Att höra, minnas och lära i bullriga miljöer

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Buller i klassrummet - Trafikbuller

Externt buller från flyg, väg och tåg

- Några studier
- Dos-effekt
- Burden of Disease
- WHO-dokument och riktlinjer
- Kostnader för inlärningsbortfall

Buller i klassrummet - Förvrängd talsignal

- Signal-brus-förhållanden
- Efterklangstid
- Några studier
- Några oväntade resultat

External noise from aircraft, road and rail

Two important field studies

A cross-sectional study

- The RANCH study

A longitudinal study

- The Munich airport noise study

The RANCH study

- Children selected from schools around London Heathrow, Amsterdam Schiphol and Madrid Barajas airports
- Aircraft 30-77 $L_{A_{eq}}$, Road traffic 32-71 $L_{A_{eq}}$
- Children aged 9-10 years, *N* > 2 800
- Tests for working memory, long-term memory, reading comprehension, attention
- Aircraft noise was associated with deficits in reading comprehension and recognition memory

The RANCH study – One basic finding

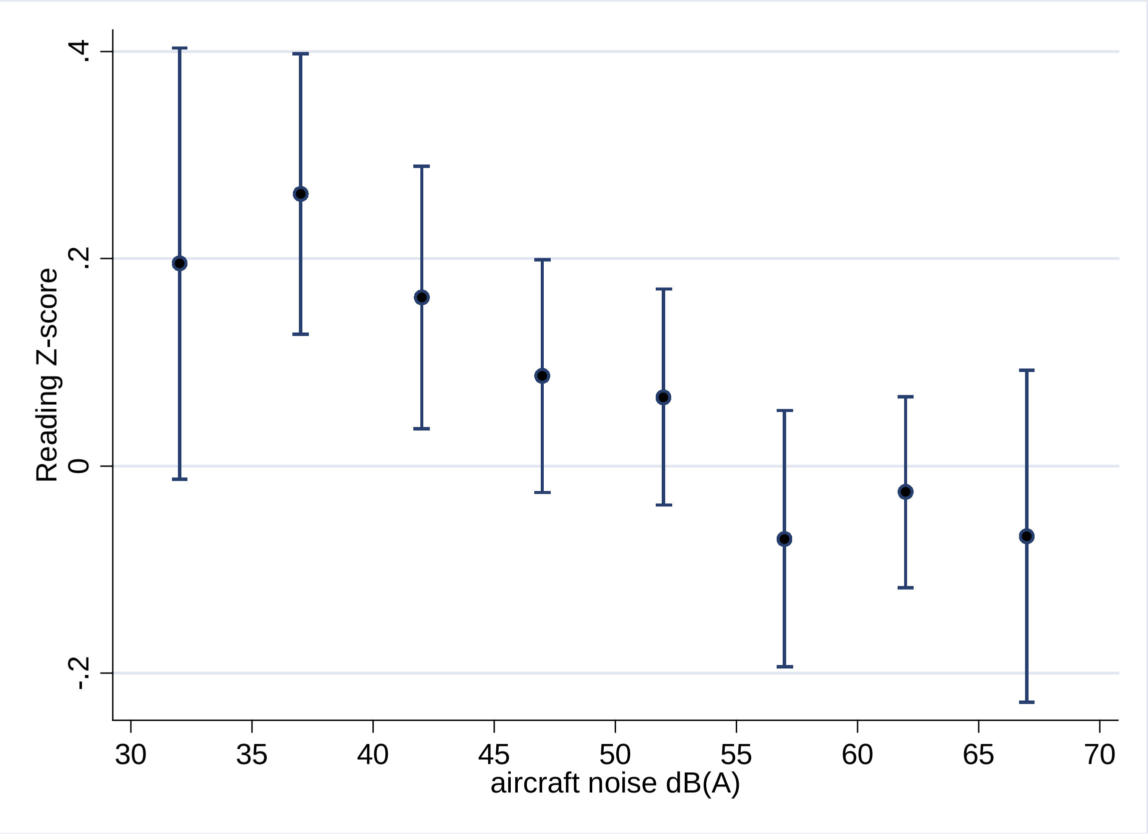


Figure. Adjusted mean reading *Z*- score (95% CI) for 5 dB bands of aircraft noise (adjusted for age, sex, and country)

The Munich Airport Noise Study

- Naturally occurring longitudinal quasi-experiment, airports relocated 1992, $L_{A_{eq}}$ ~54 quiet, 62+ noise
- One measurement before and two after relocation, interval 1 year, children (9–10 years, *N* = 326)
- At the old airport high noise exposure was associated with deficits in long-term memory and reading comprehension, which disappeared after two years
- At the new airport the very same memory and reading comprehension tasks deteriorated over a two-year period in children who became chronically exposed to aircraft noise near the new airport

The Munich Airport Noise Study

Design

Old airport – Noise before

Group	t_o-Before	t_1-After	t_2-After
Experimental group	Noise	Quiet	Quiet
Control group	Quiet	Quiet	Quiet

New airport – Noise after

Group	t_o-Before	t_1-After	t_2-After
Experimental group	Quiet	Noise	Noise
Control group	Quiet	Quiet	Quiet

