RECORDING

Ljud i byggnad och samhälle - psykoakustik

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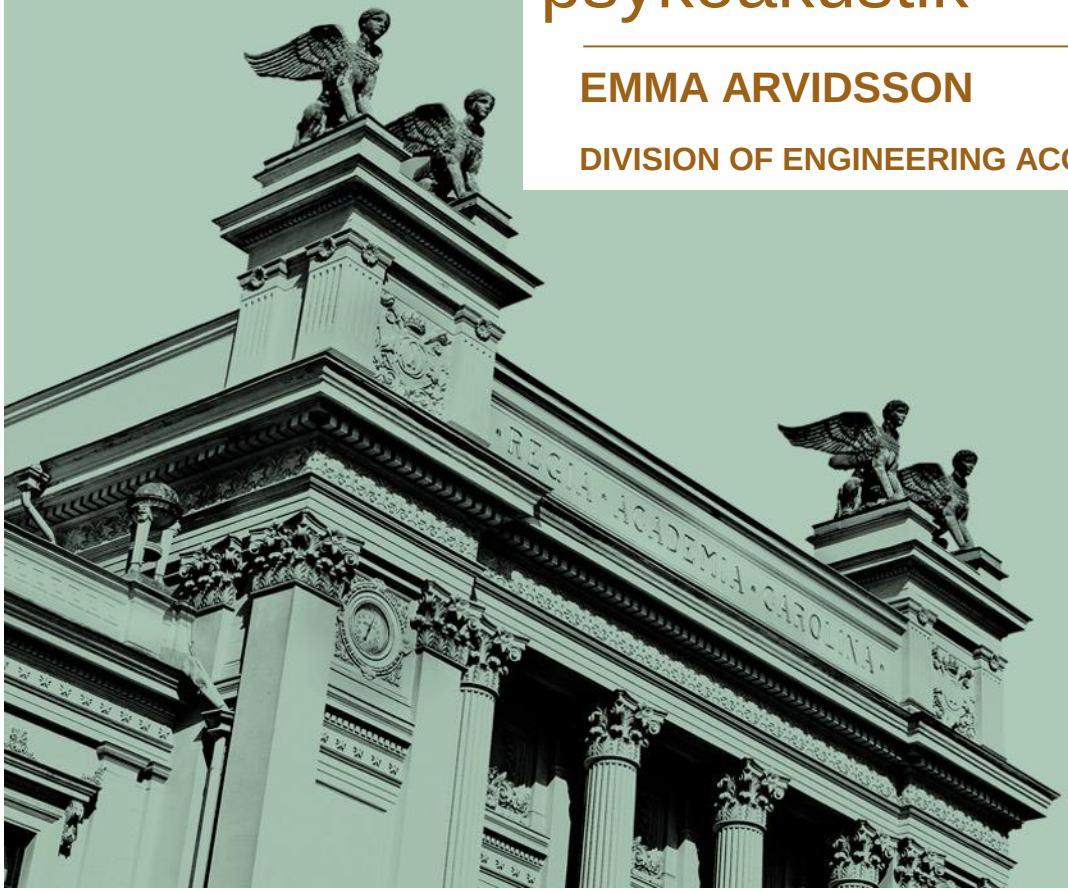

Agenda

- Psykoakustik som begrepp
- Hörseln
- Mått för att beskriva upplevelsen av ljud
- Exempel

Psykoakustik – subjektiv upplevelse

- Hörsel
  - Ålder
  - Funktion
- Preferenser
- Situation
- Subjektivt - objektivt

Psykoakustik – subjektiv upplevelse

- **Hörsel**
  - Ålder
  - Funktion
- Preferenser
- Situation
- Subjektivt - objektivt

