D1.8 – Description and results of the Foggia's Tests

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Project Duration:	July, 1st 2012 – Dec, 31th 2015 (42 months)
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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

D1.8

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D1.4	Executive Summary

This report describes the protocol for intelligibility in-vivo tests that will take place at the railway station of Foggia (Italy).
We propose to evaluate the efficiency of the technology plug into the loudspeakers on understanding the vocal announcements in the railway stations. We will use three kinds of evaluations: the accuracy of the announcement repeated by the users and recorded on a Smartphone, the level of sound quality and the listening effort for each vocal announcement.
The target population is composed of 38 persons with different hearing ability. They are coming from Italy. Three groups were established: normal hearing, presbycusis without hearing aid and presbycusis with hearing aids.
The method of comparison of means will be used to analyze the entire data corpus. A Mann-Whitney test will assess whether the difference to simple analyzes or couple analyzes is significant or not.
This test will take place in ecological environment. The recommendations from the tests of Nantes were taken into account in the development of this protocol.
It will enable us to find the best conditions to allow "For All" to understand the vocal announcements in the public open spaces.

Keywords: intelligibility, hearing impaired, protocol, for all, environmental, railway station, test in-vivo

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

Introduction

The tests were conducted in Italy at the Foggia's Railway Station. The loudspeakers of the railway station were equipped with "I'City For All" solution by technicians. This solution should allow users to better understand the vocal announcements broadcasted in the railway station and thus to feel more confident in semi-confined spaces.

The meteorological conditions were very difficult for users but also for the research team. However, tests have been conducted with great motivation and were completed in a scientific approach.

For now, the data analysis was performed on data on the two scales: the sound quality and the listening effort. We are expecting data related to vocal announcements and data for the railway station staff's questionnaires.

I. Population

This test involved 38 participants from Italy. Among these 38 people: 12 persons are from "normal hearing" group, 10 persons are from "presbycousis with hearing aids" group and 15 persons are from "presbycousis without hearing aid" group. The following table shows the proportions of the groups. All these users have gone through standard audiometric tests and the relevant audiograms have been produced.

Groups	Italy
Normal hearing	13
Presby. Without HA	15
Presby. With HA	10
TOTAL	**38**

Table 1: The Group compositions.

II. Contextualization

Participants had an appointment in the station. They settled in the test control area with the professionals. The instructions were given by the team in charge of recruitment.

Chairs were placed in the hall facing the speakers of the station. The chairs were well spaced in the station's hall in order to that the voices of other participants are not a problem in understanding the vocal announcements.

A professional seated next to each person. This professional was in charge of recording the voice of the participant, help to complete the questionnaire and sending a signal to the technicians to have tracks synchronized between all participants.

The test duration was 30 to 50 min. The transmission time between each VA was relatively diverse between each session. The participants have demonstrated a very great

patience and participated throughout the session. We thanked each participant at the end of the study.

The test conditions were harsh for the participants but also for the professionals. Indeed, the temperature in the station could climb up to 38 degrees. The air was very humid. It was hard to stay in the station without moving. In addition, all doors were open to the station. There was at times more noise than usual and may have an impact on the understanding of voice announcements (e.g. traffic noise outside).

III. Installation

Figure 1 shows the block diagram of the PA system used for the tests in Foggia. A NUT processor has been inserted in between the matrix (PC box audio) located in a technical room and the two DS280 column loudspeakers located in the main hall. A microphone placed in the hall (above the tobacco shop) is connected to the NUT processor in order to monitor the level of the background noise in the hall. The NUT processor is controlled with a laptop. During the tests, the NUT processor and the laptop were placed in the hall.

The NUT processor runs the IVA application (described in D2.7 and D2.6) which processes the vocal announces. The laptop controls the NUT processor with the IVAcontrol application (see D1.7).

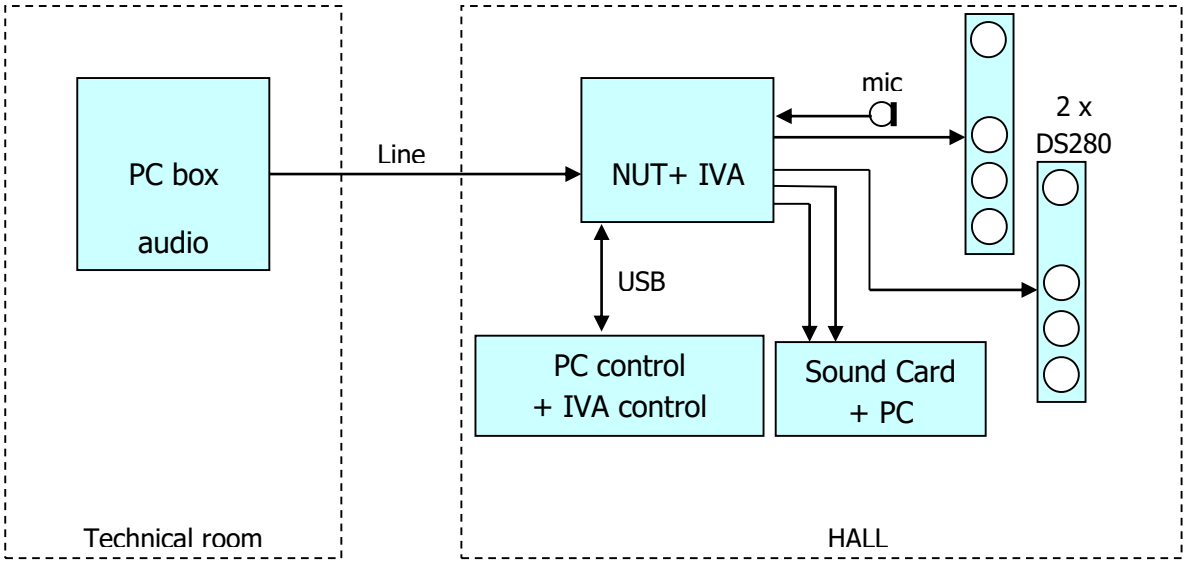


Figure 1: block diagram of the PA installation used for the tests in Foggia railway station

1- Programing the processor

The DSP code described in "D2.7 integration NUT-3-6-15.pdf" and "D2.6 integration NUT-3-6-15.pdf" was modified according to the demand of Linklab. Main modifications are:

- Modification of the presbyacusis compensation curve
- Addition of the "level adjust" block after the presbyacusis compensation
- Modification of the estimation of the noise level used in the AGC-UDR function
- Possibility to switch between AGC-SNR and AGC-UDR
- Output of non-treated VAs, treated VAs, and microphone signal for recording purpose.

2- Setting the parameters

Installation of the test equipment began at 10am on Monday 20th July 2015. The first test group was scheduled at 3pm. The technicians from Eurotel switched off the AGC and the equalizer of the PA installation of the station.

We inserted the NUT processor right upstream the DS280 active column loudspeakers. An omnidirectional microphone model AT8020 was used to capture the background noise. It was placed on top of the tobacco shop, at a height of approximately 3.5m.

The settings are:

- In_line_gain (block main) has been set to 10.0, so that the level of the VAs in the DSP is correct.
- Out_gain (block main) has been set to 0.06
- ConvertToSPL (block Level_adjust) has been set to 2.1, so that the level downstream this gain corresponds to the actual SPL of the VA measured on average over the listening area.
- Eta (blocks AGC_UDR and AGC_SNR) has been set to 4.14. This value has been obtained as the ratio (squared SPL (Pa^2) measured over the listening zone) / (Eva).

With this value, the product Eva*eta equals the mean square pressure over the listening zone when AGC gain equals 1 (or AGC is bypassed).