N ≈ 330

The Munich Airport Noise Study

Table 1. *Noise levels (24-hr dBA L_{eq}) before and after the airport switch*

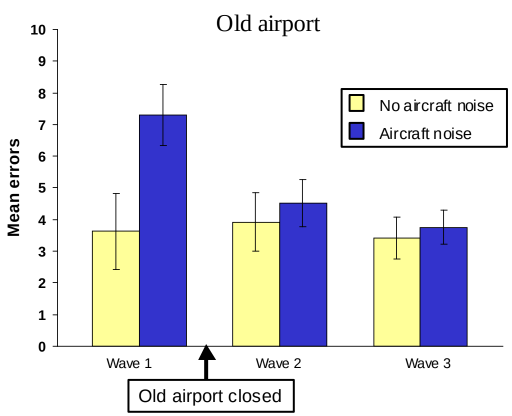
Airport and group	Before switch (Wave 1)	After switch (Wave 3)
Old airport—aircraft noise	68	54[a]
Old airport—no aircraft noise	59	55
New airport—aircraft noise	53	62
New airport—no aircraft noise	53	55

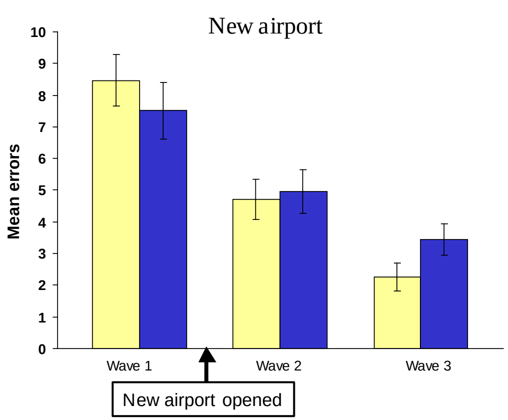
[a]This number is an average from Waves 2 and 3 because there was only one observation in Wave 3, at a suspect value of 49.

The Munich Airport Noise Study

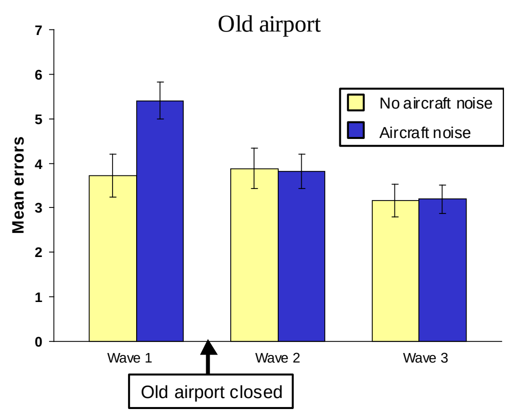
Children's cognition, some results

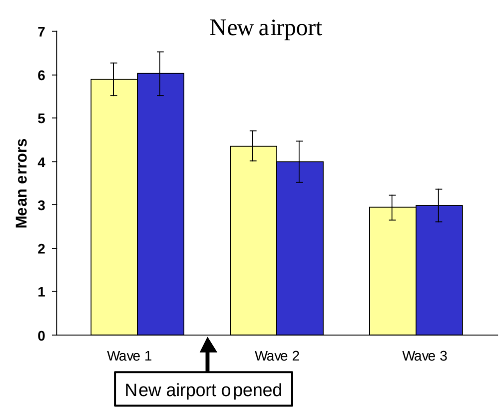
Difficult word list



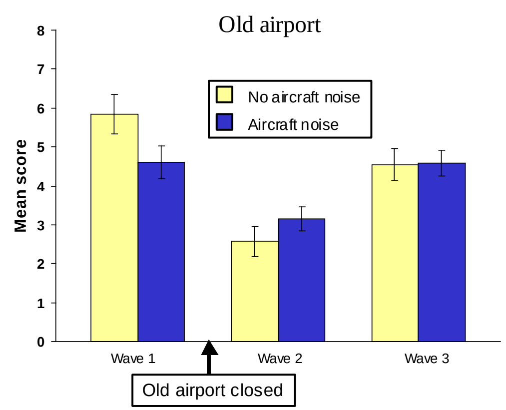


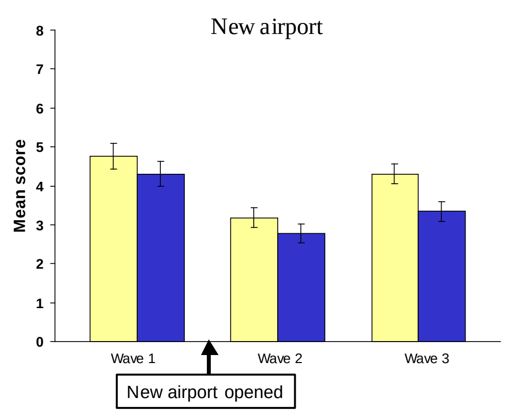
Difficult paragraphs





Long-term recall





Burden of disease (BoD)

Burden of Disease analysis provides a comprehensive and comparable assessment of mortality and loss of health due to diseases, injuries and risk factors for a region. The burden of disease is assessed using the disability-adjusted life year (DALY), a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.

