children

European researchers have investigated the effects of exposure to aircraft and road traffic noise on cognitive performance and health in children. The results suggest that exposure to high levels of aircraft noise could impair the development of reading capacity and memory in children. Thus, schools exposed to high levels of aircraft noise are not healthy educational environments.

While the effects of air pollution are well known, less attention has been paid to the effects of environmental noise on health. Noise is a public health issue because it can produce annoyance, reduces environmental quality, and may affect health and cognition. In particular, very little is known about the effects of environmental noise in child health. Children are especially vulnerable because noise could interfere with learning at a critical stage of their development.

Under the EU-funded research project RANCH [1], a team of European researchers has assessed the effects of road traffic and aircraft noise on children's cognitive development and health. Over 2800 children, aged 9-10 years, from 89 primary schools located near three major airports in Europe (Schiphol in the Netherlands, Barajas in Spain, and Heathrow in the UK) participated in the study. The authors evaluated aircraft and road traffic noise levels around the schools using external noise measurements, and compared these levels to the results of cognitive tests and health questionnaires administered in the classroom. They also used a questionnaire to obtain information from parents about their socioeconomic status, education, and the ethnic group.

The results of the study showed that:

- Exposure to aircraft noise impaired reading comprehension and recognition memory. Reading age in children exposed to high levels of aircraft noise was delayed to 2 months in the UK and to 1 month in the Netherlands for a 5 decibel change in noise exposure.
- Neither exposure to road traffic noise nor aircraft noise were found to affect sustained attention, self-reported health, or mental health.
- Long-term exposure to both aircraft and road traffic noise was associated with increased annoyance, which may imply a reduced well-being and quality of life in children.

The authors recommend that further research should be performed on the effects of exposure to noise at home and schools, the interaction with the classroom acoustics, the potential protective effects of classroom insulation against noise, and the measures that can be taken to help teachers and children to overcome noise-related effects.

This study demonstrates that schools exposed to high levels of aircraft noise are not healthy educational environments. The obtained results are relevant for the design and placement of schools in relation to airports, to the formulation of policy on noise and child health, and to a wider consideration of the effect of environmental stressors on children's cognitive development.

Source: Stansfeld S.A. et al.(2005) "Aircraft and road traffic noise and children's cognition and health: a cross-national study", The Lancet, 365(9475): 1942-1949

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Theme(s): Noise, Environment and Health

Additional Information: A recent project by the City of Graz (LIFE00 ENV/A/000240) co-funded by the EU LIFE programme developed and implemented an innovative action plan linking health, noise, mobility and the environment. For more information see the project web site, project summary and layman's report. Another recent LIFE project (LIFE02 ENV/F/000295) is developing a GIS based tool to help municipal authorities take into account all aspects of environmental noise in their town planning. For more information see the project web site and project summary.

[1] The RANCH project (Road Traffic & Aircraft Noise & Children's Cognition & Health) is funded by the European Community (QLRT-2000-00197) in the 5th research framework programme under the specific programme 'Quality of life and management of living resources' For more information see *http://ec.europa.eu/comm/environment/noise/*

ROAD TRAFFIC AND AIRCRAFT NOISE EXPOSURE AND CHILDREN'S COGNITIONAND HEALTH: EXPOSURE-EFFECT RELATIONSHIPS AND COMBINED EFFECTS (RANCH)

Contract N° QLK4-CT-2000-00197
Project type Shared Cost
Project cost € 3.580.893
EC contribution € 2.199.995
Project duration 36 Months
Project start date 01/01/2001

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Executive Summary

Background and Aims

- Research suggests that children may be a high-risk group vulnerable to the effects of noise. Previous studies have found associations between exposure to aircraft noise and children's reading comprehension and long-term memory. Associations have also been found between aircraft noise exposure and annoyance, but evidence of associations with raised blood pressure, mental health and sleep are weaker.

- Most previous studies in children have focussed on aircraft noise rather than road traffic noise and have not examined either exposure-effect relationships or the effects of exposure to more than one source of noise.

