Institute for Perception

# RASTI (Room Acoustics Speech Transmission Index)

The Institute for Perception TNO has developed a measuring device for estimating the quality of speech intelligibility in rooms, lecture halls, theatres and churches. The device consists of two separate parts. One part, the artificial talker, generates a specific test signal which is produced at the talker's position. The other part is used at the listener's position, and consists of a small portable device equipped with a microphone (figure 1). The analysis of the received test signal yields an index value which indicates the speech intelligibility for that particular talker and listener position in a room. Each measurement takes about 10 sec.

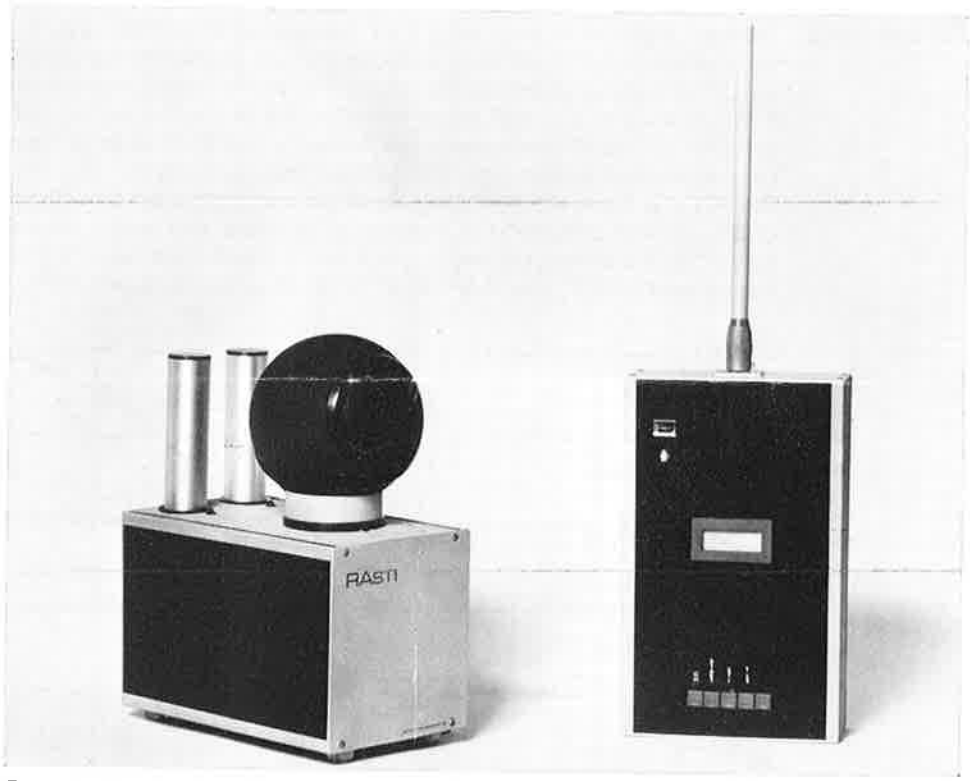


*Figure 1. Signal source and analysis part of the measuring equipment RASTI.*

**Applications**

Since one measurement takes only 10 sec, the system can be used to investigate the effect of individual variables on speech intelligibility in a room, such as various levels of interfering noise, the position of loudspeakers of public address systems, the acoustical properties of the enclosure and the position of the talker and the listener.

One example is presented in figure 2a. For one position of the source (talker), the quality index was measured at 45 different positions within the audience, which resulted in a number of contours with equal quality index (equal intelligibility), from which a region with low values clearly emerges. The effect of possible acoustical measures to improve the situation (reflectors, loudspeakers) can be estimated from a second series of similar measurements (figure 2b). This is but one application of this measuring tool, which replaces laborious intelligibility tests with talkers and listeners, by a simple of an instrument.

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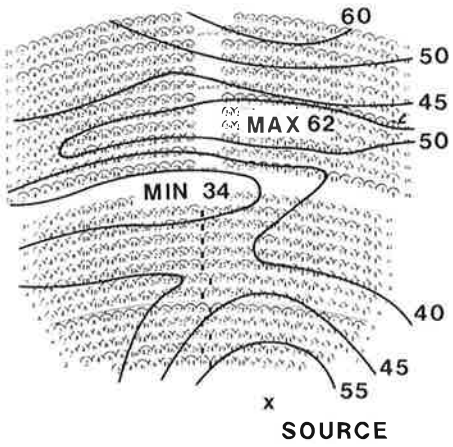


Figure 2a.

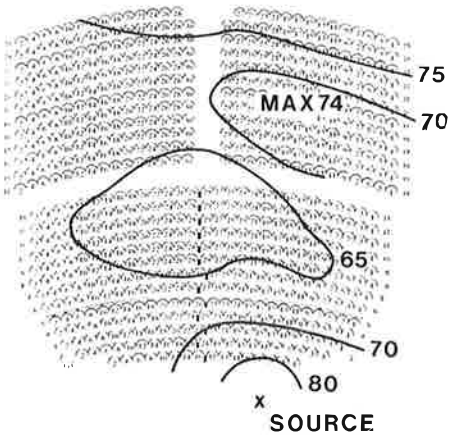


*Figure 2b.*

*Iso-intelligibility contours for a theatre, before and after the (acoustical) renovation respectively.*