Disability weights examples

A disability weight is a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (equivalent to death). Years Lost due to Disability (YLD) are calculated by multiplying the incident cases by duration and disability weight for the condition

Down syndrome	0.593
Mental retardation	0.459
Acute myocardial infarction	0.439
Multiple sclerosis	0.411
Parkinson disease	0.351
Deafness	0.229
Hearing loss, moderate, untreated	0.120
Hearing loss, moderate, treated	0.040
Migraine	0.029

Disability-Adjusted Life Years (DALYs) Lost

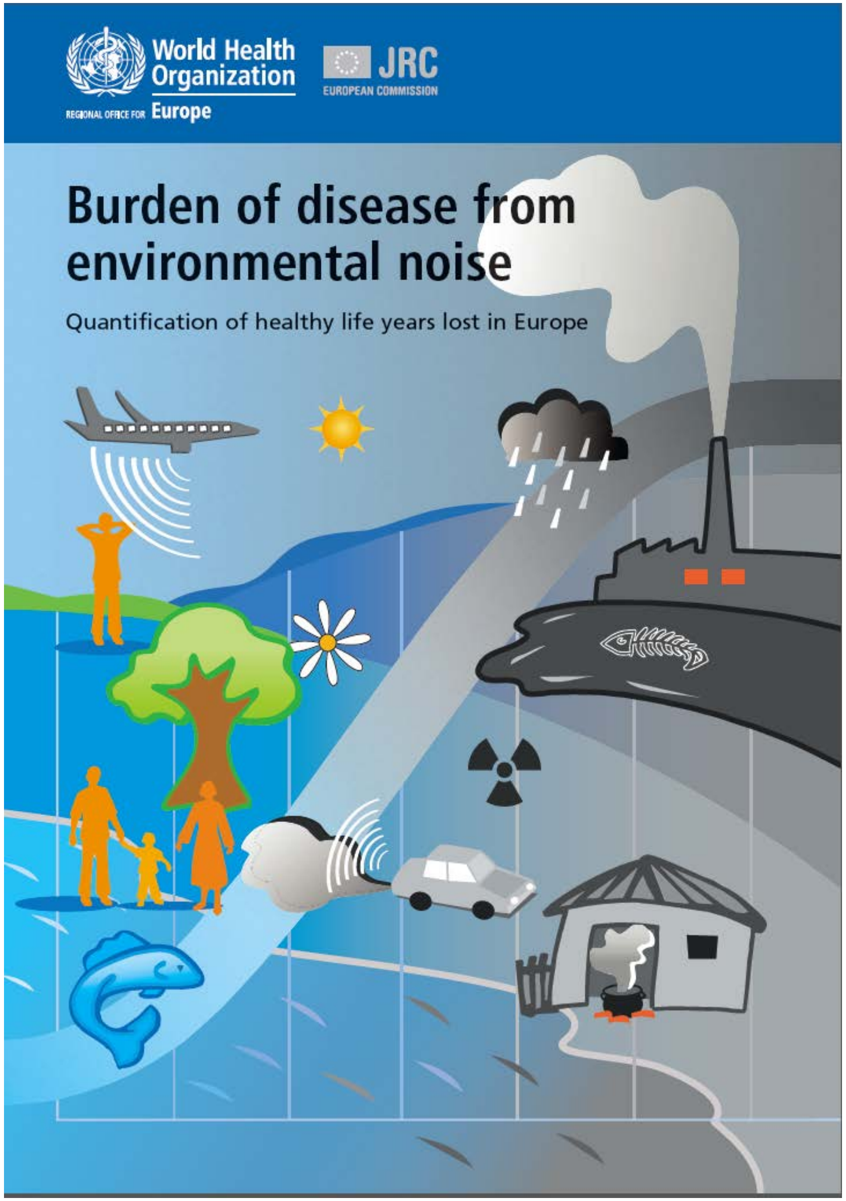
DALYs are the sum of the potential years of life lost due to premature death and the equivalent years of "healthy" life lost by virtue of being in states of poor health or disability.

Note. Years of life lost varies with average life length in different countries.

DALYs lost from noise exposure are calculated from:

- Noise exposure data
- Estimated attributable fraction due to noise
- Disability weights

WHO, 2011

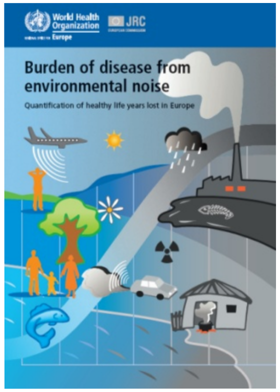


http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf

Summary BoD

Environmental Noise Burden Of Disease

Disability Adjusted Life Years (Western Europe, Major Agglomerations)



WHO 2011

Every year in the EU cities, at least:

- 61 000 DALYs for ischaemic heart disease
- 45 000 DALYs for cognitive impairment
- 903 000 DALYs for sleep disturbance
- 22 000 DALYs for tinnitus
- 654 000 DALYs for annoyance

1~1.6 million healthy life years are lost every year from traffic noise in the EU cities.

Sleep disturbance and annoyance related to road traffic noise comprise the main burden.

