



D1.2 - Protocol in-lab for the assessment of semi-confined space prototype by users: Subjective Intelligibility Measure “For All” & “Environmental” Design



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 ENEA : Italian National Agency for New Technologies, Energy, and Sustainable Economic Development
 TUM : Technische Universität München
 CRF : Centro Ricerca FIAT
 CENTICH : Centre d'Expertise National des Technologies de l'Information et de la Communication pour l'autonomie
 Active Audio,
 EPFL : Ecole Polytechnique de Lausanne – Lab. D'Electromagnétisme et d'Acoustique

D1.2

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D2.2	Executive Summary
<p>This report describe the protocol for intelligibility in-lab test that will be conducted at the EPFL. We propose two types of test: a “classic” test that is used to optimize and evaluate I’CityForAll algorithms and an “environmental” test that will be used to enlighten the difference between intelligibility for presbycusis and normal hearing persons in real simulated environment. The target population is composed of 40 persons with different hearing ability organized in four categories: normal hearing, slight hearing loss, moderate hearing loss and severe hearing loss. We measure the intelligibility as the percentage of recognized word per sentences. HINT database is used for the classic test and vocal announcements are used in the environmental test.</p> <p>Keywords: intelligibility, hearing impaired, protocol, for all, environmental.</p>	

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4	Review	CENTICH	15/07/2014
5	Approved		

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Subjective Intelligibility Measure

“For All” & “Environmental” Design

I. Definitions

Subjective test: based on human perception.

Intelligibility score: recognized words per sentence or list of words (in %).

“For All”: designed for all means that we take into consideration the specifications of the target population: normal hearing (NH) persons, hearing impaired (HI) persons, age, gender.

“Environmental”: Environmental design means that we reproduce real situations for the test: acoustic degradation, listening conditions, choice of sentences, ambient noise.

II. Aim of the test

The test is designed to achieve two goals:

- Evaluation of two I'CityForAll algorithms: objective measure of intelligibility and intelligibility enhancement algorithms.
- Evaluation of intelligibility loss in real situations (Environmental) for NH and HI persons.

III. Test plan

The test is composed of two parts:

1. The first part is the Environmental test: we use real railway station announcements, real noise and real room impulse responses. The goal of this test is to compare intelligibility of NH and HI persons in real situations: vocal announcements, real environment noise, real reverberation, railway station loudspeakers.
2. The second part is the classic test: we use phonetically balanced lists of sentences to evaluate the intelligibility enhancement algorithms with headphones.

Both parts will be conducted according to the same procedure:

1. The test-subject is asked to repeat the heard sentences or vocal announcements.
2. After each sentence, the technician stops the audio file in order to let time for the subject to repeat the sentence. The technician underlines the correctly recognized words in the sentence.
3. The whole test-session for each test-person is recorded on a digital device for later processing.

Note that the classic test will be conducted using headphones and the environmental test will use loudspeakers.

IV. Target population:

Subjects taking part in the intelligibility test should be naive: they have no knowledge about the intelligibility test procedure and the used speech material.

Panel distribution:

- Number: 40 subjects.
- Age: the sample of the test-subjects will be redressed according to European population distribution.
- Categories: the cohort should follow these categories for both presbycusis and paired persons (with or without hearing aids):
 - o Normal hearing: $dBHL < 25$ equivalent to $\%HL < 10\%$
 - o Slight hearing loss: $26 < dBHL < 40$ equivalent to $10\% < \%HL < 29\%$
 - o Moderate hearing loss: $41 < dBHL < 60$ equivalent to $30\% < \%HL < 62\%$
 - o Severe hearing loss: $61 < dBHL < 80$ equivalent to $63\% < \%HL < 91\%$
- Gender: 50% male, 50% female
- Hearing: otologically normal person with age related hearing loss (**ISO 7029:2000**)

Each subject should undergo an audiometric test. The audiogram of the subject should match his age according to ISO 7029¹ (slope hearing loss). The deduced categories from audiogram undergo two types of classification:

- dBHL: average hearing loss in dB (used by WHO organization²)
- %HL: percentage of hearing loss is weighted hearing loss measure based on the absolute reception threshold of intelligibility (used by Council on Physical Therapy and the Section on Laryngology, Otology and Rhinology³)

Note: the I'CityForAll project is focusing on presbycusis related hearing loss. The project is not concerned with hearing loss related to diseases or high noise exposure. The audiometric test should be provided for each person.

¹ ISO 7029(2000): Acoustics -- Statistical distribution of hearing thresholds as a function of age.

² Colin Mathers, Andrew Smith, Marisol Concha. Global burden of hearing loss in the year 2000. WHO Report.