- The RANCH project (Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health: Exposure-Effect Relationships and Combined Effects) examined exposure-effect relationships between chronic aircraft noise exposure, chronic road traffic noise exposure and combinations of aircraft noise and road traffic noise exposure and cognitive and health outcomes.

- In addition, the RANCH project has included studies of road traffic noise at home and sleep in Sweden and studies of soundscapes in the UK and Sweden.

Study Design and Methods

Airport Field Studies

- The RANCH project, is the largest cross-sectional study of noise and children's health, examining 9-10 year old children living around three major airports: Schiphol, Amsterdam in the Netherlands, Barajas, Madrid in Spain and London Heathrow in the United Kingdom.

- Cognitive outcomes included reading comprehension, episodic memory, working memory, prospective memory and sustained attention. Health outcomes included noise annoyance, blood pressure, overall mental health and self-reported health. Confounding factors were adjusted for at the school and individual level, across three European countries.

- Children were selected by external aircraft and road traffic noise exposure at school predicted from noise contour maps, modelling and on-site measurements. Schools were selected from a four by four grid of increasing aircraft and road traffic noise exposure. Schools matched for socio-economic position within countries were selected. In the Netherlands one class, and in the UK and Spain two classes were selected from each cell in the grid. No children were excluded from any of the selected classes.

- Standardised paper and pen cognitive tests were developed to measure episodic memory, working memory, prospective memory and sustained attention. For reading comprehension, nationally standardised tests of reading were employed in each country. A children's questionnaire assessed perceptions of noise and annoyance and opportunities for psychological restoration. Parents completed a questionnaire about confounding factors such as socioeconomic position, parental education and ethnicity. Comparable measures were achieved across countries. A sub-sample had their blood pressure measured in the Netherlands and the UK.

- The cognitive tests and questionnaires were group administered, in a fixed order, in the classroom. Written consent was obtained from the children and their parents. Indoor and outdoor noise measurements were made at the schools during testing. Blood pressure measurements were taken during the afternoon.

Sleep & Soundscape Studies

- Epidemiological questionnaire-based studies on the effects of exposure to road traffic noise were carried out on 160 children (9-12 years) and their parents at home in three Swedish residential city areas of varying road traffic noise. Half of the families also completed sleep logs and slept with wrist-actimeters as a measure of sleep quality.

- Children's and adult's 24-hour acoustic soundscapes were mapped by binaural and monaural recordings, at homes and schools, indoors and outdoors. Two psychoacoustical experiments (UK and Sweden) were conducted in which children and adults assessed perceived soundscapes of binaural recordings. The UK study focused on soundscapes dominated by extreme combinations of aircraft and road traffic noise at school, and the Swedish study on soundscapes dominated by road traffic noise at home.

- A psychological test instrument (the Children's Psychological Restoration Scale) was developed in English speaking Swedish children for assessing children's opportunities and abilities for psychological restoration when living in noise contaminated soundscapes. The psychological restoration questionnaire was included in the airport field studies child questionnaire and in the Swedish road traffic noise study.

Results
Airport Field Studies

- 2844 children, from 89 schools around Schiphol, Barajas and Heathrow participated in the study. The data was pooled across the three countries and analysed using multilevel modelling, adjusting for confounding factors at the school and the individual level.

- Aircraft noise exposure was associated in a linear exposure-effect association with reading comprehension, episodic memory and working memory. It was estimated that a 5dB (A) increase in noise was associated with a 2-month impairment in reading age in the UK and a 1-month impairment in reading age in the Netherlands.

- Aircraft noise exposure was not associated with impairment of either prospective memory or sustained attention.

- Road traffic noise exposure was not associated with either reading comprehension, episodic memory, working memory, prospective memory or sustained attention.

- There was a strong non-linear exposure-response relationship between aircraft noise exposure at school and at home and children's annoyance. Annoyance was greater at higher levels of exposure. For road traffic noise at school and annoyance the exposure-response relationship was linear. Reported annoyance was lower for road traffic noise than for aircraft noise.