Computational example: Sweden

1. Only children aged 7-19 years
2. DW = .006 (very conservative)
3. Duration of effect: 1 year, no chronic effects
4. Degree of impact an educated guess

Table 3.2. Estimated number of children aged 7–19 years in Sweden with noise-induced cognitive impairment and DALYs per year due to noise-induced cognitive impairment (NICI)

Age group and noise exposure level	No. of children aged 7–19 exposed	Percentage of children who will develop NICI	No. of children with NICI	DALYs lost for NICI
7–19 years, < 55 L_{dn}	1 012 817	0	0	0.0
7–19 years, 55–65 L_{dn}	282 993	20	56 599	339.6
7–19 years, 65–75 L_{dn}	163 838	50	81 919	491.5
7–19 years, > 75 L_{dn}	29 789	75	22 342	134.1
Total	1 489 437		160 859	965.2

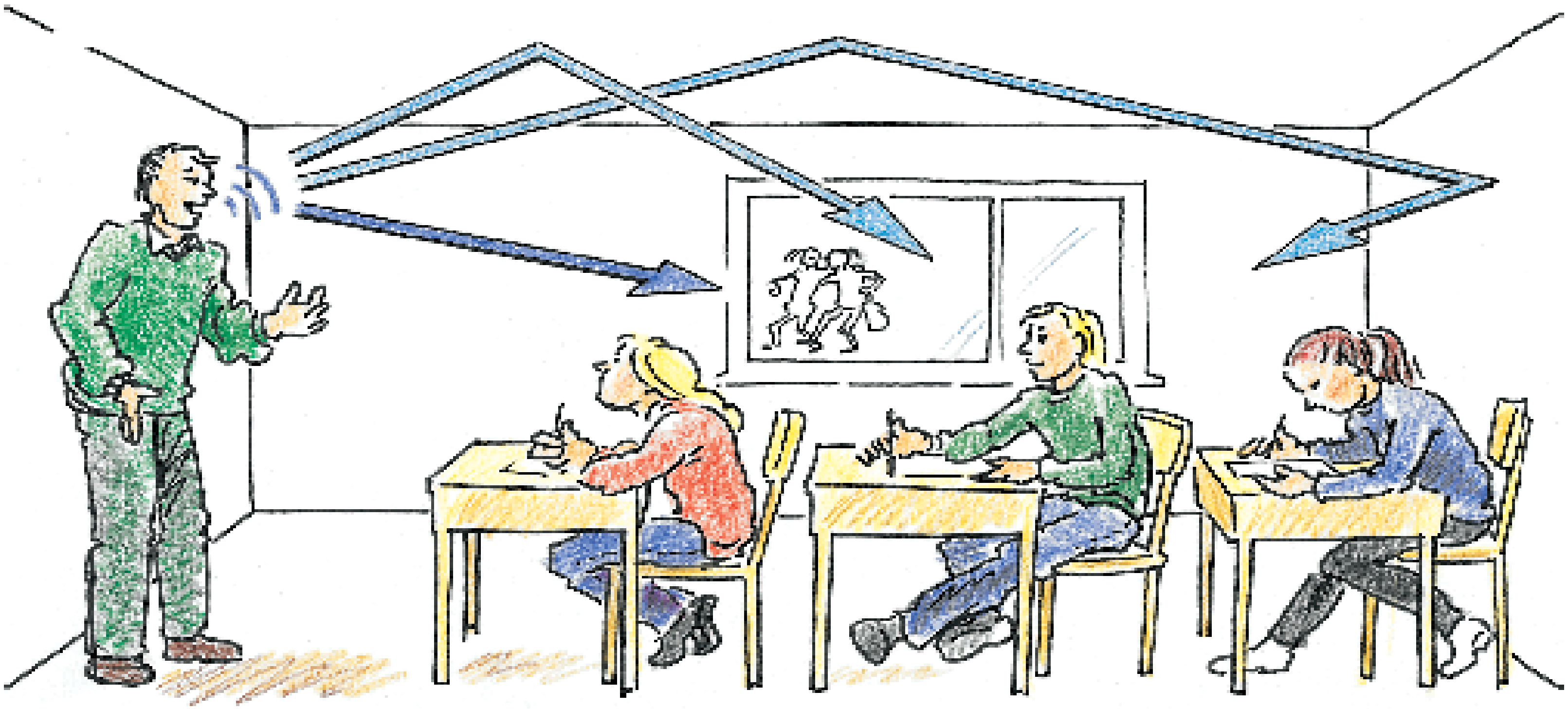
Assumed impact

Whole of EC
45 000 DALYs

Buller i klassrummet – Förvrängd talsignal

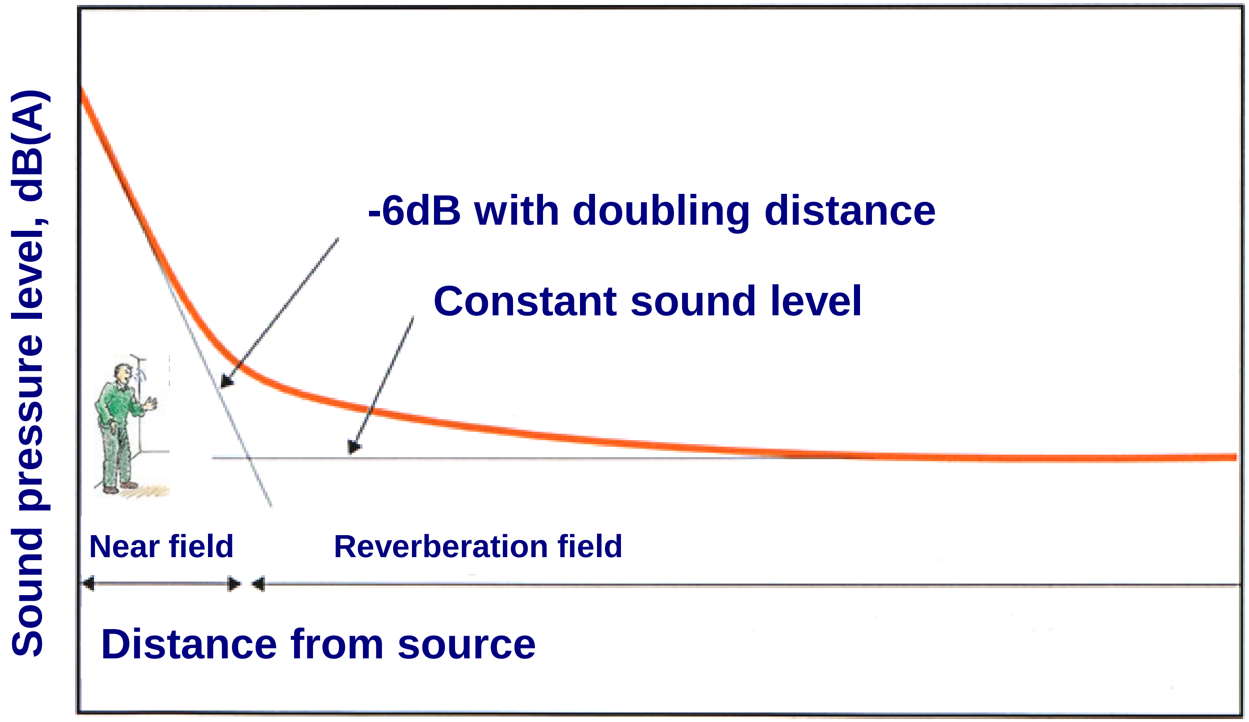
- Signal-brus-förhållanden (SNR)
- Efterklangstid (RvT)
- Några studier
- Några oväntade resultat

Speech intelligibility and memory – Reverberation time and background noise



- Direct sound: The part of the sound that goes the shortest distance from speaker to listener
- Reflected sound: The part of the sound that reaches the listenser after having been reflected by different surfaces in the room. Reaches the ear later than the direct sound

Indoor sound pressure level as a function of the distance to the sound source



An example:
When a teacher speaks at 66 dB(A), that level drops to ≈ 52 dB(A) 6 m out in an ordinary classroom. This is only 7 dB(A) above a background level of 45 dB(A)

Does reverberation time cause a problem in schools?

Measurements and recordings in two classrooms – A short lecture

- A classroom with a long reverberation time 1.6 - 2.0 s in the lower frequency bands
- Another classroom with a reverberation time around 0.3 s in all frequency bands

