D1.5 – Assessment in-vivo of the semi-confined space prototype by users In Nantes

Project acronym	I'CityForAll
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Project Duration:	July, 1st 2012 – Dec, 31th 2015 (42 months)
Co-ordinator:	CEA: Commissariat à l'Energie Atomique et aux Energies Alternatives
Partners:	UPD: Université Paris Descartes
	ENEA: Agenzia Nazionale per le Nuove tecnologie, l'EnergiA e lo sviluppo economico sostenibile
	TUM: Technische Universität München
	CRF: Centro Ricerche FIAT
	CENTICH: Centre d'Expertise National des Technologies de l'Information et de la Communication pour l'autonomie
	Active Audio

D1.5

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Once completed please e-mail to WP leader with a copy to

sylvie.ghalila@cea.fr

D1.5	Executive Summary
This report describes the protocol for intelligibility in-vivo tests that took place at the shed of Nantes (France). We proposed to evaluate the efficiency of the technology plug into the loudspeakers on understanding the vocal announcements in the railway stations. We used two kinds of evaluations: the percentage of spaces completed per sentence and the level of sound quality for each vocal announcements. The target population is composed of 46 persons with different hearing ability. They are coming from France. Three groups were established: normal hearing, presbycusis without hearing aid and presbycusis with hearing aid. There are 65 persons coming from the first step (The survey step I - Users' requirements evaluation report – Task 1.1-1.4). We conducted two tests sessions. Both sessions had different gains (insufficient diffusion level at the first session). The groups have been redrafted to have consistent groups in those analyzes (exclusion people or change of group). The analysis was made by removing the variable "long reverberation." The best configuration "For All" (three groups) is as follows: Ps-SNR-Prebsy-Conform. This solution should be tested in Foggia (Italian tests) and following the recommendations identified in this study. **Keywords**: intelligibility, hearing impaired, protocol, for all, environmental, railway station, test in-vivo	

Dissemination Level of this deliverable (*Source: I'CityForAll Technical Annex p20 & 22*)	
U	Public
Nature of this deliverable (*Source: I'CityForAll Technical Annex p20 & 22***)**	
	Report *Even a demonstrator or a prototype shall be accompanied with a report, or which basic structure is explained on page 3.*

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	1.0	Sylvie GHALILA, CEA-Linklab	

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1	Prepared	Mercier.C CENTICH	
2	Approved		
3	Released		

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Summary

I. Population (French)

This study involved 46 participants from France. Among these 46 people: 17 persons are from "normal hearing" group, 12 persons are from "presbycousis with hearing aid" group and 17 persons are from "presbycousis without hearing aid" group. The following table shows the proportions of the groups.

Groups	France
Normal hearing	17
Presby. Without HA[1]	17
Presby. With HA	12
TOTAL	**46**

Table 1: The Group compositions of persons involved.

	France (average age)
Normal hearing	60.35
Presbycousis with hearing aids	67.42
Presbycousis without hearing aids	64.45
TOTAL	63.78

Table 2: Age average of participants according the group.

II. Objective of the tests

The tests aim to assess the I'CityForall intelligibility solution proposed in the deliverables D2.4[2] and D2.5[3]. The algorithms to be tested are:

1. Speech Conformer: an algorithm developed by Active Audio to enhance voice messages intelligibility when broadcast.

2. AGC[forAll]: an algorithm developed by CEA-LinkLab to enhance the speech intelligibility for all (normal hearing and presbycusis persons). It includes two modules:

- Pre-compensation filter dedicated to the correction of age related frequency hearing loss.

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[1] HA = « Hearing Aid »

[2] CEA-LinkLab (2014)."D2.4- Software:3 kinds of parameterized software, needed for WP3 and WP4", Deliverable report, I'City For All project.

[3] CEA-LinkLab (2014)."D2.5- Software: revised version of D2.4", Deliverable report, I'City For All project.

The second level of pre-compensation is chosen for these tests.

- UDR based AGC: an automatic gain control system for the adjustment of the diffusion level regarding ambient noise and reverberation levels and including an auditory recruitment constraint.

III. Method Used

The 62 people from the first phase (The survey step I - Users' requirements evaluation report) were contacted by the CENTICH in order to participate in the second phase of the study (In-vivo test in the Nantes' shed). New participants were recruited, in France, with the help of Bucodes Company[4].

The meeting was given by the CENTICH in order to go to the shed at Nantes (Premises of Active Audio). The CENTICH is in Angers. The travel was long of one hour by car. The CENTICH has organized 6 sessions of tests so 6 travels to Nantes with people. The number of participants depended of their availabilities.

Once there, in the premises of Active Audio, people were invited to take a coffee / tea. The professionals explained the project "I City For All" to them. Afterwards, participants were asked to go to the shed in order to realize the test. Before starting, instructions were given to the group.

Then the questionnaire was distributed to all people (appendix 3). The participants had to complete 4 blanks: number of train, destination of the train, departure of the train and number of the dock in the railway station. The 32 vocal announcements were played one time to complete the first line (number of train, destination of the train, departure of the train and number of the dock in the railway station). The 32 vocal announcements were played a second time to modify the information heard according the first listening (number of train, destination of the train, departure of the train and number of the dock in the railway station). Furthermore, during the second listening, people had to complete a scale of comfort (5= Excellent; 1= Bad). The 32 vocal announcements were played with a break between every 8 vocal announcements. The professionals were attentive to the welfare of people. One man testified difficulty and could not stay in the test room so he was evacuated.

At the end, people were thanked and were prayed to follow the professionals CENTICH to go back to Angers. The people who came by themselves (car, train, etc.) were reimbursed.

IV. Test layout

The text below describes the setup used for the listening tests conducted at Active Audio within the I'CityForAll project, in March and April 2015.

Author: Xavier Meynial – April 6th 2015

The test sessions took place in a large hall, in the premises of Active Audio.

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[4] http://www.surdifrance.org/

The hall is shown on pictures (Appendix 1). These pictures were taken during test sessions. The floor dimension is approx. 60 m x 20 m, and the height is 6 m in the middle axis, and 4 m on the sides.

The reverberation time was measured in octave bands. It can be seen on Figure 1 that the mid-frequency value is approximately 2.4 sec.
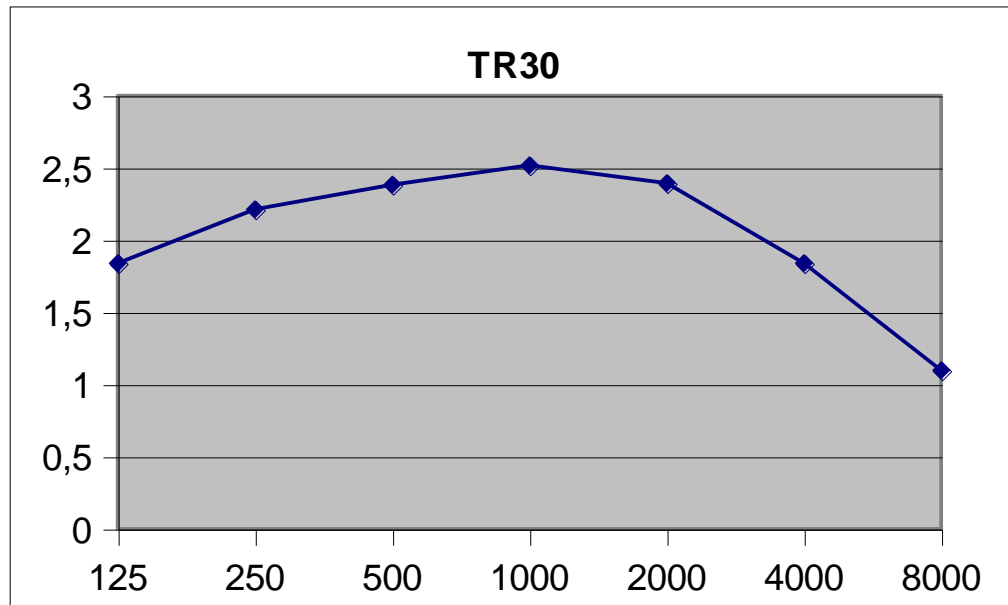

Figure 1: Reverberation Time (RT) measured in the hall, per octave bands.

