



D1.1 Users' requirements Evaluation report



Project acronym: l'CityForAll
Project name: Age Sensitive ICT Systems for Intelligible City For All
Strategic Objective: Socio-acusis ICT solutions for a better social well-being of Elderly People
Project number: **AAL 2011-4-056**
Project Duration: July, 1st 2012 – Jun, 30th 2015 (36 months)
Co-ordinator: CEA : Commissariat à l'Énergie Atomique et aux Énergies 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,
 EPFL : Ecole Polytechnique de Lausanne – Lab. D'Electromagnétisme et d'Acoustique

D1.1

Version: 2.00
Delivery Date: 2014-01-15
Due date: 2014-01-31
Task: 1.1
Leader: CENTICH
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Dissemination status: PU

This project is co-funded by the Ambient Assisted Living (AAL) Joint program, by the German BMBF, by the Agence Nationale de la Recherche – ANR, by Caisse Nationale de la Solidarité pour l'Autonomie – CNSA, by the Ministero dell'Istruzione dell'Università e della Ricerca – MIUR, and by Federal Office for Professional Education and Technology OPET

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D1.1	Executive Summary
<p>The project I'CityForAll (Age Sensitive ICT Systems for Intelligible City For All) aims at enhancing the sense of safety and self-confidence of presbycusic persons, whose hearing degradation increases with age. Two mobility situations are considered: in public confined spaces and in urban space. For public confined spaces, the ICT solutions consist of smart loudspeakers for better intelligibility of vocal announcements. For urban mobility, I'CityForAll partners will develop a system embedded in vehicles 1/ for better alarming power of safety belt warning, lane change warning... 2/ for better sound alarm localization of ambulances, police cars... since the presbycusis alters perception of distance and direction of moving sound source.</p> <p>The present document is intended to describe the methodologies and tools developed and adopted to carry out the survey planned under Task 1.1 of the project and summarize the results achieved. This survey is dedicated to user's requirements in terms of intelligibility, well-being and elderly safety, to better address the solution under elaboration. This involves a cohort of presbycusic persons, older than 50 years, wearing hearing aids or not, in Italy and France.</p> <p>The survey evaluations are carried out in two stages. The first one enabled us to confirm the suitability level of cohort behavior to the existing literature findings: 1/ users are missing important information diffused in railway stations. Difficulties met in hearing and understanding information diffused by loudspeakers are mainly attributable to the bad quality of the loudspeakers.2/ drivers wearing hearing aids have problems in localizing moving sound alarms. This explains the importance of the "I'city for all" project objective aimed at improving loudspeakers quality, particularly in railway stations and developing innovative localization solutions applicable in cars.</p> <p>An underlying objective of this first step was to raise awareness level of the cohort users to the issues addressed by the project. The objective of the second step of the survey was to identify user's needs, in more details. For this purpose, a new questionnaire focused on railway stations and cars where questions aimed at better steering the project solution under design had been proposed to the users. The users were also undergoing audiometric and audiologic tests aimed to scientifically assess their hearing capacities.</p> <p>Finally, most of the users involved in the survey will test the innovative solutions that are under development in the project in railway stations and on cars both in Italy and in France, thus contributing to their validation.</p>	

Keywords :

Users' requirements, APHAB model (Abbreviated Profile of Hearing Aid Benefit), GLASGOW model (GLASGOW HEARING AID BENEFIT), presbycusic people, Hearing impairment, Hearing aid, Audiometric/Audiologic tests, Alarm localization in car, Intelligibility in public spaces

Dissemination Level of this deliverable	
PU	Public
Nature of this deliverable	
R	Report

Due date of deliverable	30/06/2013
Actual submission date	
Evidence of delivery	Questionnaires and results of the survey in https://www-icityforall.cea.fr/doku.php?id=wp1

Document History			
Date	Version	Reviewers	Type of required action
15-05-2013	1.0	Sylvie Ghalila, CEA-LinkLab	Structural modifications
12-10-2012	2.0	Sylvie Ghalila, CEA-LinkLab	
-2013	2.1		Minor modifications
	1.2		Minor modifications
	1.2		Minor modifications
	1.3		update

Authorisation			
No.	Action	Company/Name	Date
1	Prepared	ESCOOP, CENTICH	17/07/2013
2	Approved		
3	Released		

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1. INTRODUCTION

“Presbycusis is a decrease in the perception of sounds with distortion that affects virtually everyone after 65 years, to varying degrees. It is characterized by an elevation of the threshold of perception of treble” (Pouchain & al., 2007)¹

The “I city for all” project develops two innovations:

1. smart loudspeakers for better intelligibility in confined public spaces such as train stations, airports, metro;
2. automatic outdoor alarm localization system with enhancement of indoor alarm in vehicle.

The task 1.1 under WP1 of this project is divided into two steps:

1. Survey on intelligibility, well-being and security of users when audio messages are spread in confined, semi-confined and open spaces or when they drive.
2. Assessment of auditory capacities of the involved users through specific audiometric and audiologic tests

The aim of this task is to collect the user’s requirements in terms of intelligibility, well-being and elderly safety, to better address the solution under elaboration. This involves a cohort of persons, older than 50 years, wearing hearing aids or not, in Italy and France.

The partners involved in Task 1.1 are ENEA through its subcontractor ESCOOP in Italy and CENTICH through its internal service CERTA (Assessment and rehabilitation Centre of hearing disorders) in France.

These partners are responsible for writing the report 1.1-1.4 in collaboration with CRF, CEA and EPFL.

The results of this survey will be used in the work of professionals involved in WP2, WP3 and WP4.

2. METHODOLOGY

2.1. Survey on user’s requirements

The survey was carried out in two stages.

For the first stage the partners involved in Task 1.1. have drafted two questionnaires in the period between 24th September 2012 and 22nd December 2012. They wanted to use validated models to create questionnaires focused on user’s difficulties in confined public spaces (railway stations, airports, metro) and in the car.

The questionnaire answered by users was based on two models:

- The **APHAB model: The Abbreviated Profile of Hearing Aid Benefit** is a 24-item self-assessment inventory in which patients report the extent of difficulties that they meet

¹ Pouchain, D., Dupuy, C., San Jullian, M., Dumas, S., Vogel, M.-F., Hamdaoui, J., & Vergnon, L. (2007). La presbycousie est-elle un facteur de risque de démence ? Etude AcouDem. *La Revue de Gériatrie, Tome 32*(6).

in communications or perception of noises in various everyday life situations. It was developed by University of Memphis, in 1994².

- The **GLASGOW model: GLASGOW HEARING AID BENEFIT PROFILE (GHABP)** is a self-report questionnaire for assessing aspects of auditory disability, auditory handicap, and hearing-aid benefit. The questions cover scales of initial disability, handicap, hearing aid use, hearing aid benefit, satisfaction, and residual disability. It was developed by MRC Institute of Hearing Research, Glasgow, Scotland, in 1997³.

The APHAB and the GLASGOW models were chosen and properly adapted by project's partners to collect the most useful information on the target user's requirements for the project purposes. The two questionnaires described specific contexts implying auditory perception that are considered in the project: railway and metro stations, airports and cars.

The GLASGOW questionnaire is not adapted for persons without hearing aids. Indeed, questions deal with the hearing aids efficacy in everyday life unlike the APHAB questionnaire.

For this reason, the users without hearing aids would have answered to the questionnaire based on APHAB model, while the users with hearing aids would have answered to the one based on GLASGOW model only, directly related to the use of hearing aids.

Characteristics of the questionnaires used during the first stage of the survey:

Questions referred to railway station	13
Questions referred to metro station	14
Questions referred to airport	13
Questions referred to car	14
Generic questions	2

Duration of the questionnaires delivery:

APHAB model: between 30 and 45 minutes

GLASGOW model: between 45 minutes and 1 hour

At the end of the first stage, considering the results and feedback from various users, it was too difficult to complete the questionnaire based on Glasgow model. Indeed, this questionnaire, that is too long, offered many possible answers which are in some cases only slightly different the one from the others. These difficulties often explain the number of non-responses observed. Furthermore, some questions of both questionnaires were difficult to understand for some users.

² Cox, RM and Alexander, GC. "The Abbreviated Profile of Hearing Aid Benefit (APHAB)". *Ear and Hearing*, 16, 176- 186 (1995)

³ Gatehouse, S (1999) "Glasgow Hearing Aid Benefit Profile: Derivation and validation of a client-centered outcome measure for hearing-aid services", *Journal of the American Academy of Audiology*, 10:80-103.

Conclusions of the first stage (https://www-icityforall.cea.fr/lib/exe/fetch.php?media=annex_vi_centich_survey_results.xls; https://www-icityforall.cea.fr/lib/exe/fetch.php?media=annex_vii_escoop_survey_results_en.xls) :

Most of the users, involved in this first stage interviewed both in Italy and in France, declared to go rarely to metro stations and airports. Thus, the most relevant data, in this survey, are referred to railway stations and cars.

Those observations can be explained by the transport geography in each country.

Indeed, in the both experimental areas (French and Italian) there are not metro. The nearest metro station is on average at 151 km far from the users' residence (France = average 117 km; Italy = 185 km). In France only six cities have a metro network (Lille, Lyon, Marseille, Paris, Rennes and Toulouse)⁴. In Italy only four cities have a metro network (Rome, Naples, Catania and Milan)⁵ and the nearest one to the considered experimental area is that of Naples, which is 180 km far from Cerignola, 178 km from Foggia and 198 km from Lucera, the users' cities of residence.

According Bouffard-Savary (2010)⁶, "for seniors air travel decreased significantly, especially after 75 years". This description would explain the lack of response related to areas of air transport.

For the second stage of the survey, the partners involved in Task 1.1 have drafted a new questionnaire based on APHAB model, validated on the 22nd of April (Annex VIII). The main objective of the second stage of the survey was to identify users needs and profiles, in more details. This new questionnaire was focused on railway stations and cars using questions aimed at better steering the project solution under design. More specifically, the partners decided to differentiate questions about railway station considering and distinguishing between indoor and outdoor spaces and to introduce questions about driving situations thus leading to a potential dangerous and critical situation. To complete these informations, questions about the socio-anagraphic profile of each user were also asked.

Characteristics of the questionnaire used during the second stage of the survey, based on APHAB model:

Questions referred to railway station – indoor	18
Questions referred to railway station outdoor	16
Questions referred to car	68
Generic questions	7
Socio anagraphic questions	18

Duration of the questionnaires delivery: between 45 minutes and 1 hour.

⁴ Liste des métros de France. (2013, November). *Wikipédia*. Encyclopédie. Retrieved from http://fr.wikipedia.org/wiki/Liste_des_m%C3%A9tros_de_France

⁵ http://it.wikipedia.org/wiki/Metropolitana_in_Italia

⁶ Elisabeth, B.-S. (2010). L'avion : des voyages toujours plus nombreux et plus lointains. *Revue CGDD (Commissariat Général au Développement Durable)*.

2.2 Specific audiometric and audiologic tests

In the second stage of the survey the 19 French users had undergone the following audiometric and audiologic tests, performed by the audiologist collaborating with CERTA:

- a. tonal and vocal audiograms (with and without hearing aids)
- b. Auditory filter measure
- c. subjective intelligibility assessment
- d. localization assessment

The ecological protocol of localization and intelligibility tests had been established with CEA LinkLab partners (Annex XI)

In the second stage of the survey Italian users had undergone the following audiometric tests, performed by the otolaryngologist collaborating with CERCAT, in the CERCAT premises and in the private practice facility of the same otolaryngologist:

- a. tonal test
- b. vocal audiometry test

3. Questionnaire Recipients

At the end of the project, the characteristics of our panel of 90 users were:

- Persons older than 50 years old
- Persons with or without hearing aids
- Persons with or without hearing disorders

All people of the panel were invited to participate to the different steps of user's evaluation (in-lab and in-vivo) both in France and in Italy.

3.1 First stage of the survey on user's requirements

For the first stage of the survey on user's requirements, the panel of users involved consists of 49 users (21 in France and 28 in Italy).

In France:

21 users have agreed to answer the questionnaire, including 12 patients with hearing disorders but without hearing aids (APHAB model questionnaire) and 9 patients with hearing aids (GLASGOW model questionnaire).

12 of these 21 users are women and 9 are men. The average age is 74 years;

These patients are coming from, a private practice otolaryngologist (Dr Khoury)⁷, otolaryngologist consultations of CHU d'Angers, CERTA, and the local Hearing impaired users Association.

⁷ The doctor Nassib Khoury practises his profession in the hospital of Angers, France. He works at hospital part-time. His specialities are otolaryngology, audiovestibular explorations and childhood deafness.

These users have been asked to sign the informed consent form (Annex I) and the questionnaires have been delivered and completed between 6th February and 6th March 2013.

In Italy:

The questionnaires have been delivered to the following users from 28th February to 7th March 2013:

21 users of the CERCAT (Centre for Exhibition, Research and Consulting on Technical Aids for users with low autonomy, managed by ESCOOP), 2 of which with hearing aids, 8 with hearing disorders, but without hearing aids and 11 without hearing disorders. 7 deaf users belonging to the ENS (Ente Nazionale Sordi – National body for deaf users) without hearing aids. Those 7 people are involved in our study because deaf people can still drive a car.

Thus, in total, 28 users have been interviewed aged between 52 and 77 years (most of them belonging to the age class between 60 and 69) whose educational qualification is in general quite low (ISCED 2 or Lower secondary education). The two genders are equally represented in the panel.

All users replied to the questionnaire based on the APHAB model, while only those with hearing aid replied also to the one based on Glasgow model.

These users have been asked to sign the informed consent form (Annex II)

3.2 Second stage of the survey on user's requirements and audiometric tests

For the second stage of the survey on user's requirements, the panel of users involved consists of 40 users (19 in France and 21 in Italy). All the 21 users participated in the first stage. Only 7 people (the deaf users) who participated in the first stage did not participate in the second.

In France:

19 users have agreed to answer the questionnaire and to undergo the audiometric and audilogic tests between 7th May and 4th June 2013.

This cohort includes 10 prebycusics users without hearing aids and 9 prebycusics users with hearing aids. 17 users had participated to the first stage of the survey and 2 were new users (they also have been asked to sign the informed consent form).

10 of these 19 users are women and 9 are men. The average age is 71 years (user aged between 60 and 81 years old).

In Italy:

21 users, belonging to the same panel involved in the first step of the survey have answered to the questionnaire between the 19th and the 22nd of May 2013.

In our sample, 4 of them use hearing aids and 2 persons do not have any hearing disorder. 15 persons do not wear any hearing aid even if they have hearing disorders. Furthermore, among these last 15 persons, 8 have been diagnosed (after audiometric examination) presbycusic.

Among those 21 persons, 11 are women and 10 are men. The average age is 64 years [Min:52 ; Max:76].

3.3 User's participation to the next phases of the project:

The same users who have answered to the questionnaires of the two stages of the survey, and new users have been asked to be involved in "in vivo" tests proposed in task 1.3 of WP1.

4. IMPLEMENTATION OF THE STUDY

Partners in charge of delivering the questionnaires appointed experimenters after having informed them on the project content, objectives and activities, as well as on the questionnaires content and the subject of the investigation.

In France:

For the first stage of the survey, 5 experimenters from the CENTICH and the CERTA were appointed during a specific meeting held on 14th December 2012.

During this meeting, they were made aware that the results of the questionnaires would have provided the necessary elements for the following projects activities consisting in the development of technological solutions to be then installed on cars and in confined spaces such as railway and metro stations and tested in vivo.

In January 2013, each user has received the informed consent form (Annex I) specifying the different phases of questionnaires delivery. Users were asked to sign a statement describing the values and mission of the project and stressing the ethical approach to ensure respect for the individual, the employee and encouraging responsible behaviour. The questionnaires have been delivered and completed between 6th February and 6th March 2013.

For the second stage of the survey, only one experimenter was appointed to carry out the survey with the new questionnaire based on APHAB model. This experimenter was the occupational therapist of the CENTICH and the CERTA. The audiologist collaborating with CERTA had been also appointed to carry out the audiometric tests.

In May 2013 each user had been contacted by phone and letter (all the users of the first stage of the survey and 2 new users), to choose a date to come to the CERTA to meet the audiologist in order to undergo audiometric tests, and to answer the new questionnaire based on APHAB model. 19 users have agreed to answer the questionnaire and to undergo the audiometric tests between 7th May and 4th June 2013.

In Italy:

One experimenter was appointed to carry out the survey, who directly administered the questionnaires to the CERCAT users and collected the compiled ones. He was also supported in implementing the survey by the ENS – Ente Nazionale Sordi (National Body for Deaf users), which organized a specific meeting with some of its users to explain the survey and project purpose and introduced the questionnaires content. Many of the ENS users who accepted at first to collaborate in the survey, dropped out and 7 users only returned the compiled questionnaires.

All the Italian users were asked to sign the Informed consent form (Annex II), thus to express their willingness to participate in the survey, undergo audiometric tests and participate in the in vivo tests to be organized under task 1.3.

The questionnaires were delivered to the ENS users on 28th of February 2013 during a specific meeting organized with them by the experimenter at the ENS seat in Foggia. The compiled questionnaires, together with the signed informed consent form were collected by the experimenter on 7th of March 2013. The CERCAT users received the questionnaires on 7th of March 2013 and returned the compiled ones to the experimenter on 10th of March 2013.

For the second stage of the survey in Italy the same experimenter re-contacted the 21 users who have been involved in the first stage of the survey and met them at their homeplace. More specifically, he met the users with hearing problems without hearing aids on the 19th of May 2013, those with hearing aids on the 20th of May 2013 and the users without hearing problems on the 22nd of May 2013.

5. SURVEY FINDINGS

5.1 First Stage of the survey:

5.1.1 Result of questionnaire based on APHAB model (Annex VI, VII)

In France, 12 users without hearing aids answered to the questionnaire.

In Italy, 11 normal hearing users, 8 presbycusis users without hearing aids, 7 deaf users and 2 users with hearing aids, answered to the questionnaire.

Questions referred to railway station:

In France:

11 users out of 12 users provided replies. The majority, can, in general, hear and understand vocal announcements when they are in the hall but it's more difficult on a platform and during peak hours. Most of the users miss half the time or more, information from loudspeakers. A large majority of users understand jingles and find that they help to activate their attention. Interacting with teller or desk person is in general a problem for most of the users while they are listening to vocal announcements or jingles. These difficulties are usually a cause of worries and anger for most of them. Loud sounds and noises hurt the users particularly on a platform. About 80% of users confirm that the cause of voice announcements misunderstanding is the quality of the loudspeakers.

In Italy:

The majority of CERCAT users both with and without hearing aids, stated that they can, in general, hear and understand the vocal announcements when they are both in the hall and on a platform, while more difficulties are met during peak hours. Information spread through loudspeakers are missed half the time in most cases, while jingles are always/in general heard by most of the users, even when speaking with friends, and are considered helpful in paying attention to voice announcements. Interacting with the teller or desk person is generally not a problem for most of the users while they are listening to vocal announcements. The difficulty in understanding information, which is increased by the use of music players with earphones, is usually a cause of worries and anger for most of the users. Loud sounds hurt the users and, in the case of users without hearing aids, particularly when they are on a platform, while users with hearing aids seem to meet more difficulties when they are in the hall. Replies by users with hearing aids are different from the above with reference to jingles, which can be heard by these users half the times, so less frequently than the others. Finally, both users with hearing aids ascribe the cause of difficulties in hearing well to their hearing problems, while the majority of users without hearing aids identifies in the loudspeakers bad quality the cause of the problem.

Questions referred to metro station:

In France:

The analysis of replies shows that 67% of users did not provide any answer. Seven users out of twelve have specified that they never took the subway. Only two users have justified their "no response" by the fact that they had not taken the subway recently. All users understand jingles and find that they help to activate their attention. Interacting with teller or desk person is not possible for the users while they are listening to vocal announcements. All users (4) confirm that the cause of voice announcements misunderstanding is the quality of the loudspeakers.

In Italy:

8 users (including both users with and without hearing aids) only out of 21 CERCAT users interviewed provided replies to the questions referred to the metro station. The majority of those without hearing aids, in general, stated that they do not meet difficulties neither in understanding voice announcements and jingles in the situations described nor in interacting with the teller or desk person. Noises and loud sounds occasionally represent causes of troubles for half of the interviewed when they are in the main hall, while on the platform the discomfort increases slightly. The use of music players with earphones reduces the capacity of understanding voice announcement, together with the loudspeakers bad quality and hearing problems, which seem to have the same weight in causing the problem.

Both CERCAT users with hearing aids replied to these questions but they declared to meet slightly more difficulties in understanding voice announcements and jingles in the situations described and in interacting with the teller or desk person compared to the users without hearing aids. Noises and loud sounds generally hurt these users and particularly in the hall and

the use of music players with earphones reduces the capacity of understanding voice announcement, together with the users' hearing problems, which are generally considered the cause of the problem.

Questions referred to the airport:

In France:

10 users out of 12 users provided replies. The majority, can, hear and understand vocal announcements when they are on a platform but it's more difficult in the hall and during peak hours. Most of the users miss half the time or more, information from loudspeakers. A large majority of users understand jingles and find that they help to activate their attention. But it's more difficult when they are talking to somebody. All the respondents are not able to normally communicate with a teller when a voice announcement is spread. Noises and loud sounds don't really represent causes of troubles for the majority of the users. 80% of users confirm that the cause of voice announcements misunderstanding is the quality of the loudspeakers.

In Italy:

9 users only out of 21 CERCAT users interviewed provided replies to the questions referred to the airport, including both users with and without hearing aids. The majority of those without hearing aids, in general, stated that they do not meet difficulties neither in understanding voice announcements and jingles in the situations described nor in interacting with the teller or desk person. Noises and loud sounds occasionally represent causes of troubles for the majority of the interviewed users, more frequently on platforms than in the hall. The use of music players with earphones reduces the capacity of understanding voice announcement which is mainly due to hearing problems for the majority of the interviewed, but it is interesting to highlight that most of the users stated that half the times they miss a lot of information given by the loudspeakers.

Both CERCAT users with hearing aids replied to these questions but they declared to meet slightly more difficulties in understanding voice announcements and jingles in the situations described and particularly in interacting with the teller or desk person compared to the users without hearing aids. Noises and loud sounds generally hurt these users both in the hall and on platforms. The use of music players with earphones reduces the capacity of understanding voice announcement, together with the users' hearing problems.

ENS users, all deaf users, declared that in all the three considered environments (railway station, metro station and airport) they can never hear information from the loudspeakers, and most of them are always worried, angry, or upset at the thought of not being able to understand the information. Noises and loud sounds hurt most of them half the times when they are in the hall and on platforms.

Questions referred to the car:

In France:

All users replied to the questions. The analysis of figures showed that over 75% of users who use their car properly perceive outside noise and various types of alarm. They don't always understand information given by the navigator. Background noises such as music or passengers conversations do not seem to really reduce their capacity of hearing the alarms coming from outside. A majority of users doesn't generally meet difficulties in understanding where the alarm's noise comes from (60%).

In Italy:

All the CERCAT users replied to the questions and the majority of them stated that they generally hear, understand, recognize and localize outside noise and various types of alarm. They generally understand the information given by the navigator, but the use of air conditioning, ventilation, radio, CD or music player reduces this capacity as well as that of hearing the alarms coming from outside. This situation (difficulty in perceiving the outside alarm sounds) generally is a source of worries for the users.

The CERCAT users with hearing aids meet slightly more difficulties than the others in hearing the different alarms while windows are open as well as in hearing outside "alarming" sounds both in situations of low and high traffic, thus they are able to identify the different alarm's type half of the times only. The use of air conditioning and ventilation reduces the capacity to hear and understand the alarms coming from outside less frequently than in the users without hearing aids. These users meet also more difficulties in understanding where the alarm's noise come from, which happens half the times only.

All the ENS users, stated that they can hear different alarms coming from outside during high and low traffic and when windows are closed half the times, while, if the windows are open, most of them can never hear the alarms. In situation of high traffic they can never hear outside "alarming" sounds, while during low traffic the situation improve for some of them. They declared to be always able to identify the different alarm's type but they can understand only half of the times where the alarm's noise comes from. Most of them can never understand the information from the navigator but they stated that the use of radio, CD or music players, air conditioning, ventilation and the conversations with passengers never prevent them to hear the different alarms coming from outside or the navigator information. All of them declared to be always worried, upset or angry at the thought of not perceiving the outside alarm sounds.

This analysis shows many contradictions in the replies by ENS users which can be due to the difficulties them met in properly understanding the questions. This was partly caused by their low level of education and by the fact that they preferred to compile the questionnaires at home with the support by their relatives rather than with that by the ENS staff or the "Icityforall" experimenter.

“Generic” questions:

In Italy, only 6 CERCAT users replied to the question “*What is the most annoying thing for you, noisy conversation or reverberation?*”. 4 of them (1 with hearing aid) indicated noisy conversations as the most annoying factor, while 2 indicated “*reverberation*”. Finally only 3 users replied to the question “*What could improve your sense of confidence in an unknown environment?*” as follows: 1 hearing better; 1 improving my hearing (1 person with hearing aid); 1 distinguishing noises.

5.1.2 Result of questionnaire based on Glasgow model (Annex VI, VII)

In France, 9 users with hearing aids answered to the questionnaire.

