Ergonomics of intern environments: privacy and reactions to noise pollution.

Author: G. Mario Mattia (Italy) & P.V. Brűel (DK), +39 335/6253030 m.mattia@euroacustici.org
Brűel Acoustics S.r.l -Viale Cesare Pavese 304, 00144 ROMA EUR RM, Italy -

The acoustical ergonomic is an important target for any room acoustics, intelligibility and community noise.

Environmental sound quality, room acoustics and interference of perceived sound (interference with the privacy) can start subjective effects and strong human reactions.

We live, evolve and communicate throw our senses with the physical environment around us.

As we know the human reaction to the noise pollution is very complex and not well understood: the traffic noise is the first cause of pollution and we think that it is also the first annoying noise source, but it is not so!

We have seen that generally people react to the noise of low level coming from the neighbours activity, air condition systems, musical activity near their flat, etc.

Why? Because we are very sensitive to any action that breaks our psychological privacy: when some physical agent is perceived as an invasion of our space of life (can be sound, vibration, odours, heat, a thief, dog bark, children crying, etc.) we react with an action of defence, a neuro physiological pressure called "stress" and the reactions to the stress can be very dangerous for our health!: men need to relax and found peace at home so it is very important to have a good acoustic in living environment; we need a reverberation time not too long and a low background noise, we have to avoid stationary acoustics wave for a good speech intelligibility and to avoid noise pollution at home, as we know, it is necessary a good acoustical building insulation.

About metrological approaches to the individual human reaction to the noise, our experience is that the sound level averaged as L_{Aeq} can't be a good index because we are not sensitive to a long average of sound but we have found that we react to any non interesting or unknown signals (intolerant communications, informations, sound): information of risk, dangerous to our health and to any fast variation of the sound level (sound gradient).

We have got then a good correlation with the difference of the level in Fast L_{AF} and the background level in $L_{AF}95\%$ with a variation of 10 dB in less than a second that can start a strong stress reaction and wake up the persons exposed to the noise.

From the neuropsychological point of view we have evidenced a very strong effects on the human behaviour.

All perceived signals, stored already in the brain of newborn babies, are compared with our memory data bank created as long as we live: if the signals contain some information recognized as negative or dangerous, in our neuro

vegetative system the tendency of live protection is put in activity with reactions of defence or attack: many stimulus cause stress.

Any interference with our living environment will cause stress with sleep troubles, aggressiveness, damages to the living environment with important pathological effects on the exposed people.

In our work and research we agree with the criterion to evaluate the noise pollution for administrative community with L_{Aeq} and we can apply the well known European directive based on a statistical environmental approach of the problem, but for the complains from a family at home, annoyed from the neighbours noise, that is a subjective, local and legal evaluation, we have to consider not the L_{Aeq} but any fast increase of the admitted noise above the background noise.

As we have highlighted in our experience about the human reactions for noise interference, privacy, stress,…., we have to avoid annoying sounds (also with very low level), rooms with stationary waves, long reverberation time, low acoustical building insulation, we need a good acoustical ergonomic of the internal environment: stationary waves and long reverberation time can be avoid (ex: AcoustiCone from Brüel Acoustics).

We have to empathize that we have many standards for a good acoustical ergonomics; we list some:

EN ISO 11690-1: 1998, 7.1, optimum L_{Aeq}:

a) industry, from 75 to 80 dB(A)

b) office, from 45 to 55 dB(A)

c) activity with concentration, from 35 to 45 dB(A)

EN ISO 11690-1: 1998, Practical recommendation for low noise environments, table 3:

Room volume m^3	**T60 (s)**	**Degree of degradation DL_2 (dB)**
< 200	< 0.5 – 0.8	-
200 – 1000	0.8 – 1.3	-
> 1000	-	> 3 – 4

EN ISO 11690-3: 2000, Practical recommendation for low noise environments in working environments;

APPENDX D: Evaluation of the acoustical quality in working environments.

The sound level distribution can be described with a curve of sound space decay:

- the sound space sound pressure level attenuation doubling the distance (DL_2),
- the extra sound level compared with a free field sound level (DL_f).

Conclusion:

we have seen that noise pollution has two different approaches that have to be kept separated:

1) general community evaluation based on L_{Aeq} and statistics parameters;

2) evaluation of personal behaviour has to be based on a criterion linked to neuro physiological and stress reaction:

(Short L_{Aeq} or $L_{AFmax} - L_{AF95\%} > 10$ dB, /1 s; reverberation time and other index from building acoustics);

(in many general applications we have found a well known simplest approach to define the limit of tolerability when L_{Aeq} or $L_{AF} - L_{AF95\%} > 3$ dB).