The test setup is described on Figure 2. Three sound systems were used:

- One for restitution of the background noise. Six passive 2-way speakers (ref RS120) were placed around the listening zone, turned opposite the listening zone, generating a diffuse field.

- A distributed sound system for playing the Vocal Announcements. It is composed of 8 standard wideband "Sound Projectors" (Rondson 165TRC) positioned around the users. This system is referred to as "DS" in the following.

- A centralized sound system using Line-Arrays for playing the Vocal Announcements. This system uses two 1-meter column loudspeakers ref R100 (see www.activeaudio.fr). The two columns are equalized as recommended by the manufacturer. They operate in mono mode (they play the same signal). The 2 columns are placed on the same side of the listening area. This system is referred to as "LA" in the following.
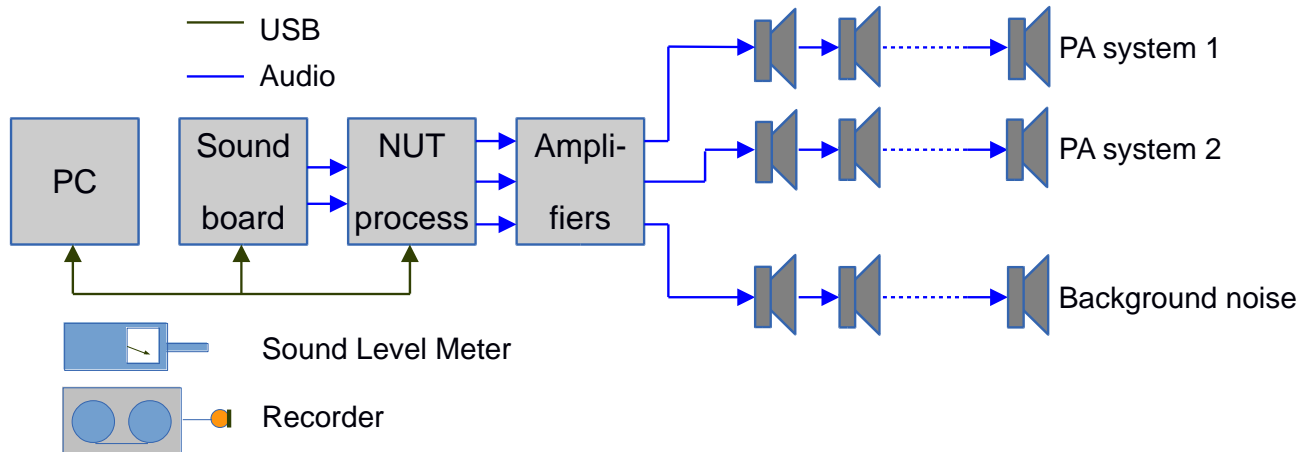
Figure 2: Test setup.

Figure 3 shows the 1/3rd octave frequency response of the six RS120, the eight Sound projectors, and the two R100. It is an average over the listening zone.
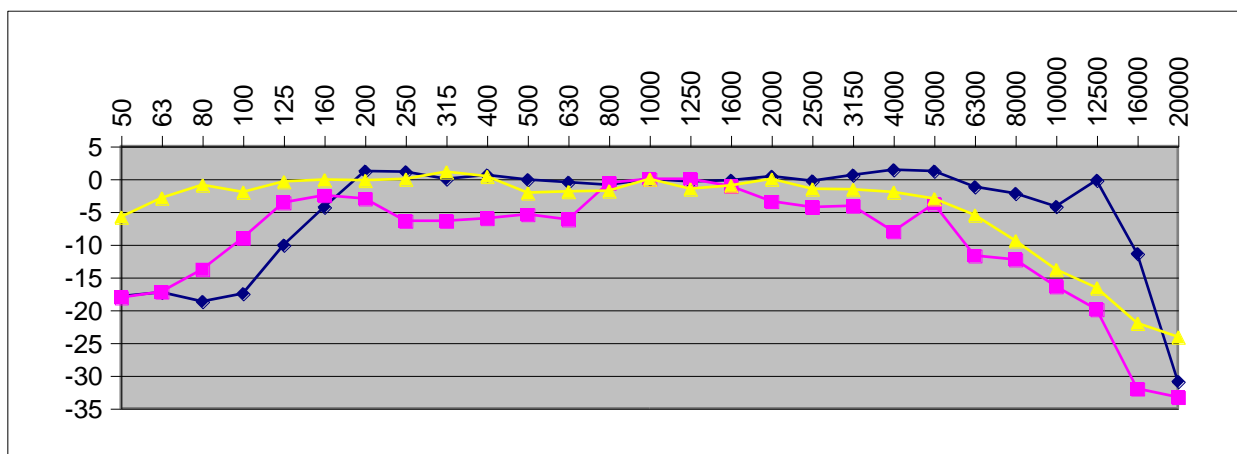

Figure 3: 1/3rd octave frequency response of the six RS120 (yellow), the eight SP (pink), and the two R100 (blue), averaged over the listening zone. All curves normalized to their 1kHz value.

1. Tuning of the speakers

After the three sound systems were equalized, the homogeneity of the sound coverage was verified with wideband SLM measurements. The coverage of all three sound systems was found to be correct, with standard deviations of the order of +/-1dB.

NB: The coverage of the RS120 system and the DS system is homogeneous because they generate essentially diffuse field over the listening zone, since they are numerous and essentially non-directional.

The LA system generates a strong direct sound. The homogeneous coverage is achieved thanks to the control of the directivity of the columns.

2. Preparation of noise and Vocal Announcements

We chose to record the treated announces in advance and then play them during the test. This has been judged preferable to an actual real time processing, since it would have been very difficult to switch from one set of filtering parameters to another at each Vocal Announcements.

The 32 announces have the format of a typical train departure announcement. French language was used; since all subjects are native French speakers.

The format of a Vocal Announcement is:

"Le train numéro NNNN à destination de DDDD, départ HH:MM, partira voie VV"

NNNN is a 4 digit number

HH is a 2 digit number, and MM a 2 digit number

VV is a 2 digit number

DDDD are 32 stations having short names.

A five second blank was inserted between the destination DDDD and "départ..." in order to give time for the subjects to fill in the NNNN and DDDD fields in the questionnaire.

The Vocal Announcements were processed using both the NUT processor and Matlab, and stored as *.wav files.