- C was set to 0.125 and D to 0.24 in blocks AGC_UDR and AGC_SNR, so the ratio C/D has been set to 0.52. This value has been chosen experimentally, so that it yields AGC gains values around 1.0 in nominal conditions, i.e. with a VA of nominal level, and a moderate background noise level.
- The time constants alpha_sig in blocks MS and MS3 have been set to 0.0001. Higher values cause the estimation of Eva to be unstable, resulting in large fluctuations of AGC gains during a VA.
- Mic_sensitivity_2 (block main) has been set to 7.0. Final measurements showed that this value does not yield true levels of Eb in blocks AGC_UDR and AGC_SNR. In fact, measurements showed that Eb_{SNR} is 4.3dB above the actual level, and Eb_{UDR} is 6.2dB above the actual level.

Note: The estimation of Eb (square noise level) by routine Estim_noiselevel (used by AGC_UDR) is based on the square of the microphone signal, contrary to the estimation of Eb in Liss_mic (used by AGC_SNR). It has been observed that the first is approximately 2 dB higher than the second. One can note that this value is very close to the theoretical value of corresponding to Gaussian noise.

Calculation of C/D :

C/D was set to 0.52 in blocks AGC_SNR and AGC_UDR.

But we have seen that for AGC_SNR, the level Eb is overestimated by a factor 2.7, so that the gain obtained ($G^2 = (C*Eb) / (D*eta*Eva)$) corresponds to an actual value of C/D = 1.4. For AGC_UDR, the level Eb is overestimated by a factor 4.2, so that the gain obtained ($G^2 = (C*Eb) / (D*eta*Eva)$) corresponds to an actual value of C/D = 2.2.

Note that, since (eta*Eva) equals the level of diffusion when AGC is bypassed (gain=1), then

C/D represents the signal-to-noise ratio. For example, C/D=2.2 means an SNR=3.4dB.

The fact we didn't have any control on the timing and the contents of announces made the tuning difficult.

3- Observations during the tests

There were several biases:

· A jingle was played before all announces. This jingle disturbs the conformer, which analyses this signal as if it was part of the speech. As a result, the gains in the frequency bands of the conformer are shifted, and the diffusion of the announcements are affected by inappropriate gains. The jingle also affects the AGC algorithms, since it introduces a bias on the estimation of Eva.

· There is a cascade of gain adjustments (each having its own time constant) in the processing: gains in conformer, gain in level_adjust, gain in AGC.

· The presby compensation applies a gain of +3dB up to 1kHz. So turning the presby compensation ON raises the level by about 3dB (since the energy of speech signal is essentially below 1kHz). But this increase will affect the gain in the level_adjust block, and will also affect the gain of the AGC (since the Eva will be affected), both of them with their own time constants. As a result, management of level appears rather complicated.

· Breathing pauses in speech introduce another bias: the update of level Eva should be frozen during the breathing pauses. Typically, Eva is underestimated by about 1dB.

· Short term variations of the AGC gains were observed, resulting from variations in the noise level. Gains could vary by up to 5dB. It seems that the estimation of Eb in the AGC algorithms does not always yield adequate gains.

· We have checked variable alphau in the Estim_NoiseLevel block. It appears that alphau almost always equals 0.00025. Clapping hand near the microphone causes alphau to jump to 0.025, but only for a very short duration (1/10th second).

· In normal operation of the station, the VAs are diffused at a very low level because the employees of the ticket office complain when level is higher. The level used for our tests was significantly higher than this "normal" level.

IV. Procedures

Users visited Foggia Railway Station. The appointment was given to each by the team of ESCOOP.

Once everyone was present, we proposed them some water and a chair to sit. The instructions were given by the team of ESCOOP.

The chairs were then installed in the hall so as to be facing the speakers. Professional was accompanying each user. Professional recorded with a smartphone, the voice of the participant and also helping the user to fill the two scales.

The testing had duration on average of 30 min.

The question sheet was collected by the CENTICH team. The video recordings were harvested later (after testing) by ESCOOP team.

The participants were thanked and left the station.

Groups of 6-7 persons has been defined by the team responsible for the tests according to their origin city. So the group will be composed of persons from different groups of the study (normal hearing, presbycusis without hearing aid and presbycusis with hearing aid).

The meeting point will be at the railway station of Foggia, in the main hall.

The groups arrived on site around half an hour before the start of the test session. All instructions were provided once on site. The participants were accompanied by professionals/assistants to perform the evaluations. Participants were autonomous to fill in the questionnaire(s) provided. People needing assistance can find support from local professionals/assistants. The test sessions were the following:

Day	Hour	Number of participants
Monday 20th July	3:00 pm	5
Monday 20th July	5:00 pm	6
Tuesday 21th July	10:00 am	8
Tuesday 21th July	12:00 am	2
Tuesday 21th July	3:00 pm	2
Tuesday 21th July	5:00 pm	6
Wednesday 22th July	3:00 pm	5
Wednesday 22th July	5:00 pm	4

Table 2: Number of participants per session.

During the morning session of DAY 2, apart from the target end users, also people working in the Foggia railway station will be involved in the study. They will be asked to answer the questions specified in Annex 6a and 6b.

During the tests, the system will be managed by a technician from Active Audio. He/she will use random series that manage the three variables of the evaluation: Acoustic environments, distribution systems and Algorithms.

During the tests, the participants will listen to around 10 - 16 vocal announcements to evaluate the intelligibility of the message. All vocal announcements are contained in Appendix 2. Each test session will last around 1 hour.

The "Environmental acoustics" refers to the situation described below:

- the person is located in the main hall of the railway station, which is characterized by a high reverberation time, high noise level but quite constant, high density of persons standing.

Only the technicians and professionals assisting the users in the execution of the tests will be informed of the current condition during the tests.

During the tests the users will listen to announcements with the: ICity algorithms OFF And ON.

The users will be asked to repeat the announcements they hear. Intelligibility scores will be derived (S1 with the : ICity algorithms OFF and S2 : ICity algorithms ON).

Comparison of S1 and S2 gives the improvement gained with I City algorithms.

V. Evaluations

a. Repeat vocal announcement:

Each participant should repeat each vocal announcement which will be recorded by a recording device (e.g. a Smartphone) and evaluate the sound quality of each vocal announcement. The professional/assistant should not influence the answer of the person. Each professional will record the vocal announcements that will be diffused by the loudspeakers during the tests and that will be written down in Appendix 2.

b- Sound quality:

For each vocal announcement, the participant must complete a sound quality scale in five points (1= Excellent; 5= Bad) to assess the sound quality of the message.

c- Listening effort:

For each vocal announcement, the participant must complete a listening effort scale in five points (1 = No meaning understood despite the maximum effort possible, 5 = Complete relaxation possible. no effort required).

VI. Experience plan

Each test condition is played twice. This experience plan allows us to measure several conditions (Gain, Conformer and Pre-compensation).

The experience plan had also help to avoid the measurement problems related to conformer. Indeed, the conformer takes time to adapt when there is a change of speaker.

In our study, it is not possible to control the variable "speaker". So we have to adapt our method.

Combinaton	Conformer	Presby	Gain
1	OFF	ON	SNR
2	OFF	ON	SNR
3	OFF	ON	UDR
4	OFF	ON	UDR
5	OFF	OFF	UDR
6	OFF	OFF	UDR
7	OFF	OFF	SNR
8	OFF	OFF	SNR
9	ON	OFF	SNR
10	ON	OFF	SNR
11	ON	OFF	UDR
12	ON	OFF	UDR

Table 3: Experience plan - Foggia (By the Linklab)

VII. Data analysis

1. Description of the users

For the Tests in the Foggia's railway station, 38 persons participated. The next table (table 1) proposes a description of the cohort: deficiency, dates of tests, hours of tests, assistants in charge of people, participants with more data than 12 answers for each dimensions (two scales and vocal announcement) and the average age according to deficiency.

