Intelligibility tests in subway stations & trains using auralisation

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SCOPE

RATP is working with GENESIS to improve the intelligibility of announcement in subway stations and trains.

Reference intelligibility assessment by direct *in situ* tests in public areas must be conducted at night, leading to many issues (tiredness of subjects, logistical constraints, …).

The purpose of this study is to validate an easier and more accurate intelligibility test protocol, based on auralisation and headphone rendering.

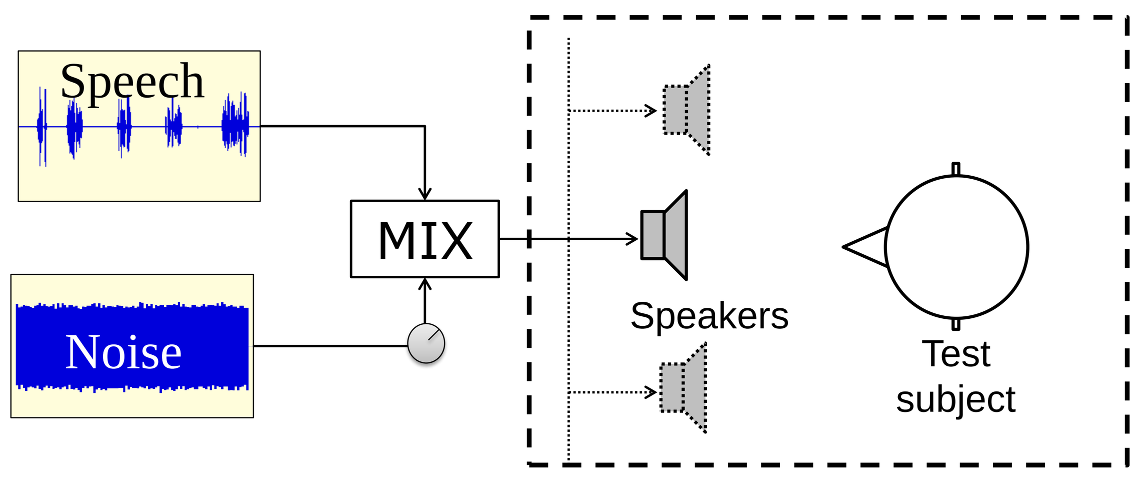
This in-lab protocol is implemented in GeneINTEL© GENESIS software which will be used in further studies to improve intelligibility indicators for PA systems in highly reverberant and noisy environments.

TEST METHOD

Direct intelligibility test using **pseudo-open corpus** with **free choice**:
- 10 phonetically balanced lists of 34 short words
- Each subject must write (or type) the word he just heard
- Number of subjects chosen according to ISO TR 4870 (3 subjects per config.)