For simulating a **longer reverb** than the natural reverb of the hall (figure 1), some Vocal Announcements were convolved with a long electronic reverb. The RT resulting from the convolution of this electronic reverb with the acoustic reverb of the hall is shown on figure 4. The mid-frequency value is 4.5 sec.
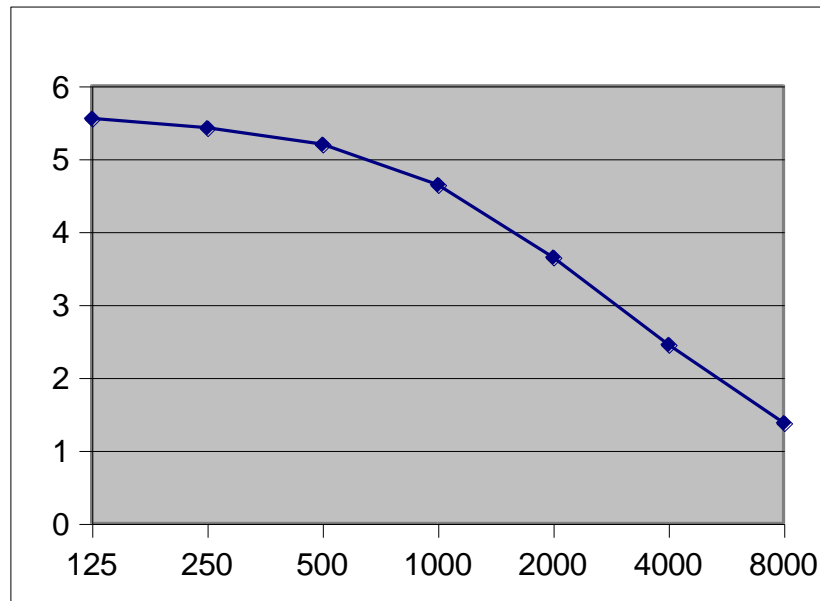
Figure 4: Reverberation Time achieved when convolving electronic and acoustic reverbs.

Two levels of **background noise** are considered:

- 70 dBSPL, corresponding to a moderate level that can be encountered in "semi-quiet" periods,

- 80 dBSPL, corresponding to the rush hour in a large railway station.

An excerpt of a recording, realised at the Montparnasse railway station in Paris, on a Wednesday around 4 pm was used. This excerpt was chosen so that the sound level is very constant. The 1/3rd octave spectrum of this noise, averaged over the listening area, is shown on figure 5.
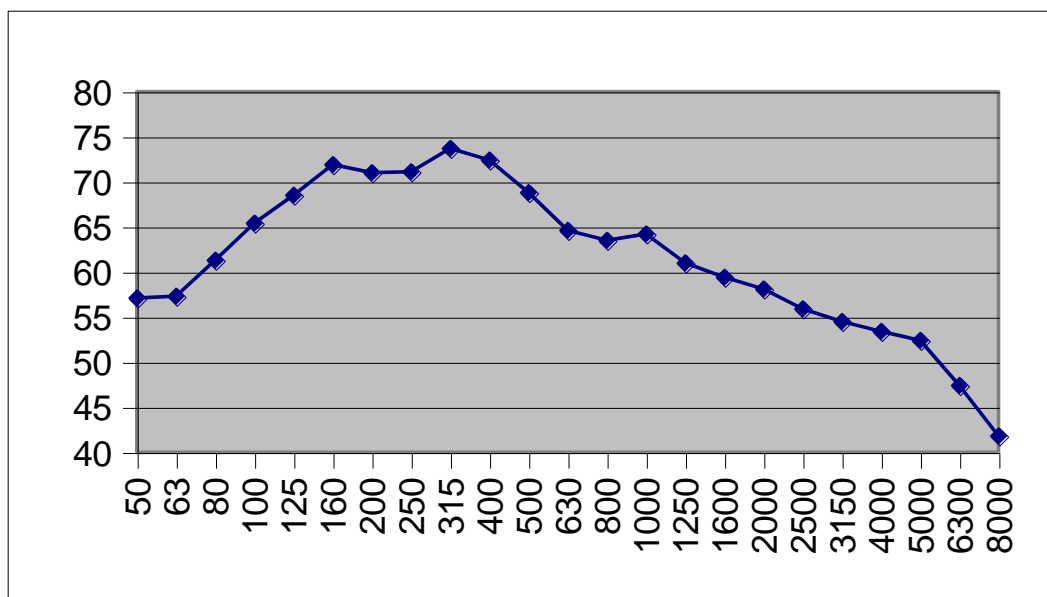

Figure 5: Third-octave spectrum (in dBSPL) of the noise, averaged over the listening zone.

V. Experience plan

The 32 announces are:

- 16 announces recorded by SNCF for the I'City project. The speaker is the female voice ("Simone") used by SNCF in the entire automatic announcement systems. It is a "professional" voice, highly trained, with a clear timbre, a good articulation, and a constant flow.

- 16 male announces were recorded by Active Audio. The speaker is a nonprofessional person. The timbre is more bass, the flow and articulation less regular.

Therefore, we have two very different voices, the female one being obviously easier to understand.

For the 16 Vocal Announcements using the UDR based AGC (called AGC_UDR), the level of the vocal announcements' diffusion was set according to the specification of Linklab.

For the remaining 16 Vocal Announcements, the level of diffusion was set according to a specified Signal-to-Noise Ratio (SNR).

Other 2 parameters identifying each Vocal Announcements are:

- Conformer ON / OFF

- presbycousis compensation ON / OFF

The speech Conformer was set on "Standard", which means the target spectrum is the normalized female voice spectrum of standard CEI-268-16.

The Presbyacusis compensation used is between the 40 years and the 50 years corrections, as can be seen on figure 6. It has a maximum at 5.5 kHz, and then decreases, so that sibilant consonants are less annoying than what is obtained with the plateau above 8kHz of the blue curves.
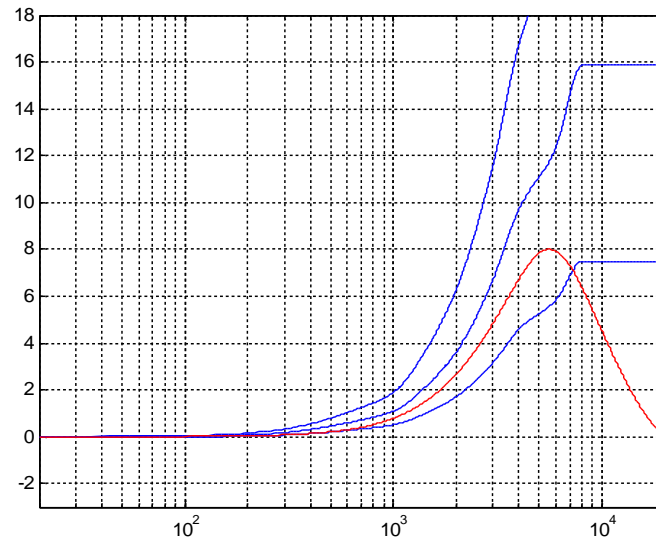
Figure 6: Frequency response of the presbyacusis compensation (in dB). Blue curves, from bottom to top: corrections corresponding to 40, 50, and 60 years. Red curve: Compensation used in the tests.

So, each combination is identified by a set of 6 parameters:

- Speaker (Male / Female)

- Level of noise (Low / High)

- Reverb (Mid / High)

- Level of Diffusion (SNR / UDR),

- Conformer ON / OFF

- presbycousis compensation ON / OFF.