Items	Effectives (%)
Deficiencies :	
- Presby. with HA	10 (27.0%)
- Normal Hearing	12 (32.4%)
- Presby.	15 (40.5%)
Dates :	
- 20/07/15	10 (27.0%)
- 21/07/15	18 (48.6%)
- 22/07/15	9 (24.3%)
Hours:	
- 10:00 am	8 (21.6%)

- 12:00 am	2 (5.4%)
- 3:00 pm	12 (32.4%)
- 5:00 pm	15 (40.5%)
Assistants:	
- Massimo Librato	1 (2.7%)
- Teresa Carbone	1 (2.7%)
- Marco Sbarra	1 (2.7%)
- Cendrine Mercier	2 (5.4%)
- Massimo Mason	2 (5.4%)
- Michele Bellosguardo	3 (8.1%)
- Andrea Zanela	6 (16.2%)
- Dr Cerullo	6 (16.2%)
- Alessandra Brescia	7 (18.9%)
- Anna Mantuano	8 (21.6%)
More data:	
- Yes	4 (10.8%)
- No	33 (89.2%)
Items	**Mean (standard deviation)**
Age:	64.10 (9.28)
- Presby. with HA	67.33 (9.09)
- Normal Hearing	57.64 (6.46)
- Presby.	67.79 (8.76)

Table 4: Description of the population (effectives and mean).

2. Data analysis: descriptive and statistical.

During the first session (20/07/15 at 3:00 pm) we had problems with the vocal announcements. Indeed, some people gave more answers than the others. Those problems were solved after this session. One technician gave the signal to hear for each vocal announcement to all the participants and assistants. For the first analyses, we can't take into account the people with more answers. We need the data treatment (vocal announcements) by Italians partners in order to know which data we can take for the analysis.

So for those first analyses we used the answers of 33 persons of the cohort. Both scales (quality of sound and listening effort) were treated by a descriptive analysis and by a statistical analysis.

The test used for the statistical analysis was the non-parametric test: Wilcoxon Test.

a. Description of the two scales:

- Quality of sound: is a likert scale in five points (1= Bad quality of sound; 5 = Excellent quality of sound). For the needs of the analysis, we used average scores. The average scores are in the range [1; 5].

- Listening effort: is a likert scale in five points (1= No meaning understood despite the maximum effort possible; 5 = Complete relaxation possible; no effort required). For the needs of the analysis, we used average scores. The average scores are in the range [1; 5].

b. Simple analysis for the two scales: quality of sound and listening effort.

- **Quality of sound:**

It is important to know that the higher the score is close to 1, the more the participant finds the sound with bad quality.

Variable	Condition	Deficiencies		
		Normal Hearing	Presby. With HA	Presby. Without HA
Conformer	ON	2.04 (0.92)[1]	1.91 (0.90)[2]	2.29 (0.82)[3]
	OFF	2.91 (0.97)	3.08 (0.73)	2.55 (0.77)
Presby.	ON	3.02 (0.92)[4]	3.22 (0.78)[5]	2.60 (0.83)
	OFF	2.42 (0.92)	2.42 (0.74)	2.39 (0.78)
Gain	SNR	2.53 (0.89)	2.35 (0.80)[6]	2.29 (0.77)

[1] The difference is significant for the group "Normal Hearing" between conditions "Conformer ON" and "Conformer OFF" ($Z = -2.94$; $p < 0.05$).

[2] The difference is significant for the group "Presby with HA" between conditions "Conformer ON" and "Conformer OFF" ($Z = -2.37$; $p < 0.05$).

[3] The result tends to a significant difference for the group "Presby without HA" between conditions "Conformer ON" and "Conformer OFF" ($Z = -1.87$; $p = 0.06$).

[4] The difference is significant for the group "Normal Hearing" between conditions "Presby ON" and "Presby OFF" ($Z = -2.74$; $p < 0.05$).

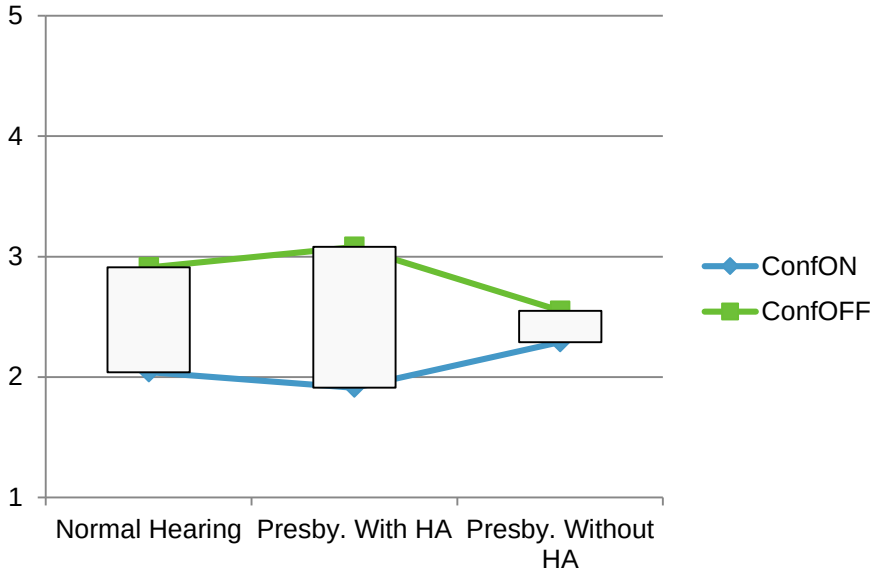
[5] The difference is significant for the group "Presby with HA" between conditions "Presby ON" and "Presby OFF" ($Z = -2.54$; $p < 0.05$).

	UDR	2.71 (0.91)	3.02 (0.71)	2.63 (0.82)

Table 5:Average scores according the three variables and the deficiency (quality of sound).

Yellow: tends to a significant difference; Green: significant difference.

All the average scores are between 2 (poor quality) and 3 (medium quality). There are no answer with a "good" or "excellent" quality for the scale of the quality of sound.



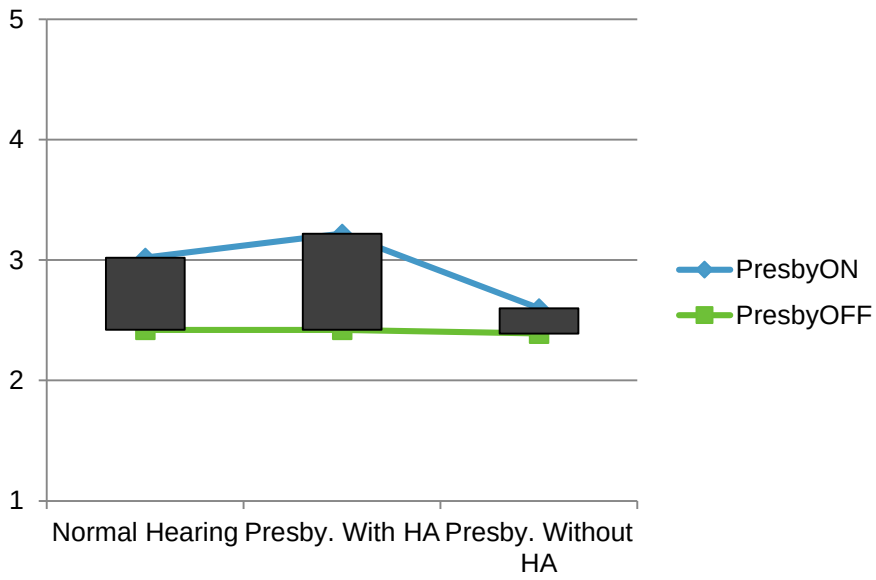
Graph 1: Conformer according the deficiency (quality of sound).