In situ

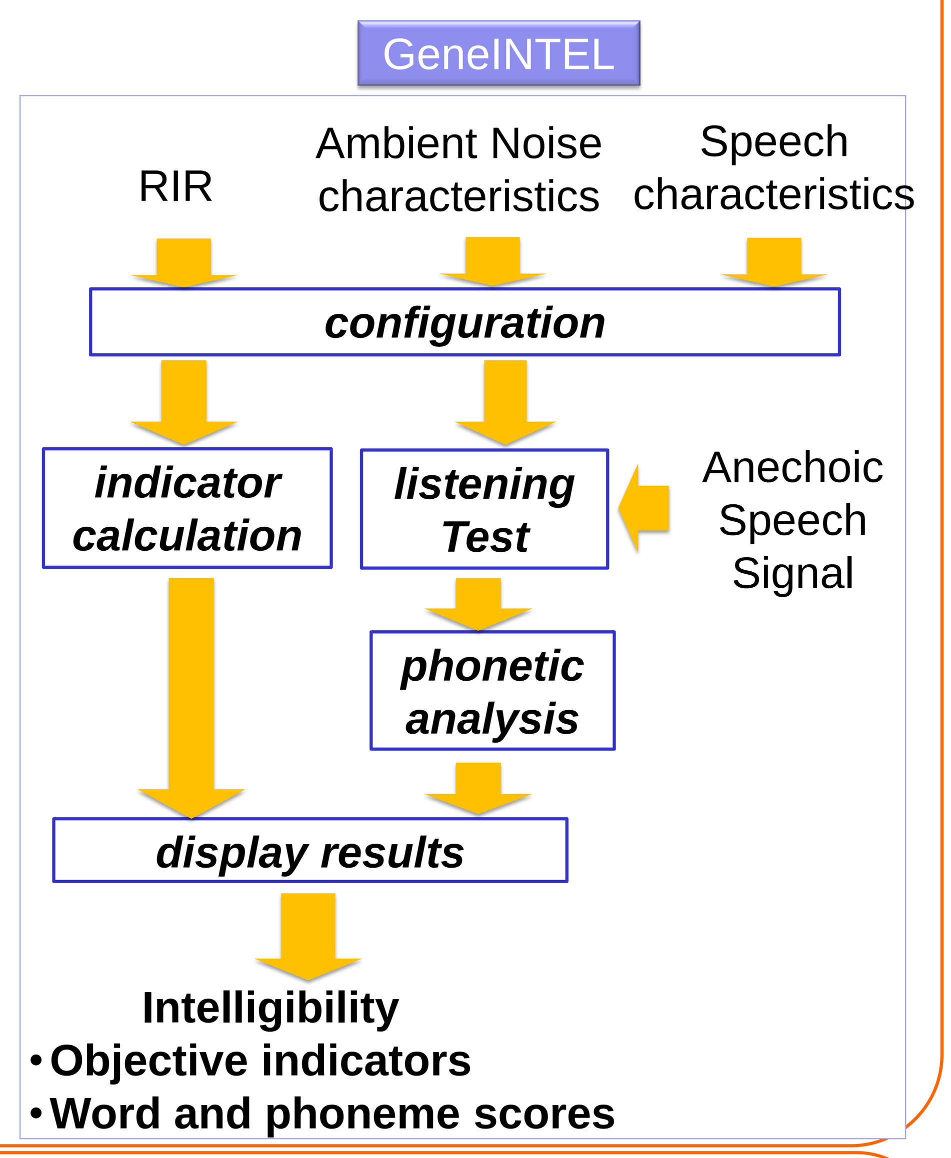
- The lists of anechoic recorded words mixed with stationary noise are rendered through the Public Address (PA) system in a given area.
- Subjects are located at a given position in the area and perform the intelligibility test.
- Room Impulse Responses (RIR), noise spectra and speech levels are measured to calculate intelligibility indicators.



In lab

Genesis software **GeneINTEL** is used to:

- Simulate real *in situ* listening conditions by convolution of anechoic speech signals with the RIR, mixed with recorded or synthetized ambient noise
- Conduct intelligibility tests with headphones
- Automatically provide a phonetic transcription of orthographic answers
- Calculate the mean and standard deviation of word and phoneme scores for each configuration



TESTED CONFIGURATIONS

In situ

49 configurations corresponding to combinations of:
- Several listening positions in a reverberant room (650 m^3, RT_{1kHz}=2.8s)
- Several PA speaker models and configurations
- Broadband stationary noise played through the PA system at various SNR (between -6 and +17 dBA)

In lab

45 configurations corresponding to combinations of:
- RIR corresponding to 3 RATP areas with PA systems:
  - MI2N train (RT_{1kHz} = 0.5 s)
  - Vincennes RER Station (RT_{1kHz} = 1.7 s)
  - Ticket hall of station "Bibliothèque F. Mitterrand" (RT_{1kHz} = 4.6 s)
- 12 types of noise (from *in situ* measurements)
- 3 SNR (-5, 0 and +10 dBA)