Results: Means 2.16 (long RvT) and 4.00 (short RvT), $F(1,17) = 16.60$, $p < .001$

To hear but not remember

Signal-to-noise ratio (SNR) and Reverberation time (RvT)

Participants heard word lists and repeated the words directly, showing no significant difference in speech intelligibility

Number of correctly recalled words

SNR 27 dB ***Good***	SNR 4 dB ***Bad***
11.0	8.5

p <.001

Short RvT (0.5 s)	Long RvT (1.2 s)
13.0	10.8

p =.025

Conclusion: Fewer word are remembered after hearing them under them under a low SNR or a long RvT

The role of Working Memory (WM)

- WM is employed for temporary storage of information, to elaborate the information, to link it together with information in long-term memory and to transfer the information to long-term memory
- WM has a limited capacity
- The more of that capacity that is taken up by identifying the words that are heard, the less is left for elaboration of the information, for storing, and for memory and learning

Recent studies

Recall of words spoken in the first and second language:

Effects of signal-to-noise ratios and reverberation times for school children in Grade 4 and College students

Materials and Procedure

Free recall of words in wordlists

Children Grade 4, *N* =72, run as a group in their classrooms
College students, *N* =48, run individually in the lab with headphones and computer

Signal-to-Noise ratio (SNR) +3 and +12 dB
Reverberation time (RvT) 1.2 and 0.3 s
Language (Lang) English and Swedish

12 wordlists in each language
For children grade 4 - 8 words in each list
For college students - 12 words in each list

Words with high ranks were taken from language specific category norms for 24 categories, which were sorted by Graeco-Latin squares into 24 lists with equal average ranks of the words

Materials and Procedure

The presentation orders of the lists were counter-balanced across experimental conditions and subjects