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Hörselorganet

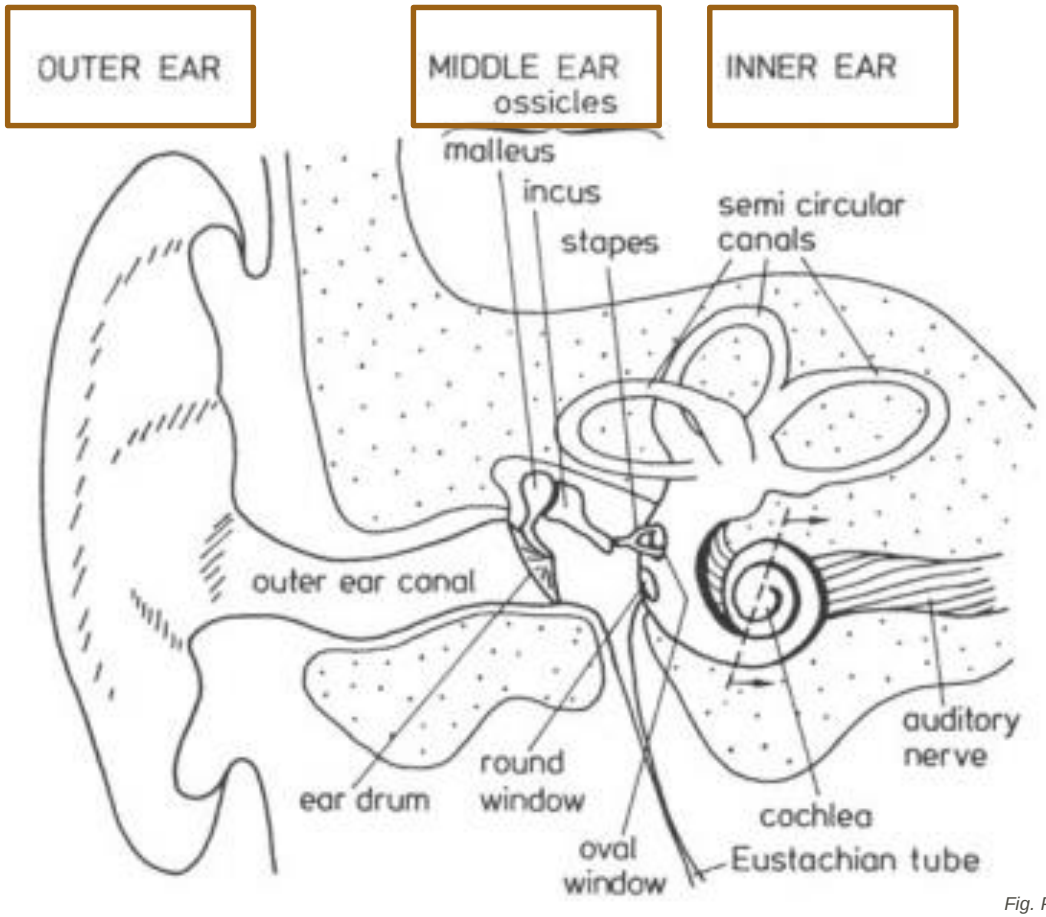