In Italy, only 2 CERCAT users replied to this questionnaires (those with hearing aids) and with reference to all the three considered environments (railway station, metro station, airport), both of them stated that they always meet difficulties in hearing voice announcements and interacting with the teller or desk person while listening to vocal announcements. They are really worried, upset or angry at the thought of not being able to understand the information. Both of them are, in most of the cases, reasonably satisfied with their hearing aids.

Questions referred to railway station:***In France:***

The results show that the commonest problem encountered is the interaction with a teller or a responsible person when a voice announcement is spread. Generally the interviewed presbycusic users state that they do not try to understand an announcement when approaching a teller or a controller and vice versa. The hearing aid is satisfactory; difficulty in perceiving the information causes little or no frustration nor anger at all. However, the difficulties to understand the announcements are moderate, and loud sounds are difficult to manage. Only one person of the panel justified this appraisal by the fact that the extensive use of signage in the station helps in understanding the information.

Questions referred to metro station:***In France:***

The majority of users have not responded. 5 users out of 9 said they never took the subway.

Questions referred to the airport:***In France:***

4 out of 9 users reported that they never took the plane and only two users were able to respond.

Questions referred to the car:

In France:

Users' responses show that between 70% and 100% of them perceive the majority of all external alarms. About 80% of users have a localization problem. Note that users are aware that they should not multiply the sound sources, thus they avoid turning on the radio if they should listen to their navigator or chat with a passenger, for example.

In Italy:

Both users stated that they meet moderate-great difficulties in hearing the different alarms coming from outside. They are also moderately/quite a lot worried, upset or angry at the thought of not being able to understand the information. Both of them are reasonably satisfied with their hearing aids in all the situations described.

5.1.3 Conclusions of the First Stage of the survey:

This first stage of the survey enabled us to confirm the suitability level of cohort behaviour to the existing literature findings:

- users are missing important information diffused in railway stations. Difficulties met in hearing and understanding information diffused by loudspeakers are mainly attributable to the bad quality of the loudspeakers.
- drivers wearing hearing aids have problems in localizing moving sound alarms.

This explains the importance of the "I'city for all" project objective aimed at improving loudspeakers quality, particularly in railway stations and developing innovative localization solutions applicable in cars.

According to the results of this first stage of the survey, the main objective of the second stage of the survey was to identify users' needs and profiles, in more details. This new questionnaire was focused on railway stations and cars using questions aimed at better steering the project solution under design. The users were also undergoing audiometric tests aimed to scientifically assess their hearing capacities.

5.2 Second Stage of the survey (Annex IX, X):

5.2.3 Socio anagraphic review:

In France:

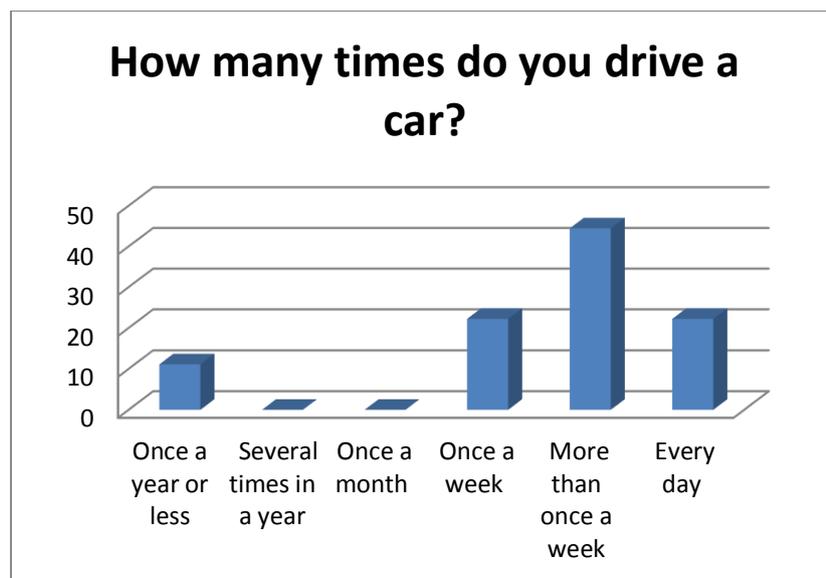
19 users have agreed to answer the questionnaire and to undergo the audiometric and audiologic tests.

This cohort includes 10 prebycusics users without hearing aids and 9 prebycusics users with hearing aids. 17 users had participated to the first stage of the survey and 2 were new users.

10 of these 19 users are women and 9 are men. The average age is 71 years (user aged between 60 and 81 years old).

The 9 users with hearing aids are 8 men and 1 women, with an average age of 71 years old. They wear their hearing aids all day and then when they attend public transport, public places and when driving their vehicle. 8 of them are driving an average of 12500 km / year (one user is visual impaired).

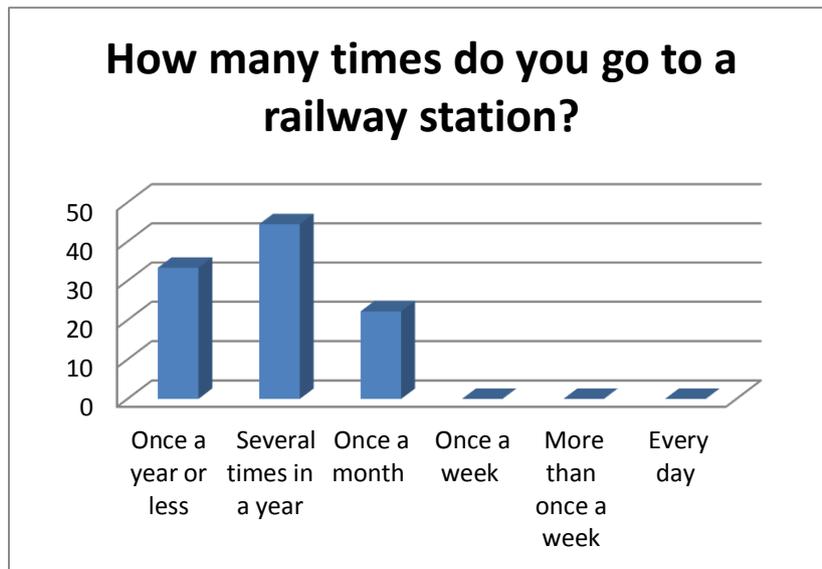
The majority drive between daily and weekly mainly in the city.



Graphic 1: How many times do you drive a car? (Percentage)

They use little or no cell phone in the car but 6 of them use a navigator (rather occasionally) and radio (rather often). Only one user uses the parking aid. One person has difficulty in noticing hazard warning lights.

They go to a railway station between once a month and once a year or less.

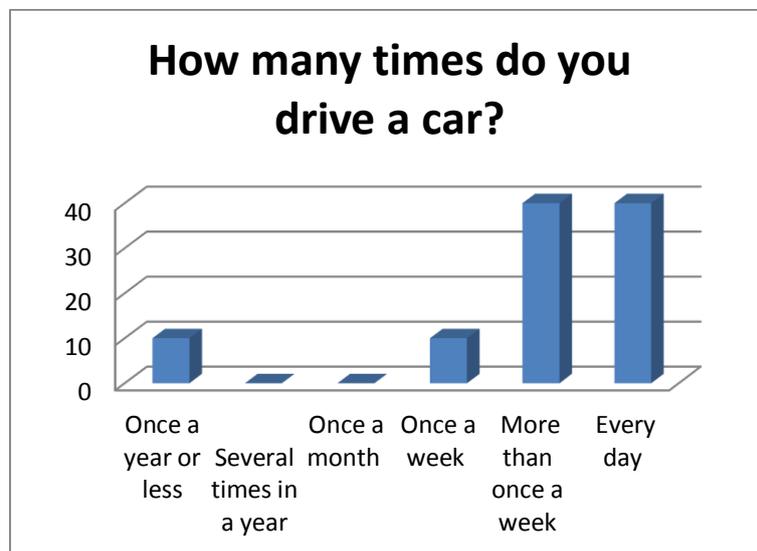


Graphic 2: How many times do you go to a railway station? (Percentage)

4 occasionally use their mobile phones in this situation, others do not use it. They do not use music players / DVD, and two of them occasionally use a digital tablet.

The 10 users without hearing aid, are 1 men and 9 women with an average age of 72 years old.

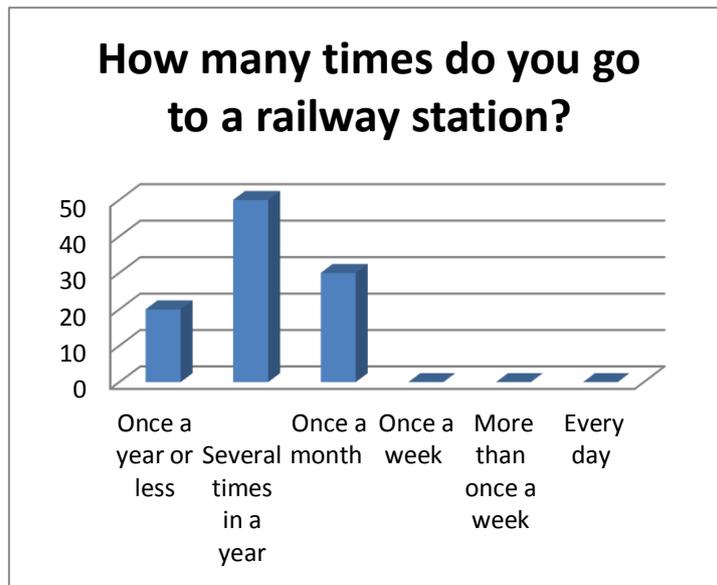
9 of them are driving an average of 7300 km / year (one user is visual impaired). The majority of them (8) drive between daily and several times a week, mostly in the city.



Graphic 3: How many times do you drive a car ? (Percentage)

They do not use the cell phone in the car but four of them occasionally use a navigator (rather occasionally) and 9 use the radio (rather often). Only one person uses the parking aid. One person has difficulty in noticing hazard warning lights.

They go to a railway station between once a month and once a year.



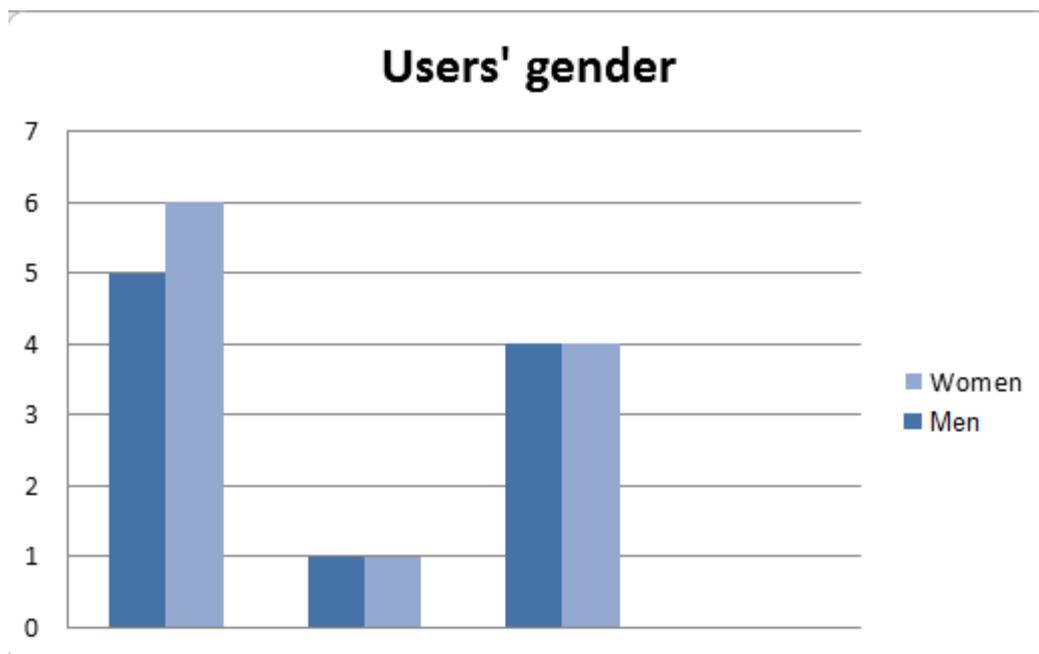
Graphic 4: How many times do you go to a railway station? (Percentage)

4 users, use their mobile phones in this situation (2 occasionally, 2 often), the others do not use it. They do not use music players / DVD, and one occasionally uses a digital tablet.

In Italy:

The questionnaires have been delivered to the following users between the 19th and the 22nd of May 2013 by the same experimenter involved in the first phase of the survey.

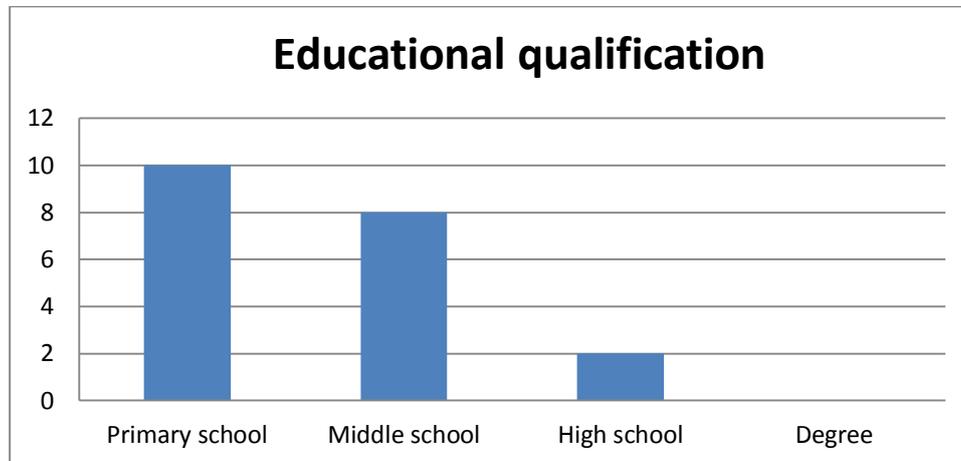
21 users of the CERCAT (Centre for Exhibition, Research and Consulting on Technical Aids for people with low autonomy, managed by ESCOOP), 2 of which with hearing aids (1 man and 1 woman), 8 with hearing disorders, but without hearing aids (4 men and 4 women), and 11 without hearing disorders (5 men and 6 women):



Graphic 5: Users' gender (frequency)

They are aged between 52 and 76 years, with an average age of 64 years.

Their educational qualification is in general quite low (ISCED 2 or Lower secondary education):



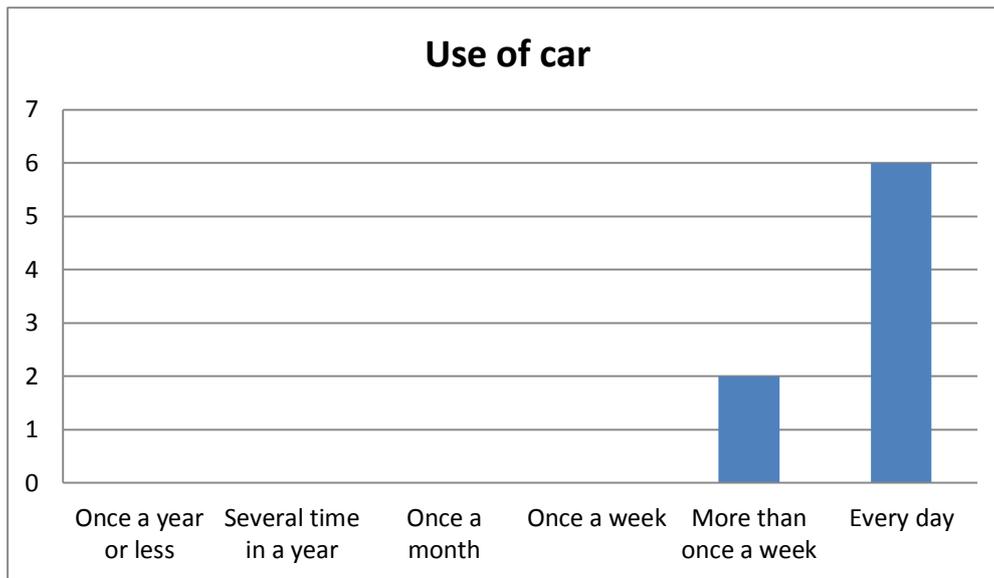
Graphic 6: Educational qualification (frequency)

With regards to the use of hearing aid, the two users concerned stated that they have been using it for 1 to 10 years and both of them wear it for 8 to 16 hours per day. They both consider the level of their hearing impairment severe when they are not wearing their hearing aid, while when they do, they consider it as a mild impairment. None of them uses any specific device/adaptor for their hearing aid.

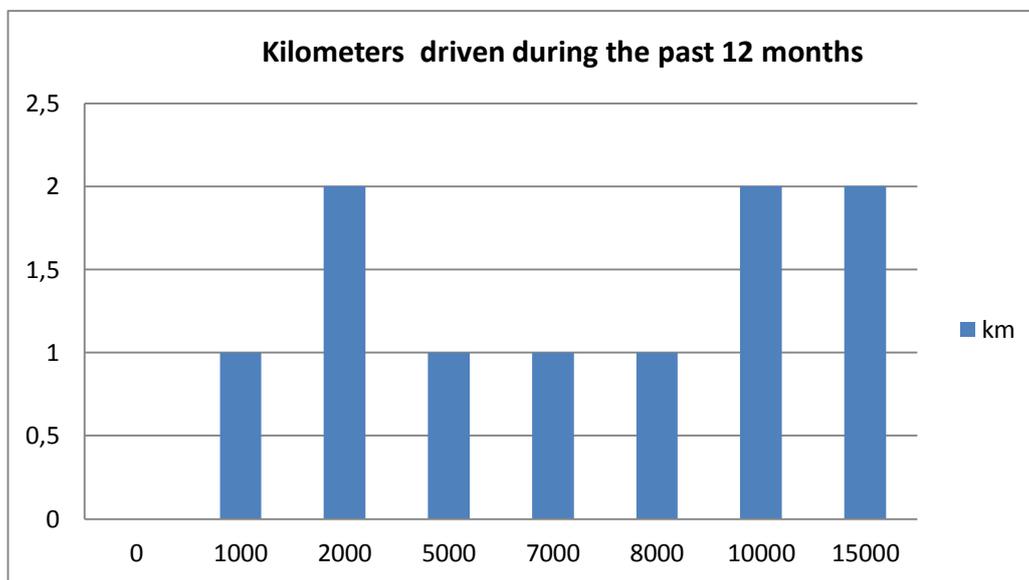
QUESTIONS REFERRED TO CAR:

In Italy, 10 users, all women and all housewives, don't have a driving license. They have anyway answered to the questions referred to the car, imagining themselves as passengers. Those who have a driving license, has got it between the age of 20 and 26 (average 23,3) and they have been driving a car for around 43 years on average.

The majority of Italian users use the car every day/more than once a week and they have been driving for approximately 7500 Km during the past 12 months. They drive mainly in towns, but many of them drive in rural areas too (Italian users who reported to drive more frequently in rural areas than in town work as farm hands or as farmers). Few of them reported to drive on the highway too but less frequently. These results are shown in the following

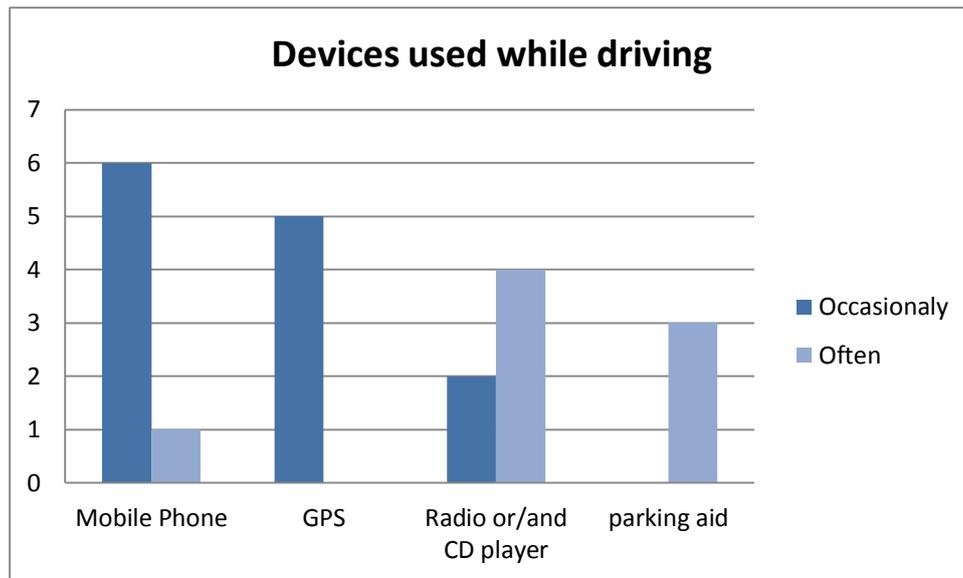


Graphic 7: Use of car (frequency)



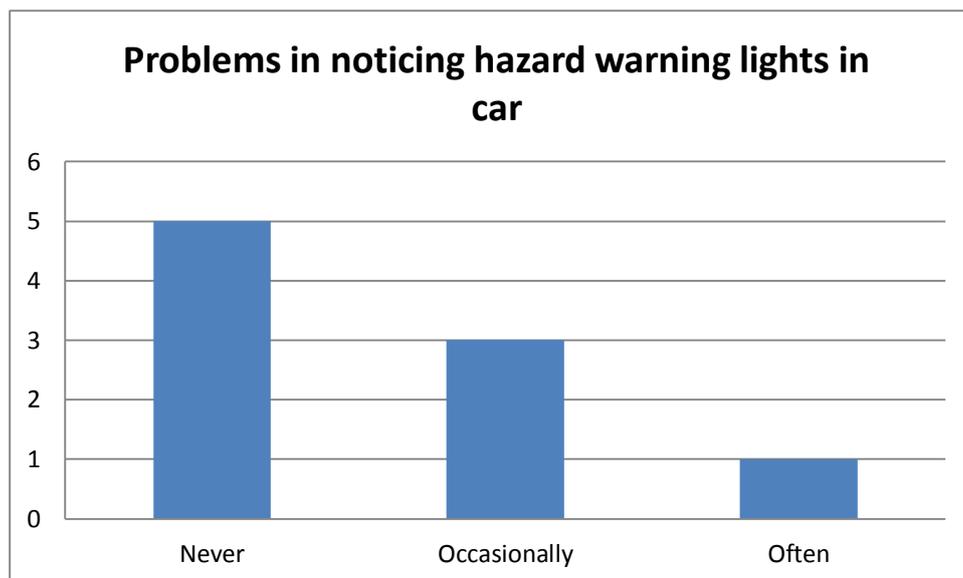
Graphic 8: Kilometers driven during the past 12 months (Frequency)

Around the 66% of the Italian users stated that they occasionally use a mobile phone while driving, 55% occasionally use the navigation system and 44% never use it, the majority stated that they often use on board radio and/or CD player and never a parking aid:



Graphic 9: Devices used while driving (frequency)

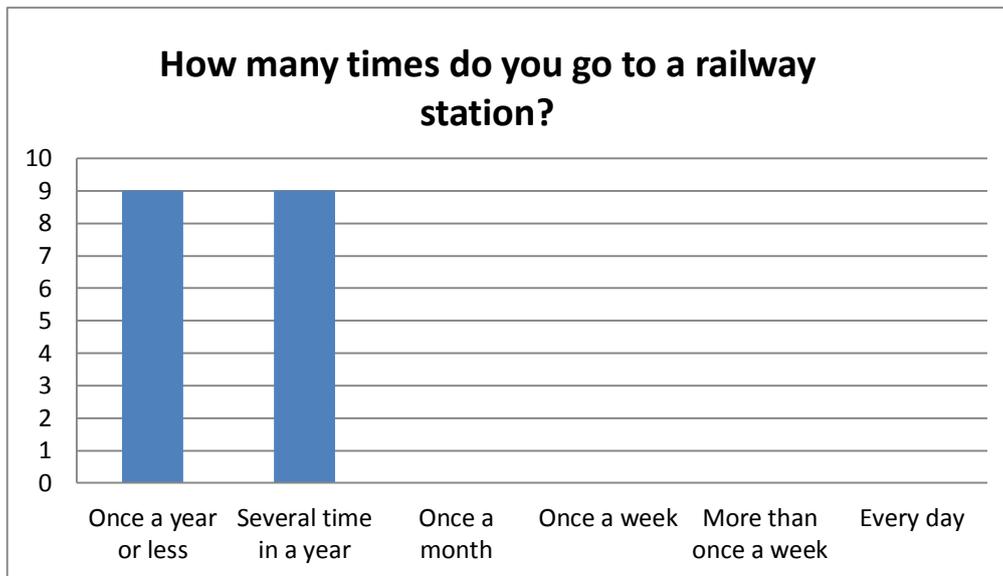
Finally, the majority of Italian users stated that they never have problems in noticing hazard warning lights in car:



Graphic 10: Problems in noticing hazard warning lights in car (frequency)

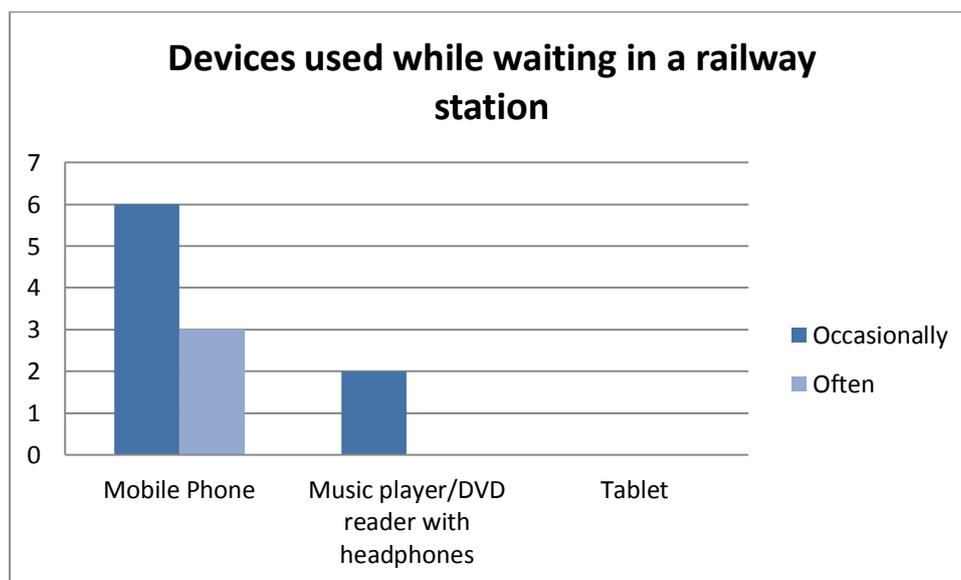
QUESTIONS REFERRED TO RAILWAY STATION:

Most of the Italian users reported to go rather infrequently in a railway station:



Graphic 11: How many times do you go to a railway station (frequency)?