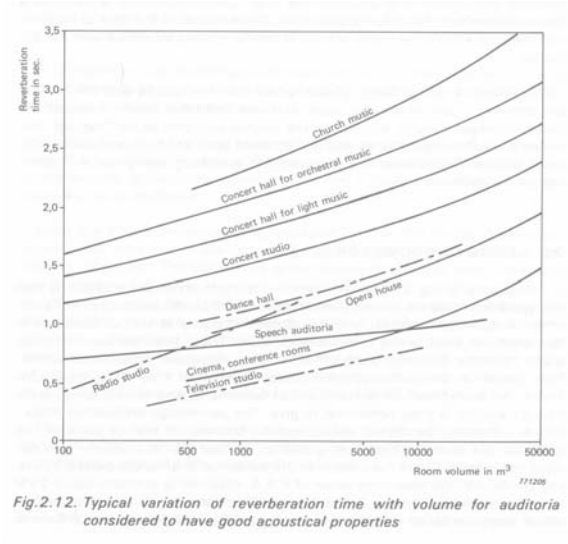
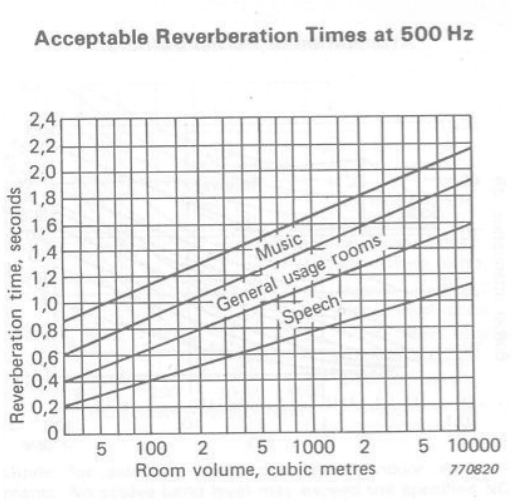
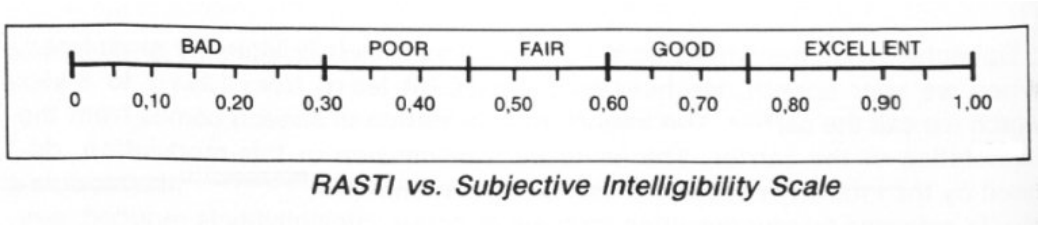


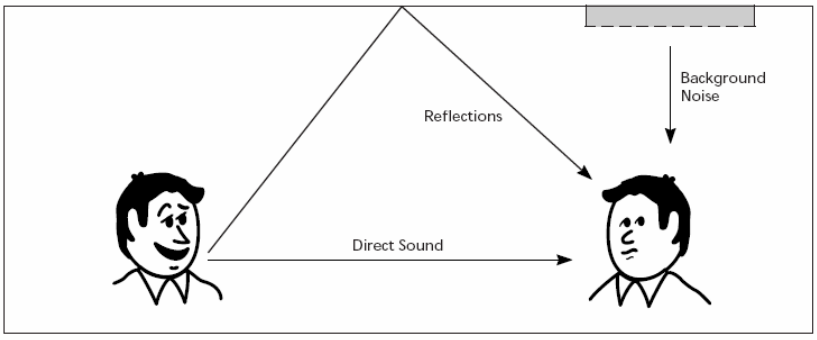
Fig. 2.12. Typical variation of reverberation time with volume for auditoria considered to have good acoustical properties



RASTI STI: IEC 60286-16, Sound system equipment – Part 16: Objective Rating Of Speech Intelligibility by Speech Transmission Index. 1998.