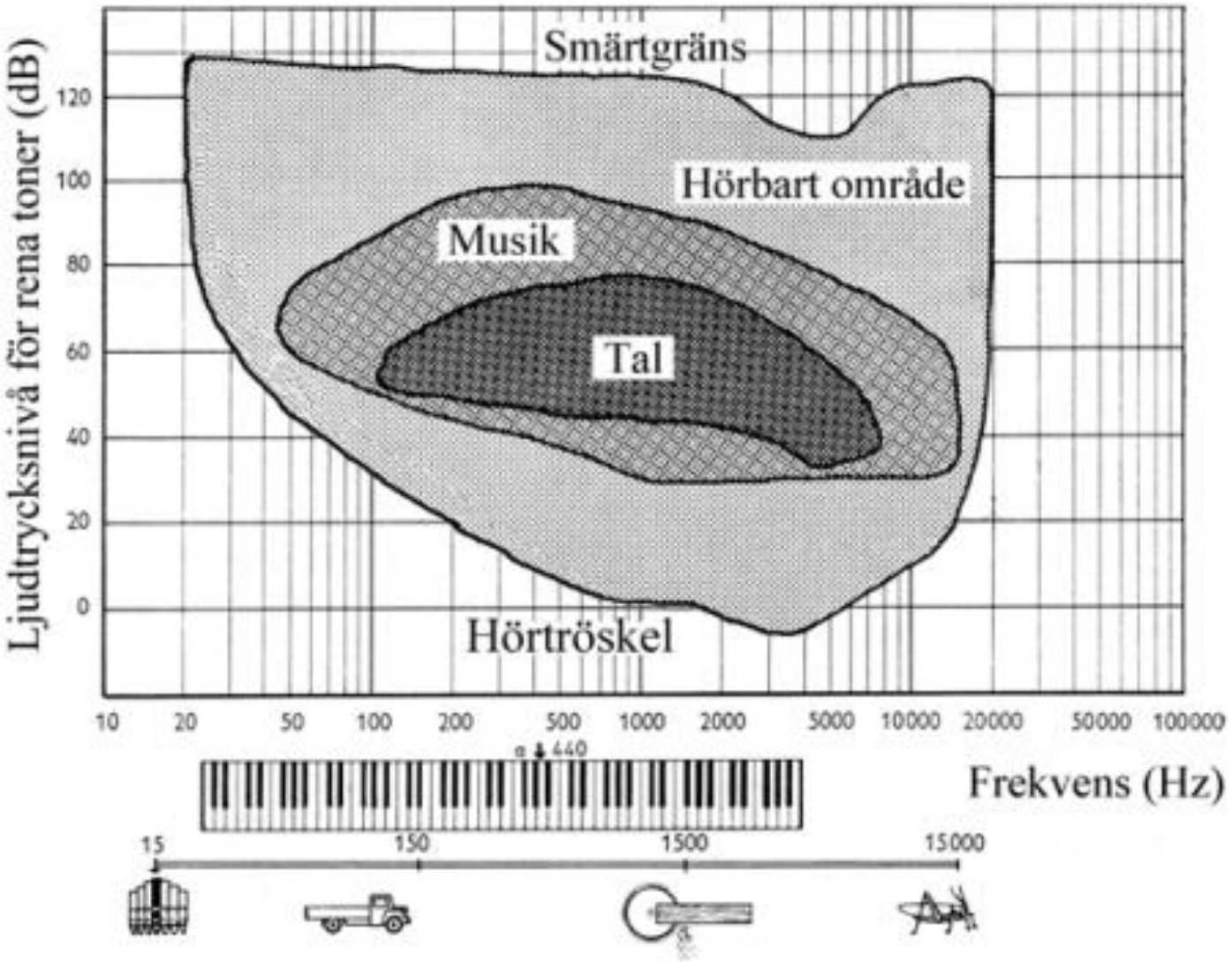
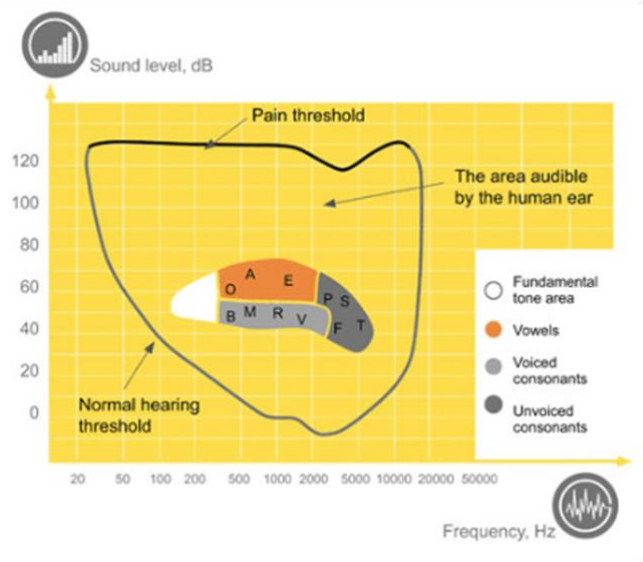
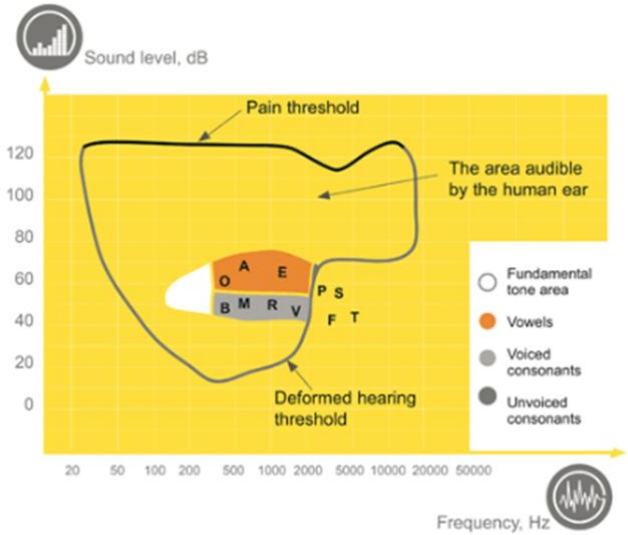