A 7th parameter is the PA system used for diffusion: SP / LA.

Table 3 gives the set of parameters corresponding to each Vocal Announcements.

VA#	Speaker	PA system	Reverb	Bckgrnd noise	Gain according	Conformer	Presby	Noise level (dB)	Level VA Sessions 1 and 2	Level VA Sessions 3, 4, 5	SNR
1	F	DS	Middle	Moderate	SNR	OFF	OFF	70	75	75	5
2	F	DS	Middle	Moderate	SNR	OFF	ON	70	75	75	5
3	F	DS	Middle	Moderate	SNR	ON	OFF	70	75	75	5
4	F	DS	Middle	Moderate	SNR	ON	ON	70	75	75	5
5	M	LA	Middle	Moderate	UDR	OFF	OFF	70	78,5	78,5	8,5
6	M	LA	Middle	Moderate	UDR	OFF	ON	70	78,5	78,5	8,5
7	M	LA	Middle	Moderate	UDR	ON	OFF	70	78,5	78,5	8,5
8	M	LA	Middle	Moderate	UDR	ON	ON	70	78,5	78,5	8,5
9	M	DS	Long	Moderate	UDR	OFF	OFF	70	72	75,5	2
10	M	DS	Long	Moderate	UDR	OFF	ON	70	72	75,5	2
11	M	DS	Long	Moderate	UDR	ON	OFF	70	72	75,5	2
12	M	DS	Long	Moderate	UDR	ON	ON	70	72	75,5	2
13	F	LA	Long	Moderate	SNR	OFF	OFF	70	75	78,5	5
14	F	LA	Long	Moderate	SNR	OFF	ON	70	75	78,5	5
15	F	LA	Long	Moderate	SNR	ON	OFF	70	75	78,5	5
16	F	LA	Long	Moderate	SNR	ON	ON	70	75	78,5	5
17	F	DS	Middle	High	UDR	OFF	OFF	80	89	89	9
18	F	DS	Middle	High	UDR	OFF	ON	80	89	89	9
19	F	DS	Middle	High	UDR	ON	OFF	80	89	89	9
20	F	DS	Middle	High	UDR	ON	ON	80	89	89	9
21	M	LA	Middle	High	SNR	OFF	OFF	80	85	85	5
22	M	LA	Middle	High	SNR	OFF	ON	80	85	85	5
23	M	LA	Middle	High	SNR	ON	OFF	80	85	85	5
24	M	LA	Middle	High	SNR	ON	ON	80	85	85	5
25	M	DS	Long	High	SNR	OFF	OFF	80	85	88	5
26	M	DS	Long	High	SNR	OFF	ON	80	85	88	5
27	M	DS	Long	High	SNR	ON	OFF	80	85	88	5
28	M	DS	Long	High	SNR	ON	ON	80	85	88	5
29	F	LA	Long	High	UDR	OFF	OFF	80	83	86	3
30	F	LA	Long	High	UDR	OFF	ON	80	83	86	3
31	F	LA	Long	High	UDR	ON	OFF	80	83	86	3
32	F	LA	Long	High	UDR	ON	ON	80	83	86	3

Table 3: Set of parameters corresponding to each of the 32 Vocal Announcements.

Recordings

Sessions 2, 3, 4, 5, and 6 were recorded with a Zoom H2 recorder.

The directivity of the recorder was set on "2 ch surround" (2 cardioid patterns) pointing towards the nearest LA speaker. The capsule was at height 1.20 m.

Summing the 2 channels of the recording yields an omnidirectional pattern.

Geometric data

Figure 7 gives the:

- Loudspeaker positions

- Listening positions

- Recording positions

Figure 7: Coordinates of loudspeakers, listening points, and recording points.
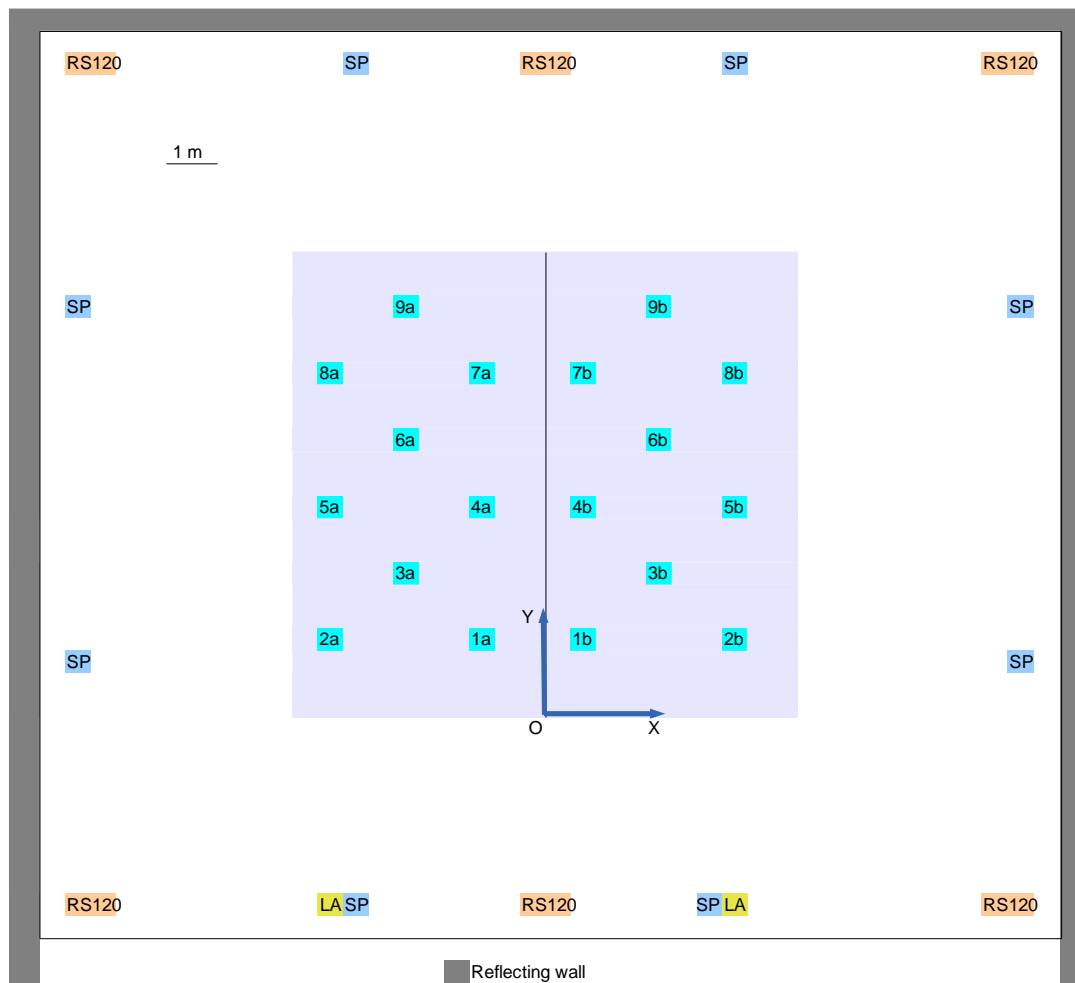
N°	X (m)	Y (m)
1	+/- 1,25	1,5
2	+/- 3,75	1,5
3	+/- 2,5	3
4	+/- 1,25	4,5
5	+/- 3,75	4,5
6	+/- 2,5	6
7	+/- 1,25	7,5
8	+/- 3,75	7,5
9	+/- 2,5	9

Listening points coordinates

	X (m)	Y (m)
SP	+/- 3,80	-3,50
	+/- 8,80	1,00
	+/- 8,80	9,00
	+/- 3,80	13,50
LA	+/- 3,50	-3,50
RS120	0	-4,00
	0	14,00
	+/- 9,00	-3,50
	+/- 9,00	-13,50

Loudspeaker coordinates

Session	X (m)	Y (m)
March 30 pm	-4,00	1,50
March 31 am	-4,00	6,00
March 31 pm	-0,50	5,50
April 4th am	- 2,50	6,00

Recording points

VI. Analysis method and Results

a. Gain update during the experimentations

The tests were carried in two sessions regarding the gain values. At the beginning of the first session of the tests (G1), diffusion level was insufficient, so we added few dB to the gain values. Since we didn't perceive any improvement, we came back to the initial gain values at G2.