³ Fowler EP, Sabine PE. Tentative standard procedure for evaluating the percentage loss of hearing in medicolegal cases. JAMA 1947;133(5):396-397

V. Clean speech material

We use different types of speech material:

- a. HINT database (classic test): 5 phonetically balanced lists with 20 sentences each (Appendix 1). The duration of a list is 2 minutes. In the case of French HINT database, the talker is a man. If it is possible, the HINT sentences should be provided with male and female voices.
- b. Vocal announcements of railway station provided by SNCF (France) read by a woman (Simone).

The test sequences are composed of two sentences separated by 0.5s of silence. The sequence starts and ends with 0.5s of silence as shown on figure 1. Each sequence is degraded according to a different test condition (reverberation and noise) and will be randomly presented to the listener.

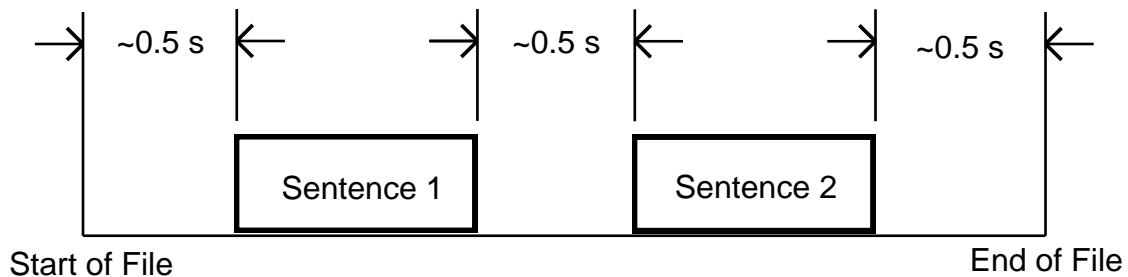


Figure 1: sequence composition [ITU-T Q7/C12]⁴

VI. Degraded speech material

1. Acoustic distortions :
 - a. Reverberation: clean sentences are convolved with room impulse responses (RIR) to obtain reverberated speech.
 - i. Classic test: the RIR are generated with image source model [Lehman2008]⁵ of railway stations with different reverberation times (TR60). This step will be carried out in-lab with Matlab.
 - ii. Environmental test: we use real measured RIR in railway station.
 - b. Noise: we add noise at different SNR.

⁴ Q7/12 Rapporteurs, « T09-SG12-100518-TD-GEN-0281_Handbook of subjective testing practical procedures », UIT-T SG12 Q7/12, Mai 2010.

⁵ E. Lehmann and A. Johansson, Prediction of energy decay in room impulse responses simulated with an image-source model, Journal of the Acoustical Society of America, vol. 124(1), pp. 269-277, July 2008.

- i. Classic test: we add babble noise.
- ii. Environmental test: we add railway station noise provided by SNCF.

2. Degradation procedure (see tables 1 and 2):

- We have 5 HINT lists: each list contains 20 sentences. We use one test condition for each 2 sentences. A test condition consists in an acoustic distortion with noise and reverberation.
- When we use one list of HINT, we cover all the phonetic balance of the language and 10 test conditions.
- One list of HINT database lasts 2 minutes. If we let 2 minutes to the subject to repeat the sentences of each list, the HINT test will last **20 minutes minimum**.

3. I'CityForAll Speech enhancement:

We use the pre-compensation algorithm developed at CEA-LinkLab to enhance the clean speech before degradation. The goal of the test is to choose the best level of pre-compensation through the subjective evaluation of intelligibility and global sound level.

Table 1: Degradation plan

Hint List	List 1	List 2	List 3	List 4	List 5
Enhancement (pre-comp)	Without enhancement		Frequency pre-compensation Level 1	Frequency pre-compensation Level 2	Frequency pre-compensation Level 3
Distortion	Acoustic Distortion (noise+reverberation)				
Nb test cond.	20 test conditions		10 test conditions	10 test conditions	10 test conditions
Note	The 20 conditions should cover the possible SNR and RT60 in the railway station.		The 10 conditions are chosen from the 20 conditions of Lists 1 and 2 in order to measure the contribution of each Pre-compensation filter. The conditions are the same for the lists 3, 4 and 5.		

How to choose the 20 conditions?

We know from previous tests (CENTICH/CERTA) that noise results in higher intelligibility degradation than reverberation. Besides, the intelligibility change from 0% to 100% of correct recognition occurs for a different SNR range for HI compared to NH as illustrated in figure 2 (approximately between [-15;-5] dB for NH and [-5;15] dB for HI).

Hence, we choose:

- More values of SNR than values of TR60.
- SNR values that cover the entire range of %C for NH and HI.
- TR60 values should correspond to real railway station impulse response.⁶
- $nSNR \times nTR60 = 20$ conditions.