Participants obtained an average score of 2.80 (0.84) to the OFF position and an average score of 2.11 (0.86) to the ON position.

All groups have an average score "conformer OFF" higher than their score "conformer ON" (see table 2).

Sound quality seems to be better when the conformer is OFF and this for all three groups. Note that the difference is significant for the first two groups (Normal Hearing and Presby. with HA). The difference tends to a difference for the third group "Presby. without HA".

[6] The result tends to a significant difference for the group "Presby without HA" between conditions "Conformer ON" and "Conformer OFF" ($Z = -1.87$; $p = 0.06$).

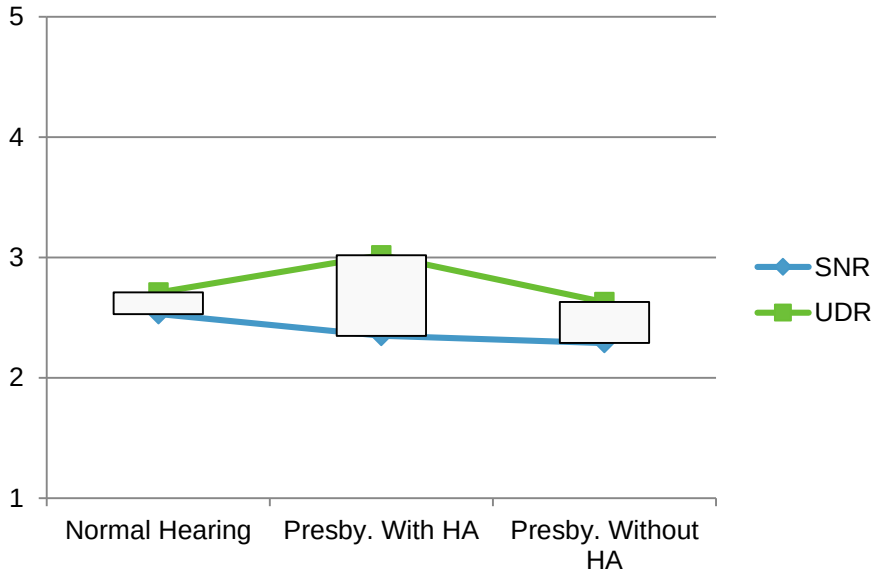


Graph 2: Presby. filter according the deficiency (quality of sound).

Participants obtained an average score of 2.41 (0.80) to the Presby. OFF position and an average score of 2.90 (0.87) to the Presby. ON position.

All groups have an average score "Presby. ON" higher than their score "Presby. OFF" (see table 2).

Sound quality seems to be better when the Presby. filter is ON and this is true for the three groups. Note that the difference is significant for the first two groups (Normal Hearing and Presby. with HA). The difference is not significant for the third group "Presby. without HA".



Graph 3: Gain according the deficiency (quality of sound).

Participants obtained an average score of 2.39 (0.80) to the SNR gain and an average score of 2.75 (0.82) to the UDR gain.

All groups have an average score "UDR gain" higher than their score "SNR gain" (see table 2).

Sound quality seems to be better when the gain is UDR and this is just for one group. Indeed, difference is significant for the "Presby. with HA" group.

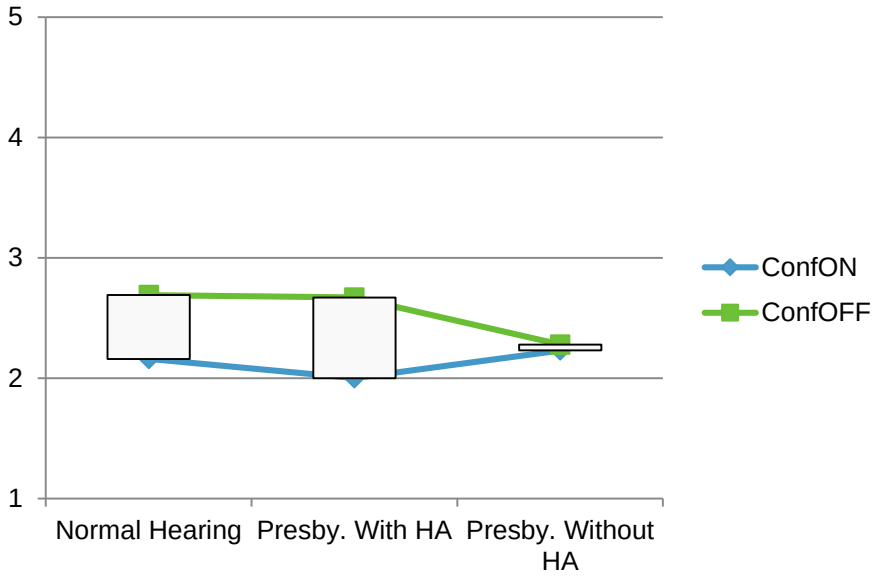
- **Listening effort :**

It is important to know that the closer the score is to 1, the more the participant needs maximal effort to understand the vocal announcements.

Variable	Condition	Deficiencies		
		Normal Hearing	Presby. With HA	Presby. Without HA
Conformer	ON	2.16 (0.96)[7]	2.00 (1.25)	2.23 (0.75)
	OFF	2.69 (0.85)	2.67 (1.06)	2.28 (0.65)
Presby.	ON	3.23 (0.94)[8]	3.13 (1.40)	2.85 (0.85)[9]
	OFF	2.54 (0.92)	2.53 (1.11)	2.31 (0.78)
Gain	SNR	2.68 (0.87)	2.33 (1.20)	2.33 (0.72)
	UDR	2.71 (0.91)	3.02 (0.71)	2.63 (0.82)

Table 6:Average scores according the three variables and the deficiency (listening effort).

All the average scores are between 2 (poor quality) and 3 (medium quality). There are no answer with a "good" or "excellent" quality for the scale of the listening effort.



Graph 4: Conformer according the deficiency (listening effort).

Participants obtained an average score of 2.52 (0.83) to the OFF position and an average score of 2.15 (0.94) to the ON position.

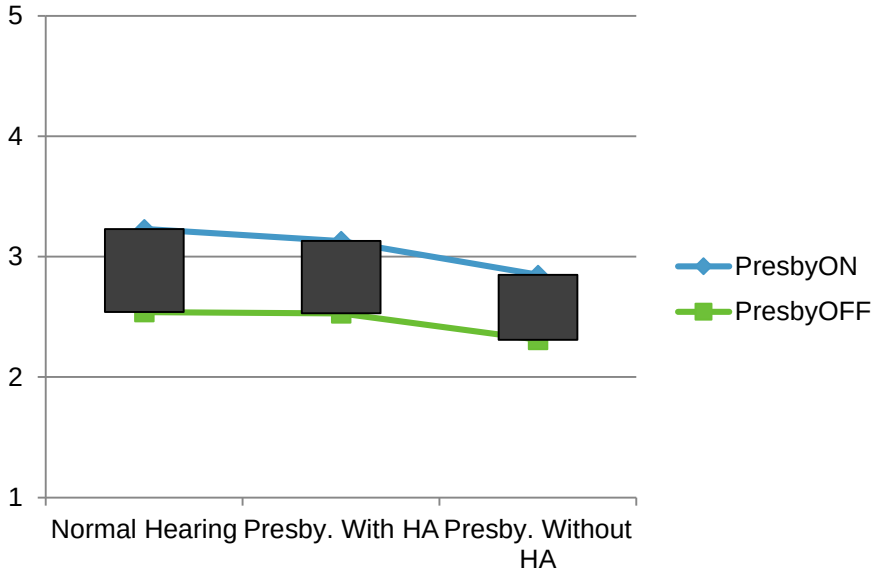
All groups have an average score "conformer OFF" higher than their score "conformer ON" (see table 3).