Examples of the words

Swedish RvT =1.2, SNR = +3 dB

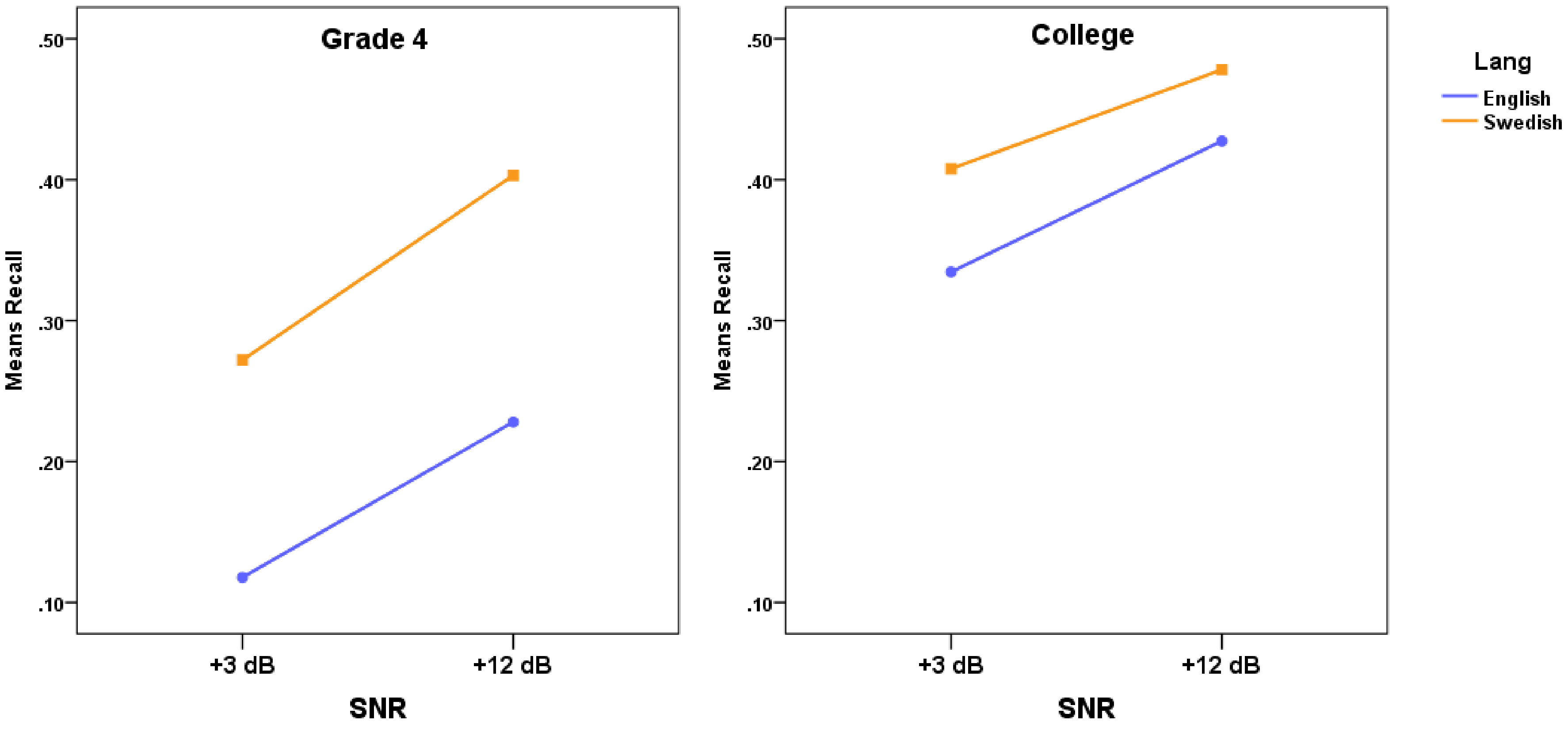
English RvT = 1.2, SNR =+12 dB

Swedish RvT = 0.3, SNR =+3 dB

English RvT = 0.3, SNR =+12 dB

Lang*SNR*Study

Looking at the slopes, there are more marked increases in recall with improved SNR for Grade 4 than for the College students, and the most marked increase for Grade 4 is with the Swedish words



Relative improvement of recall with a +5 dB increase of SNR

		Recall - Improvement per SNR 5 dB, %
Grade 4		
	English	50.4
	Swedish	26.0
College		
	English	15.4
	Swedish	9.5