Fig. Psychoacoustics, Fastl and Zwicker, 2007


Smärtgräns
Hörbart område
Musik
Tal
Hörtröskel
Ljudtrycksnivå för rena toner (dB)
120
100
80
60
40
20
0
10
20
50
100
200
500
1000
2000
5000
10000
20000
50000
100000
Frekvens (Hz)
a 440
15
150
1500
15000

Hörselnedsättning





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Psykoakustik

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Psykoakustik – subjektiv upplevelse

- Hörsel
  - Ålder
  - Funktion
- **Preferenser**
- **Situation**
- Subjektivt - objektivt

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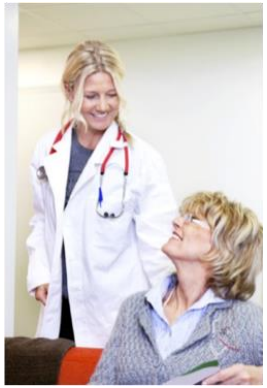
Akustikens påverkan

Concentration
Productivity



Faster recovery

Learning,
higher grades

Pleasure

Good room acoustics

Recover?

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Buller

Buller: oönskat ljud

- Personlighet
- Känslighet
- Aktivitet/uppgift
- Miljö
- Förväntningar
- etc

Buller och dess påverkan på människor

- Cardiological
  - Increased blood pressure
  - Increased heartrate
- Hearing impairments
  - Hearing losses
  - Tinnitus
  - Audio fatigue
- Voice problems
  - Phonation
  - Voice quality and endurance
- Well being
  - Energy losses
  - Stress
  - Concentration, observe correct information and perform tasks
  - Sleeping disturbance
  - Social interaction

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Psykoakustik – subjektiv upplevelse

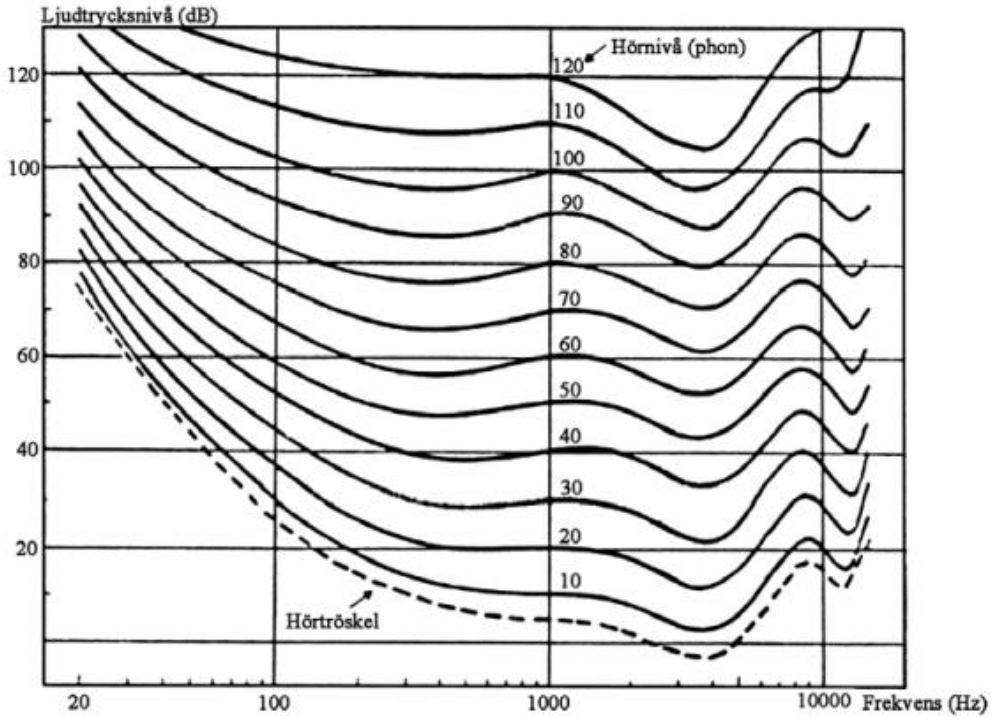
- Hörsel
  - Ålder
  - Funktion
- Preferenser
- Situation
- **Subjektivt - objektivt**