[7] The difference is significant for the group "Normal Hearing" between conditions "Conf OFF" and "Conf OFF" ($Z = -2.32$; $p < 0.05$).

[8] The difference is significant for the group "Normal Hearing" between conditions "Presby ON" and "Presby OFF" ($Z = -2.81$; $p < 0.05$).

[9] The difference is significant for the group "Presby without HA" between conditions "Presby ON" and "Presby OFF" ($Z = -2.14$; $p < 0.05$).

Listening effort seems to be higher when the conformer is ON position. The difference is significant for the first group: "Normal Hearing".

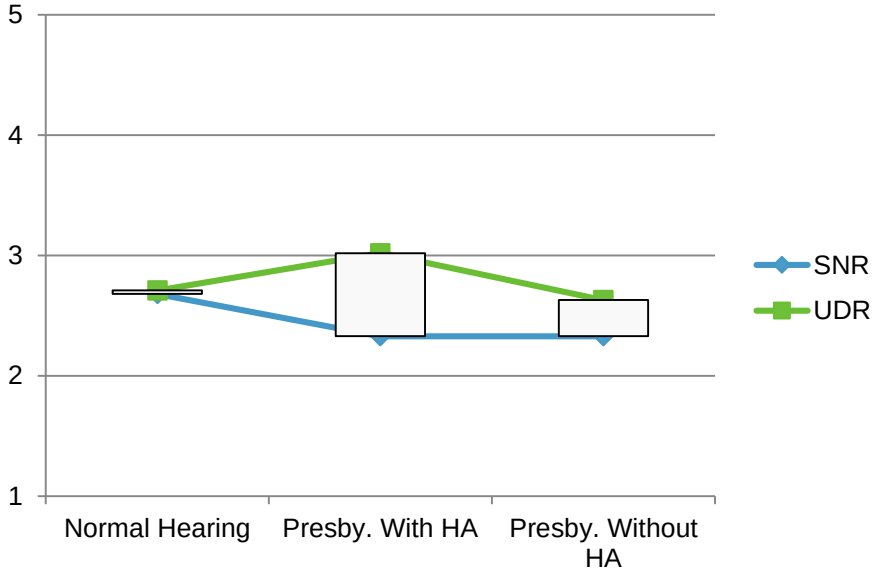


Graph 5: Presby. filter according the deficiency (listening effort).

Participants obtained an average score of 2.45 (0.90) to the Presby. OFF position and an average score of 3.05 (1.02) to the Presby. ON position.

All groups have an average score "Presby. ON" higher than their score "Presby. OFF" (see table 3).

Listening effort seems to be higher when the Presby. filter is OFF. The difference is significant for two groups: "Normal Hearing" and "Presby. without HA".



Graph 6: Gain according the deficiency (listening effort).

Participants obtained an average score of 2.46 (0.89) to the gain SNR and an average score of 2.75 (0.82) to the gain UDR.

All groups have an average score "Gain UDR" higher than their score "Gain SNR" (see table 3).

There is no difference significant for each group.

Summary of the simple analysis:

- **Quality of sound:**

Normal Hearing	Conformer OFF	Filter Presby. ON	
Presby. With HA	Conformer OFF	Filter Presby. ON	Gain UDR
Presby. Without HA		Filter Presby. ON	

- **Listening effort:**

Normal Hearing	Conformer OFF	Filter Presby. ON	
Presby. With HA			
Presby. Without HA		Filter Presby. ON	

The tests do not allow us to conclude on a solution "for all" in the two variables: sound quality and listening effort. However, the position "Presby. ON" generally gives better performance in most cases.

Some aspects of the solution seem to help certain groups. Indeed, the filter Presby. ON position allows the three groups to increase the quality of sound for the vocal announcements in the railway station. The UDR gain provides better sound quality only for the group "Presby. With HA".

Some aspects allowed participants to reduce their effort to listen. Indeed, thanks to the filter Presby. the effort was reduced for both groups: "Normal hearing" and "Presby. without HA". The UDR gain had no impact on the perception in the effort to all users.

The conformer appears not to have had any impact in this analysis for both scales.

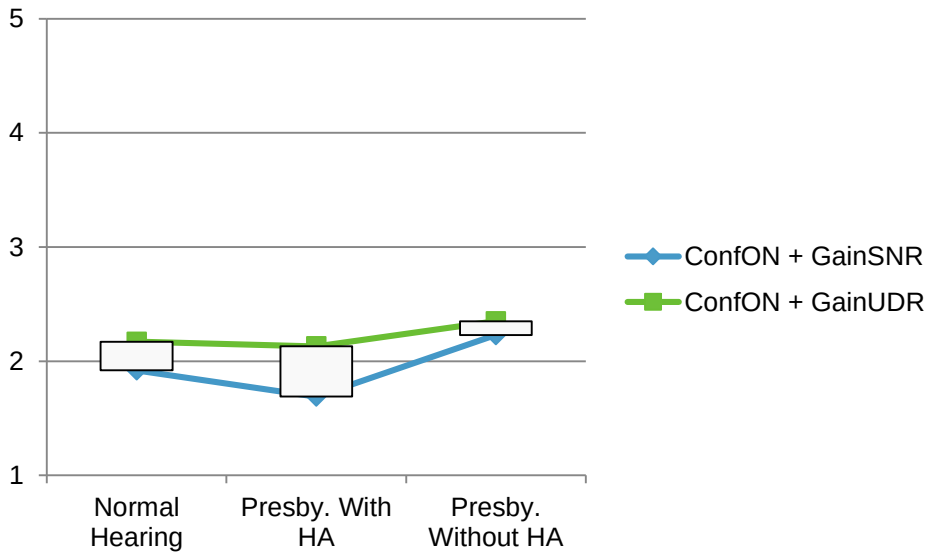
c. Complex analysis with two variables for the two scales: quality of sound and listening effort.

- **Quality of sound :**

Condition	Deficiencies		
	Normal Hearing	Presby. With HA	Presby. Without HA
ConfON + PresbyON			
ConfON + GainSNR	1.92 (0.87)	1.69 (1.0)	2.23 (0.93)
ConfON + GainUDR	2.17 (1.11)	2.13 (0.88)	2.35 (0.92)
PresbyON + GainSNR	2.88 (1.07)	2.88 (0.92)[10]	2.35 (0.83)[11]
PresbyON + GainUDR	3.17 (0.96)	3.56 (0.82)	2.85 (1.03)

Table 7:Average scores according the three couple of variables and the deficiency (sound quality).

All the average scores are between 2 (poor quality) and 4 (good quality). There are no answer with an "excellent" quality for the scale of the quality of sound.



Graph 7: Conformer ON and Gain SNR/UDR according the deficiency (quality of sound).

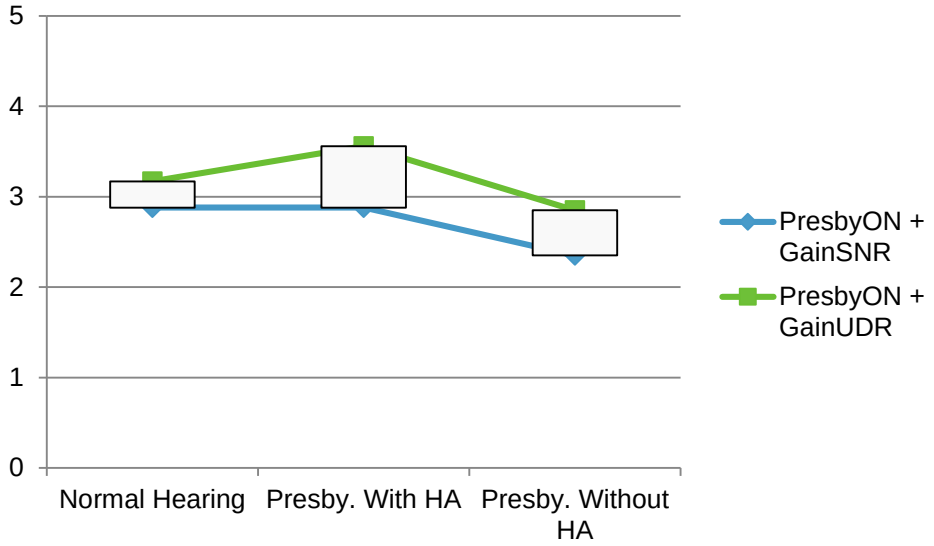
[10] The difference is significant for the group "Presby with HA" between conditions "PresbyON + GainSNR" and "PresbyON + GainUDR" ($Z = -2.06$; $p < 0.05$).