**The test signal**

The test signal is a very simplified substitute for normal speech. It contains only two octave bands, and each band contains a specific temporal fluctuation pattern which is to some degree representative of the fluctuations in speech. The approach is based on the idea that these very fluctations are the carriers of the information, and the analysis of the signal at the listener's position has to indicate to what degree the original fluctuations (information) have been preserved.
Specifically, the test signal consists of the two octave bands with center frequencies of 500 Hz and 2000 Hz, the intensity of the first one being modulated sinusoidally with modulation frequencies of 1, 2, 4 and 8 Hz, and the second one with modulation frequencies of 0.7, 1.4, 2.8, 5.6, 11.2 Hz. The two octave bands, and the various

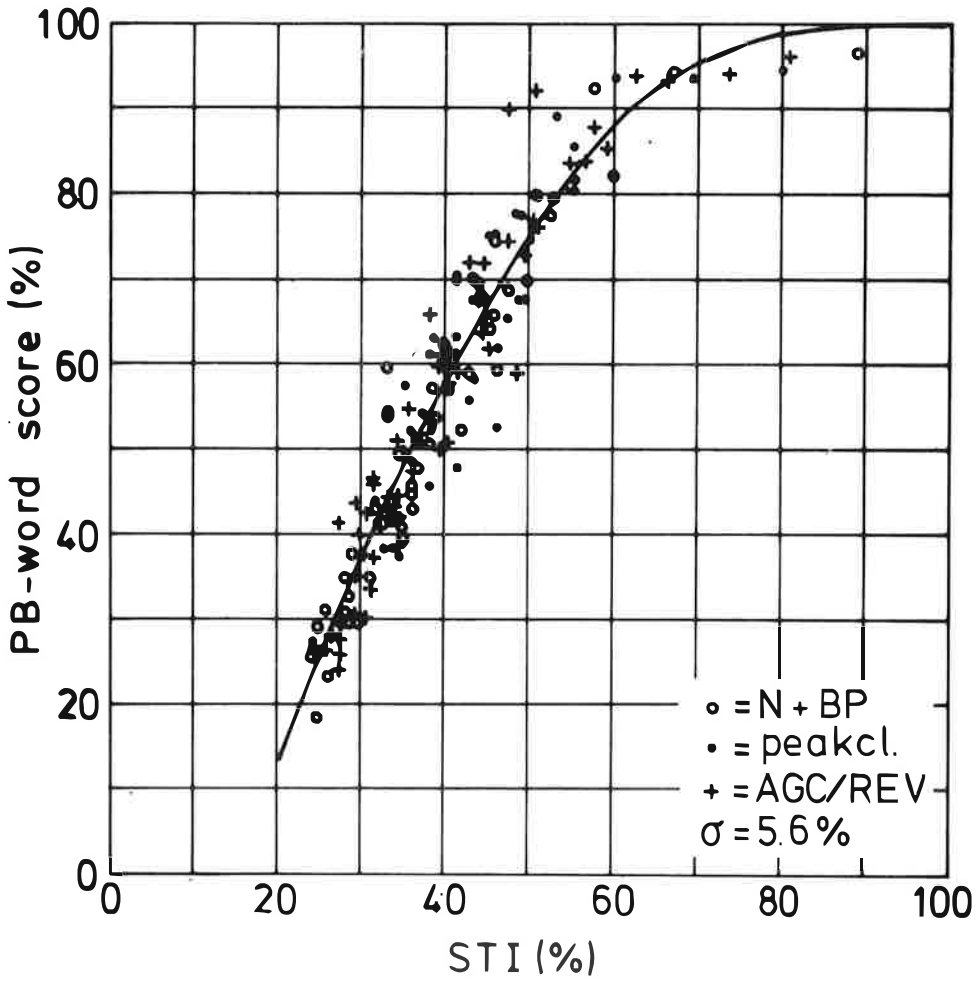


*Figure 3. Relation between the objective STI and PB-word score for 167 different transmissior channels. The disturbances were combinations of bandpass limiting, noise, peak chipping, automatic gain control and reverberation.*

modulations within each band, are generated simultaneously, and the level of the ongoing test signal has to be matched to the level of speech normally produced at that position.

**Analysis** The analysis of the signal at the listener's position quantifies to what extent the original modulations of the test signal are preserved. This is performed for each octave band and for each individual modulation frequency/simultaneously. From the decrease of the observed modulation indices relative to the original ones the index is derived, which is called the Speech Transmission Index (STI). The index is 100% when the original modulations are perfectly preserved, and it reduces to 0% when none of the original modulations can be traced in the received test signal.

**Accuracy** The basic principle which underlies the present measuring system has been evaluated extensively by means of intelligibility tests with talkers and listeners. For that purpose, for each of 167 different speech transmission channels both the physical index STI and the intelligibility score were determined. (The latter was based on the use of lists with phonetically balanced words, PB-words, leading to a PB-word score between 0% and 100%.) The results are presented in figure 3. The relevance of the STI as a predictor of PB-word score can be estimated from the scatter of the data points around the best-fitting curve, suggesting an accuracy of $\pm$ 6% (Steeneken and Houtgast, 1979).

The present system embodies several simplifications compared with the original approach to which figure 3 applies. It has been developed primarily for applications in room acoustics, which has the same accuracy as the system of figure 3.

**References**


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