Session	Number of participants	Participants involved in CENTICH tests
G1: 30/03/2015	18	2 impaired
G2: 31/03/2015 04/04/2015 07/04/2015	26	3 impaired

Table 4: Two sessions of tests

Eight configurations were modified in the following table. Indeed, the gain values changed between G1 and G2 according to those eight configurations.

Table 5: Table of experience plan.

b. Description of the cohort per session

1. Group 1: Session of 30/03/2015

One deaf man with one cochlear implant was not included in the study because his situation didn't reply to the exigence of the tests. One woman was classified as "normal hearing" person (74 years) was removed to another group as "presbycusis person". The next table shows the proportions of persons according their own hearing situation.

		Male*	Female	Total
Normal hearing		0	9	9
Hearing-impaired	With HA	2	1	3
	Without HA	1	5	6
Total		3	15	18

Table 6: Update of the population classification for the group 1.

2. Group 2: Session of 31/05/15, 04/04/15 and 07/04/15)

One deaf man with one cochlear implant chose to leave by himself the studybecause the test, for him, was too noisy. One woman was classified as "normal hearing" person (65 years) was removed to another group as "presbycusis person". The next table shows the proportions of persons according their own hearing situation.

		Male*	Female	Total
Normal hearing		1	5	6
Hearing-impaired	With HA	3	4	7
	Without HA	7	6	13
Total		11	15	26

Table 7: Update of the population classification for the group 2.

c. Synthetic reverberation configurations: to be excluded

1. Reasons for excluding the effect of long reverberation

The initial experience plan is composed of 32 combinations of altered reverberations: medium natural reverberation "RM" and long synthetic reverberation "RL". For the analysis of the tests results, only the test combinations relative to medium reverberation "RM" are considered.

Synthetic long reverberation is realized by convolving the VA with an impulse response before its diffusion:

- The directivity of the array loudspeakers (LA) is not well performing (better intelligibility scores are obtained with sound projectors)

- With the synthetic reverberation, early reverberation disappears, then the UDR based AGC calibration does not make sense.
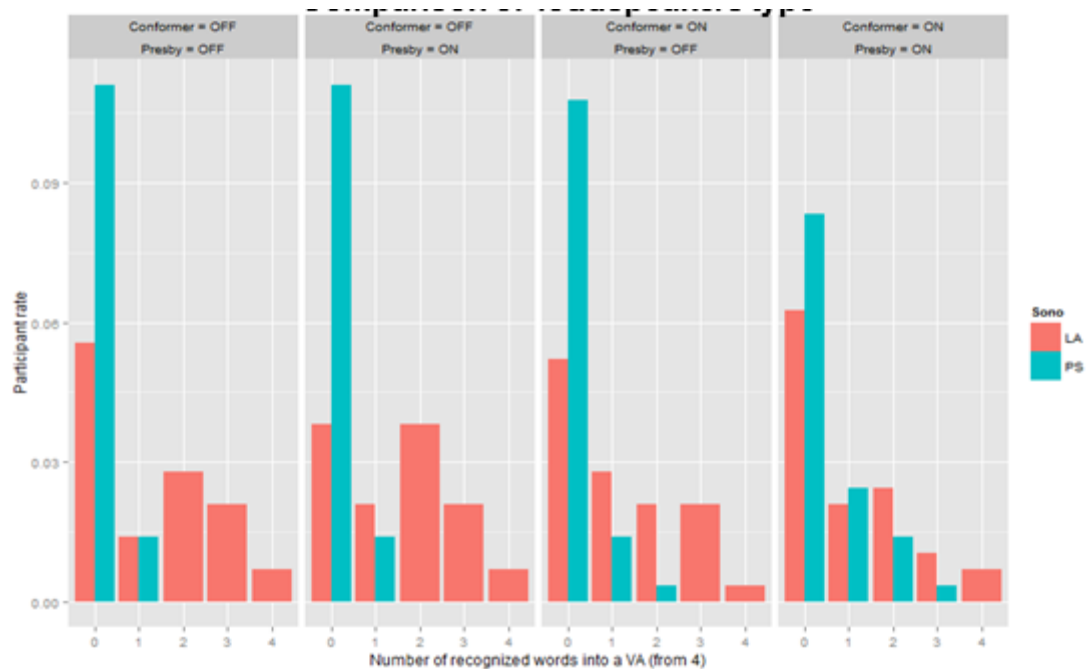
Graph 1: Intelligibility scores for long reverberation configurations. Comparison of loudspeakers type.

d. Summary of resulting tests: Cohort and intelligibility

The initial experience plan is composed of 32 combinations. The following analysis was treated with 16 configurations (without Long Reverberation and with Medium Reverberation).

		Male*	Female	Total
Normal hearing		1	16	17
Hearing-impaired	With HA	5	5	10
	Without HA	8	9	17
Total		14	30	44

Table 8: Total population of tests

The 16 configurations used for tests analysis and mean of their intelligibility							Intelligibility score between 0 and 1 0 => 0% words recognition 1 => 100% words recognition			SIM*forall* score (*)
Combinaison	Locuteur	Sono	Bruit	Gain	Conformer	Précomp	Presby_with HA	Presby_without HA	NH	NH
1	F	PS	BFA	SNR	OFF	OFF	0,505	0,831	0,986	0,341
2	F	PS	BFA	SNR	OFF	ON	0,601	0,870	1	0,379
3	F	PS	BFA	SNR	ON	OFF	0,369	0,838	1	0,339
4	F	PS	BFA	SNR	ON	ON	0,458	0,809	0,979	0,349
25	M	LA	BFA	UDR	OFF	OFF	0,410	0,660	0,694	0,355
26	M	LA	BFA	UDR	OFF	ON	0,494	0,729	0,861	0,364
27	M	LA	BFA	UDR	ON	OFF	0,482	0,810	0,972	0,366
28	M	LA	BFA	UDR	ON	ON	0,595	0,778	0,909	0,350
5	F	PS	BFO	UDR	OFF	OFF	0,589	0,791	0,951	0,390
6	F	PS	BFO	UDR	OFF	ON	0,666	0,921	0,979	0,397
7	F	PS	BFO	UDR	ON	OFF	0,785	0,911	0,979	0,361
8	F	PS	BFO	UDR	ON	ON	0,648	0,940	0,986	0,383
29	M	LA	BFO	SNR	OFF	OFF	0,589	0,823	0,916	0,338
30	M	LA	BFO	SNR	OFF	ON	0,738	0,942	0,986	0,330
31	M	LA	BFO	SNR	ON	OFF	0,827	0,801	0,965	0,319
32	M	LA	BFO	SNR	ON	ON	0,630	0,891	0,951	0,355
						Average	0,586	0,834	0,944	0,357

1st best score
2st best score
3rd best score

(*) SIM*forall* algorithm: Objective intelligibility measure for normal hearing and hearing impaired persons, developed in the I'CityForAll project (D2.3)

Table 9: Intelligibility score between 0 and 1 for the three groups.