While they are waiting in a railway station, the device that is mostly used is the Mobile phone, followed by music players/DVD readers with headphones which are used occasionally only. Finally, none of the Italian users interviewed uses tablets while waiting in a railway station:



Graphic 12: Devices used while waiting in railway station (frequency)

5.2.4 Generic questions

In France:

QUESTIONS REFERRED TO CAR:

All users prefer driving windows closed because of the noise, air currents and the use of air conditioning .

14 of 19 users prefer a visual indicator on their dashboard indicating the direction of the alarm with an arrow to locate an external alarm, only 3 users choose an enhanced friendly sound tuned accordingly to their ear perception (2 users without opinion). User's recommendation to improve intelligibility in cars:

- Using visual indicators
- Improve the soundproofing of vehicles and make them quieter
- Increase the sound level of internal alarms signal.
- Transmit audio signals to the hearing aid with an inductive loop.

QUESTIONS REFERRED TO RAILWAY STATION:

Noisy conversations are more annoying in a closed space for 16 by 19 users. 14 of 19 users prefer to hear vocal announcements diffused by the loudspeakers at a slower rate in order understand them, they insist on their need for articulation and good diction. 12 of them think that it would also allow them to better remember them.

User's recommendation to improve intelligibility the railway station:

- Multiply Loud-speakers
- Improve the quality of audio equipment
- Limit the reverberation
- Vary the tone of the messages (lower)
- Adapt the sound diffusion to the soundscape place
- Repeat the vocal announcement and increase the number of billboards,
- Test the equipment with hearing impaired users and use the inductive loops

In Italy:

Few users only replied to the generic questions None of them provided any comment to improve the intelligibility in car and railway station.

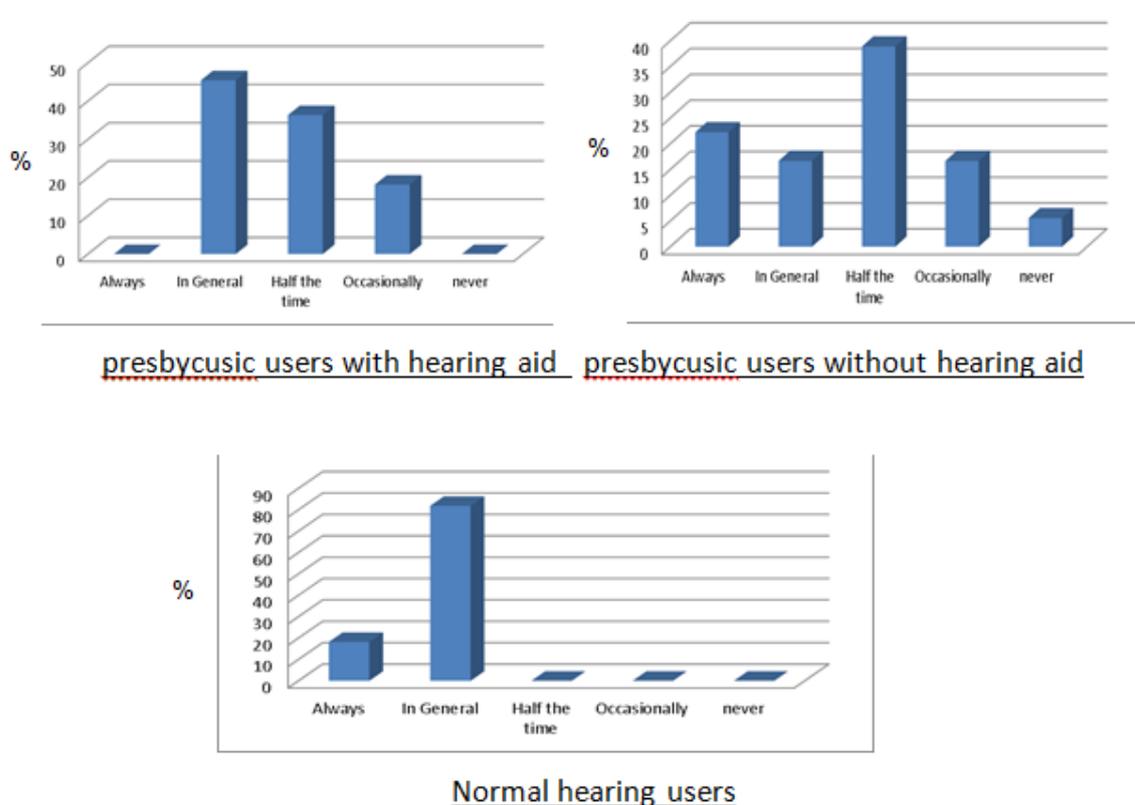
Among those who have provided replies to the generic questions included in the questionnaire, one of the users with hearing impairment but without hearing aid, stated that she would prefer an enhanced friendly sound tuned accordingly to her ear perception to inform her about the direction of an coming alarm. The other 2 users who provided a reply, one with hearing impairments and with hearing aid and the other with hearing impairments but without hearing aid, did not specify which kind of device/system/solution they would prefer, different from an enhanced friendly sound and a visual indicator. The same 2 users, one with hearing impairments and with hearing aid and the other with hearing impairments but without hearing aid stated that noisy conversations are more annoying in a closed space, while another user with hearing impairments but without hearing aid consider them more annoying in open ones.

Finally, for two users, one with hearing impairments and with hearing aid and the other with hearing impairments but without hearing aid, to understand the vocal announcements

diffused by the loudspeakers and to remember them, it is not necessary to hear them at a slower rate.

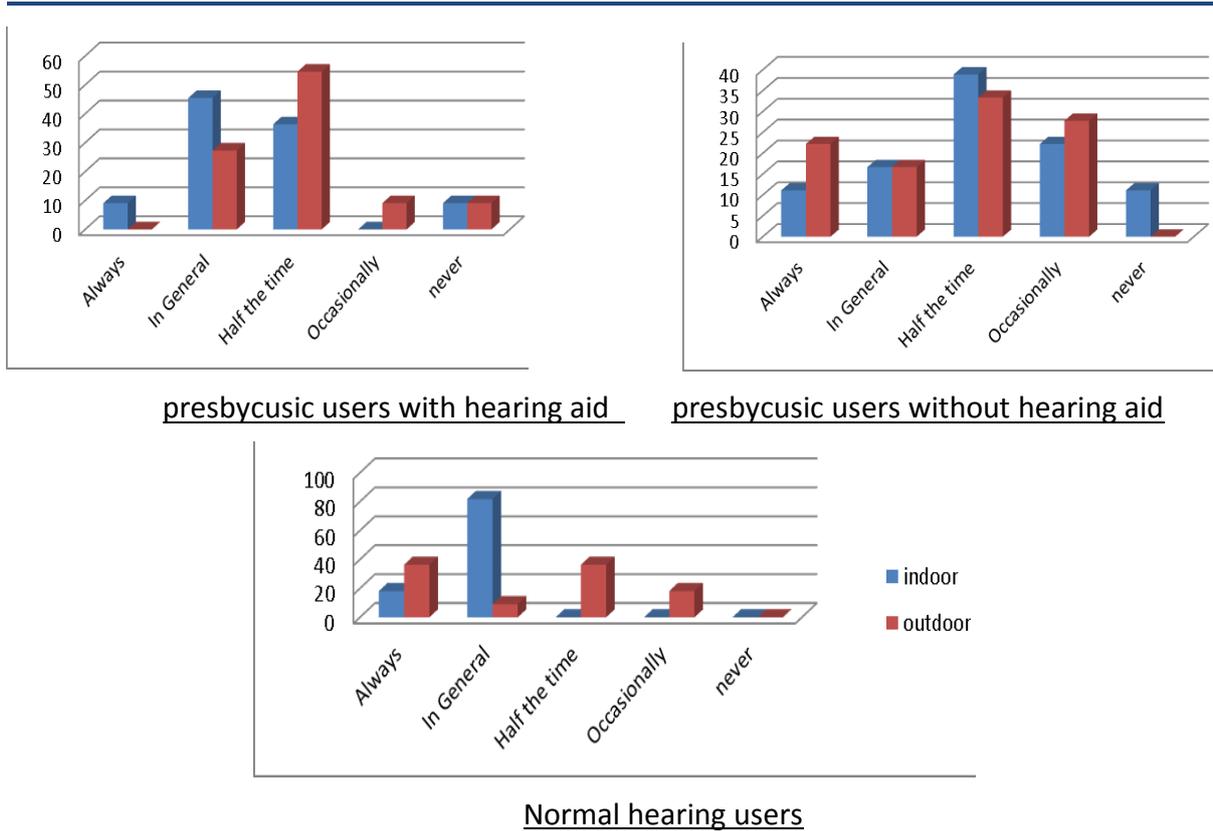
5.2.5 Result of questionnaire based on Aphab model second version, questions referred to the railway station:

For each question, the results are compared between normal-hearing users (8 Italians), presbycusic users without hearing aid (10 French and 8 Italian) and presbycusic users with hearing aids (9 French, 2 Italians).



Graphic 13: Difficulty to hear and understand the vocal announcements in the main hall of a railway station

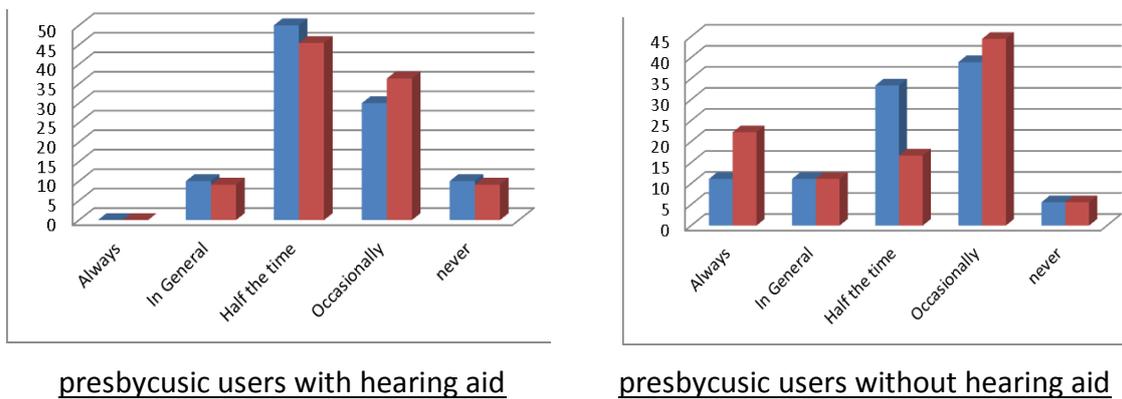
The majority of presbycusic users with or without hearing aids can hear and understand a voice announcement half the time or less frequently in the main hall of a railway station while normal hearing users generally have no difficulty.

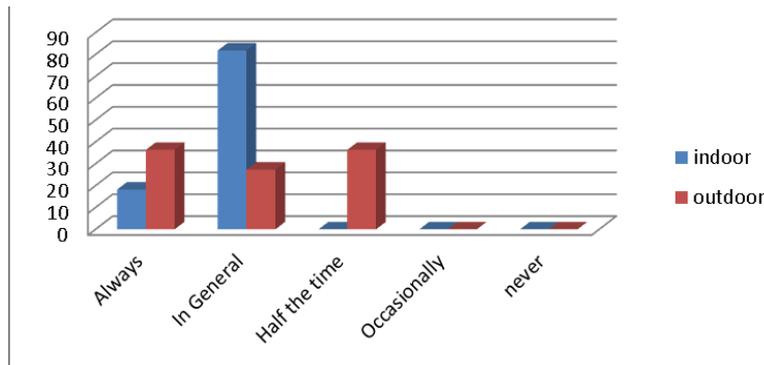


Graphic 14: Difficulty to hear and understand the vocal announcements in the platform of a railway station (percentage)

Outdoor, the majority of presbycusis users with or without hearing aids can hear and understand the vocal announcements half the time or less frequently. Presbycusis users with hearing aids have less trouble indoor.

Normal hearing users generally have no difficulty indoor but can meet difficulties outdoor.

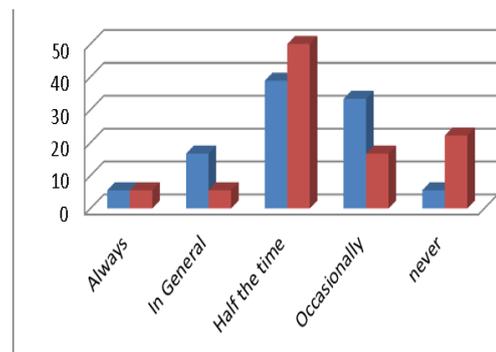
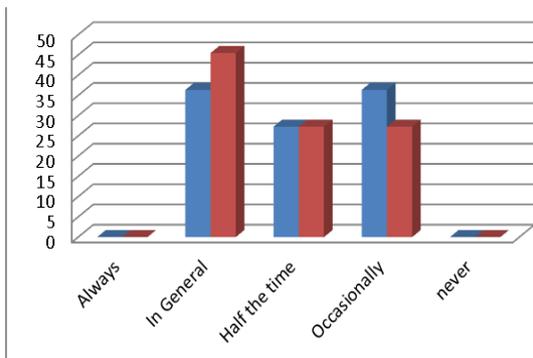




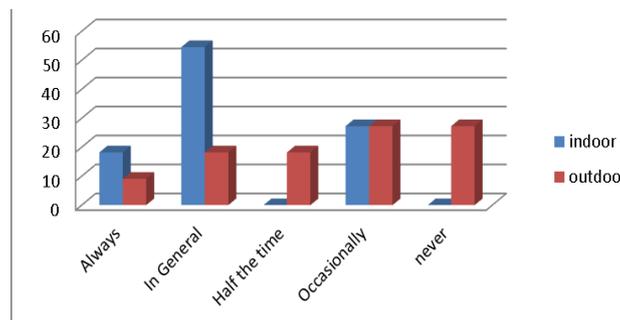
Normal hearing users

Graphic 15: Capacity to hear and understand the vocal announcements in railway station during peak hour (percentage)

During peak hours, presbycusics users with and without hearing aids capacity to hear and understand the vocal announcements greatly reduced, but the difference between indoor and outdoor is not significant. In contrast, normal hearing users have no more difficulties during peak hours but their understanding is better indoor than outdoor.



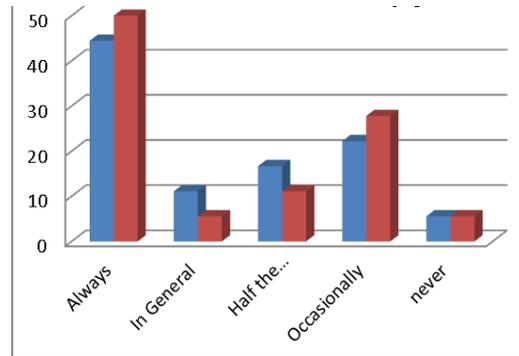
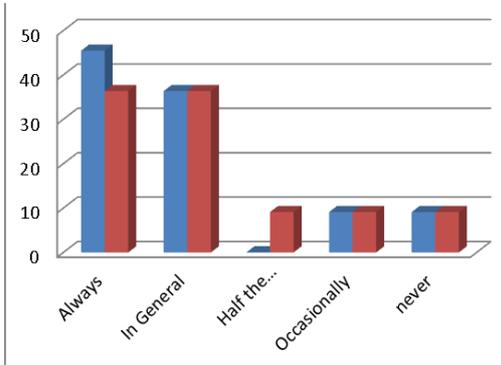
presbycusic users with hearing aid presbycusic users without hearing aid



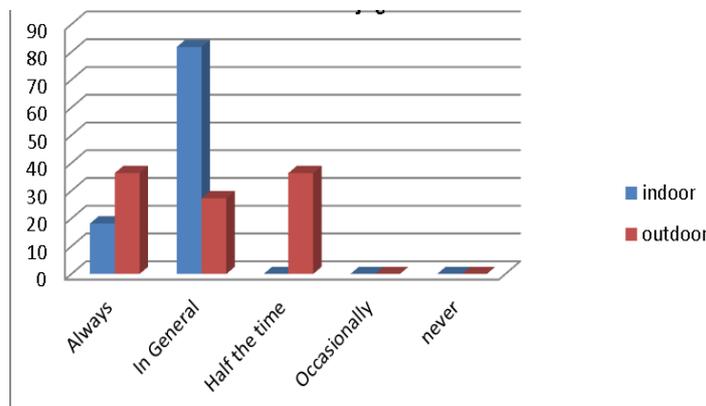
Normal hearing users

Graphic 16: Frequency in which the users miss a lot of information diffused by the loudspeakers(percentage)

The majority of presbycusics users with and without hearing aids miss, half the time or more, a lot of information diffused by loudspeakers whether indoor or outdoor. The normal hearing users confirm that they are more in trouble outdoor.



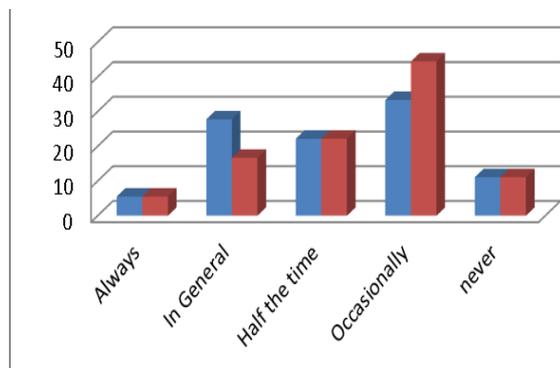
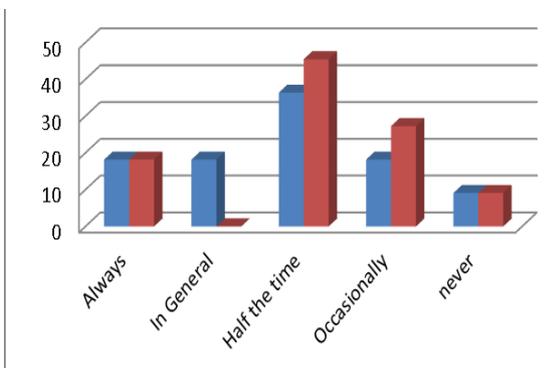
presbycusic users with hearing aid presbycusic users without hearing aid



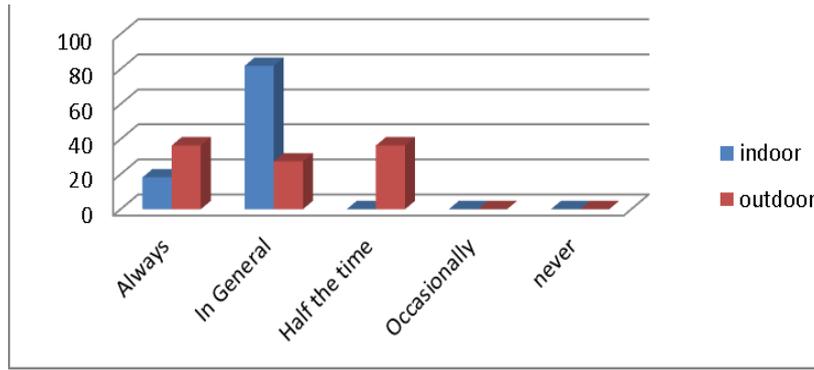
Normal hearing users

Graph 17: Capacity to hear the jingles (percentage)

Generally jingles are well received by the majority of the users, but users have more difficulties in perceiving it outdoor than indoor.



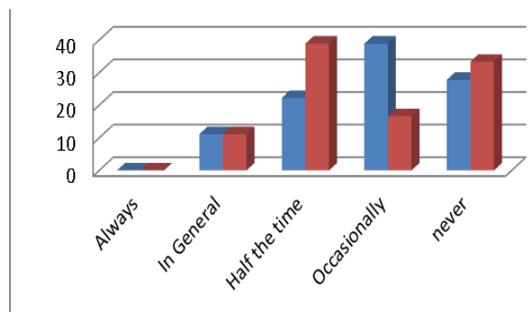
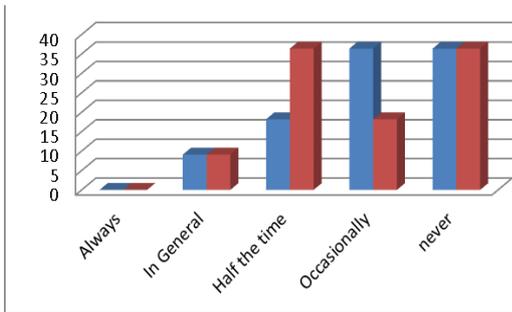
presbycusic users with hearing aid presbycusic users without hearing aid



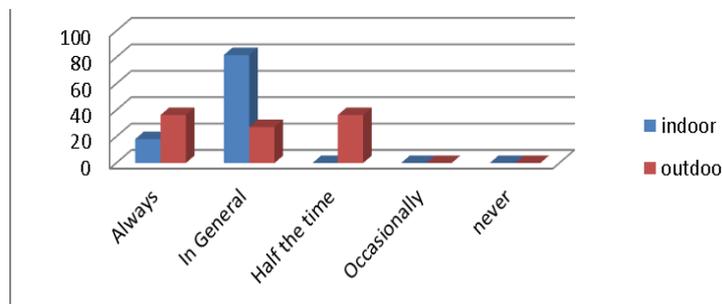
Normal hearing users

Graph 18: Capacity to hear jingles and vocal announcements while they are speaking with somebody (percentage)

The presbycusics users with and without hearing aids have half the time or more, and especially outdoor, difficulties in hearing the vocal announcements while they are speaking with somebody. They state that they must make a choice between hear the vocal announcements and speak with somebody. The normal hearing users have little or no difficulty indoor but outdoor it can be more difficult.



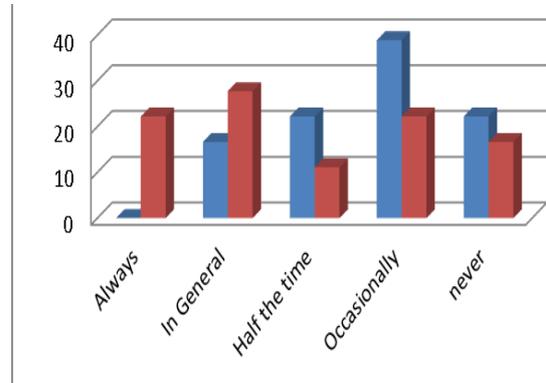
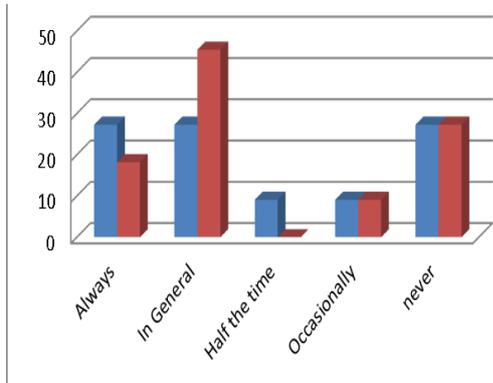
presbycusic users with hearing aid presbycusic users without hearing aid



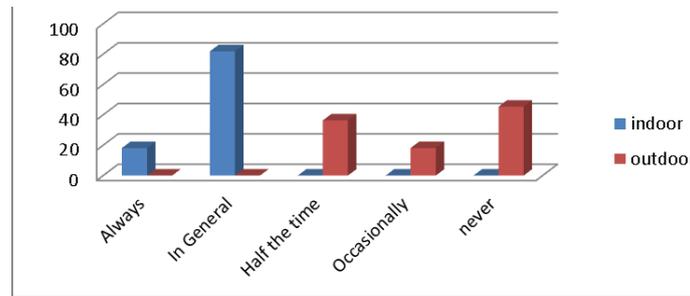
Normal hearing users

Graph 19: Capacity to interact with the information teller or desk person while they are listening to vocal announcements (percentage)

The presbycusics users with and without hearing aids are in trouble indoor and outdoor to interact with the information teller or desk person while they are listening to vocal announcements. They state that they must make a choice between one and the other. The normal hearing users have little or no difficulty indoor but outdoor it can be more difficult.