- The relationship between noise exposure and blood pressure was inconsistent. Aircraft noise exposure at school was not associated with children's blood pressure. Aircraft noise exposure at home was significantly related to systolic blood pressure but not to diastolic blood pressure or heart rate. For road traffic noise, there was an inverse relationship for systolic blood pressure and no association for diastolic blood pressure or heart rate.

- There was no association between aircraft noise or road traffic noise and overall mental health or self-reported health.

- Combined effects and cognition: High road traffic noise exposure reduced the effect of high aircraft noise on reading comprehension. There were no other combined effects of aircraft and road traffic noise exposure on cognitive outcomes.

- Combined effects and annoyance: Children exposed to aircraft noise experienced greater annoyance from aircraft noise when also exposed to road traffic noise and vice versa, children exposed to road traffic noise who are also exposed to aircraft noise report higher annoyance from road traffic.

- Combined effects and health: There was no association between combined noise exposure and overall mental health, self-reported health or blood pressure.

Sleep and Soundscape Studies

- Weak exposure-effect relationships between exposure to road traffic noise and sleep quality and alertness in the morning were found in the Swedish sleep studies. No exposure-effect relationships were found between road traffic noise exposure and difficulties falling asleep and awakenings in children but there was some evidence of daytime sleepiness among children exposed to noise levels above 55 dB $L_{Aeq,\ 24h}$.

- In the soundscape experiments children were able to assess the magnitude and quality of sounds as reliably as adults. Children exposed to high aircraft noise and children from schools with low or no aircraft noise exposure did not differ in their perceptual scaling of soundscapes. This means that children can judge and respond to noise in a consistent manner.

- A health evaluation model for children was developed and tested at a pan-European level. An analysis of this model demonstrated that children's psychological restoration combined with adults' social support may serve as protective factors for reducing children's self-reported annoyance at school and at home as well as reducing their self-reported symptoms and sleep disturbance.

Conclusions

- Similar effects of noise on cognitive performance and health were found across Spain, the Netherlands and the United Kingdom.

- High levels of chronic aircraft noise exposure impair children's reading and their ability to perform complex cognitive tasks.

- Road traffic noise did not show exposure-effect relationships with children's cognition and low levels of road traffic noise would probably not interfere with children's school work. In this study, the highest noise levels for schools were 71 LAeq 16hr dB which is lower than previous studies where cognitive impairments were found, therefore an effect of road traffic noise at high levels cannot be ruled out.

- The results for noise annoyance both confirm previous findings that children experience annoyance and extend knowledge on exposure-effects for aircraft and road traffic noise exposure. This implies an impaired quality of life for children.

- There is no evidence for exposure-effect relationships between noise exposure and children's self-reported health or overall mental health and inconclusive evidence for blood pressure and sleep disturbance.

- Effects of combined exposure to aircraft and road traffic noise were only observed for reading comprehension and annoyance: high levels of road traffic noise moderated the effects of high aircraft noise on reading comprehension; high road traffic noise augmented children's annoyance response to aircraft noise and high aircraft noise augmented children's annoyance response to road traffic noise.

- Opportunities for psychological restoration may potentially protect against adverse reactions to noise and improve children's well-being.

Policy recommendations and future research

- The results of the RANCH project, adding to previous research, provide evidence that aircraft noise exposure impairs child development, education and quality of life. The implications for policy are as follows:

- Since similar effects were found in the RANCH project across Europe, this implies that similar health-based guidelines on daytime aircraft noise limits for children can be applied in European countries.

- In the planning process noise exposure should be considered with other environmental aspects. It is recommended that new schools should not be planned close to existing airports, where noise exposure exceeds the WHO (2000) recommended levels for school playgrounds. It is advised that measures need to be taken to reduce noise in existing schools, where noise exposure is excessive.

- Children exposed to adverse environmental conditions, such as aircraft and road traffic noise should have quiet relaxing areas at or near home for psychological restoration.

- Further research should examine (i) whether sound insulation at school can protect against cognitive impairments related to chronic aircraft noise exposure and (ii) examine the role of classroom acoustics and teacher communication in the causation of noise effects on children's cognitive performance.