[11] The result tends to a significant difference for the group "Presby without HA" between conditions "PresbyON + GainSNR" and "PresbyON + GainUDR" ($Z = -1.85$; $p = 0.06$).

Participants obtained an average score of 1.98 (0.92) to the "Conformer ON + Gain SNR" position and an average score of 2.23 (0.96) to the "Conformer ON + Gain UDR" position.

All groups have an average score "Conformer ON + Gain UDR" higher than their score "Conformer ON + Gain SNR" (see table 4).

The quality of sound seems to be better when the Conformer is ON position and with the Gain UDR. The difference is not significant for all the groups.



Graph 8: Presby. filter ON and Gain SNR/UDR according the deficiency (quality of sound).

Participants obtained an average score of 2.66 (0.95) to the "Presby. ON + Gain SNR" position and an average score of 3.13 (0.97) to the "Presby. ON + Gain UDR" position.

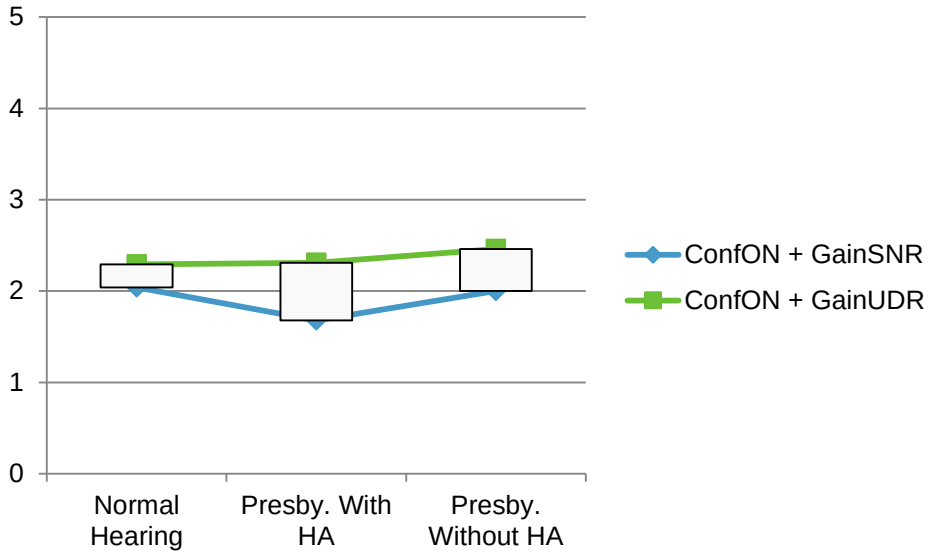
All groups have an average score "Presby. ON + Gain UDR" higher than their score "Presby. ON + Gain SNR" (see table 4).

The quality of sound seems to be better when the Presby. filter is ON position and with the Gain UDR. The difference is significant for the "Presby. with HA" group and tends to the significant difference for the "Presby. without HA" group.

- **Listening effort :**

Condition	Deficiencies		
	Normal Hearing	Presby. With HA	Presby. Without HA
ConfON + PresbyON			
ConfON + GainSNR	2.04 (1.10)	1.68 (1.39)[12]	2.00 (0.89)[13]
ConfON + GainUDR	2.29 (1.05)	2.31 (1.19)	2.46 (0.78)
PresbyON + GainSNR	3.17 (1.09)	2.81 (1.46)[14]	2.77 (0.78)
PresbyON + GainUDR	3.29 (0.96)	3.44 (1.37)	2.92 (1.10)

Table 8:Average scores according the three couple of variables and the deficiency (listening effort).



Graph 9: Conformer ON and Gain SNR/UDR according the deficiency (listening effort).

Participants obtained an average score of 1.94 (1.07) to the "Conformer ON + Gain SNR" position and an average score of 2.36 (0.96) to the "Conformer ON + Gain UDR" position.

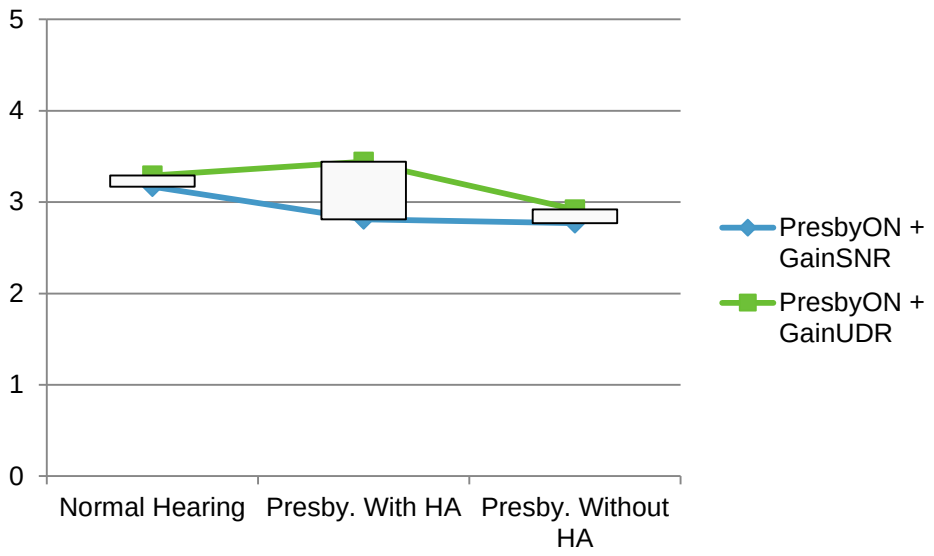
All groups have an average score "Conformer ON + Gain UDR" higher than their score "Conformer ON + Gain SNR" (see table 5).

The Listening effort seems to be higher when the Conformer is ON position and with the Gain SNR. The difference is significant for two groups: "Presby. with HA" and "Presby. without HA".

[12] The difference is significant for the group "Presby with HA" between conditions "ConfON + GainSNR" and "ConfON + GainUDR" ($Z = -2.04$; $p < 0.05$).

[13] The difference is significant for the group "Presby without HA" between conditions "ConfON + GainSNR" and "ConfON + GainUDR" ($Z = -2.05$; $p < 0.05$).

[14] The difference is significant for the group "Presby with HA" between conditions "PresbyON + GainSNR" and "PresbyON + GainUDR" ($Z = -2.23$; $p < 0.05$).



Graph 10: Presby. filter ON and Gain SNR/UDR according the deficiency (listening effort).

Participants obtained an average score of 2.92 (1.07) to the "Presby. ON + Gain SNR" position and an average score of 3.18 (1.11) to the "Presby. ON + Gain UDR" position.

All groups have an average score "Presby. ON + Gain UDR" higher than their score "Presby. ON + Gain SNR" (see table 5).

The listening effort seems to be higher when the Presby. filter is ON position and with the Gain SNR. The difference is significant for the "Presby. with HA".