Three surprises with RvT

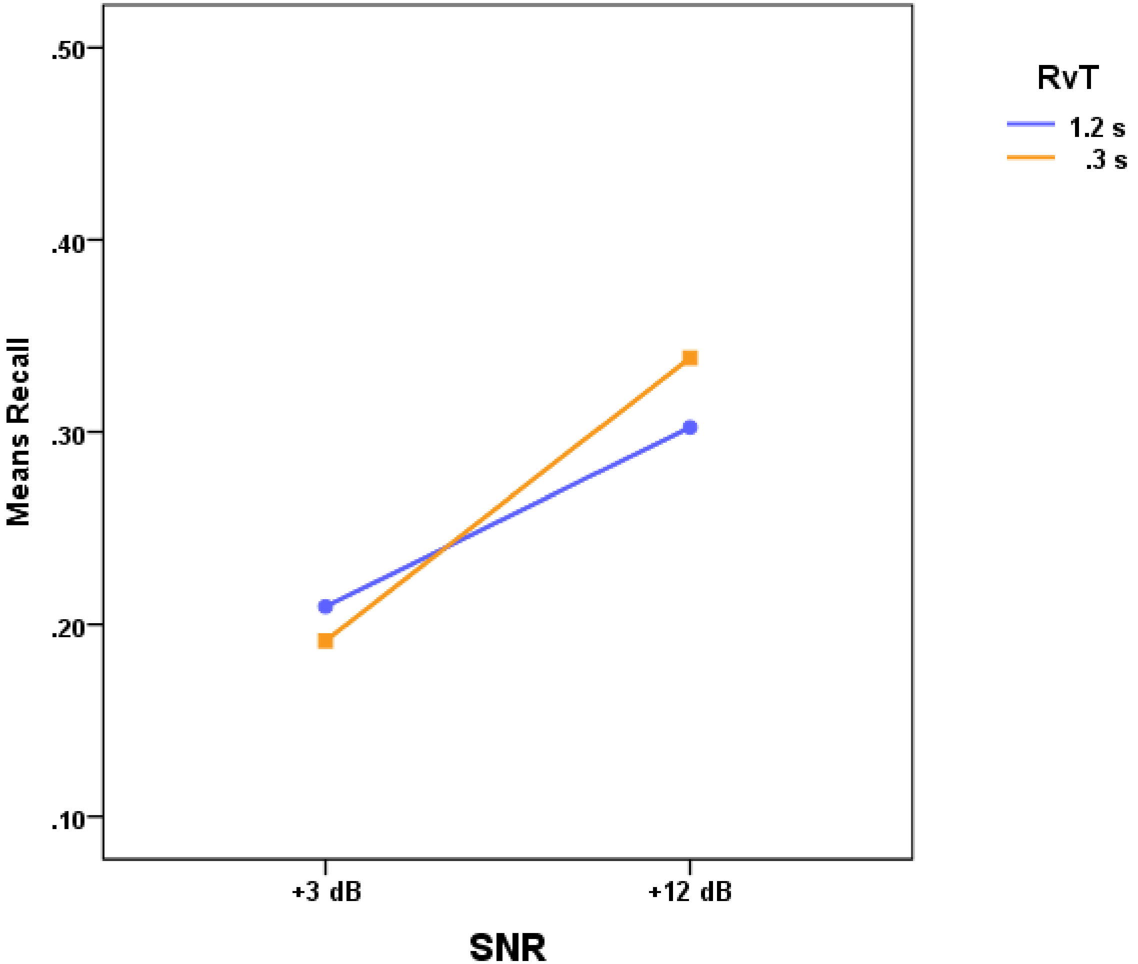
In three of our recent studies there was no main effects of reverberation tim (RvT), but there were unexpected interaction effects with SNR or with different sub-groups.

Surprise I

For the children in grade 4 there was an unexpected crossover interaction SNR*RvT

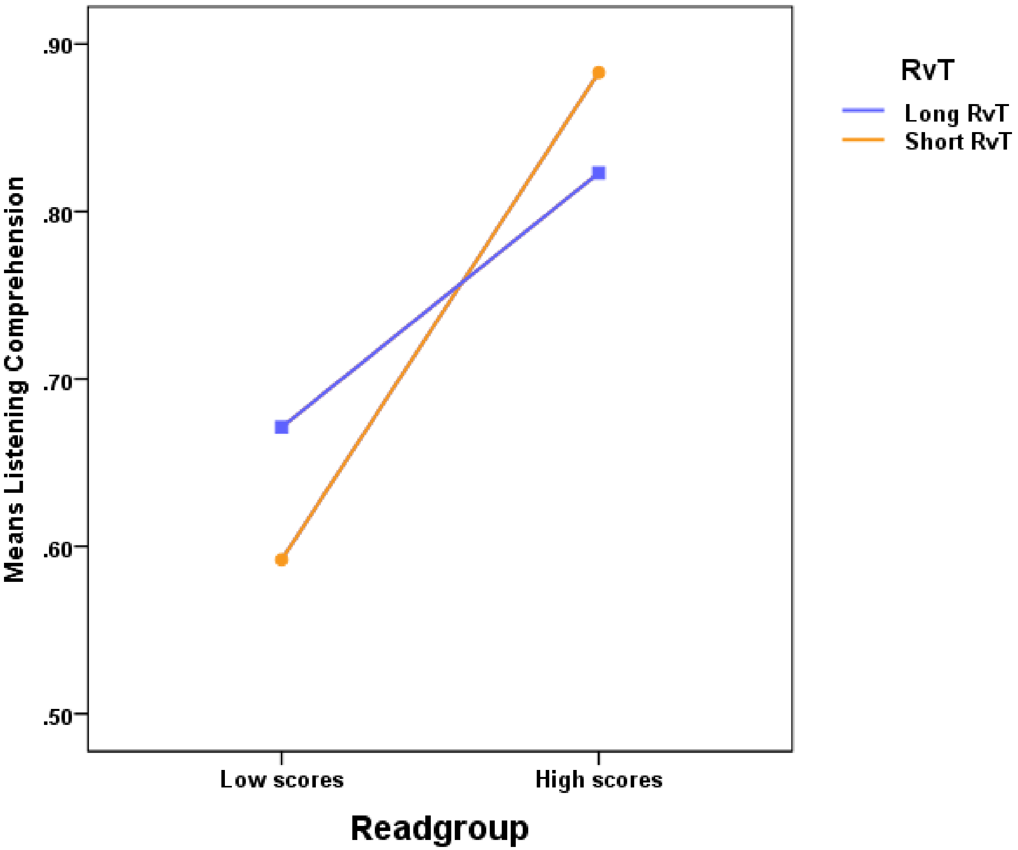
At both SNR levels the simple main effects of RvT was significant and in different directions.