The best scores, for the 16 vocal announcements, are not at the same level in all configurations for all three groups.

NH : Locuteur: F ; Sono: PS ; Noise : BFA ; Gain : SNR ; Conformer : ON or OFF ; Precomp : ON or OFF. - **Presby. Without HA** : Locuteur: M ; Sono: LA ; Noise : BFO ; Gain : SNR ; Conformer : OFF ; Precomp : ON.- **Presby. With HA** : Locuteur: M ; Sono: LA ; Noise : BFO ; Gain : SNR ; Conformer : ON ; Precomp : OFF.

e. Intelligibility scores statistical analysis

For barplots representation of intelligibility results, we use the two following measures:

For a given gain and algorithms configuration, for each k=0, 4

A. Intelligibility score =number of recognized words per VA

B. Participant rate recognizing k words: $\dfrac{Nb\ participants\ recognizing\ k\ words}{total\ Nb\ of\ participants}$

1. Variables of the study

- Three variables related to algorithms: Gain, Presby and Conformer.
- Four variables related to test conditions: Locuteur, Sono, Noise and Reverberation.
- The reverberation was set to RM and noise always decreases intelligibility.

Due to RM restriction, Sono and Locuteur have the same distribution. Indeed, all configurations of LA have one Male voice as locuteur and all configurations of PS have Female voice as Locuteur.

Therefore, we can only analyze the behavior of four following variables: Gain, Presby, Conformer and Sono. Furthermore, Sono will accumulate the effects of Sono and Locuteur.

2. Model description

Goal: Find the relevant factors into the four variables Gain, Presby, Conformer and Sono impacting the number of recognized words into vocal announcements (VA).

We suppose that Yi: number of correct words into a VA in configuration i=1..8, 25..32

Yi ~ Binomial (n, pi); With E (Yi) = n*pi with n=4 number of words to be recognized; pi: probability to recognize a word in configuration i

The model used fits binomial distribution with a logit link. The link function must map from $(0, 1) \rightarrow (-\infty, \infty)$. A common choice is logit (pi). Therefore, the result model is:

$$\log\left(\frac{pi}{1 - pi}\right) = a0\ +\ a1*\text{Gain}\ +\ a2*\text{Conformer}\ +\ a3*\text{Presby}\ +\ a4*\text{Sono}\ +\ a12$$
$$*\ \text{Gain:Conformer}\ +\ a14*\text{Gain:Sono}\ +\ a13*\text{Gain:Presby}\ +\ a23$$
$$*\ \text{Conformer:Presby}\ +\ a123*\text{Gain:Conformer:Presby}$$

<u>Rmk:</u> $\left(\frac{1}{a0}\right)$is the intercept of the model. For two variables X1 and X2, if X1=1-X2 then coef(X1)= - coef(X2). For example, GainSNR=1-GainUDR, therefore coef(GainUDR)=-Coef(GainSNR)

To fit the model, we use the iterative reweighted least squares[5] (IWLS). The AIC[6] criterion is used to select the most relevant variables in explaining the intelligibility score. This criterion deals with the trade-off between the goodness of fit of the model and the complexity of the model.

This model is estimated first for the three participant's classes (Normal, Presby with HA and Presby without HA) then for the whole participants.

To test the best configuration significance, we use the paired Wilcoxon test.

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[5] P. J. Green, Iteratively Reweighted Least Squares for Maximum Likelihood Estimation, and some Robust and Resistant Alternatives, Journal of the Royal Statistical Society. Series B (Methodological), Vol. 46, No. 2 (1984), pp. 149-192

[6] Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer, New York.

3. Model – Normal Hearing

> **Yi ~ GainUDR + ConformerON + PresbyON + SonoPs + GainUDR:ConformerON + GainUDR:SonoPs + GainUDR:PresbyON + ConformerON:PresbyON + GainUDR:ConformerON:PresbyON**

Conjoint interaction between Conformer ON*Presby ON decreases the intelligibility compared to their own effect alone. : **exp(coeff_ConformerON)*exp(coeff_PresbyON)=exp(0,1506+1,8564)=7,44** .

As PresbyON is a significant positive factor with high effect, thus for Normal class, PresbyON has to be preferred to the interaction ConformerON and PresbyON.

Higher the model coefficient is, more the distribution is shifted to higher number of recognized words (right side).

Graph10: Model normal hearing.

4. Model – Presbycusic with HA

> **Yi ~ GainUDR + ConformerON + PresbyON + SonoPs + GainUDR:ConformerON + GainUDR:SonoPs + GainUDR:PresbyON + ConformerON:PresbyON + GainON:ConformerON:PresbyON**

Conjoint interaction between GainUDR*SonoPs increases the intelligibility compared to their own effect alone: **exp(coeff_UDR)*exp(coeff_SonoPs)=exp(-0.8535 - 0.7020)=0.21.**
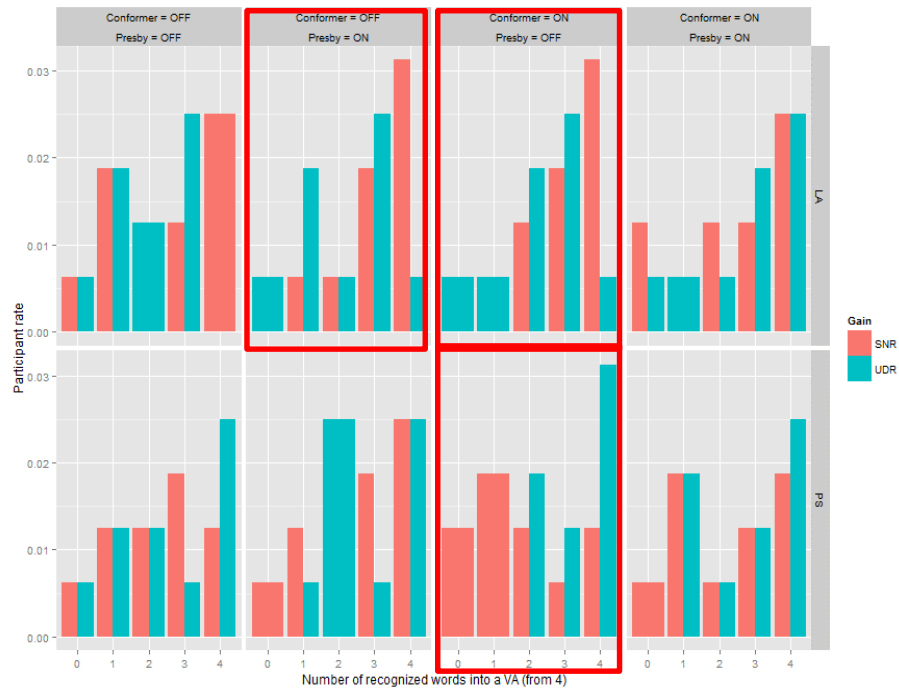
Graph11: Presbycusic with HA. Three best configurations.