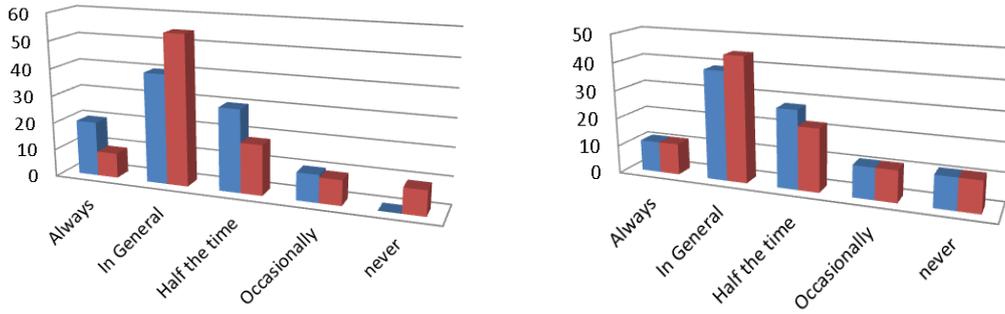
presbycusic users with hearing aid presbycusic users without hearing aid



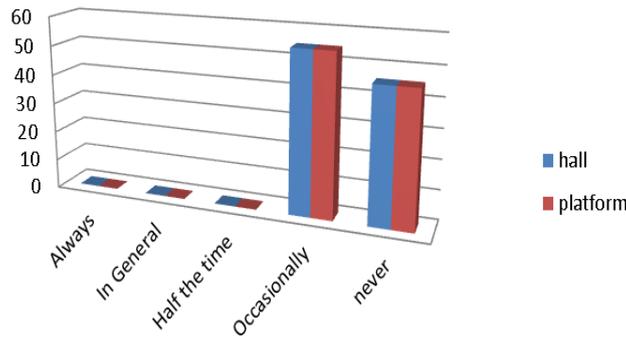
Normal hearing users

Graph 20: Frequency in which the users are worried, upset or angry at the thought of not being able to understand the vocal announcements (percentage)

Outdoor presbycusics users with and without hearing aids are mostly half the time or more worried, upset or angry at the thought of not being able to understand the vocal announcements. Indoor presbycusics users without hearing aids are less affected. It could be explain by the possibility to read the information signboard when you are on the main hall of a railway station. Normal hearing users' results are contradictory, because they seem to be more affected inside than outside but they describe more difficulties outside. According to the Italian audiologist this is due to the fact that when a person is entering in a railway station, he/she is assailed by a high number of sounds and information, apart from lights, warning lights, wide screens and advertisements that can produce a feeling of confusion and bewilderment and of worries that is weakened when the person goes outdoor where warning lights, screens for information etc. are reduced, thus leaving more space for sounds and jingles even if the feeling of confusion and bewilderment does not disappear completely.



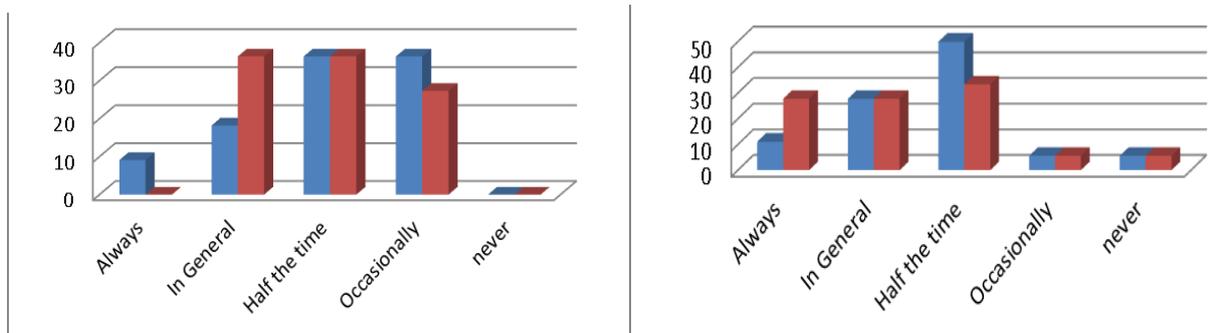
presbycusic users with hearing aid presbycusic users without hearing aid



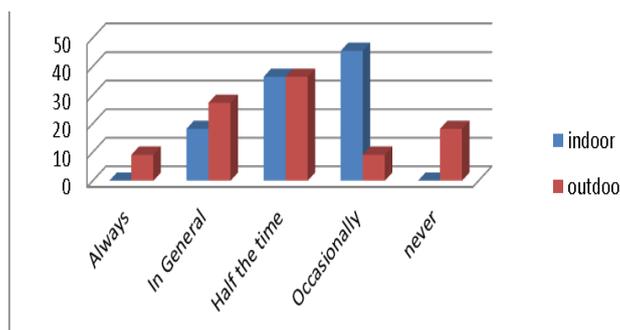
Normal hearing users

Presbycusics users with and without hearing aids are most commonly generally hurt by noises and loud sounds either in the hall or on the platform. In contrast, normal-hearing users have little or no embarrassment.

Graph 21: Frequency in which the users are hurt by noises and loud sounds (percentage)



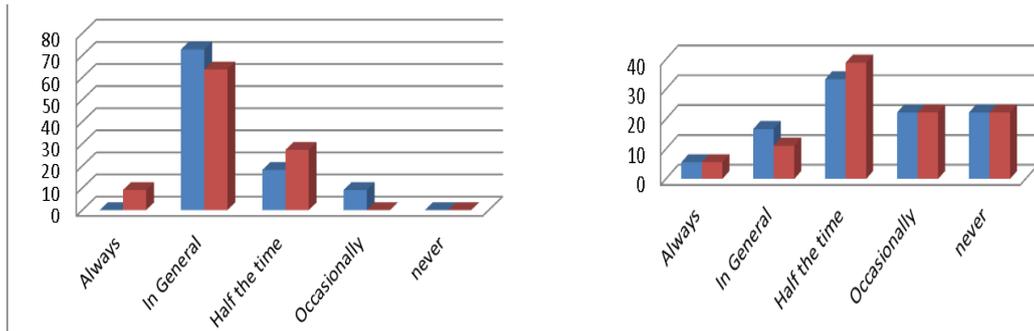
presbycusic users with hearing aid presbycusic users without hearing aid



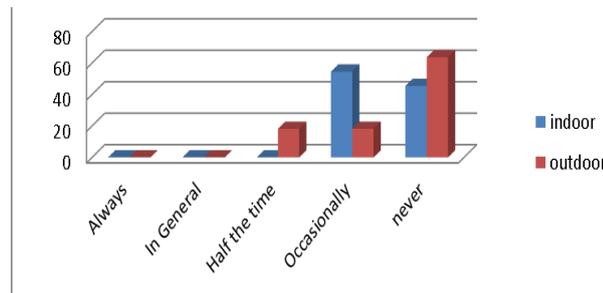
Normal hearing users

Graph 22: Frequency in which the usersthink that the feeling not to hear well is due to the loudspeakers bad quality (percentage)

Outdoor, presbycusics users with and without hearing aids and normal hearing users mostly think that half the time or more their difficulties are due to the loudspeakers bad quality. In contrast, indoor, presbycusics users with hearing aids and normal hearing users mostly think that the loudspeakers bad quality is the cause of their difficulties half the time or less frequently.



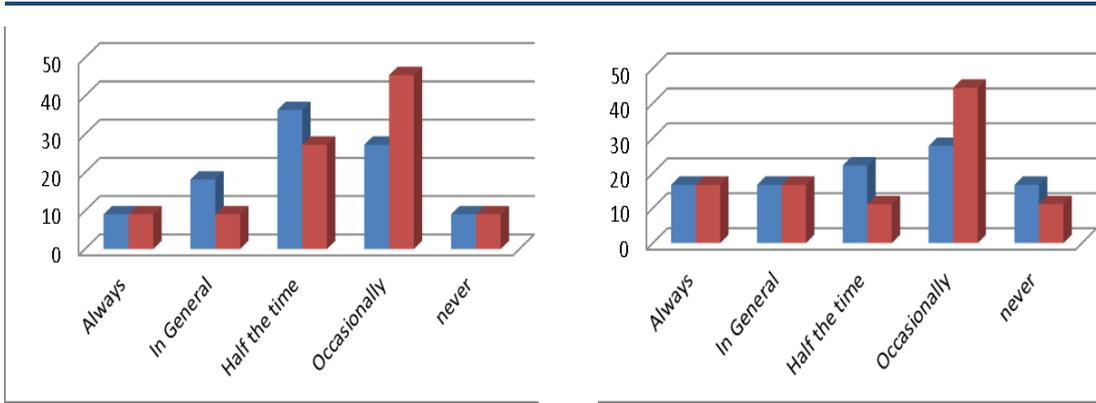
presbycusic users with hearing aid presbycusic users without hearing aid



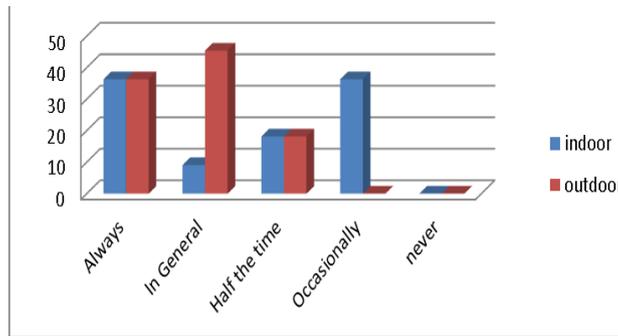
Normal hearing users

Graph 23: Frequency in which the users think that the feeling not to hear well is due to their hearing problems (percentage)

In both environments (indoor and outdoor), the majority of presbycusic users with hearing aids consider that, in general, their difficulties are due to their hearing problems, while the majority of presbycusic users without hearing aids think that the latter are half the time or less frequently the cause of their difficulties.



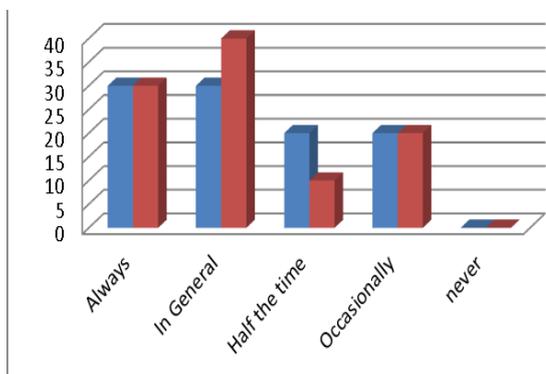
presbycusis users with hearing aid presbycusis users without hearing aid



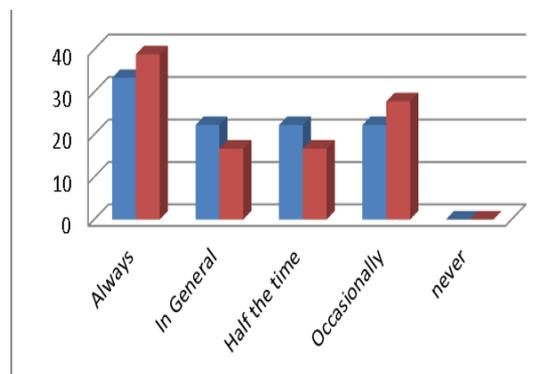
Normal hearing users

Graph 24: Capacity to perceive where jingles, vocal announcements and alarms come from (percentage)

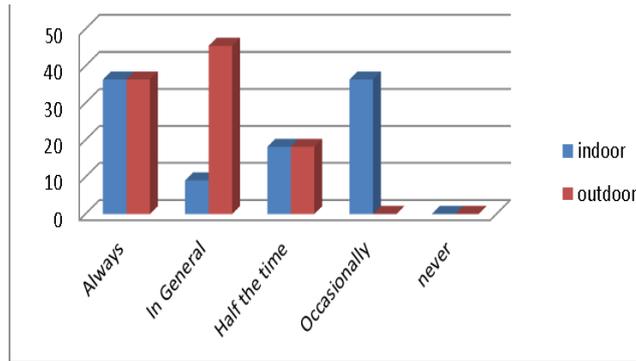
Presbycusics users with and without hearing aids are mostly able to perceive where jingles, vocal announcements and alarms come from only half the time or less. The location is more difficult for us outdoor. The normal-hearing users seem to have difficulties to perceive where jingles, vocal announcements and alarms come from indoor.



presbycusis users with hearing aid



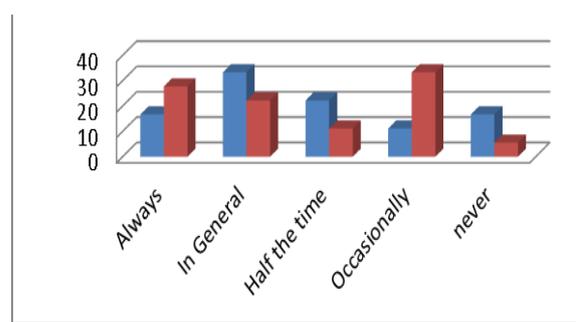
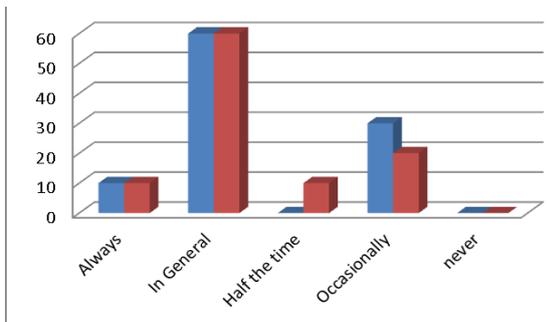
presbycusis users without hearing aid



Normal hearing users

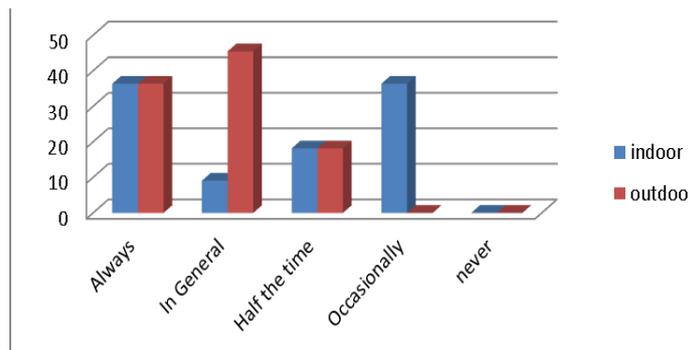
Graph 25: Frequency in which the users are able to recall the information given in the vocal announcements by the loudspeakers (percentage)

Presbycusic users with and without hearing aids and normal-hearing users are mostly able to recall the information given in the vocal announcements by the loudspeakers, in general or always. Nevertheless, the normal-hearing users seem to have more difficulties indoor.



presbycusic users with hearing aid

presbycusic users without hearing aid



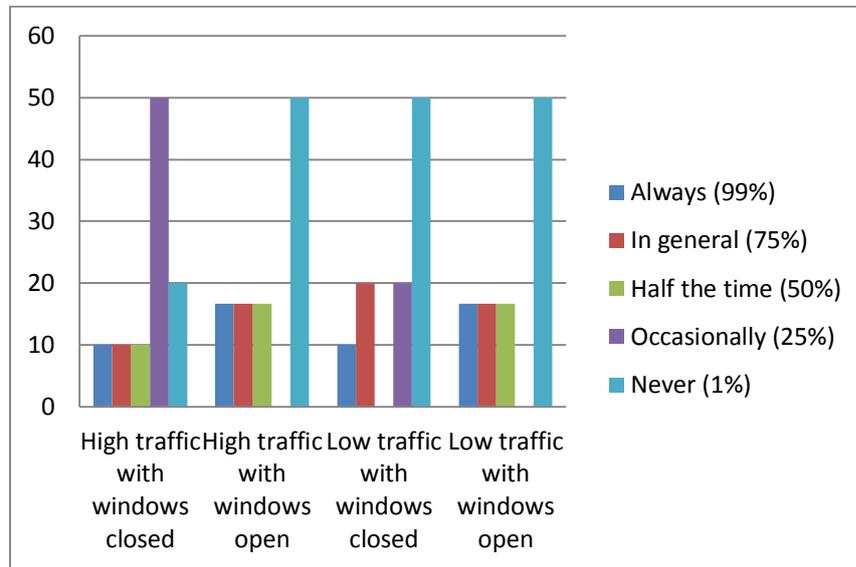
Normal hearing users

Graph 26: Frequency in which the users think that the time duration of the vocal announcements is satisfactory (percentage)

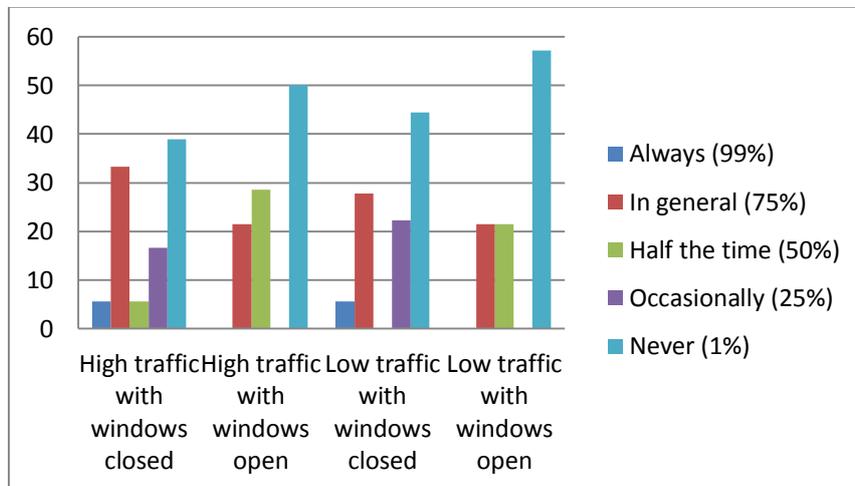
Presbycusics users with hearing aids believe mostly that the time duration of the vocal announcements is in general satisfactory, indoor or outdoor. Presbycusics users without hearing aids and normal-hearing users are more divided even if half the time or more they feel that the time duration of the vocal announcements is satisfactory.

5.2.6 Result of questionnaire based on Aphas model second version, questions referred to the car:

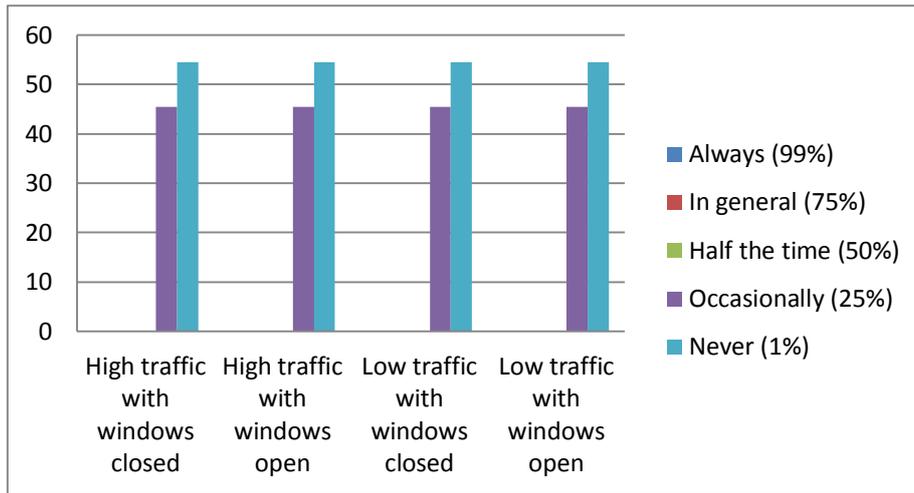
For each question, the results are compared between normal-hearing users (8 Italians), presbycusic users without hearing aid (10 French and 8 Italian) and presbycusic users with hearing aids (9 French, 2 Italians).



presbycusic users with hearing aids



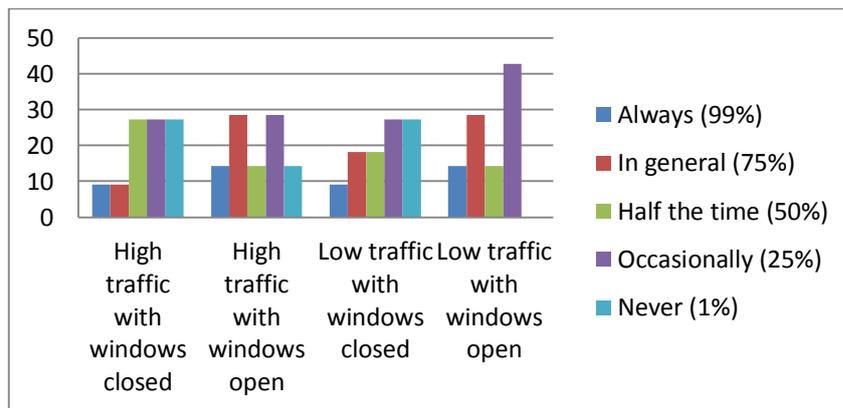
presbycusic users without hearing aids



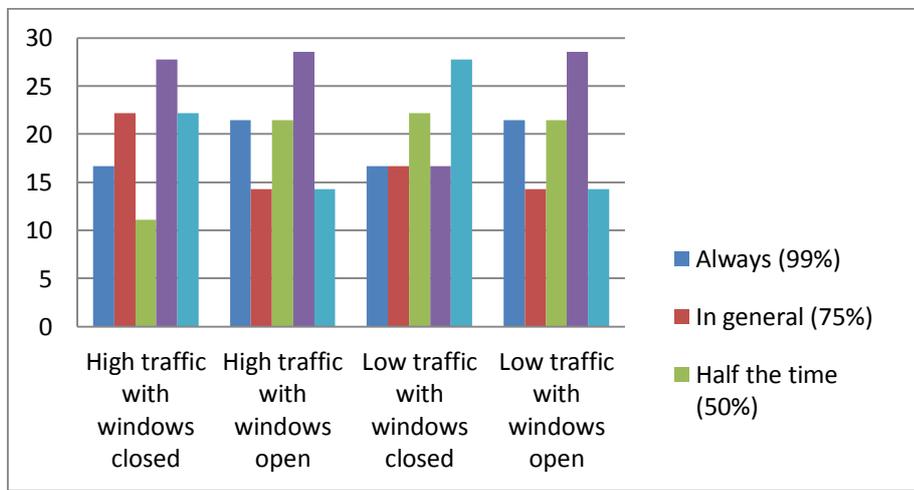
normal hearing users

Graph 27: Frequency in which the users hear too late or not at all different alarms coming from outside such as fire car, police car, ambulance, in the following conditions

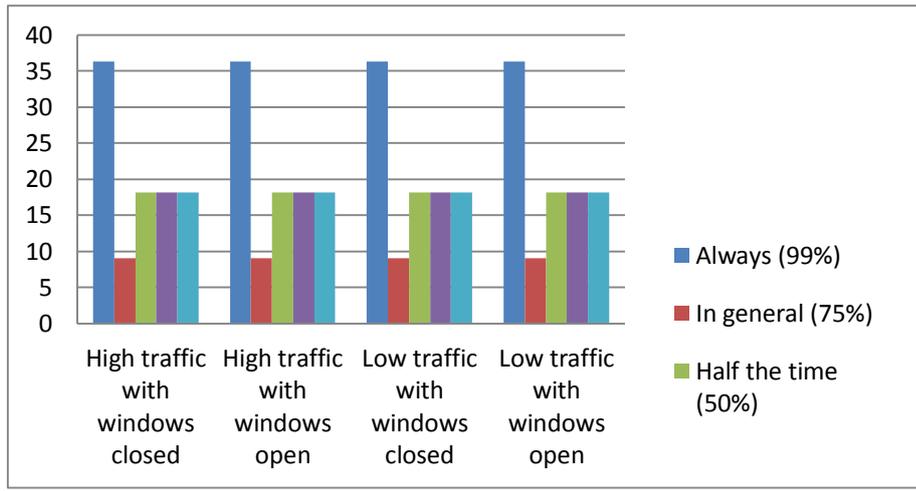
The majority of users with or without hearing aids often meet difficulties in perceiving the different types of alarms coming from outside the car. This is more emphasized in the case of users who do not use hearing aids during high traffic and windows closed.