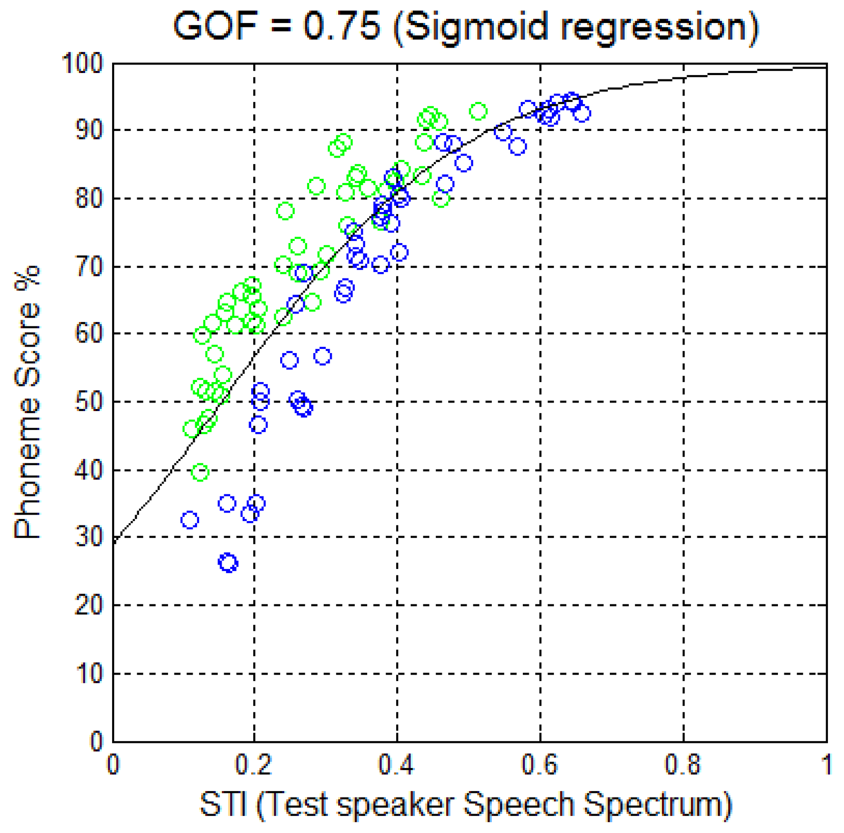
Only mono signals are used

RESULTS AND FURTHER WORKS

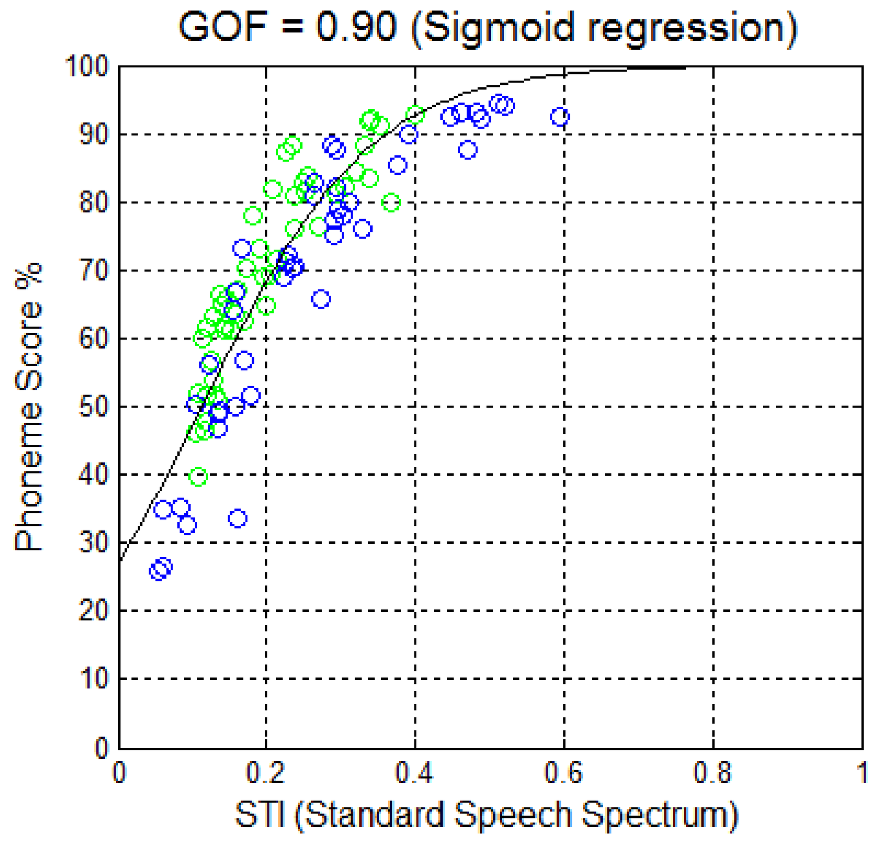
Comparison between mean scores of phonemes and various standardized or new objective indicators (STI, SII, U50, ….) for each type of test (sigmoid regression and Goodness Of Fit computation).