5. Model – Presbycusic without HA

Yi ~ GainUDR + ConformerON + PresbyON + SonoPs + GainUDR:ConformerON + GainUDR:SonoPs + GainUDR:PresbyON + ConformerON:PresbyON + GainUDR:ConformerON:PresbyON

Conjoint interaction between Conformer ON*UDR increases the intelligibility compared to their own effect alone: **exp(coeff_ConformerON)*exp(coeff_UDR)= exp(0.12967 -0.90967)=0.46.**

Conjoint interaction between UDR*SonoPs increases the intelligibility compared to their own effect alone: **exp(coeff_UDR)*exp(coeff_SonoPs)=exp(-0.90967 -0.04993)=0.38.**
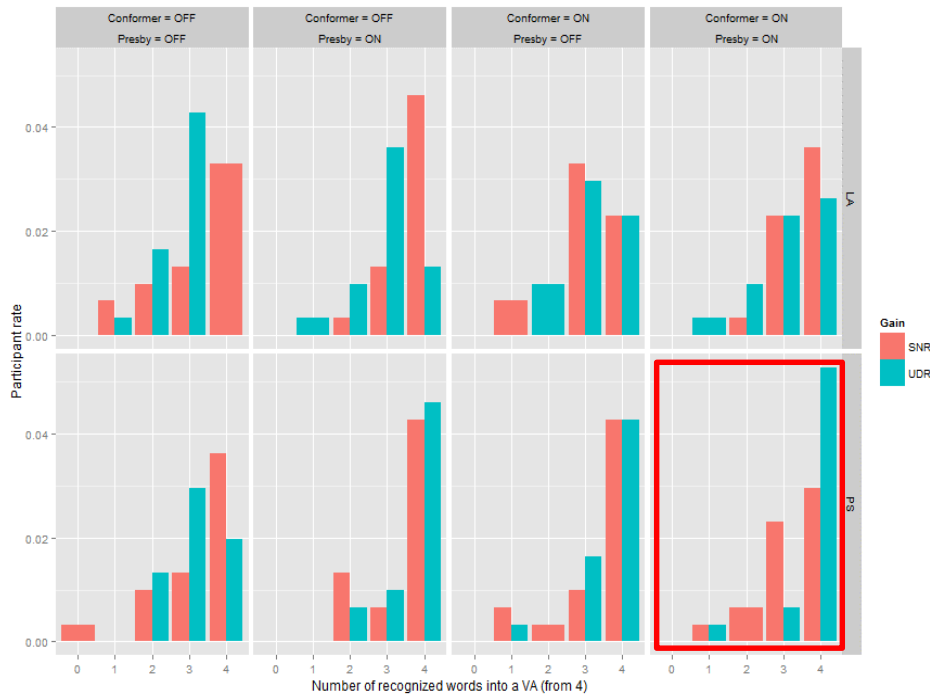
Graph12: Presbycusic without HA. Best configuration.

6. Model – All groups of participant

Yi ~ GainUDR + ConformerON + PresbyON + SonoPS + GainUDR:ConformerON + GainUDR:SonoPS + GainUDR:PresbyON + ConformerON:PresbyON + GainUDR:ConformerON:PresbyON

Conjoint interaction between GainUDR*ConformerON increases the intelligibility compared to their own effect alone: **exp(coeff_UDR)*exp(coeff_ConformerON)=exp(0.1939 – 0.9938)=0.45.**

As for Normal class, conjoint interaction between Conformer ON*PresbyON decreases intelligibility compared to their own effect alone. As PresbyON is a significant positive factor with high effect, thus for Normal class, PresbyON has to be preferred to the interaction ConformerON and PresbyON: **exp (coeff_ConformerON)*exp(coeff_PresbyON)=exp(0,1939+0,6831)=2,40.**

Conjoint interaction between GainUDR*SonoPs increases the intelligibility compared to their own effect alone: **exp(coeff_UDR)*exp(coeff_SonoPs)=exp(-0.9938 +1.0512)=1.05.**

6. Two best configurations for the 4 test conditions
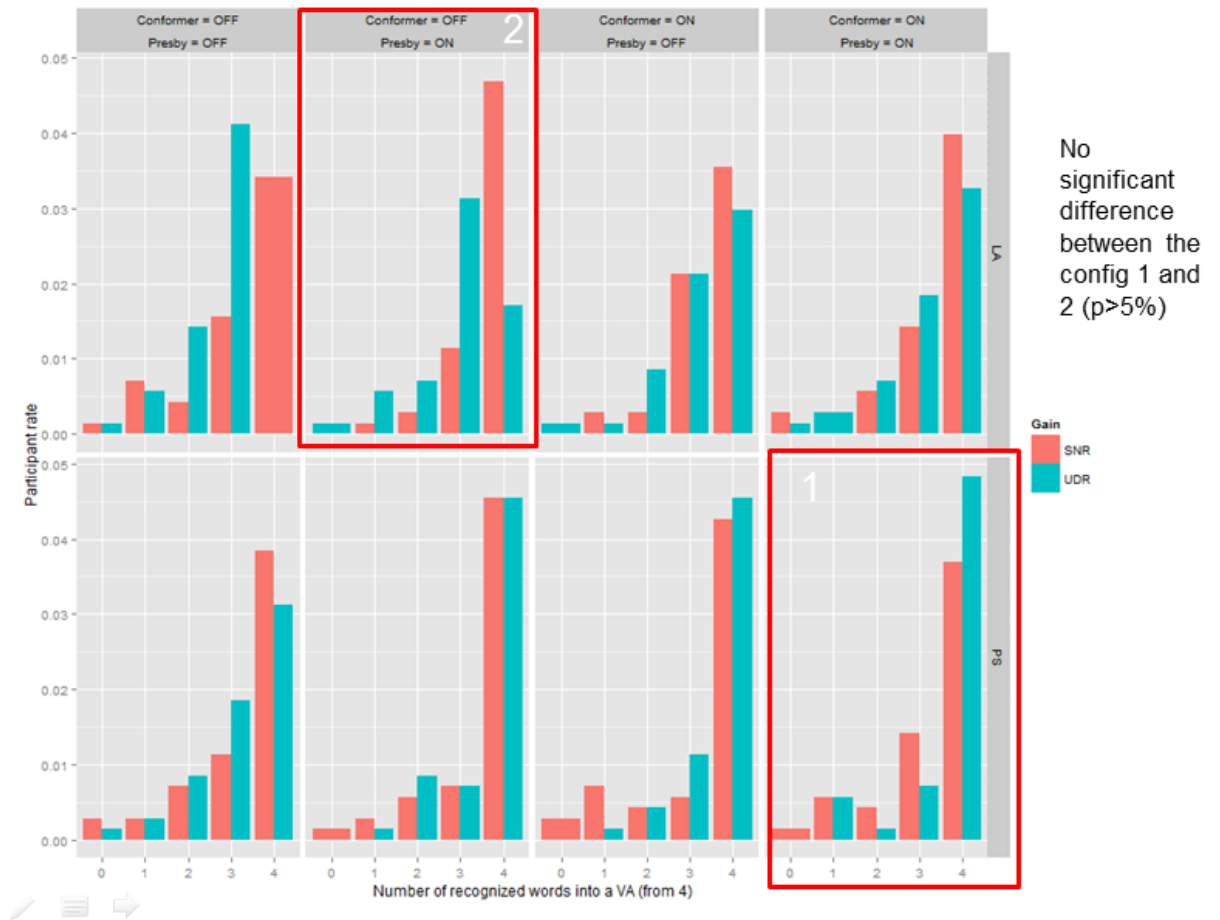
Graph13: Two best configurations for the 4 test conditions.