Perception of sound

Loundness

Loudness

- Upplevd ljudstyrka
- Jämför upplevelsen vid olika frekvenser

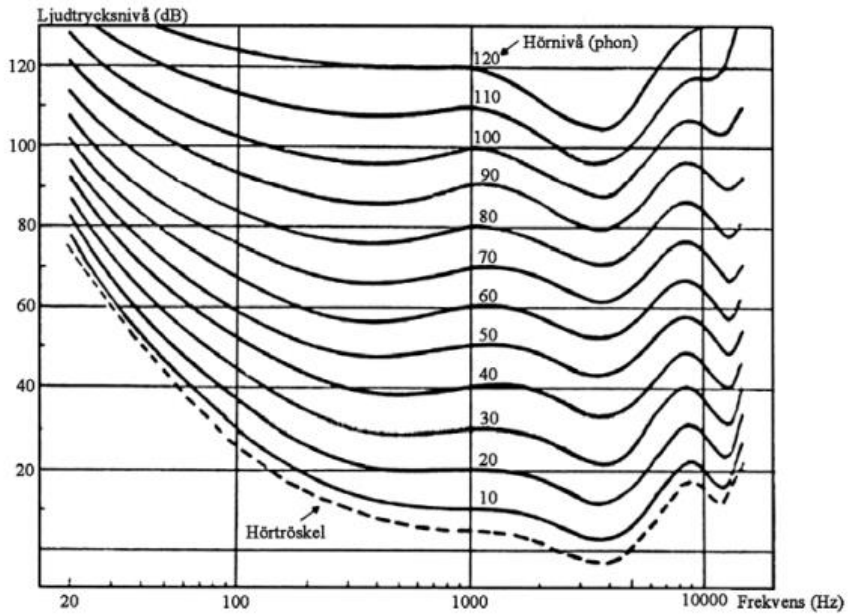


Perception of sound

Loudness

Exempel

Tal vid 1000 Hz, ljudtrycksnivå 60 dB
Tal vid 50 Hz, ljudtrycksnivå 80 dB



Vägd ljudtrycksnivå

Frekvens [Hz]	A-filter [dB]	B-filter [dB]	C-filter [dB]
10	-70.4	-38.2	-14.3
12.5	-63.4	-33.2	-11.2
16	-56.7	-28.5	-8.5
20	-50.5	-24.2	-6.2
25	-44.7	-20.4	-4.4
31.5	-39.4	-17.1	-3.0
40	-34.6	-14.2	-2.0
50	-30.2	-11.6	-1.3
63	-26.2	-9.3	-0.8
80	-22.5	-7.4	-0.5
100	-19.1	-5.6	-0.3
125	-16.1	-4.2	-0.2
160	-13.4	-3.0	-0.1
200	-10.9	-2.0	0
250	-8.6	-1.3	0
315	-6.6	-0.8	0
400	-4.8	-0.5	0
500	-3.2	-0.3	0
630	-1.9	-0.1	0
800	-0.8	0	0
1000	0	0	0
1250	0.6	0	0
1600	1.0	0	-0.1
2000	1.2	-0.1	-0.2
2500	1.3	-0.2	-0.3
3150	1.2	-0.4	-0.5
4000	1.0	-0.7	-0.8
5000	0.5	-1.2	-1.3
6300	-0.1	-1.9	-2.0
8000	-1.1	-2.9	-3.0
10000	-2.5	-4.3	-4.4
12500	-4.3	-6.1	-6.2
16000	-6.6	-8.4	-8.5
20000	-9.3	-11.1	-11.2

$$L_{vägt} = 10\log\left(\sum 10^{(L_n + \text{vägning})/10}\right)$$

Exempel

Beräkna den A-vägda ljudtrycksnivån, L_A, ur givna oktavbandsnivåer.