The 20 test conditions are summarized in table 2.

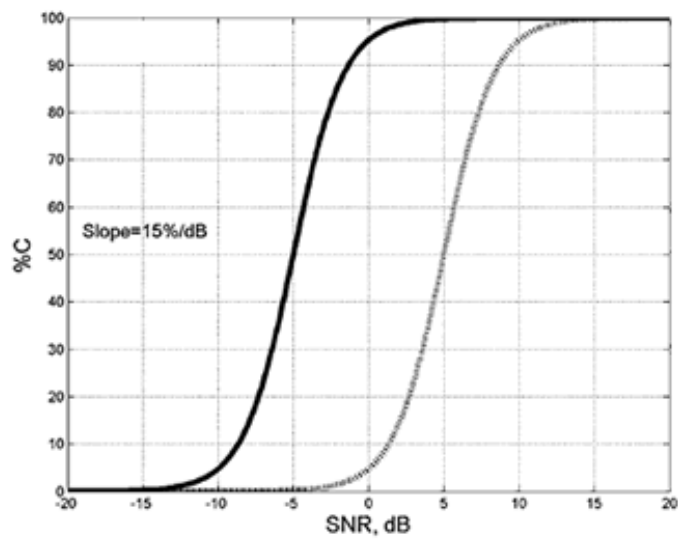


Figure 2: Word recognition performance in percent correct as a function of SNR. Solid line represents the performance of a patient with a 0 dB hearing loss for speech-in-noise, dotted line represents the performance for a patient with a 10 dB loss.⁷

Table 2: Test conditions for HINT test. The hatched and yellow cells are the 20 conditions proposed for the test. The yellow cells are the 10 conditions proposed for lists 3, 4 and 5. Note that the red cell condition is not taken into account.

	TR60=0.5 s	TR60=2 s	TR60=4 s
SNR=-8 dB			
SNR=-6 dB			
SNR=-4 dB			
SNR=-2 dB			
SNR=0 dB			
SNR=2 dB			
SNR=4dB			

⁶ N. Remy, "Maitrise et prédiction de la qualité sonore du projet architectural: Application aux espaces publics en gare", PhD Thesis, CRESSON, 2001.
⁷ Schuknecht, H. F. (1992). Disorders of Aging in Pathology of the Ear. Cambridge, Harvard University Press.

3. Vocal announcements database:

- 8 vocal announcements provided by SNCF.
- The vocal announcements can be difficult to repeat given their length.
- The 8 sequences last 1 min so we can carry out the test with vocal announcements in 2 or 3 minutes.
- The vocal announcements are distorted with an SNR=10dB and a real measured RIR with:
 - o Sample Rate: 44.1 kHz
 - o Number of Channels: 2
 - o Bits per Sample: 16
 - o Duration: 8.03 s
 - o File Size: 1.35 MB
 - o File Format: wav Source Sound: Starter's pistol
 - o Microphone: AKG451 pair, XY
 - o Source Location: Hall center
 - o Microphone Location: Center front of Hall
 - o Source Receiver Distance (m): 6 m
 - o Source Height: 2 m
 - o Receiver Height: 1.5 m
 - o RT60: 4.11s, EDT: 4.22s, D50: 0.10, C50: -9.57dB, C80: -6.71dB

VII. Equipment and environment

Listening room characteristics:

- Noise level : <30dB(A)
- Reverberation time : TR60<0.5s
- Diffusing level: 75 Leq

Equipment:

- Headphone: THD<0.1% (1KHz, 100dB)
- Loudspeakers: one to play the announcement (railway station loudspeaker) and one to play ambient noise (omni-directional loudspeaker)
- Sound card: SNR>100 dB
- PC
- Sound level meter
- HATS for calibration

Annex: Informed Consent delivered in Switzerland

Formulaire de consentement

Je soussigné(e) Mme/M, certifie avoir parfaitement pris connaissance du contenu du présent formulaire et avoir été informé de la nature et des objectifs de cette étude.

J'atteste avoir eu la possibilité de poser toutes les questions que je souhaitais à l'évaluateur de l'étude.

Je comprends les conditions de ma participation à cette étude.

En particulier, je comprends que j'ai la possibilité de ne pas participer à cette évaluation et que malgré mon accord à participer, j'ai le droit de refuser de répondre à certaines des questions qui me seront posées lors des entretiens et mises en situations prévues sans avoir à fournir d'explications.

Je comprends que toutes les données enregistrées au cours de ce test seront utilisées dans le cadre de la recherche scientifique.

Je peux à tout moment interrompre ma participation en concertation avec l'évaluateur de l'étude.

Fait à, le

Signature, précédée de la mention « lu et approuvé »