VII. Conclusions and recommendations for Foggia

a. Conclusions of the analysis using the 4 variables gain, Prebsy, Conformer and Sono

The results exhibit significant positive effects for all the classes when PresbyOn and ConformerOff using SNR gain and, if Sono is Ps (or/and Locuteur=F) using UDR gain.

Goals of Foggia tests might include the assessment of the speaker gender in order to conclude on Nantes tests regarding Sono effect.

Using variable	Proba to recognize a word =X*Proba to not recognize a word
SNR	4.5-Normal, 2.3-With HA, 2.5-Without HA, 2.7-All
PS	5.8-Normal
LA	2-With HA
Presby	6.4-Normal, 1.9-With HA, 2.1-Without HA, 1.98-All

Couple of variables	Effect
Conformer-Presby	Negative: Normal, All
UDR-PS (Locuteur=F)	Positive : 3.6-With HA, 2.6-Without HA, 2.9-All
Conformer-UDR	Positive : 2-All

Table 10a: Positive factors

Class	configuration
Normal	Ps-SNR-Presby no significant difference with Ps-SNR-Conformer
With HA	LA-SNR-Presby no significant difference with : Ps-UDR-Conformer and LA-SNR-Conformer
Without HA	Ps-UDR-Presby-Conformer
All	Ps-UDR-Presby-Conformer no significant difference with : LA-SNR-Presby

Table10b: Best configurations

b. Recommendations for Foggia Tests

Only the real reverberation of the railway station will be considered for the assessment of the algorithms. The precompensation filter will be used by adding a low pass filter (cut off frequency=8 kHz corresponding to the upper limit of flatness of the frequency response of Foggia loudspeakers) after the precompensation filter. The resulting product of these two filters (see figure below its shape: Adapted Precomp) will permit to:

1) Maintain the original shape of the precompensation filter (D2.4)

2) Take into account the frequency response of Foggia loudspeakers
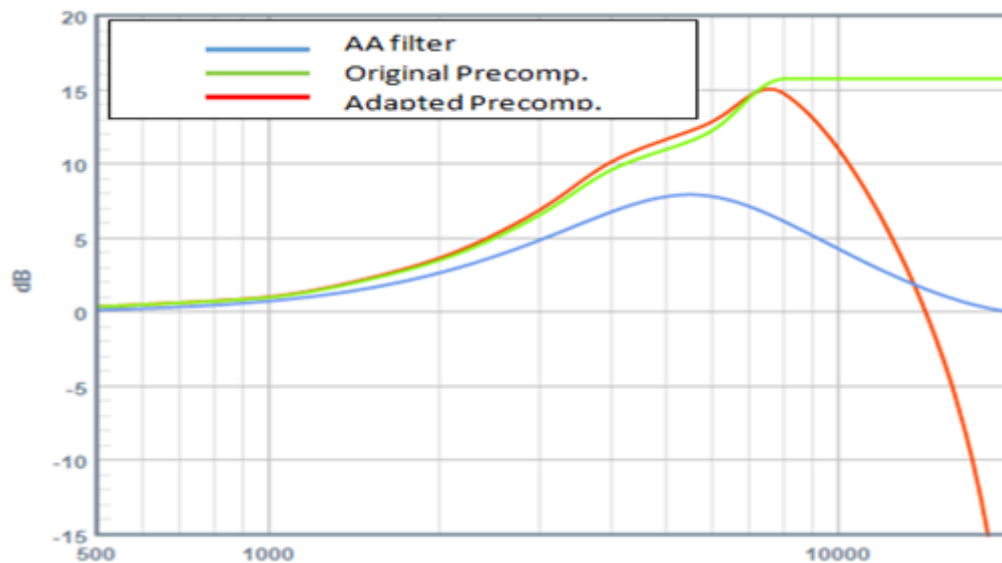
Graph14: Precompensation filter adapted to HP (cutoff frequency = 8000 Hz)

c. SIM*forall* assessment

SIM*forall* algorithm was designed to measure the speech intelligibility by comparing the clean vocal announcement before diffusing with the distorted vocal announcement recorded in the railway station. The recorded vocal announcement is distorted by the ambient noise and acoustic reverberation.

Known that each vocal announcement (VA) were subjectively assessed in two part by the subject, we split each VA in two sequences to compare between the subjective score and the objective score obtained by the SIM*forall* algorithm. The objective score of each VA was obtained by averaging the the scores of the two sequences and the subjective intelligibility scores were computed by counting the recognized words per VA.

Results show a good correlation between the proposed SIM*forall* algorithm and the subjective score with an R square of 0.9 for noamal hearing persons. This analysis was made only for normal hearing persons because we didn't have the audiogram of hearing impaired persons to do it.

Graph15 shows the mapping between the subjective and the SIM*forall scores.* Each point of the map is an average of intelligibility over normal hearing persons for a given test condition. This results is coherent with the test made Inlab at the EPFL.

We can deduce that for a SIM*forall* score between:

- [0:0,25] => **the intelligibility is poor**
- [0,35:0,4] => **the intelligibility is good**

Graph15: Mapping for all NH

VIII. Appendixes

Appendix 1: Picture of the hall in the shed

Appendix 2: Picture of the hall in the shed during the session of test

Appendix 2: French questionnaire (4 pages)

Nom :		Date :		Place :

1

Le TGV n°   à destination de   départ   h   partira voie
Le TGV n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

2

Le TER n°   à destination de   départ   h   partira voie
Le TER n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

3

Le TGV n°   à destination de   départ   h   partira voie
Le TGV n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

4

Le TGV n°   à destination de   départ   h   partira voie
Le TGV n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

5

Le TGV n°   à destination de   départ   h   partira voie
Le TGV n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

6

Le TER n°   à destination de   départ   h   partira voie
Le TER n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

7

Le TER n°   à destination de   départ   h   partira voie
Le TER n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

8

Le TGV n°   à destination de   départ   h   partira voie
Le TGV n°   à destination de   départ   h   partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

9	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

10	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

Confort | 1 | 2 | 3 | 4 | 5 |

11	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

| 1 | 2 | 3 | 4 | 5 |

12	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

| 1 | 2 | 3 | 4 | 5 |

13	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

| 1 | 2 | 3 | 4 | 5 |

14	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

| 1 | 2 | 3 | 4 | 5 |

15	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

| 1 | 2 | 3 | 4 | 5 |

16	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

| 1 | 2 | 3 | 4 | 5 |

17	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

18	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

19	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

20	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

21	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

22	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

23	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

24	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

25	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

26	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

27	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

28	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

29	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5

30	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

31	Le TGV n°	à destination de	départ	h	partira voie
	Le TGV n°	à destination de	départ	h	partira voie

1	2	3	4	5

32	Le TER n°	à destination de	départ	h	partira voie
	Le TER n°	à destination de	départ	h	partira voie

1	2	3	4	5