presbycusic users with hearing aids



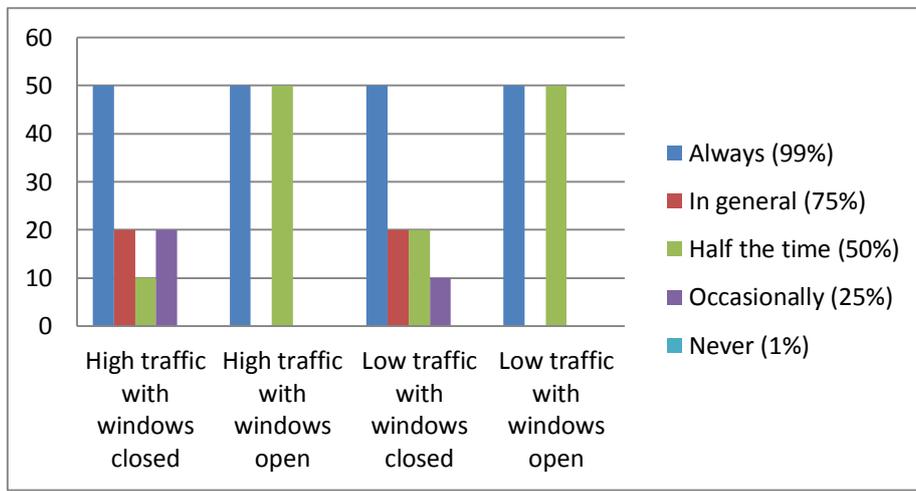
presbycusic users without hearing aids



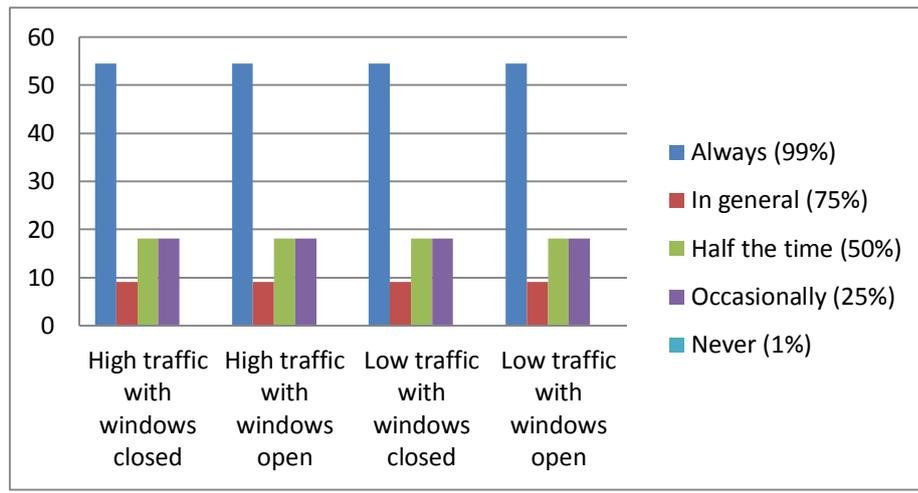
Normal hearing users

Graph 28: Frequency in which the users can distinguish and identify, easily, different alarms such as fire car, police car, ambulance, in the following conditions:

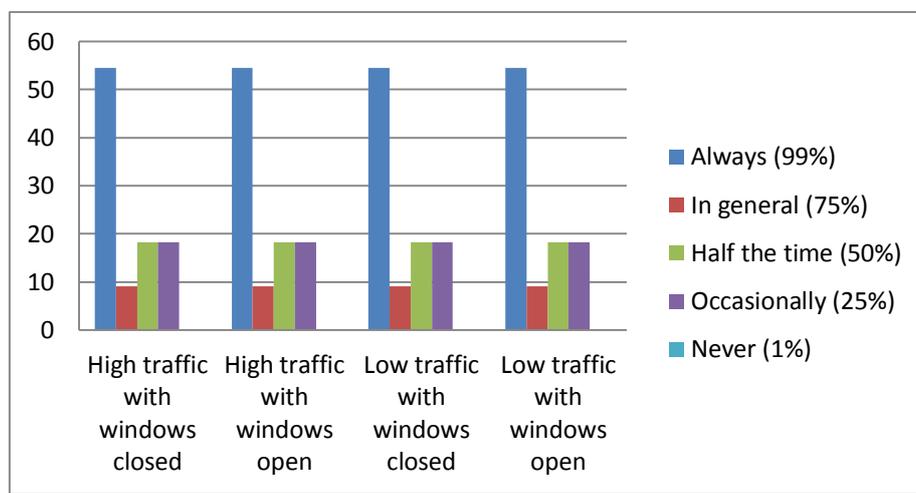
We can notice that, in general, among the presbycusic users wearing a hearing aid and those who do not use it, the problem of distinguishing and identifying different alarms exists, particularly for presbycusic users that do not use hearing aids. They are occasionally or almost never able to distinguish the alarms in all the four considered conditions contrary to what can be observed in normal hearing users.



presbycusic users with hearing aids



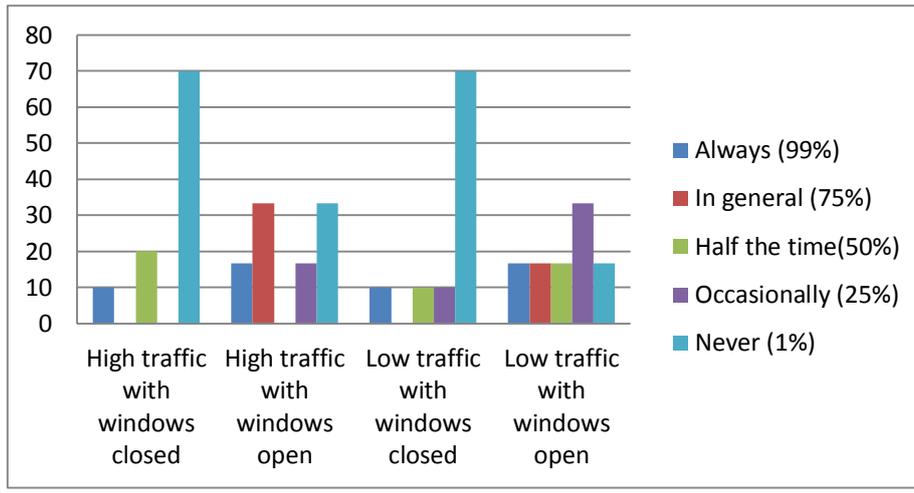
presbycusis users without hearing aids



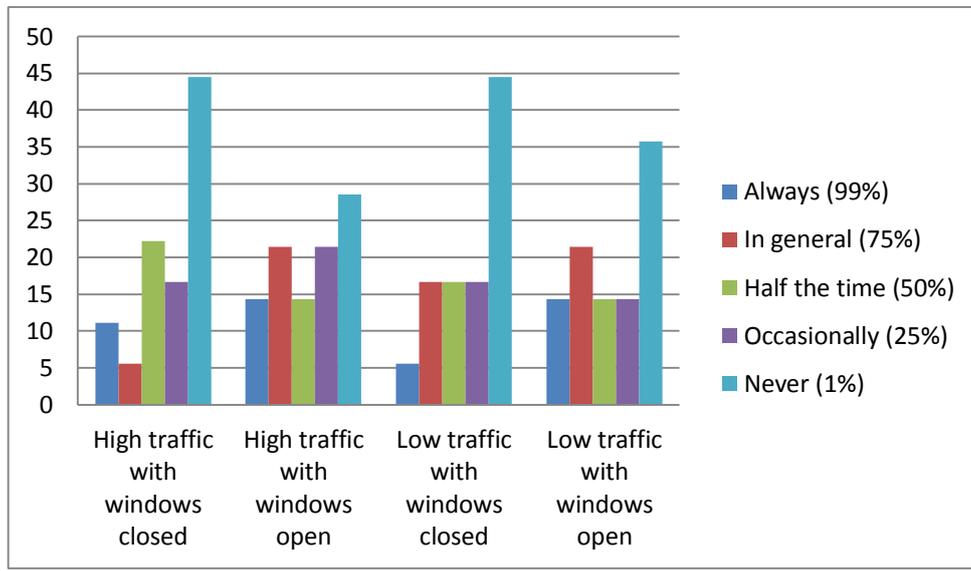
Normal hearing users

Graph 29: Capacity to hear alarming sounds such as horn or screeching tires in the following conditions

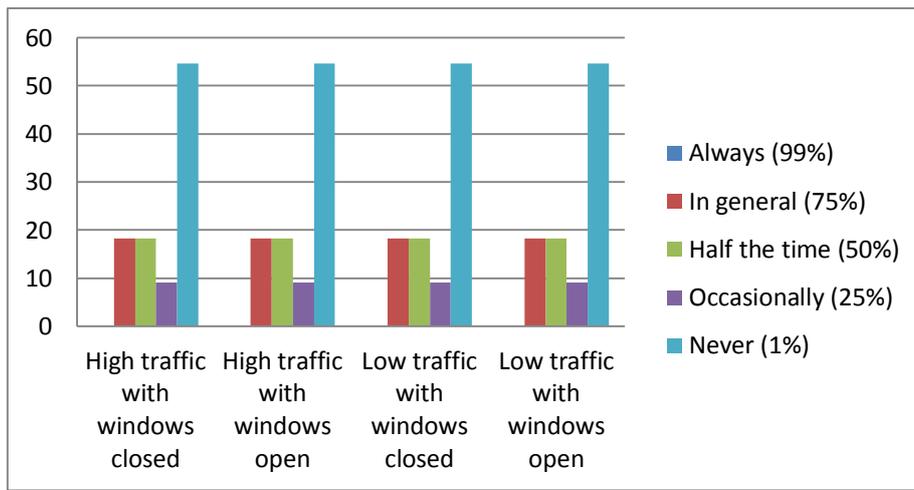
Alarming sounds, due to their typical nature, are perceived by almost all the users belonging to the three categories without great distinctions among them. Only the presbycusis users with hearing aids meet difficulties in perceiving these sounds with open windows both during low and high traffic.



presbycusic users with hearing aids



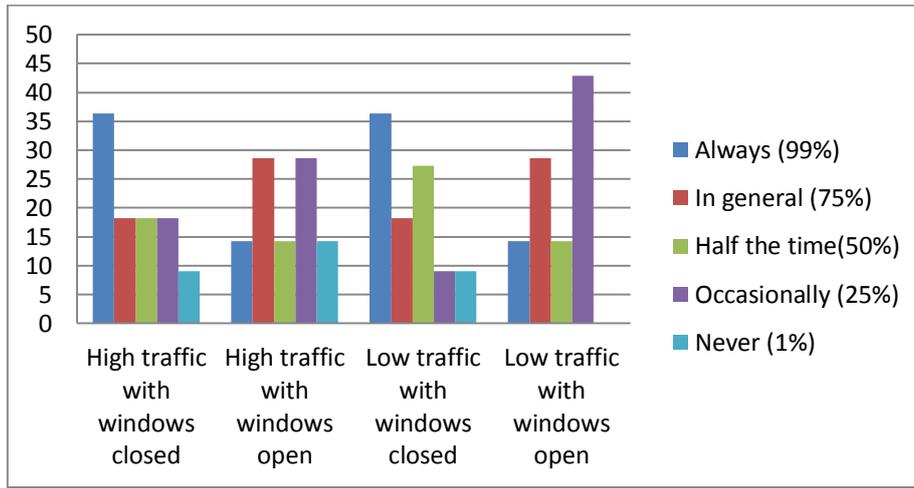
presbycusic users without hearing aids



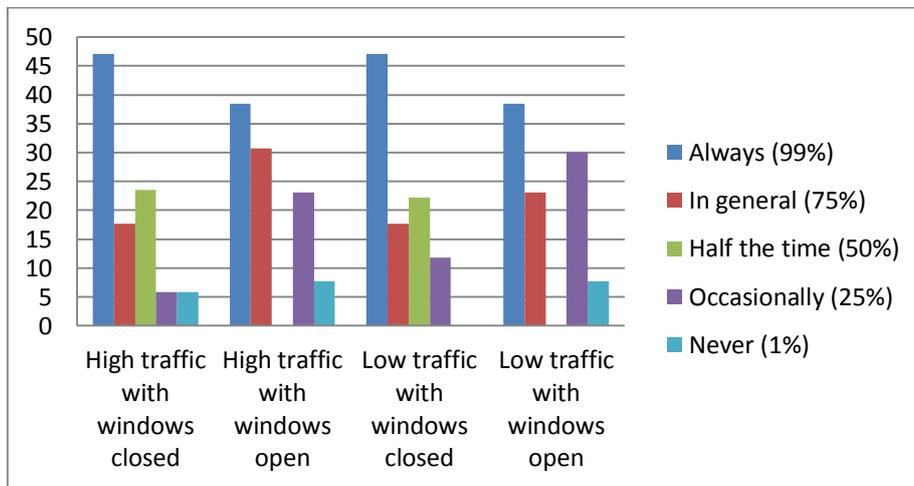
Normal hearing users

Graph 30: Frequency in which users have problems in hearing in-car alarms (parking aid bip, safety belt undo bip, fuel gauge bid, other dashboard alarm, etc.), in the following conditions

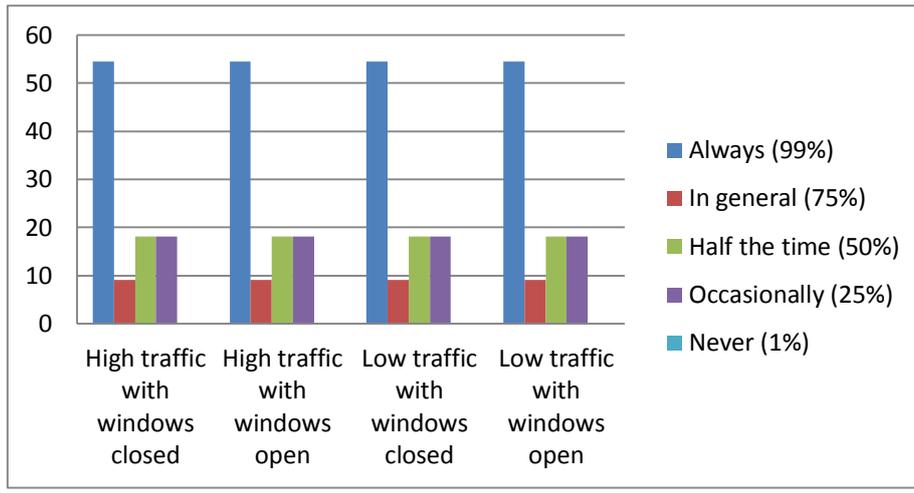
Any significant problem is observed in any of the three categories of users in perceiving in-car alarm bips (e.g. parking aid bip, safety belt undo bip, fuel gauge bid, other dashboard alarm, etc.) when windows are closed. This is due to the fact that noises are inside the car and thus they are more easily perceivable. Presbycusic users with and without hearing aids have more difficulties when windows are open.



presbycusic users with hearing aids



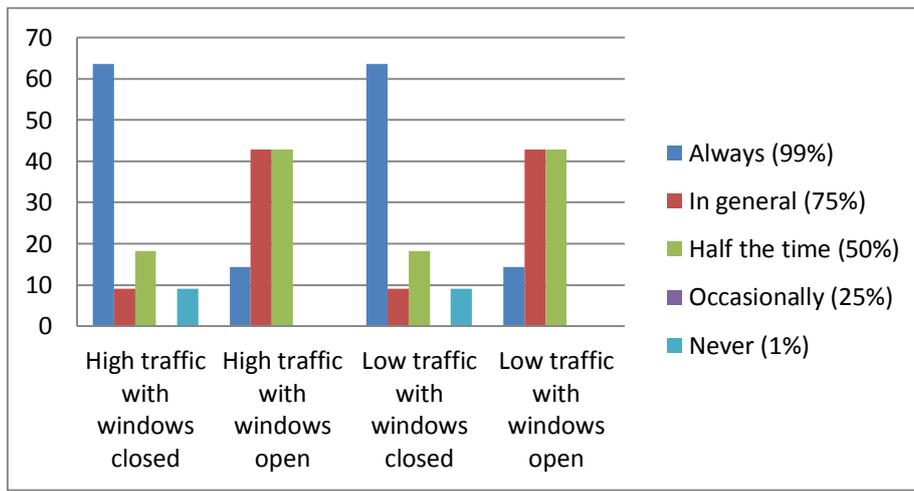
presbycusic users without hearing aids



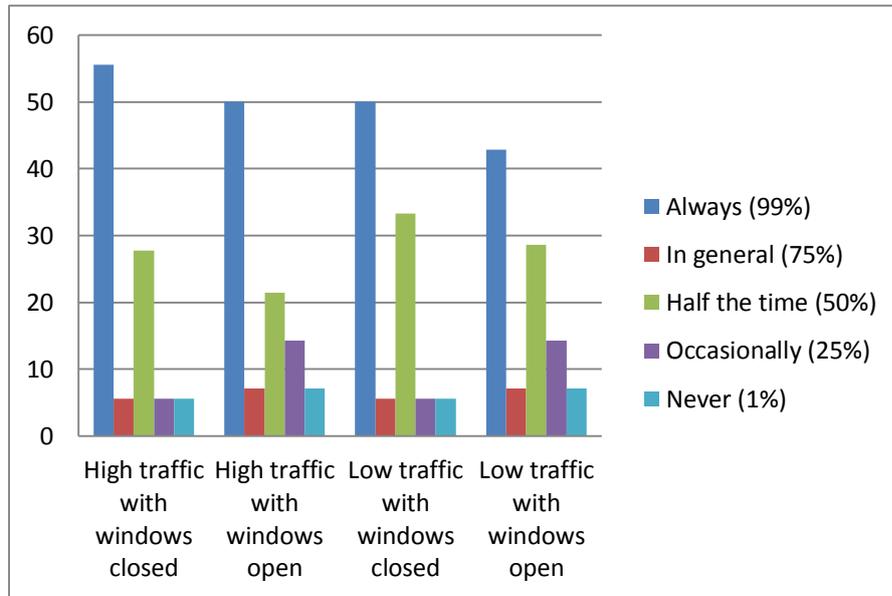
Normal hearing users

Graph 31: Capacity to distinguish different in-car alarm bips (parking aid bip, safety belt undo bip, fuel gauge bip, dashboard alarm bip), in the following conditions

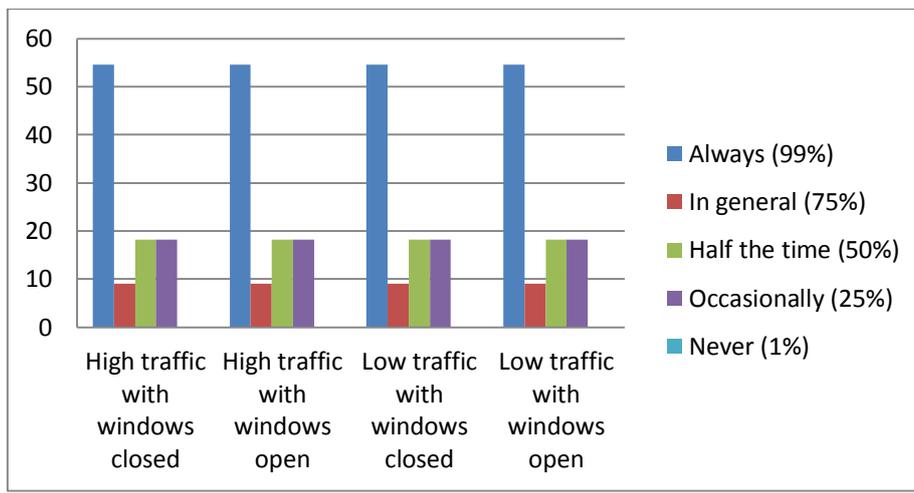
Any significant problem is observed in any of the three categories of users in distinguishing in-car alarm bips (e.g. parking aid bip, safety belt undo bip, fuel gauge bid, other dashboard alarm, etc.). This is because the noises are inside the car and thus they can be distinguished more easily, even if a little bit less while windows are open for presbycusic users with and without hearing aids.



presbycusic users with hearing aids



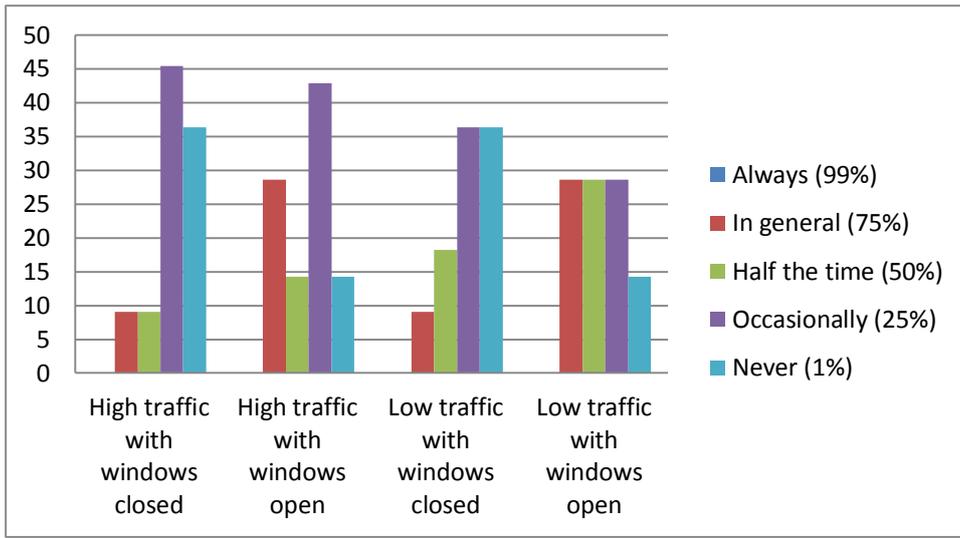
presbycusic users without hearing aids



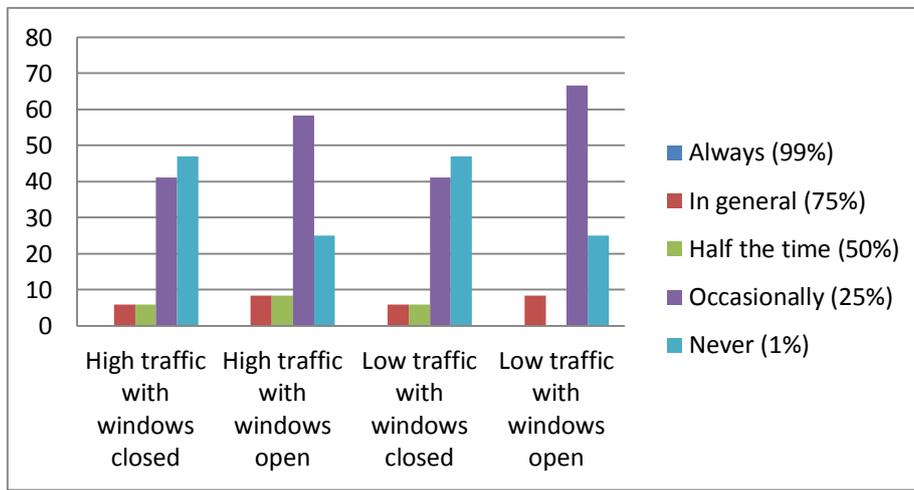
Normal hearing users

Graph 32: Capacity to distinguish the tic tac turn signal from the other in-car alarm sounds, in the following conditions

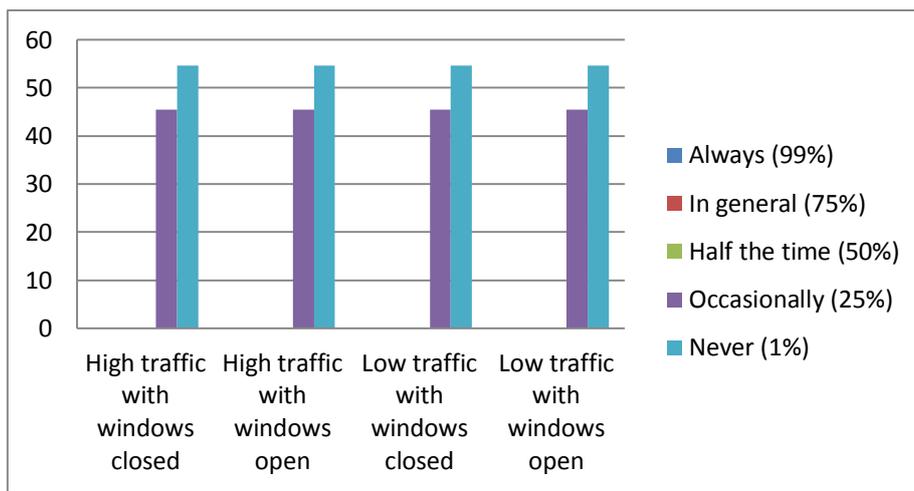
Presbycusic users with hearing aids meet more difficulties in distinguishing the tic tac turn signal during high or low traffic while windows are open (due to sound dispersion), those who do not use any hearing aid , meet slightly more difficulties in the same conditions.