f [Hz]	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*
L_n [dB]	*85*	*87*	*92*	*85*	*77*	*70*	*65*

Lösning: A-vägningen ges ur Tabell 9.

ΔA_n [dB]	*-26.2*	*-16.1*	*-8.6*	*-3.2*	*0*	*+1.2*	*+1.0*
$L_n+\Delta A_n$ [dB]	*58.8*	*70.9*	*83.4*	*81.8*	*77*	*71.2*	*66*

$L_A = 10\log(10^{5.88}+10^{7.09}+10^{8.34}+10^{8.18}+10^{7.7}+10^{7.12}+10^{6.6}) \approx 87$ dB(A)

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Ekvivalent ljudtrycksnivå

- Den konstant ljudnivå med samma totala ljudenergi
- Används ofta för riktlinjer kring ljudnivåer

$$L_{eq,T} = 10\log\left(\frac{1}{T}\int_0^T \frac{p^2(t)}{p_{ref}^2}dt\right) = 10\log\left(\frac{1}{T}\int_0^T 10^{L_p(t)/10}dt\right)$$

Exempel

Ett kortvarigt starkt ljud bidrar kraftigt till den ekvivalenta ljudnivån. Vad motsvarar en konstant ljudnivå på 100 dB(A) i 15 min i ekvivalent ljudnivå under 8 timmar?

Lösning: $L_{eq,T} = 10\log\left(\frac{1}{T}\int_0^T 10^{L_p(t)/10}dt\right) = 10\log\left(\frac{1}{8}\int_0^{1/4} 10^{100/10}dh\right) = 85\ dB(A)$

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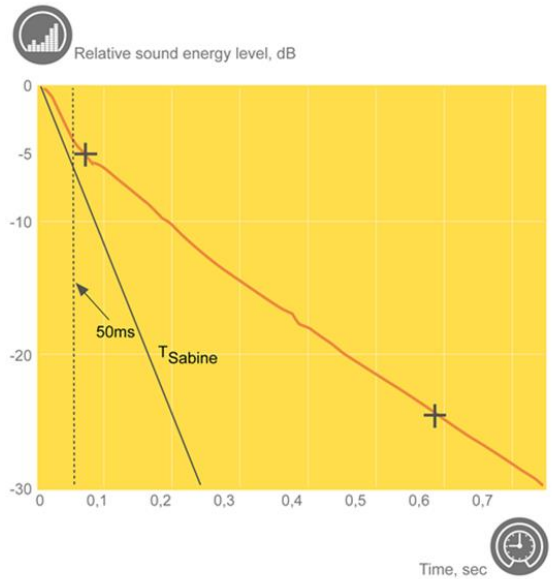
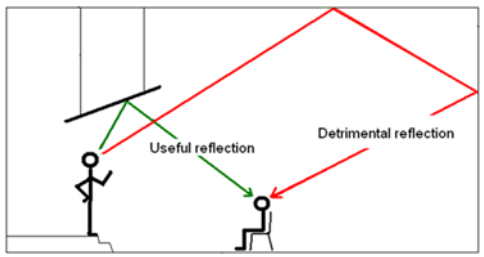
Rums akustiska parametrar

- Reverberation time T_{20} (s) (ISO 3382-2)
- Speech clarity C_{50} (dB) (ISO 3382-1)
- Sound strength G (dB) (ISO 3382-1)
- Spatial decay D_{2S} (dB), L_{pA4m} (dB), r_d (m) (ISO 3382-3)



$$C_{50} = \frac{\int_0^{50\,ms} h^2(t)dt}{\int_{50\,ms}^{\infty} h^2(t)dt} \qquad G = \frac{\int_0^{\infty} h^2(t)dt}{\int_{0ms}^{t_{dir}} h_{10m}^2(t)dt}$$

h(t) is the impulse response
h10m is the impulse response at 10 meter in a free field.