Summary of the complex analysis:

- **Quality of sound:**

Normal Hearing		
Presby. With HA		Presby. ON + Gain UDR
Presby. Without HA		Presby. ON + Gain UDR

- **Listening effort:**

Normal Hearing		
Presby. With HA	Conformer ON + Gain UDR	Presby. ON + Gain UDR
Presby. Without HA	Conformer ON + Gain UDR	

The tests do not allow us to conclude on a solution "for all" in the two variables: sound quality and effort listening.

Some aspects of the solution seem to help certain groups. Indeed, "Presby. filter. ON position + the Gain UDR" allow two groups to increase the sound quality for the vocal announcements in the railway station.

Some aspects allowed participants to reduce their effort to listen. Indeed, the "Conformer ON + the Gain UDR" promote listening for two groups: "Presby. with HA." And "Presby. without HA". In addition, the "Presby. Filter ON + the Gain UDR" has reduced the effort for the group "Presby. With HA".

Note that there is no ideal combination for the "Normal Hearing" group.

d. Analysis of the staff's questionnaire

We collected 11 staff's questionnaires during the test. The following table allows us to have a description of this professional group who works all the week in the railway station.

Items	Indicators			
	Average	Standard deviation	Min	Max
Age (year)	42.90	12.38	20.00	60.00
Work year pass through the railway station.	12.20	11.31	0.02	32.00
Hours work per day	6.94	1.48	4.00	9.00

Items	Indicators	
.	Answers	Headcount (%)
Do you have hearing problems?	No Yes	11 (100) -
Did you always work in the railway station?	No Yes	7 (63.6) 4 (36.4)
From where you are, do you hear the station announcements?	No Yes	7 (63.6) 4 (36.4)
do you pay attention to the content of voice announcements	No Yes Not really	6 (54.5) 3 (27.3) 2 (18.2)
Is the railway station noisy?	A little A lot No	8 (72.7) 2 (18.2) 1 (9.1)
Are you accustomed to the noise and voice announcements?	A little Yes	6 (54.5) 5 (45.5)
Does the noise bother you?	Sometimes Never Often	5 (45.5) 4 (36.4) 2 (18.2)
Do the vocal announcements bother you?	Never Sometimes	8 (72.7) 3 (27.3)
What is the sound level in your office/workspace?	Satisfactory Moderately satisfactory	9 (81.8) 2 (18.2)
Do you have the ability to isolate yourself and to keep concentrated on your job tasks when there is too much noise in your work environment?	Very often Often Sometimes	5 (45.5) 4 (36.4) 2 (18.2)
How do you do?	Keep concentrated Be use to	6 (54.5) 3 (27.3)

	Close windows Take a break	1 (9.1) 1 (9.1)
After work, do you need silence?	No Yes A little	7 (63.6) 3 (27.3) 1 (9.1)
If you have a previous job, do you feel, after work, a difference between about your tiredness in your old job and the new job? If you have previous job	Never Sometimes Very often	5 (45.5) 2 (18.2) 1 (9.1)
Do you perceive any difference in the sound quality and intelligibility of the announcements in the railway station today compared to the usual standards?	Negative change No change Little change Positive change	1 (9.1) 1 (9.1) 1 (9.1) 1 (9.1)

Conclusion

Those tests took place in ecological environment. It was interesting to evaluate the technologies in the railway station: Foggia (Italy).

The final interpretation enables us to judge whether the solution found in Nantes is also functional in Foggia Railway Station. Recall that the solution found in Nantes is as follows: PS-UDR-Comformer ON-Presby ON. Those test should also enable us to find the best conditions to allow "For All" to understand the vocal announcements in the public open spaces.

However, the tests could not allow us to conclude a suitable solution "For All". A conclusion could be provided with new tests.This report gives us the information needed to understand the overall results. The explanation of biases encountered brings us a contrasting light of the results in this report (part "3- Observations During The tests").

The majority of the staff interviewed does not always hear the voice announcement and do not pay attention. However, they find that the train station is a little bit noisy. The conditions in their workspace appear to be adapted to their needs in terms of noise. People interviewed may not have heard of difference between days with or without ICFA tests.

Glossary

DSP: Digital Signal Processor
PA: Public address
VA:Vocal announces
IVA: Name of the NUT application which runs the I'City algorithms
IVAcontrol: Name of the PC application which was developed for controling the IVA code parameters
UDR: Useful to Detrimental Ratio
AGC: Automatic Gain Control
RT: Reverberation time
SPL: Sound Pressure Level
SNR: Signal to Noise Ratio
Preby: Presbycousis
HA: Hearing Aids

Annexes

1. Simple analysis - Average comparison - Sound quality.

Tableau de bord

Deficiencie		QmoyConfOFF	QmoyConfON	QmoyPresbOFF	QmoyPresbON	QmoySNR	QmoyUDR
Normal hearing	Moyenne	2,9063	2,0417	2,4167	3,0208	2,5278	2,7083
	N	12	12	12	12	12	12
	Ecart-type	,97428	,92216	,92062	,91985	,88999	,91045
Presby with HA	Moyenne	3,0781	1,9062	2,4219	3,2188	2,3542	3,0208
	N	8	8	8	8	8	8
	Ecart-type	,73173	,89580	,74083	,78419	,79899	,70956
Presby without HA	Moyenne	2,5481	2,2885	2,3942	2,5962	2,2949	2,6282
	N	13	13	13	13	13	13
	Ecart-type	,76808	,81551	,78203	,82625	,76725	,82258
Total	Moyenne	2,8068	2,1061	2,4091	2,9015	2,3939	2,7525
	N	33	33	33	33	33	33
	Ecart-type	,84496	,86157	,80056	,86589	,80236	,82087

2. Simple analysis - Average comparison - Listening effort.

Tableau de bord

Deficiencie		EMoyConfOFF	EMoyConfON	EMoyPresbyOFF	EMoyPresbyON	EMoySNR	EMoyUDR
Normal hearing	Moyenne	2,6875	2,1667	2,5417	3,2292	2,6806	2,7083
	N	12	12	12	12	12	12
	Ecart-type	,85030	,95545	,91907	,94423	,87461	,91045
Presby with HA	Moyenne	2,6719	2,0000	2,5313	3,1250	2,3333	3,0208
	N	8	8	8	8	8	8
	Ecart-type	1,05842	1,25357	1,11353	1,39514	1,19854	,70956
Presby without HA	Moyenne	2,2788	2,2308	2,3077	2,8462	2,3333	2,6282
	N	13	13	13	13	13	13
	Ecart-type	,65183	,75320	,78331	,85109	,72008	,82258
Total	Moyenne	2,5227	2,1515	2,4470	3,0530	2,4596	2,7525
	N	33	33	33	33	33	33
	Ecart-type	,83236	,93737	,89706	1,01696	,89465	,82087

3. Complex analysis - Average comparison - Sound quality.

Tableau de bord

Deficiencie		QMoyConfONGainSNR	QMoyConfONGainUDR	QMoyPresbyONGainSNR	QMoyPresbyONGainUDR
Normal hearing	Moyenne	1,9167	2,1667	2,8750	3,1667
	N	12	12	12	12
	Ecart-type	,87473	1,11464	1,06867	,96138
Presby with HA	Moyenne	1,6875	2,1250	2,8750	3,5625
	N	8	8	8	8
	Ecart-type	,99777	,87627	,91613	,82104
Presby without HA	Moyenne	2,2308	2,3462	2,3462	2,8462
	N	13	13	13	13
	Ecart-type	,92681	,92161	,82625	1,02844
Total	Moyenne	1,9848	2,2273	2,6667	3,1364
	N	33	33	33	33
	Ecart-type	,92267	,96088	,94923	,97044

4. Complex analysis - average comparison - Listening effort.

Tableau de bord

Deficiencie		EMoyConf ONGainSNR	EMoyConf ONGainUDR	EMoyPresby ONGainSNR	EMoyPresby ONGainUDR
Normal hearing	Moyenne	2,0417	2,2917	3,1667	3,2917
	N	12	12	12	12
	Ecart-type	1,09665	1,05439	1,09406	,96433
Presby with HA	Moyenne	1,6875	2,3125	2,8125	3,4375
	N	8	8	8	8
	Ecart-type	1,38712	1,19336	1,46232	1,37419
Presby without HA	Moyenne	2,0000	2,4615	2,7692	2,9231
	N	13	13	13	13
	Ecart-type	,88976	,77625	,78037	1,09632
Total	Moyenne	1,9394	2,3636	2,9242	3,1818
	N	33	33	33	33
	Ecart-type	1,07353	,96236	1,06889	1,10975

5. Pictures of the railway station of Foggia (Italy).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6. Italian questionnaire - 3a. Questionnaire on sound quality

Questionario sulla qualità del suono
Stazione Ferroviaria – Tests di ascolto

Istruzioni: Completate la scala della qualità del suono con riferimento all'annuncio vocale sentito (barrare la casella corrispondente).