presbycusis users with hearing aids



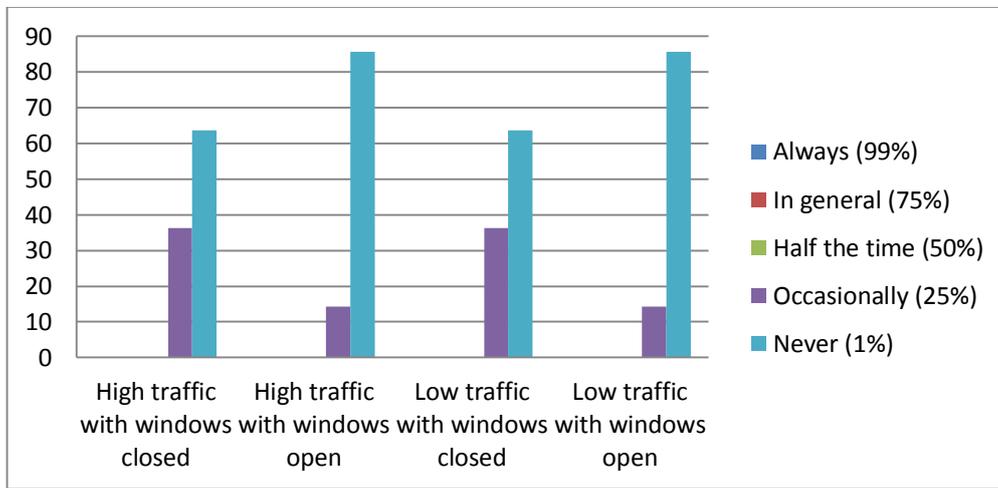
presbycusis users without hearing aids



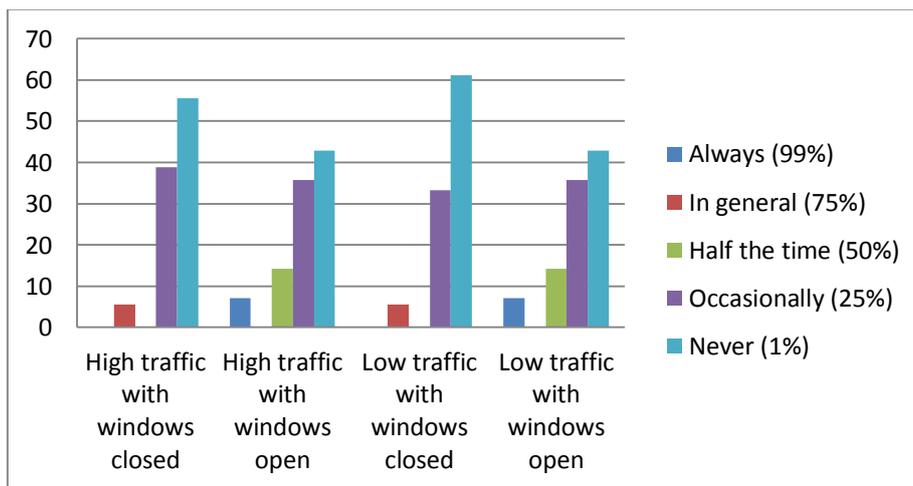
Normal hearing users

Graph 33: Frequency in which the use of air conditioning, ventilation and/or car engine noise prevent the users from hearing navigator information and in-car alarms, in the following conditions

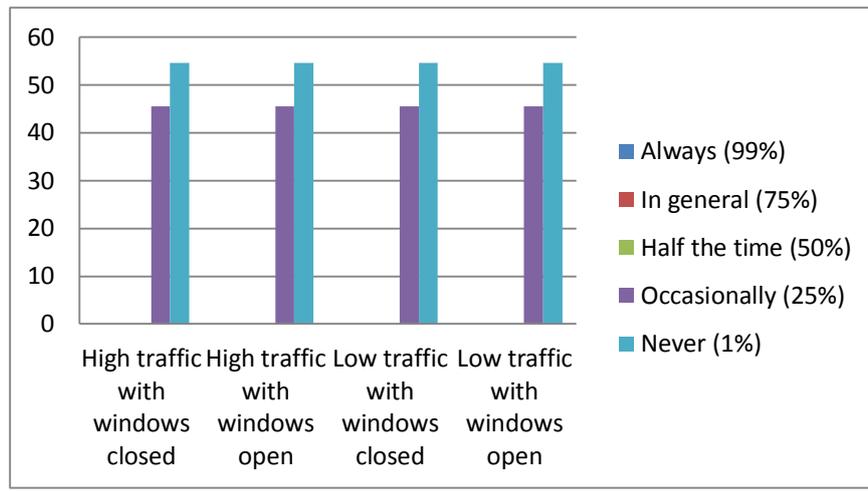
Any significant problem is observed in any of the three categories of users in hearing navigator information and the various in-car bips while using air conditioning, ventilation and/or car engine noises, etc. and this is because noises are inside the car and thus they can be more easily distinguished, even if a little bit less while windows are open for presbycusic users with hearing aids.



presbycusic users with hearing aids



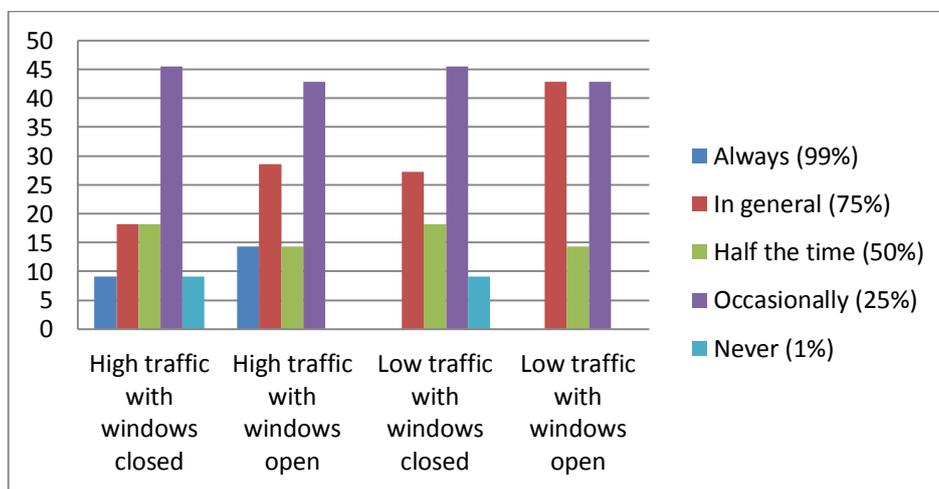
presbycusic users without hearing aids



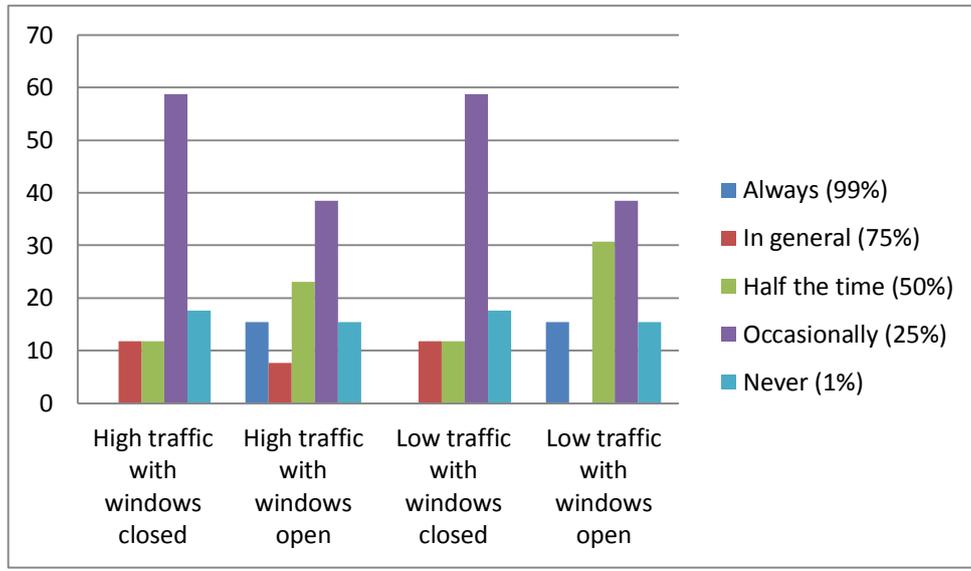
Normal hearing users

Graphic 34: Frequency in which the use of air conditioning, ventilation and/or car engine noise prevent the users from hearing alarms coming from outside, in the following conditions

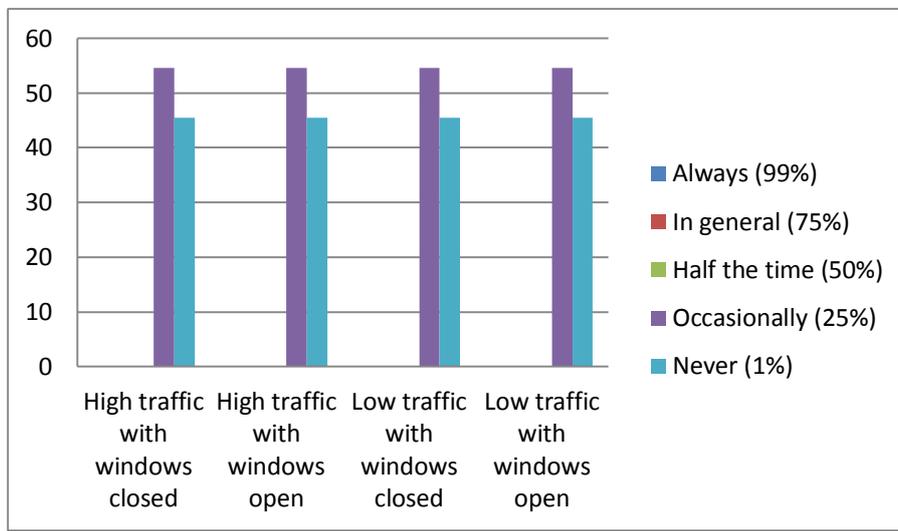
Any significant problem is observed in hearing alarms coming from outside (ex: Ambulance, ...) for normal hearing users and for presbycusic ones who wear hearing aids; greater but moderate problems are met by presbycusic users who do not use hearing aids particularly when windows are open.



presbycusic users with hearing aids



presbycusis users without hearing aids



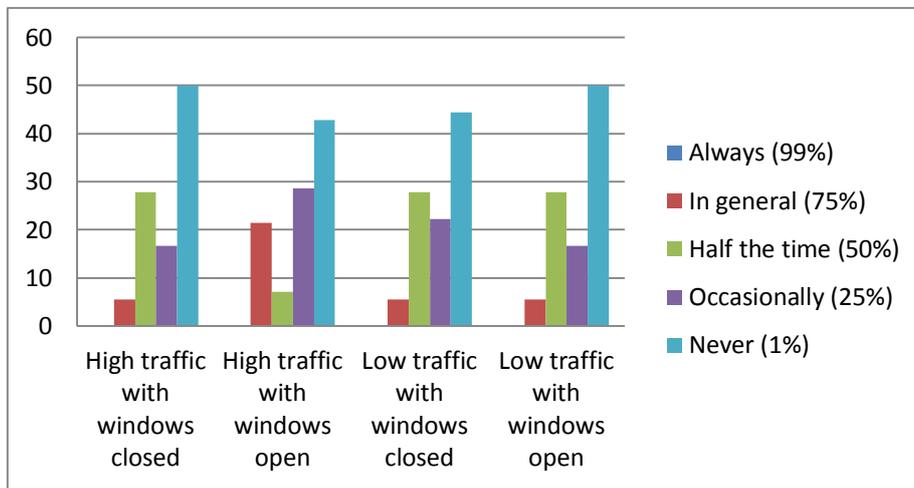
Normal hearing users

Graphic 35: Frequency in which passenger conversation and the use of radio, CD or music player prevent the users from hearing navigator information and in-car alarms, in the following conditions

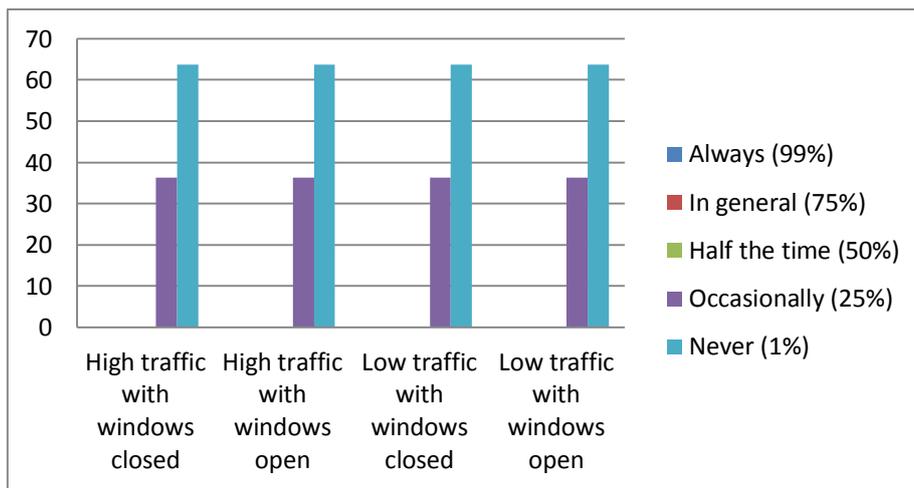
Passenger conversation and the use of radio, CD or music player prevent just a little from hearing navigator information and in-car alarms the normal hearing users. It's more difficult for presbycusis users, particularly with hearing aids. But they explain that they often choose between listening radio, CD or music player and listening to navigator information.



presbycusis users with hearing aids



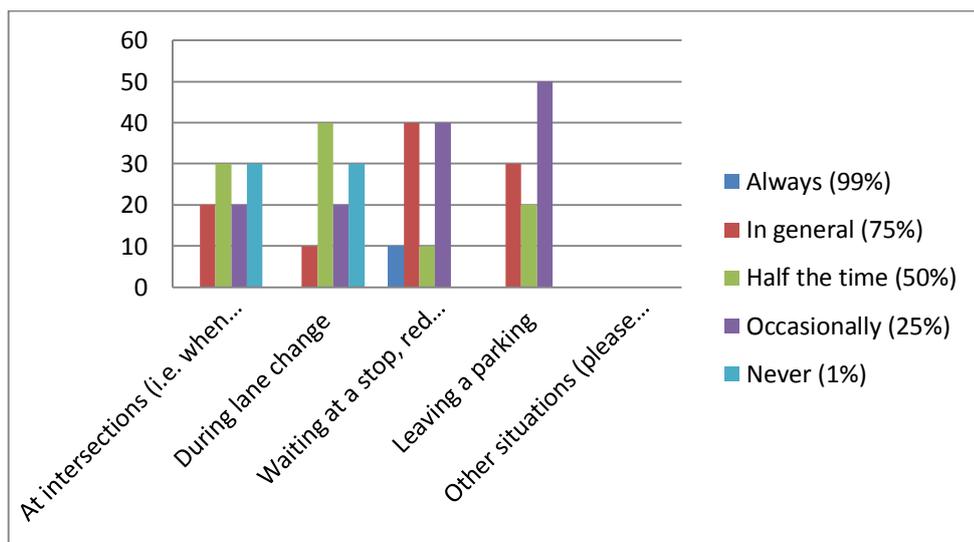
presbycusis users without hearing aids



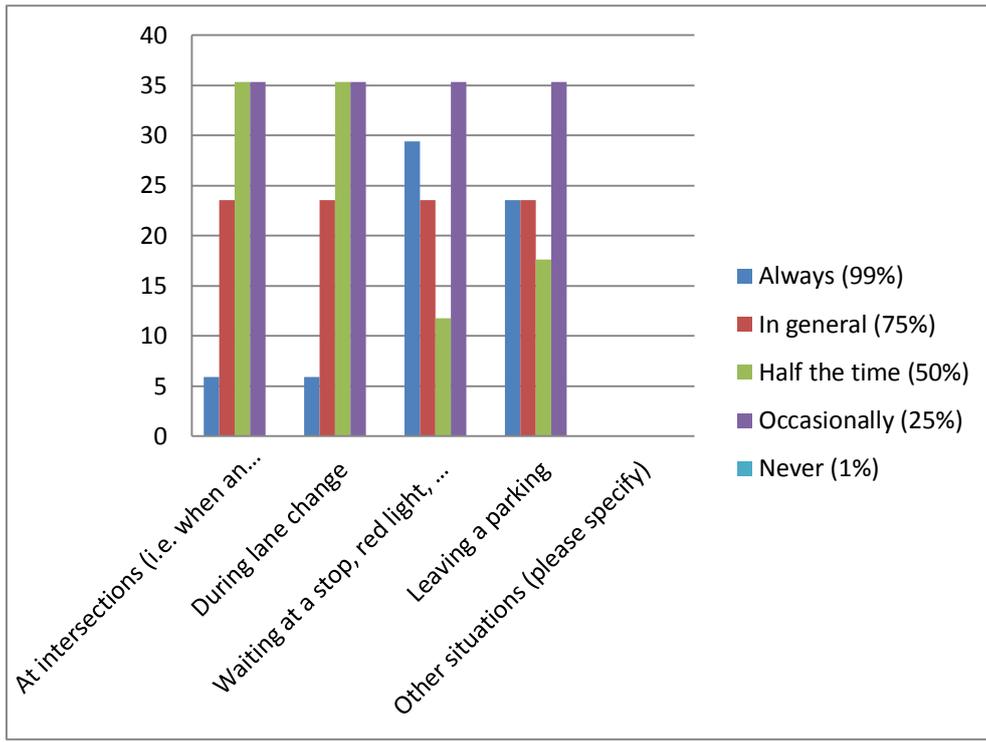
Normal hearing users

Graphic 36: Frequency in which passenger conversation and the use of radio, CD or music player prevent the users from hearing outside alarms (eg. Ambulance or others listed under question 1.), in the following conditions

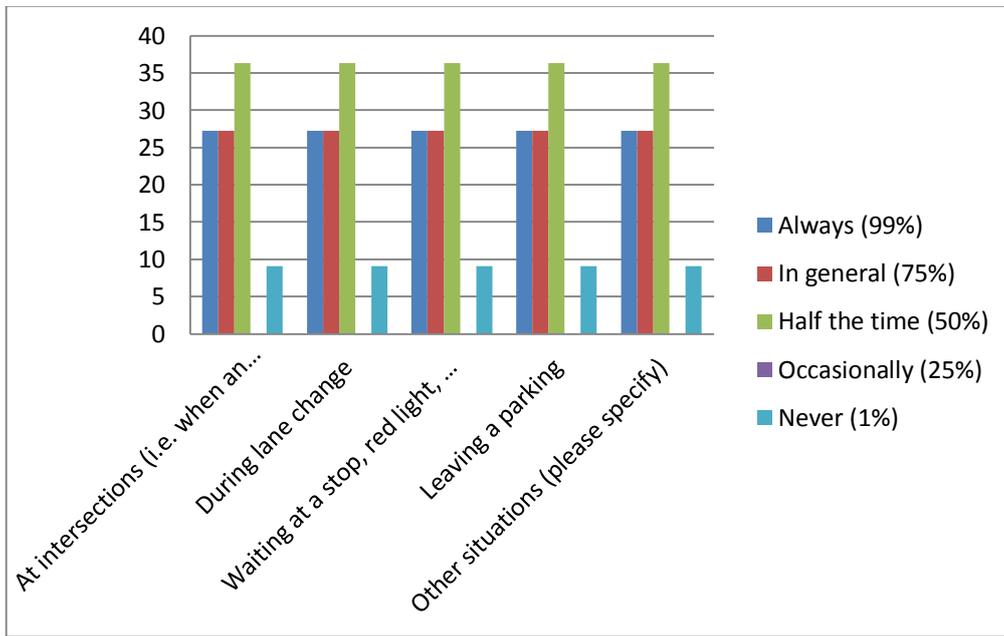
Substantially, passenger conversation and the use of radio, CD or music player do not prevent from hearing outside alarms (ex: Ambulance, ...) in all the three categories of users, with slight uncertainties for presbycusis users without hearing aid.



presbycusis users with hearing aids



presbycusic users without hearing aids

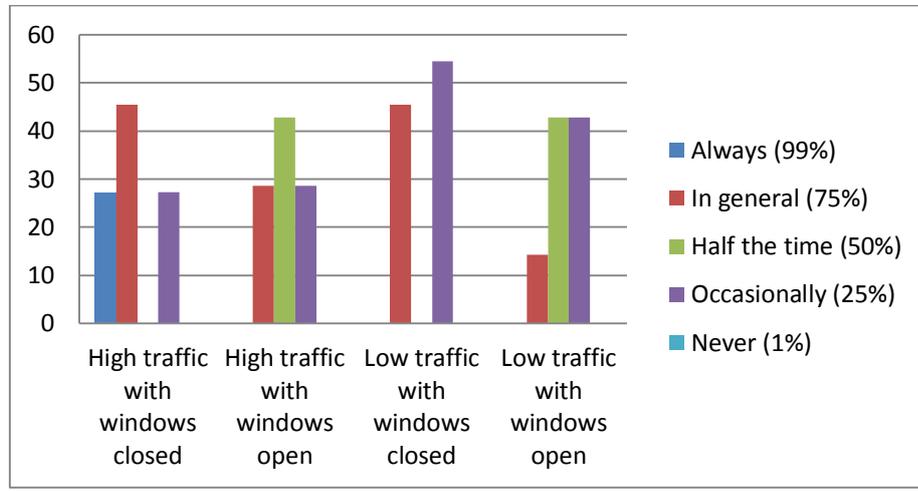


Normal hearing users

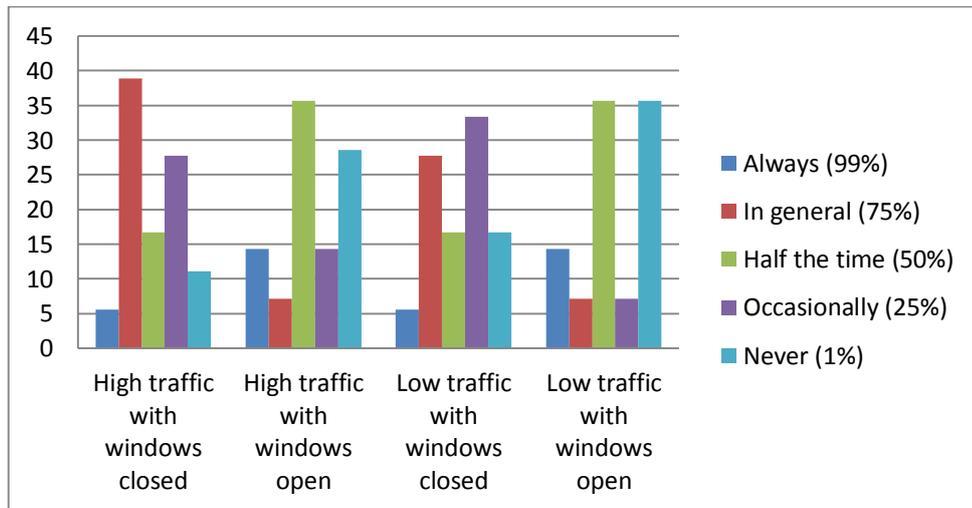
Graphic 37: Capacity to easily estimate the distance of the coming alarm source in the following situations

Distance from a source of sound is in general or always easily estimated by the majority of normal hearing users in all situations but some of them (46%) have difficulties half the time or

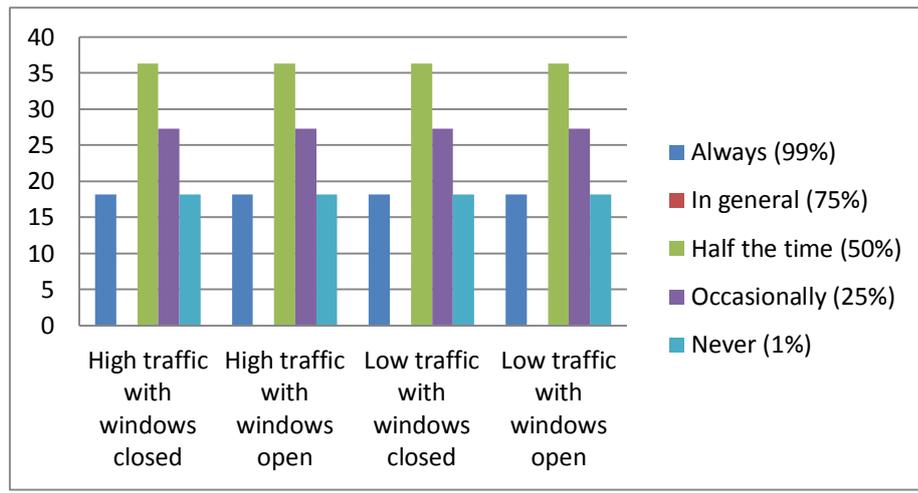
more. Presbycusic users with and without hearing aids are in majority half the time or more not able to easily estimate the distance from a source of sound, particularly when the car is moving.