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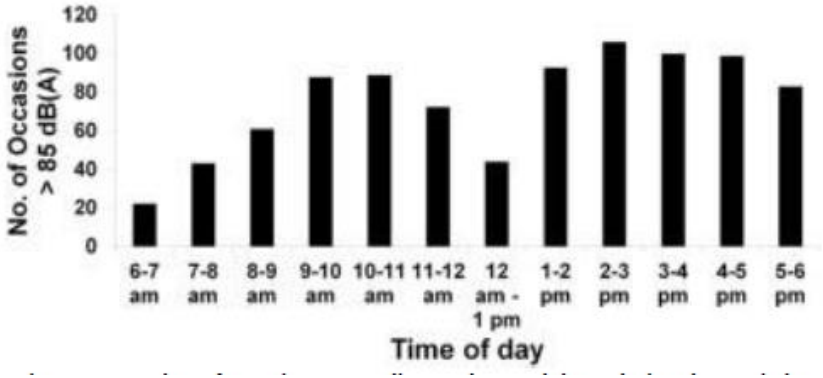
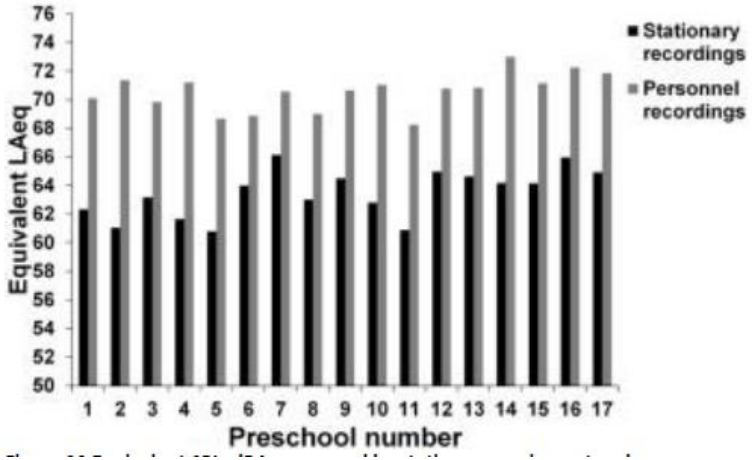
Exempel

Förskola

- Most noisy environment
- Children exposed to higher levels
- Children's auditory system more sensitive
- Several activities ongoing – several different sound sources
- Learning speech, communication and socialize





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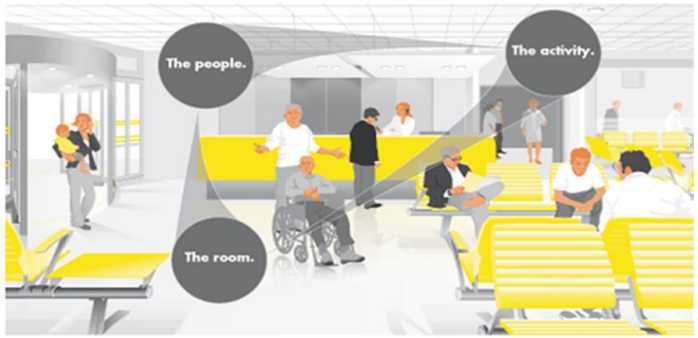
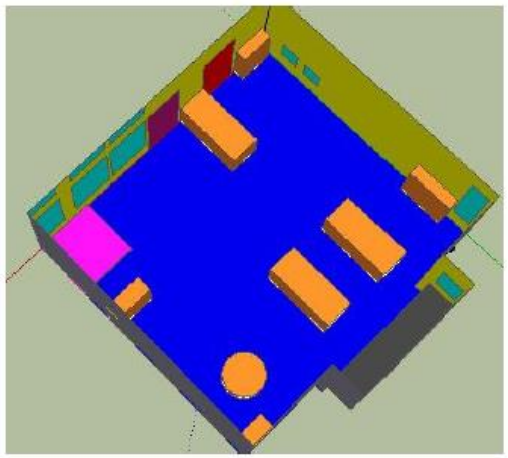
Exempel