Annuncio Vocale n°	Scala della qualità del suono				
	1	2	3	4	5
	Cattiva	Scarsa	Media	Buona	Eccellente
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐
11	☐	☐	☐	☐	☐
12	☐	☐	☐	☐	☐

7 .Italian questionnaire – 3b. Questionnaire on listening effort

SCALA DELLO SFORZO UDITIVO

Istruzioni: Completate la scala dello sforzo uditivo *(Sforzo richiesto per comprendere i significati delle frasi)* con riferimento all'annuncio vocale sentito (barrare la casella corrispondente).

Annuncio Vocale n°	Scala dello sforzo uditivo				
	1	2	3	4	5
	Nessun significato compreso nonostante lo sforzo massimo possibile	*Considerevole sforzo richiesto*	*Sforzo moderato richiesto*	*Attenzione necessaria; nessun apprezzabile sforzo richiesto*	*Completo rilassamento possibile; nessuno sforzo richiesto*
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐
11	☐	☐	☐	☐	☐
12	☐	☐	☐	☐	☐

8. Questionnaire addressed to people working in the railway station of Foggia (Italian version)

1. DOMANDE GENERALI RELATIVE AL LAVORATORE:

1.a Da quanto tempo lavora in una stazione ferroviaria?_____ (Anni/dal…)
1.b Quanti anni ha? _____ (Anni/anno di nascita)
1.c Ha problemi di udito? 1 = Si 0 = No ; se si, di che tipo?
1.d .Ha sempre lavorato in una stazione ferroviaria? 1 = Si 0 = No
1e. Se no, che lavoro svolgeva prima?
1f. Qual è il suo orario di lavoro?
1g : Dove lavora nella stazione ?
1h : che tipo di lavoro svolge? (allo sportello, nell'edicola, comunicazione con il pubblico, ecc.)?

- COMMENTI LIBERI:

---

2. DOMANDE RELATIVE ALLA PERCEZIONE DEGLI ANNUNCI VOCALI IN AMBIENTI RUMOROSI DELLA STAZIONE :

2a : Dalla sua potazione di lavoro sente gli annunci della stazione? 1 = No 2 = Si 3= Non completamente
2b : Presta attenzione al contenuto degli annunci vocali? 1 = No 2 = Si 3 = Non tanto
- COMMENTI LIBERI:

2.c : La stazione è rumorosa ? 1 = No 2 = Un pò 3 = molto
2.c : Si è abituato al rumore ed agli annunci vocali 1 = No 2= un pò 3 = Non tanto
- COMMENTI LIBERI:

2.d : Le crea disagio? (1 = Molto spesso 2 = Spesso 3 = Talvolta 4 = Mai)
2.e : In questa scala, qual è il livello sonoro nel suo ufficio/luogo di lavoro?
(1 = Molto soddisfacente 2 = soddisfacente 3 = Abbastanza soddisfacente 4 = 5 = Per niente soddisfacente)
2.f : Riesce ad isolarsi ed a rimanere concentrato sulle sue mansioni lavorative quando c'è troppo rumore nel Suo ambiente di lavoro?
(1 = Molto spesso 2 = spesso 3 = Talvolta 4 = Mai)
Come fa?

2g : Dopo il lavoro, ha bisogno di tranquillità/silenzio? 1 = No 2 = Un pò 3 = Non tanto

2h. Se svolgeva un altro lavoro in precedenza, avverte una differenza dopo il lavoro rispetto

alla Sua stanchezza tra il lavoro precedente e quello attuale? (1 = Molto spesso 2 = Spesso 3 = Talvolta 4 = Mai)
- COMMENTI LIBERI:

---

3. DOMANDE RELATIVE ALLE SOLUZIONI I'CITY FOR ALL

Avverte qualche differenza oggi nella qualità del suono e nell'intelligibilità degli annunci rispetto al solito?
1= Un cambiamento peggiorativo 2=Nessun cambiamento 3= Qualche cambiamento 2= Un cambiamento migliorativo
- COMMENTI LIBERI:

Ha suggerimenti per migliorare la qualità degli annunci vocali e/o il rumore ambientale?

9. Questionnaire addressed to people working in the railway station of Foggia (English version).

1. GENERAL QUESTIONS RELATED TO THE WORKER:

1.a Since how long you work in a railway station? _____ Year (s)
1.b How old are you? _____ Year (s)
1.c Have you hearing problems ? 1 = Yes ; 0 = No
If yes, what kind of problems:
_____
_____
_____
1.d .Are you always work in a railway station? 1 = Yes ; 0 = No
1e. If not, what was your previous job? _____
1f. What are your working hours? _____
1g : Where you work in the station? _____
1h : What is the nature of your work (at the counter, selling newspapers, discuss with the public ...)?
_____
_____

- FREE COMMENTS:

---

2. QUESTIONS RELATED TO THE PERCEPTION OF VOCAL ANNOUNCES IN NOISY AMBIANCES OF THE RAILWAY STATION:

2a : From where you are, do you hear the station announcements? 1 = No 2 = Yes 3= Not really
2b : Do you pay attention to the content of voice announcements? 1 = No 2 = Yes 3 = Not really

- FREE COMMENTS:

2.c : Is the railway station noisy ? 1 = No 2 = A little 3 = A lot
2.c : Did you accustomed to the noise and voice announcements? 1 = No 2 = A little 3 = Not really

- FREE COMMENTS:

2.d : Does The noise bother you? (1 = Very often 2 = Often 3 = Sometimes 4 = Never)

2.dd : Do the vocal announcements bother you? (1 = Very often 2 = Often 3 = Sometimes 4 = Never)
2.e : On this scale, what is the sound level in your office/workspace? (1 = Very satisfactory 2 = Satisfactory 3 = moderately satisfactory 4 = 5 = Very satisfactory Not at all satisfactory)
2.f : Do you have the ability to isolate yourself and to keep concentrated on your job tasks when there is too much noise in your work environment? (1 = Very often 2 = Often 3 = Sometimes 4 = Never)
How do you do?

_____
_____
_____

2g : After work, do you need quiet ? 1 = No 2 = A little 3 = Not really
2h. If you have a previous job, do you feel, after work, a difference between about your tiredness in your old job and the new job? (1 = Very often 2 = Often 3 = Sometimes 4 = Never)

- FREE COMMENTS:

---

3. QUESTIONS RELATED TO I'CITY FOR ALL SOLUTION

Do you perceive any difference in the sound quality and intelligibility of the announcements in the railway station today compared to the usual standards? 1= Negative change 2=No change 3= Little change 2= Positive change

- FREE COMMENTS:

Have you suggestions to ameliorate the quality of vocal announces and/or the ambient noise?

_____
_____
_____

Thank you for your participation.