presbycusic users with hearing aids



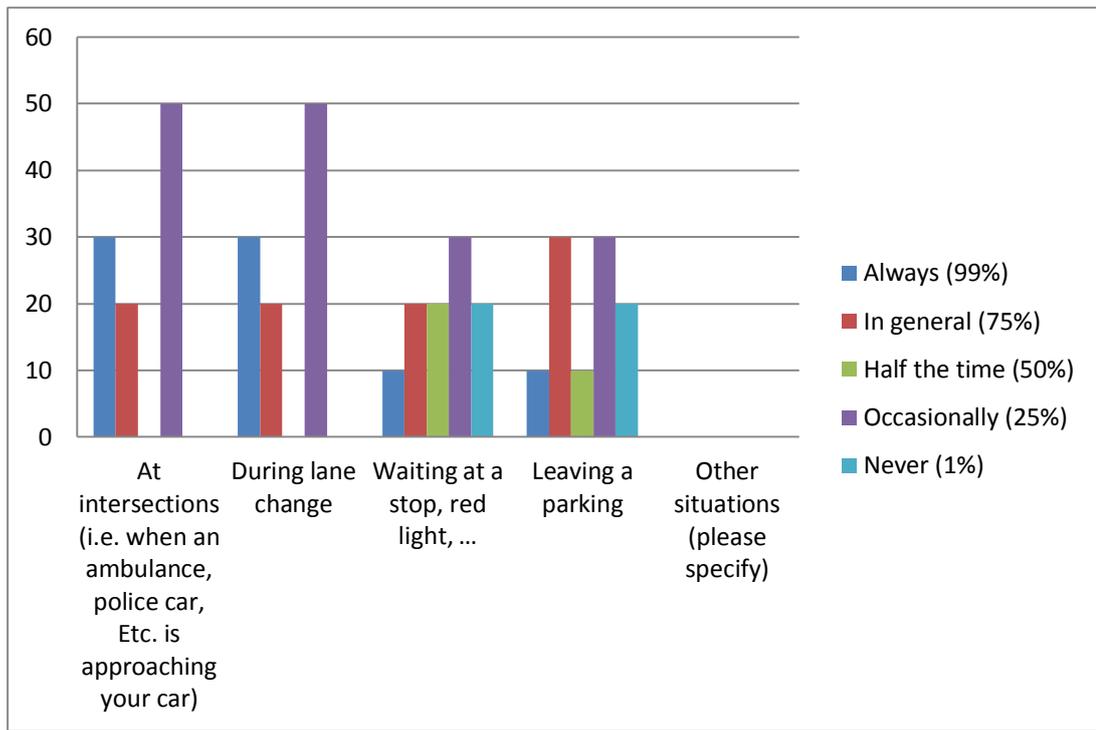
presbycusic users without hearing aids



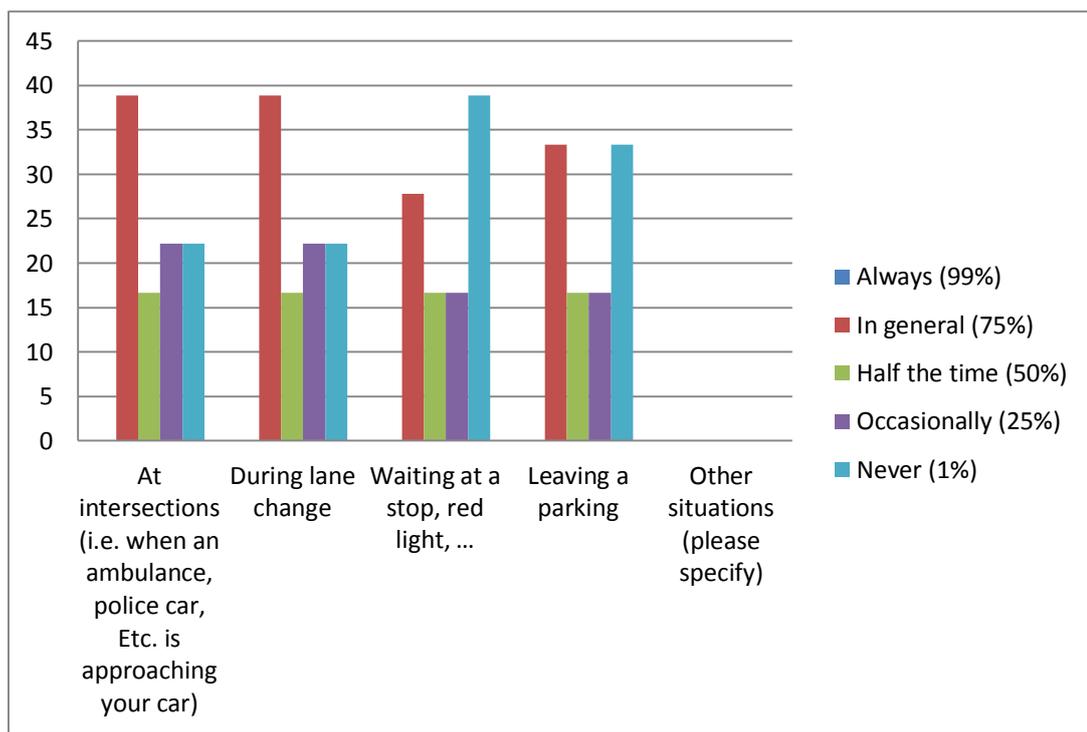
Normal hearing users

Graphic 38: Frequency in which estimating the distance of the coming alarm source in the situation above, is more difficult, in the following conditions

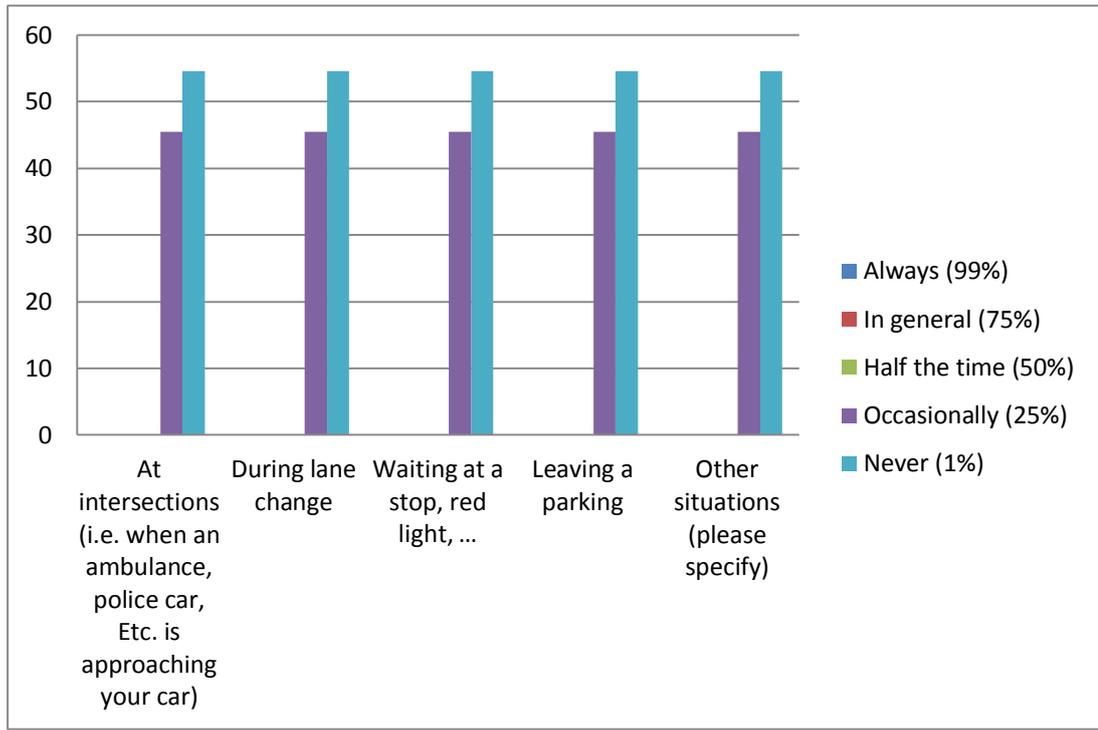
The majority of normal hearing users meet half the time or occasionally difficulties in estimating the distance of the source of an alarm in the described situations. Presbycusic users with and without hearing aids have more difficulties during high traffic and with closed windows.



presbycusic users with hearing aids



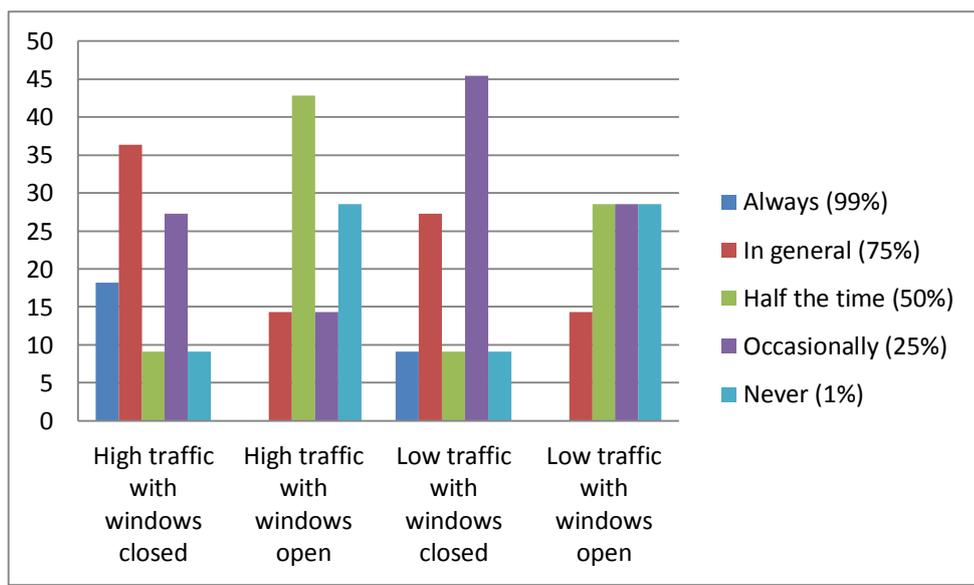
presbycusic users without hearing aids



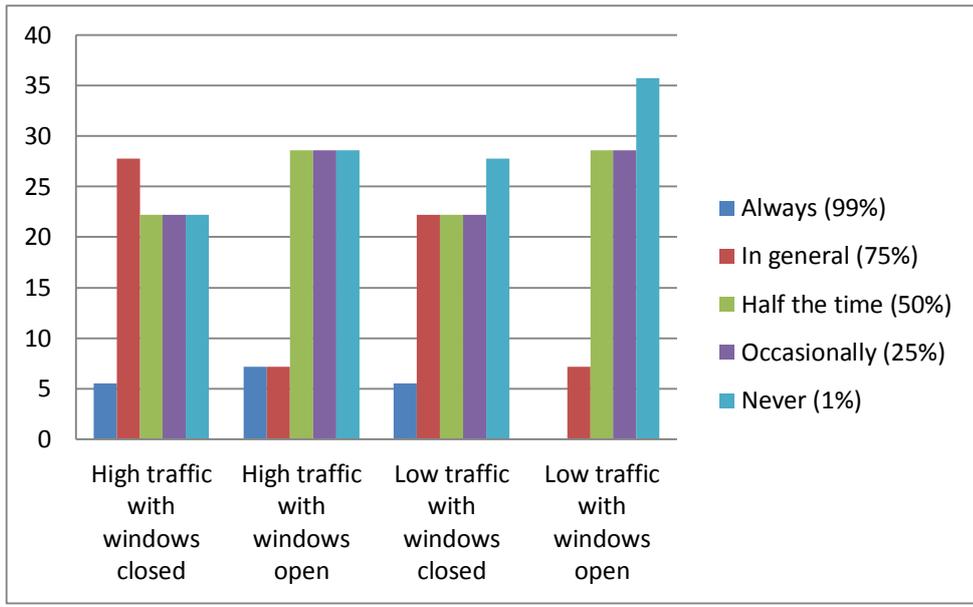
Normal hearing users

Graphic 39: Frequency in which users have problems in recognizing if an alarm is coming from the front or the back (ex: while an ambulance is passing), in the following conditions

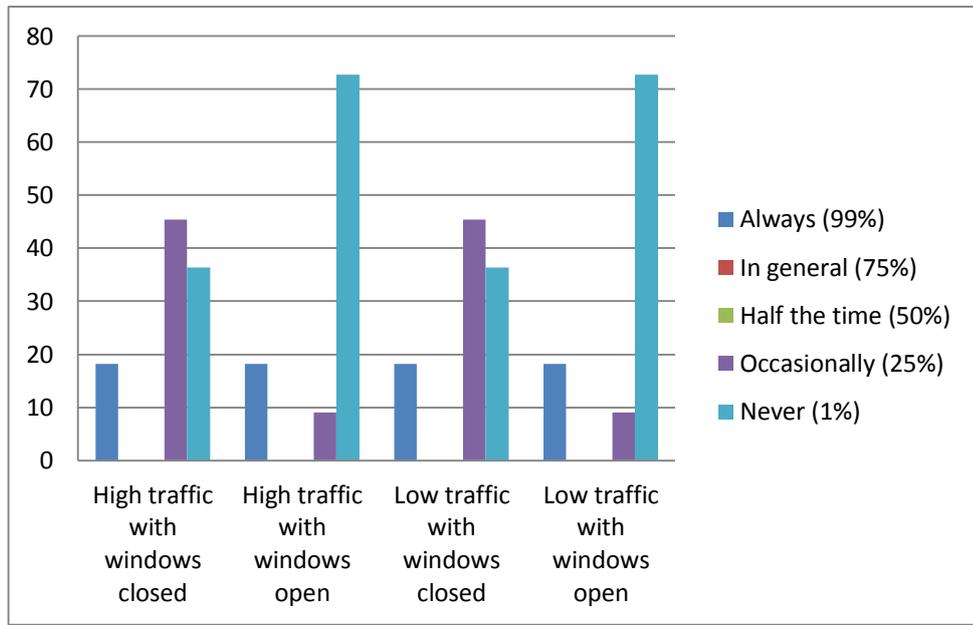
The majority of normal hearing users haven't problems in recognizing if an alarm is coming from the front or the back. Presbycusic users with and without hearing aids have problems in recognizing if an alarm is coming from the front or the back particularly at intersections and during lane change:



presbycusic users with hearing aids



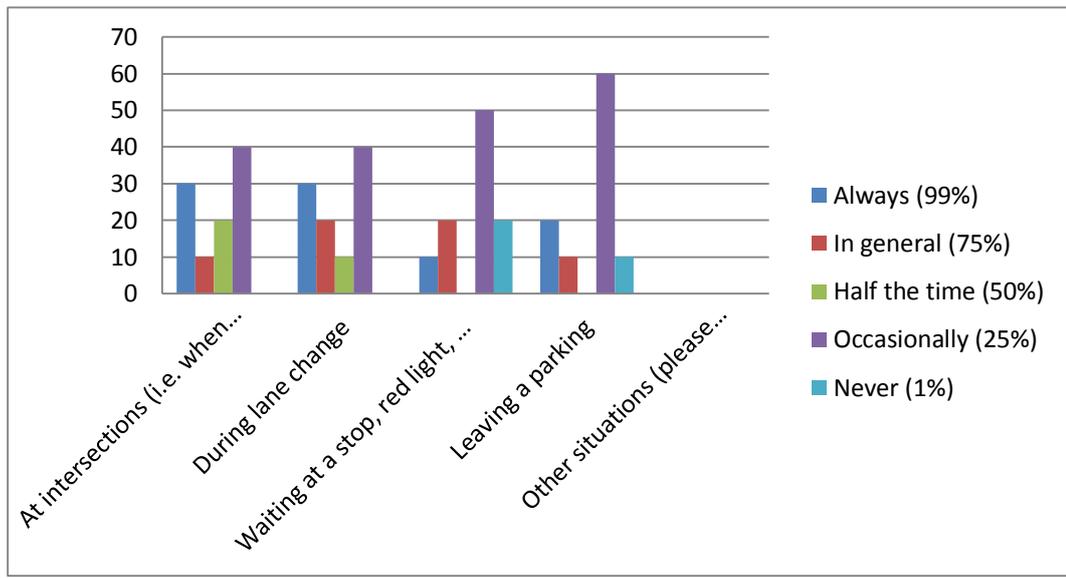
presbycusis users without hearing aids



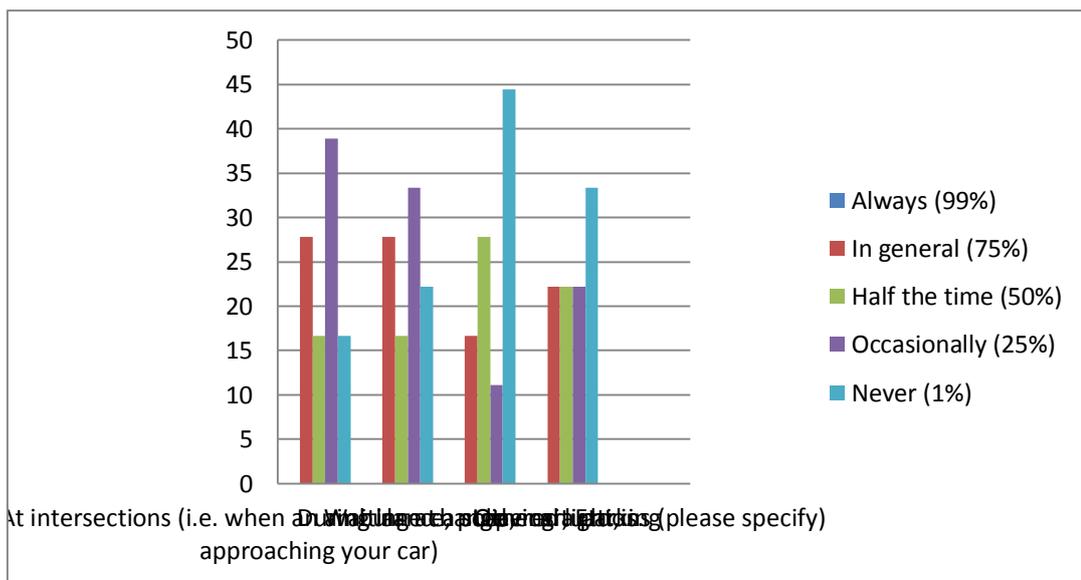
Normal hearing users

Graphic 40: Frequency in which recognizing if an alarm is coming from the front or the back, is more difficult, in the following conditions

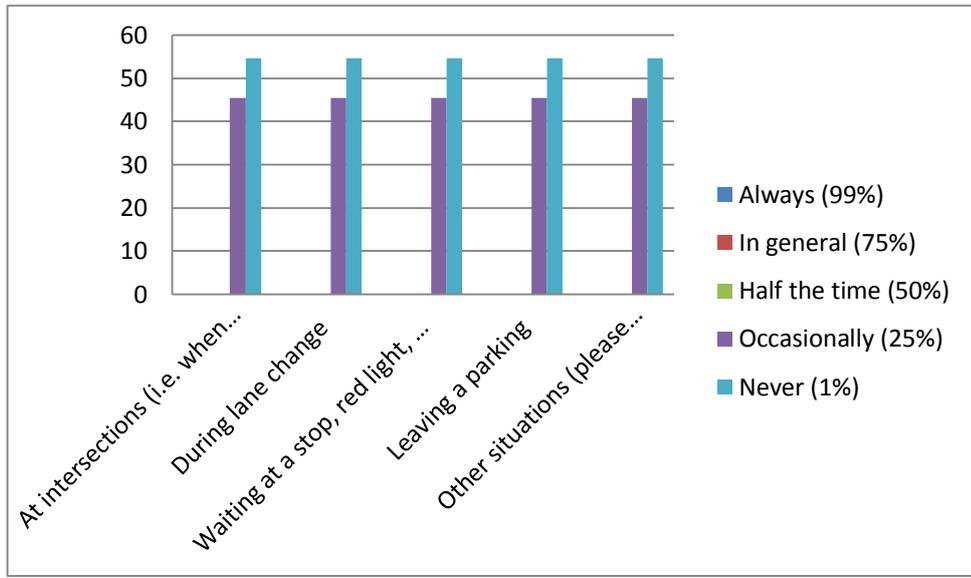
Recognizing if an alarm is coming from the front or the back is more difficult during high traffic for presbycusis users wearing hearing aids.



presbycusic users with hearing aids



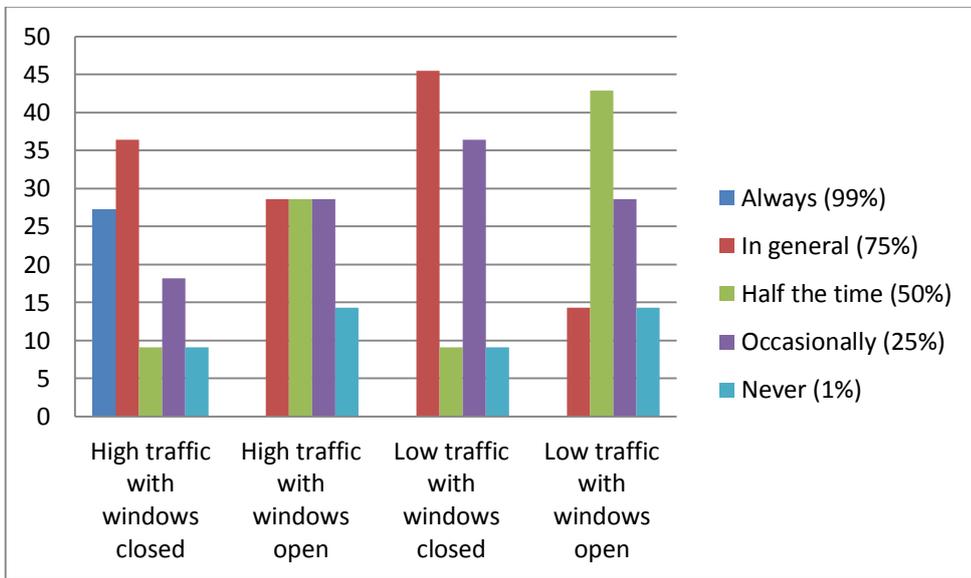
presbycusic users without hearing aids



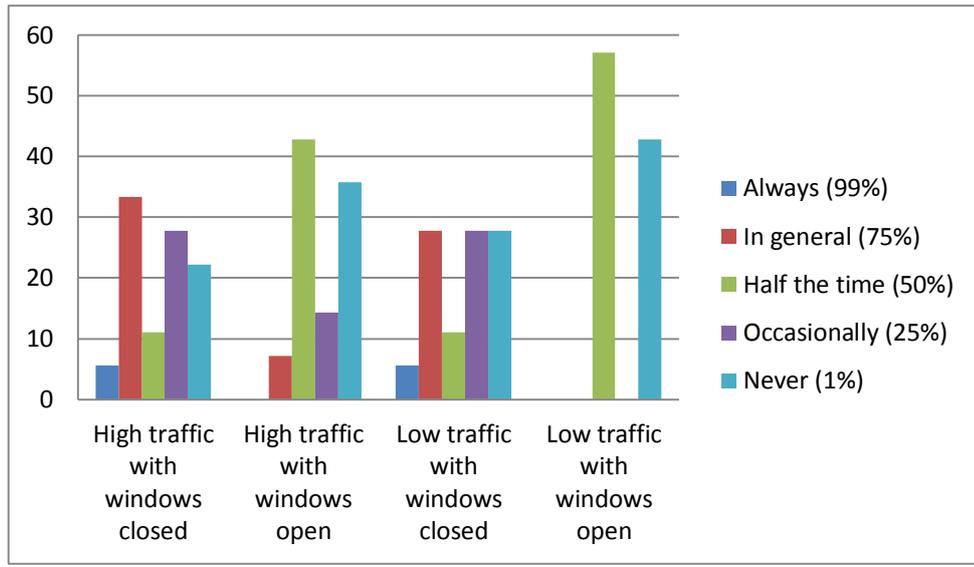
Normal hearing users

Graphic 41: Frequency in which users have problems in recognizing if an alarm is coming from their left or their right (ex: while an ambulance is passes), in the following conditions

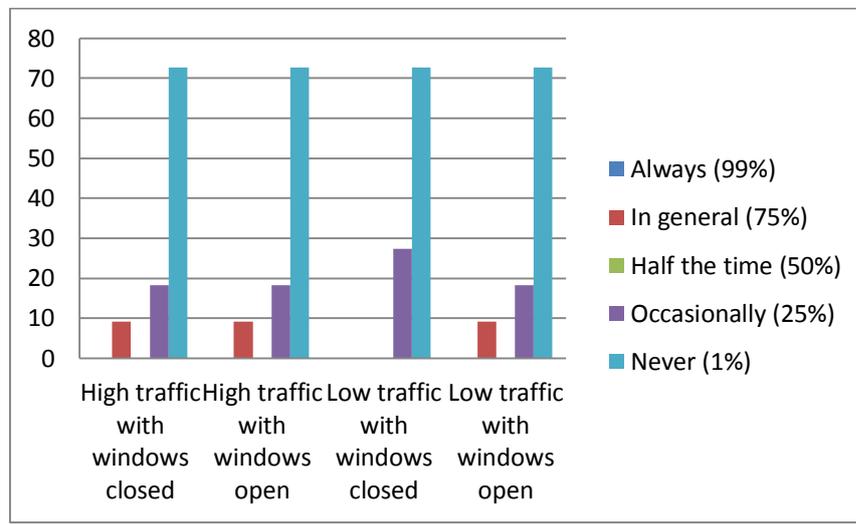
Normal hearing users don't have problems in recognizing if an alarm is coming from the left or the right. Presbycusic users with and without hearing aids have more problems in recognizing if an alarm is coming from the left or the right at intersections and during lane change.



presbycusic users with hearing aids



presbycusis users without hearing aids



Normal hearing users

Graphic 41: Frequency in which recognizing if an alarm is coming from the left or the right, is more difficult, in the following conditions

Recognizing if an alarm is coming from the left or the right is more difficult during high traffic with windows closed for presbycusis users with and without hearing aids. The influence of windows closed is important for presbycusis users and particularly with hearing aids.