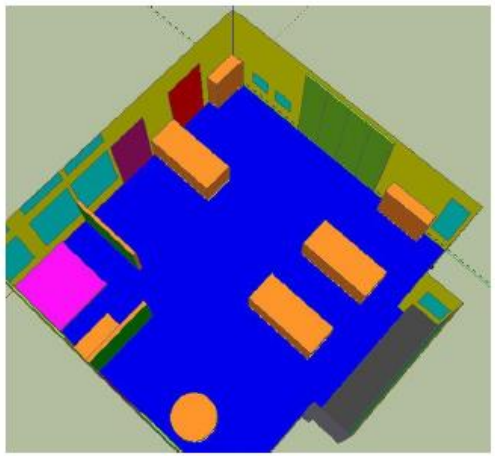
Förskola

Akustiska åtgärder
- **Skärma av, rum i rummet**
- **Absorption, tak väggar**
- **Mattor**

Möjlig förbättring
- **Avgränsar ljudkällor, men överblick**
- **Minska efterklangstid, öka taltydligheten**
- **Sänka ljudnivå, sänka sound strength**

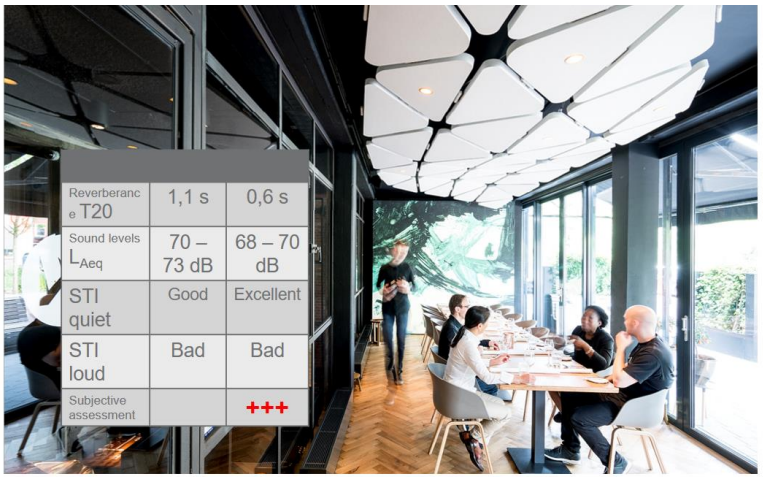






Examples

Restaurang Zarzo, Eindhoven



Reverberance T20	1,1 s	0,6 s
Sound levels L_{Aeq}	70 – 73 dB	68 – 70 dB
STI quiet	Good	Excellent
STI loud	Bad	Bad
Subjective assessment		+++

Ecophon SAINT-GOBAIN
A SOUND EFFECT ON PEOPLE

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Thank you for your attention!

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Ljud i byggnad och samhälle (VTAF01)

Final lecture

MATHIAS BARBAGALLO
DIVISION OF ENGINEERING ACOUSTICS, LUND UNIVERSITY

Course is finished, what's next? ☺

- Basic acoustics
    - SDOF, resonance, wave equation, modes in structures and rooms, transmission/reflection of waves between media, coincidence, musical acoustics.
- Traffic noise / External noise
    - SPL, SWL, SIL. Propagation of sound waves from sources.
- Building acoustics
    - Requirements (SS 25267, BBR, SS 25268) – Rw, Lnw, T20, Lp
    - Väggar – enkelvägg, dubbelvägg, flankerande transmission
- Measurement techniques (Juan)
- Room acoustics (Erling)
    - Sabine, different types of absorbers, different measures for room acoustics (T20, C50, G, STI).
- Hearing system and psychoacoustics (Emma)
- Acoustics in practice (Emma, Mathias)
    - Industry, consultancy, research, public and private employers

Thank you for your attention!

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