RASTI vs. Subjective Intelligibility Scale



Intelligibility

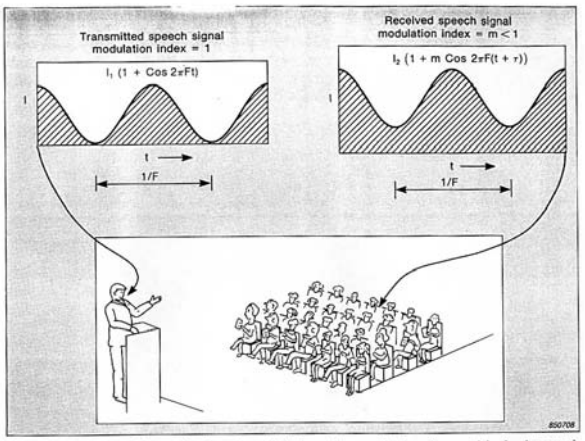
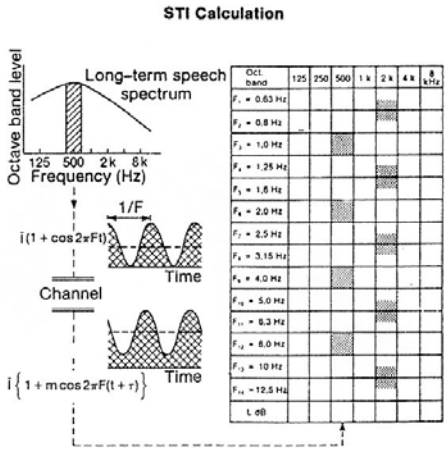
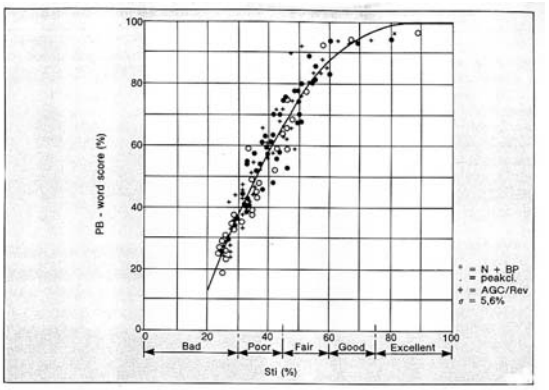
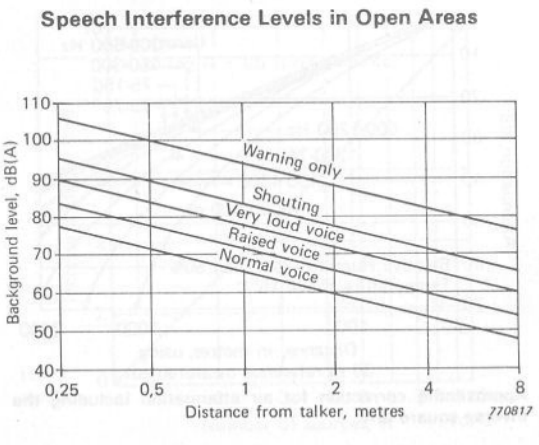


Illustration of the reduction in modulation of a speech signal caused by background noise and reverberation

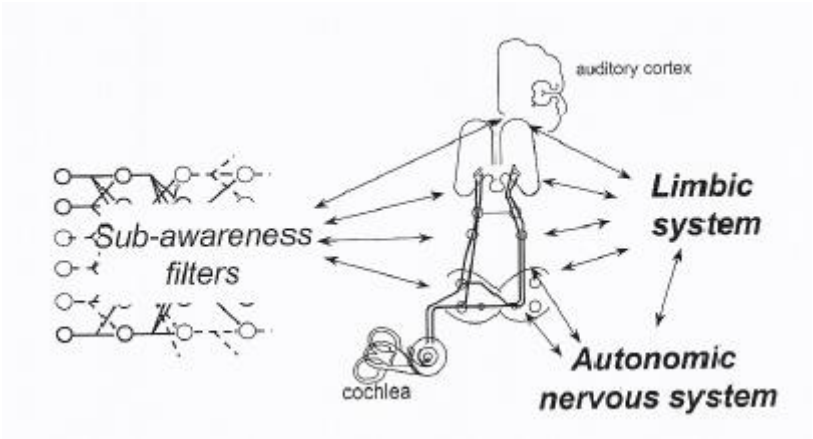




Relation between the objective STI and PB-word score for 167 different transmission channels. The disturbances were combinations of bandpass limiting, noise, peak clipping, automatic gain control and reverberation.



Speech indexes



Filters (memory and data bank) in the Limbic System