Comparison of STI results, based on either standardized or test speaker speech spectra.

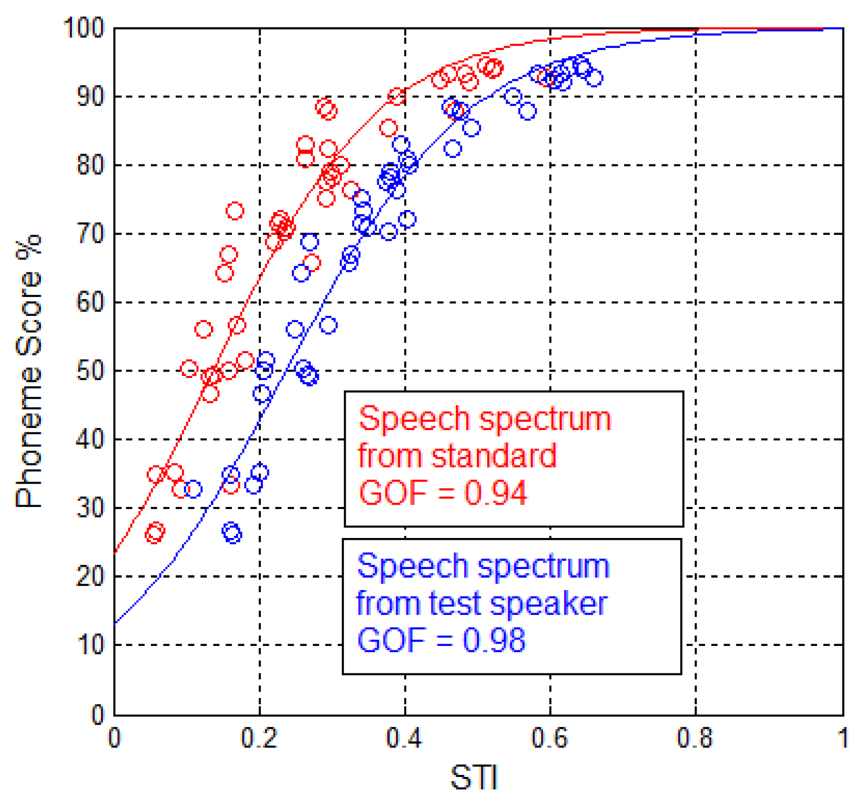
Speech spectrum of the test speaker
in situ and **in lab** results
GOF = 0.75 (Sigmoid regression)



IEC 60268-16 speech spectrum for men
in situ and **in lab** results
GOF = 0.90 (Sigmoid regression)



Speech spectrum of **IEC60268-16 standard** and **test speaker** (for in lab results only)



- By using auralisation and headphone rendering, GeneINTEL provides proper reproduction of *in situ* intelligibility test conditions in a controlled laboratory environment.
- As expected, the accuracy of STI is improved by using the spectrum of the test anechoic speech signals instead of standardized speech spectra. However, it introduces a small bias probably due to a bandwidth difference between in-lab and *in situ* experimental setup (to be confirmed).
- In a next step, existing indicators will be improved by taking into account temporal and spectral masking effects more accurately.
- Furthermore, the cocktail party effect for PA systems will be studied and added to the models.