That is, at the lower +3 dB SNR level a short RvT impaired recall, but at SNR +12 dB the shorter RvT improved recall.



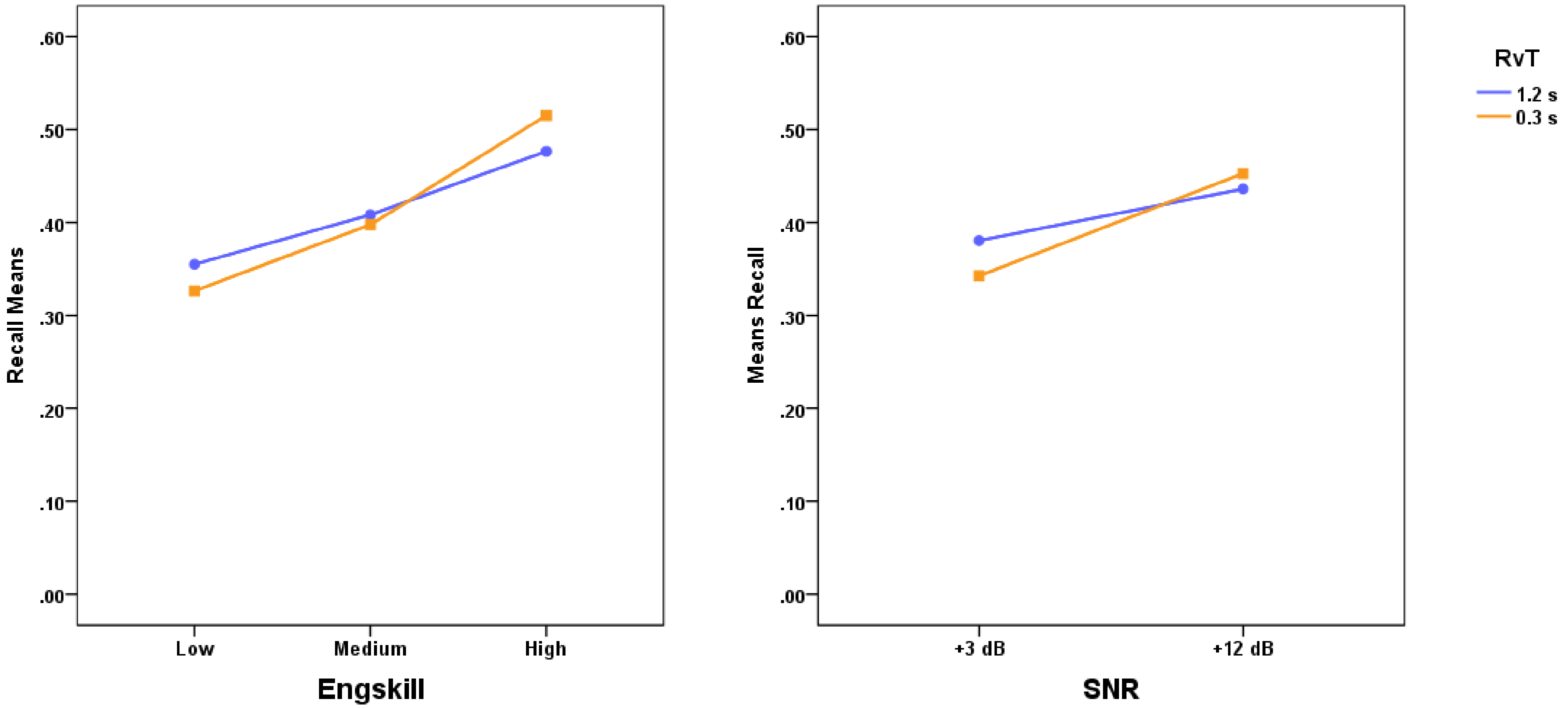
Surprise II

In another recent experiment, we employed two classrooms with different RvTs (.33 and 1.07 s). The Swedish pupils in grade 9, age 15 years, performed an English listening comprehension test. test. An unexpected significant crossover interaction between RvT and English reading skill was found, indicating that a short RvT impaired recall for the pupils with the lower scores on the reading test, while recall for the pupils with the lower reading scores was improved with the shorter RvT.



Surprise III

With these two unexpected findings I made a closer post-mortem analysis of the word list experiment with the college students above. When they are group into three groups of how skilled they were in English, based on their recall scores for the words, crossover interactions involving RvT turned up again, although only with borderline , $p < .10$, in RvT*SNR interaction.



Conclusions

- SNR is a stronger determinant of recall than RvT is
- For SNR recall has a higher effect size value than speech intelligibility has
- A SNR improvement to +12 dB from +3 dB is more important for Grade 4 than for College students, in particular for the Swedish words
- There are indicators of a crossover interactions involving RvT, where a long RvT may actually improve recall, at least for participants who are on the lower side of (English) language proficiency

A breakthrough or hoax?

Do we have a stimulus ghost in the speech machinery?

or

Have we stumbled upon a new and real effect?

or

Is it something as opaque as the Soviet foreign policy, as stated by Winston Churchill, in a broadcast 1st October 1939?

"It is a riddle wrapped in a mystery inside an enigma"