5.3 Specific audiometric and audiologic tests (Annex XII)

In France:

In the second stage of the survey the 19 French users had undergone the following audiometric and audiologic tests, performed by the audiologist collaborating with CERTA:

- a. tonal and vocal audiograms (with and without hearing aids)
- b. Auditory filter measure
- c. subjective intelligibility assessment
- d. localization assessment

The ecological protocol of localization and intelligibility tests had been established with CEA LinkLab partners (Annex XI)

The users were divided in 3 groups:

- Group 1: 10 presbycusic users without hearing aids
- Group 2: 9 presbycusic users with hearing aids
- Group 3: 4 young normal hearing users (test group)

In Italy:

In the second stage of the survey the 21 users had undergone the following audiometric and audiologic tests, performed by Dr. Longo, the Italian ENT doctor involved in the project :

- a. tonal audiometric examination (n = 21 users)
- b. vocal audiometric test (n= 30 users)

The ecological protocol of localization and intelligibility tests had been established with CEA LinkLab partners (Annex XI)

The users were divided in 3 groups (examen **a**/examen **b**):

- Group 1: 8/8 presbycusic users without hearing aids
- Group 2: 4/12 presbycusic users with hearing aids
- Group 3: 9/10 normal hearing people

The objective of the study is to evaluate the most environmentally friendly way, hearing abilities of the users:

- Understanding a short verbal message in a noisy environment, like a railway station
- Locating a sound , alarm type, at 360 °

The results obtained will allow to assess the difficulties encountered in the situations described, in order to design adapted solutions for presbycusic people, wearing hearing aids or not.

The assessment, in-lab by an audiologist, also serves to standardize the tests created for the project.

Two types of information had been identified:

- Objective data: the patient's responses to each event during the assessment.
- Subjective data: The patient's remarks throughout the testing (Ex. : feelings).

The both data allow us to promote the adaptability of future compensation's solutions.

5.3.1 Tonal and vocal Audiogram

In France

Tonal Audiogram:

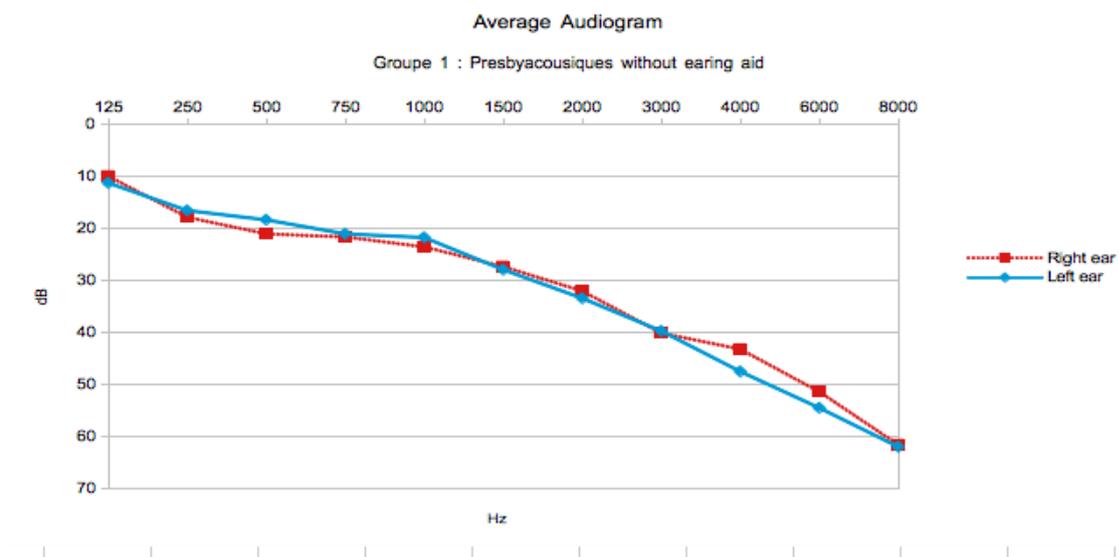
In this test the audiologist uses an audiometer to play different tones through a headphone (without hearing aids) or through loud speakers (with hearing aids). The tones are of varied pitches, frequencies that can be measured in hertz (11 frequencies from 125Hz to 8000 Hz) as well as of varied loudness that can be measured in decibels. The audiologist controls the volume of the tone and keeps on reducing the loudness, until the user cannot hear anymore. Then, he'll increase the tone, till the user get to hear it again. The user's need to raise his hand if he can hear the tone. The test is repeated several times with higher-pitched tones.

Vocal Audiogram:

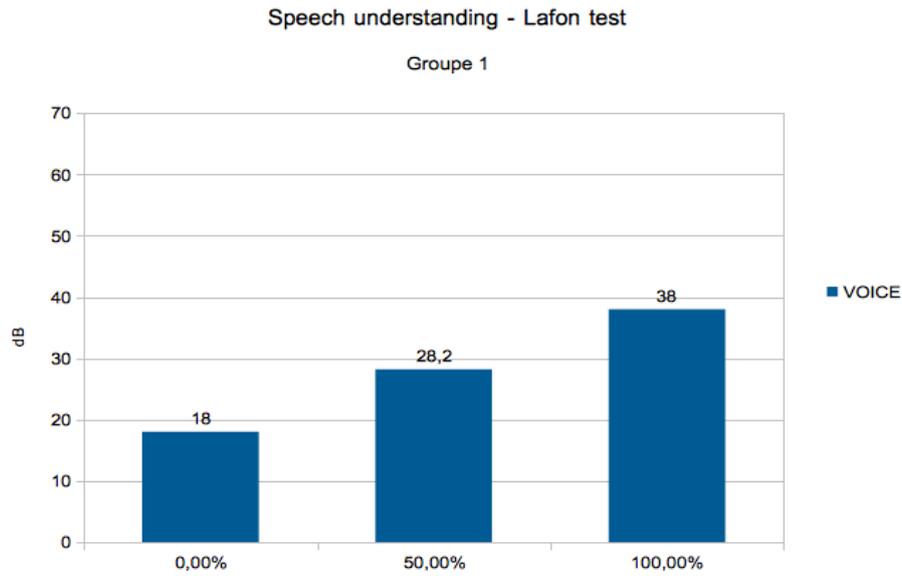
In this test the audiologist uses an audiometer to play different lists of words (List of Lafon) through loud speakers. The audiologist controls the volume of the loudness and asks the user to repeat the words when he can hear and understand them. The aim of the examination determines the intelligibility point of the tested words. The audiologist searches the loudness to understand 100%, 50 % and 0% of the words.

-Group 1: 10 presbycusis users without hearing aids

Average hearing loss without hearing aids : 31 dB



Graphic 42: Average audiogram - Presbycusis without hearing aids

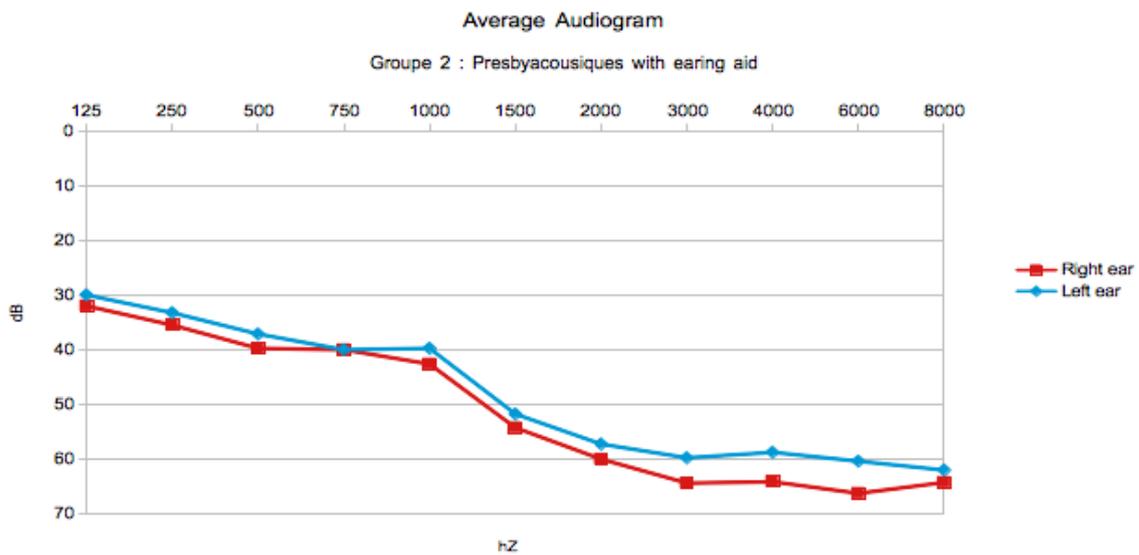


Graphic 43: Speech understanding (Lafon test) - Presbycousics without hearing aids

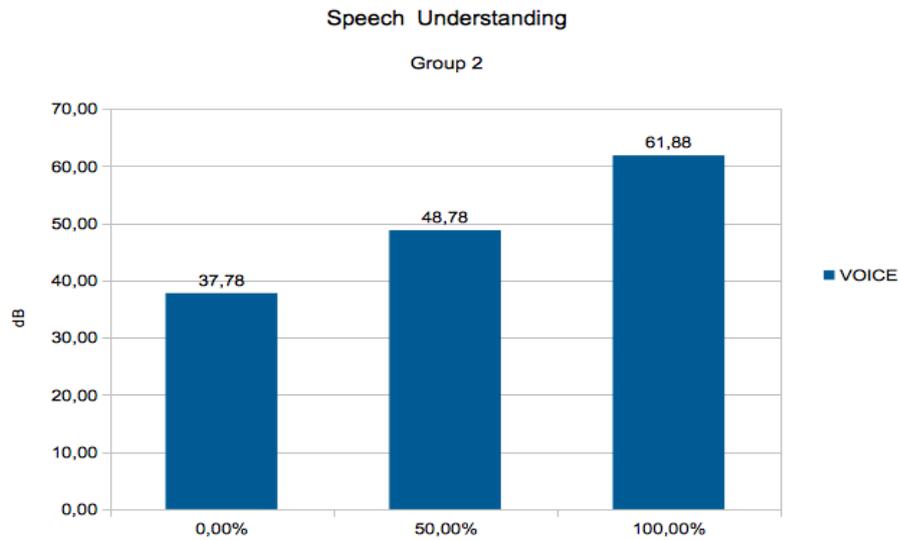
- Group 2: 9 presbycusic users with hearing aids

Average hearing loss without hearing aids : 50dB

Average hearing loss with hearing aids : 37 dB



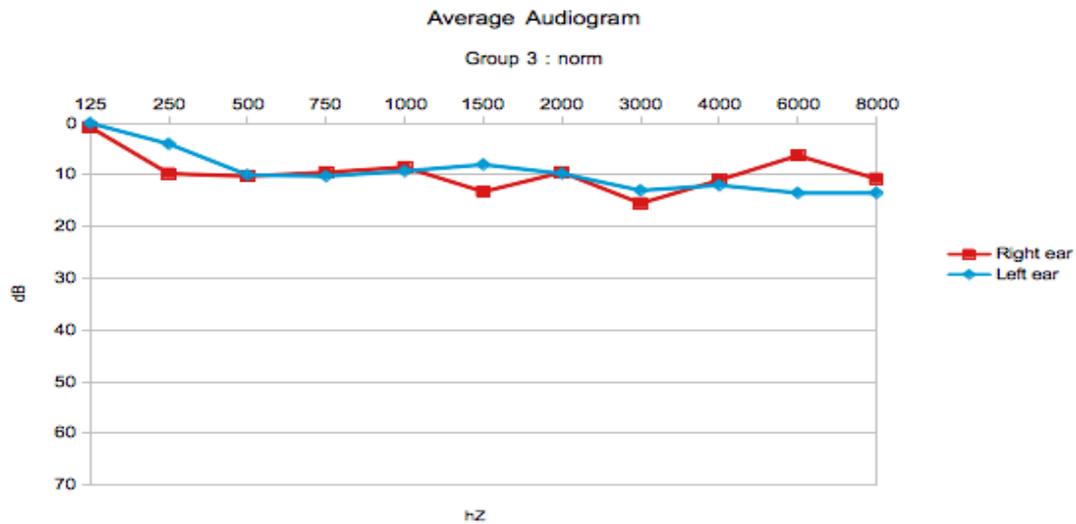
Graphic 44: Average audiogram - Presbycousics with hearing aids



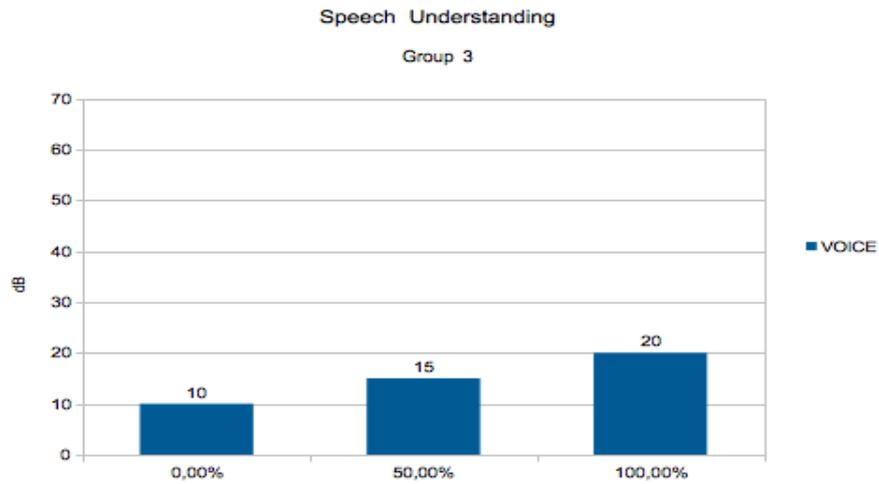
Graphic 45: Speech understanding (Lafon test) - Presbycousics with hearing aids

- Group 3: 4 young normal hearing users (test group)

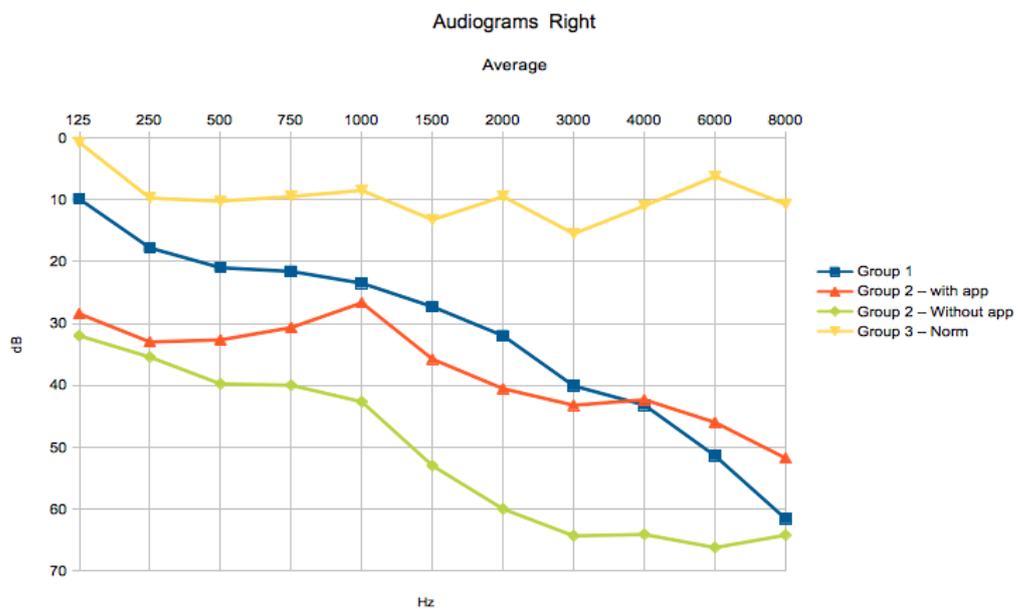
Average hearing loss without hearing aids : 10 dB



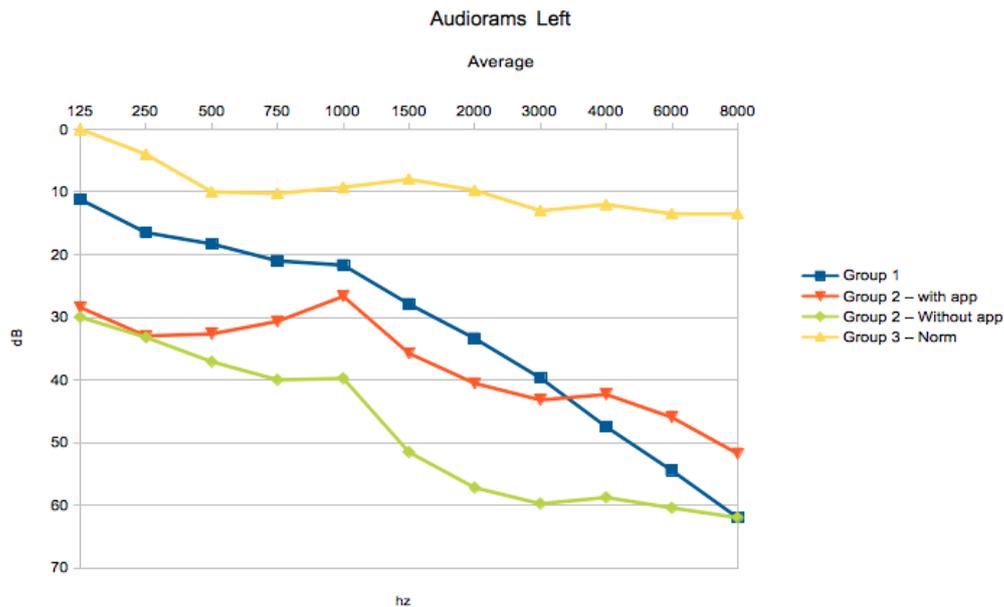
Graphic 46: Average audiogram - Normal hearing users



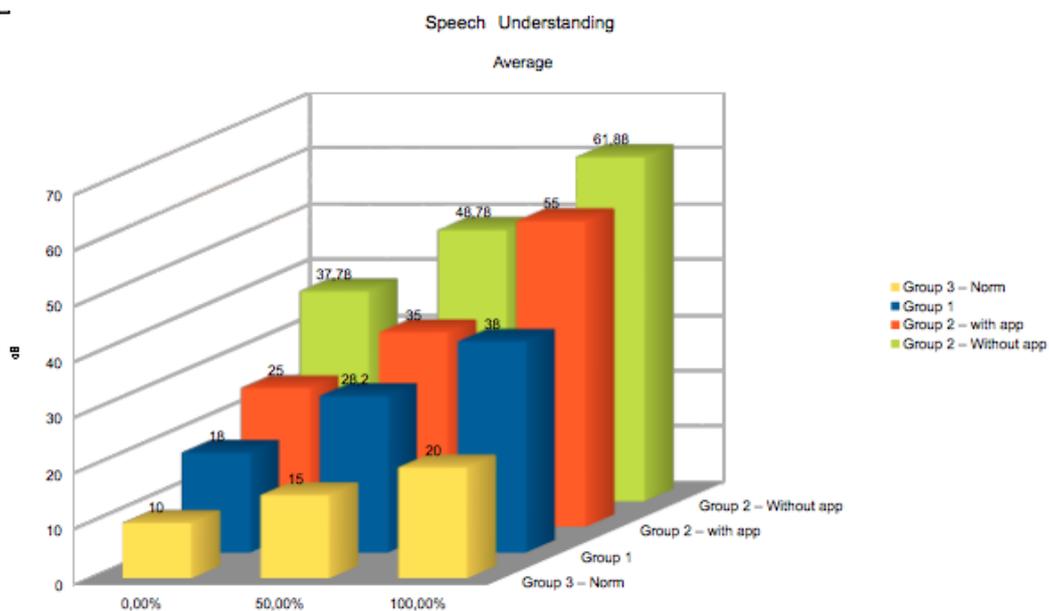
Graphic 47: Speech understanding (Lafon test) - Normal hearing users



Graphic 48: Average right audiograms for the 3 groups:



Graphic 49: Average left audiograms for the 3 groups:



Graphic 50: Speech understanding average for the 3 groups.

The tonal audiogram shows that the curve of prebycusics users when they wear their hearing aids is quasi similar to that of prebycusics users without hearing aids. But when comparing the vocal audiogram we realize that the ability to understand of prebycusics users with hearing aids, even when they wear their equipment, are lower than those of prebycusics users without hearing aids.

In Italy:

Tonal audiogramme:

In patients with hearing loss, the first step is represented by audiologic assessment, followed by the audiometric examination, which consists in detecting the hearing thresholds through aerial conduction, i.e. the detection using headphones of the minimum intensity value in decibels (dB) for each frequency-test that the examined ear can perceive.

The audiometric examination is carried out with the audiometer, a device that emits tones at different frequencies to the patient.

The patient, who is set in a soundproof booth and wears headphones, is asked to respond (with the button or the arm) every time he/she hears a sound.

The test starts by the 1000hz tone, which the human ear is most sensitive to, transmitting the sound to the right or left earphone of the headphone at an intensity that is certainly perceived by the patient.

Then the intensity is lowered in 5dB steps using the volume control, until the patient can no longer hear the sound.

The last value in decibels which the patient has heard and for which he/she responded, is considered the threshold for the given frequency (method of descending threshold).

Alternatively, the tone at high intensity is first transmitted and the intensity is then lowered to zero and then increased in 5 dB steps until the patient responds: the first value of intensity for which the patient responds is taken as the threshold (method of ascending threshold).

The latter is a more precise method and it is commonly applied in Italy.

Thus, by threshold we mean the minimum intensity value that is perceived (minimum audibility perception). Using the same procedure the threshold for high-frequencies is determined (in succession: 2000, 4000, 8000 Hz) and for low pitches (500, 250, 125 Hz).

These should be examined for the last, when the person is already trained to the examination, because the vibratory-tactile component of the low-frequency tones, could determine confused answers.

Vocal audiogramme:

Vocal audiometry is the study of the hearing function through the emission of verbal-vocal auditory stimuli. It is a type of audiometry in which the normal situation of auditory stimulation are reproduced closer to the user compared to those which the person is subjected to in his/her daily life.

It is useful to diagnose disorders in higher hearing functions, such as those occurring due to pathologies of the central brain system. It allows an assessment of the correct functioning of the whole hearing apparatus and of all those extra-auditory structures contributing to understand the system of sound symbols represented by the verbal language.

Furthermore, vocal audiometry concerns the study of the so-called "central deafness", the evaluation of the prosthetic therapy of deafness and the functioning before and after functional ear-surgery

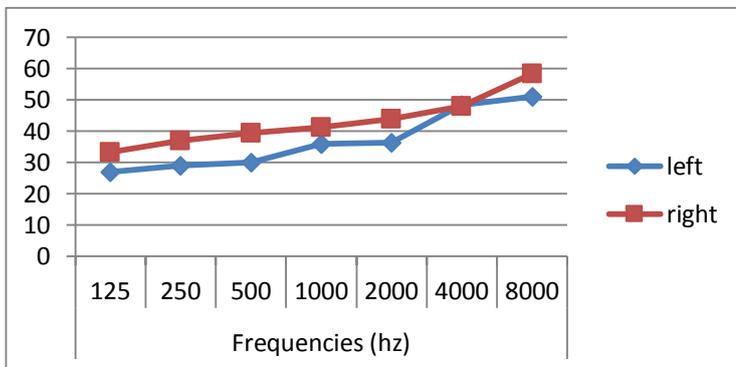
The patient is invited to sit in a soundproof booth where the vocal audiometric test can be carried out in free field where two loudspeakers are placed before the patient or with headphones. In both cases the material to use can be of different nature:

- PHONEMES: which are the auditory units of language; they have no meaning if taken individually.
- LOGATOMES: verbal events composed of two, three or four phonemes (C.V.C., C.V.C.V.)
- WORDS: they can be monosyllabic, bisyllabic or multisyllabic. In the Italian language the monosyllabic are just a few, so they are scarcely used. Only bisyllabic words are used (cielo, era, tordo, alpi, freno, chiuso, arti, radio, bionda, ali).
- PHRASES: verbal material composed of a set of semantic elements (words) that have, as a whole, a logical meaning. They are very much used in Italy for this method.

The patient is invited to repeat the words that he/she perceives and the doctor set them in a graph that has, on the x-axis, the figures of the vocal message intensity in dB, and on the y-axis, the percentages of identified material/words.

By connecting the points related to the various intensity levels under investigation, we get, in a normal hearing person, a "S" curve defined vocal pronunciation curve or intelligibility curve, while in patients with hearing disorders, we can get pathologic auditory curves: straightened curve, parallel curve, oblique curve, "plateau" curve, dome curve and finally, roll-over curve.

Tonal audiogramme - Results:

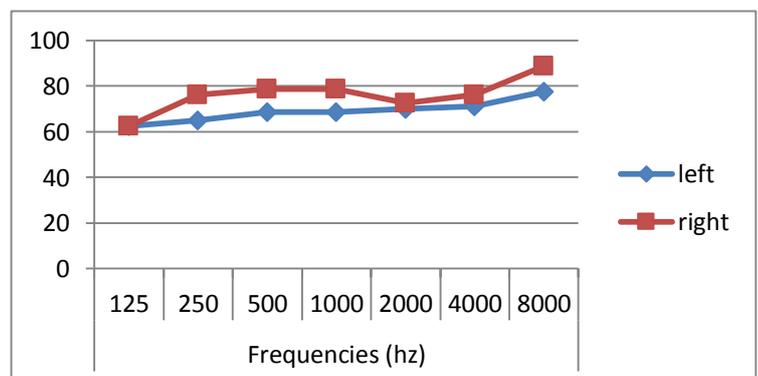


The data deriving from the tonal audiometric examination show that, in presbycusis patients without hearing aid, as we move towards the high-pitches (1000-2000-4000-8000 Hz) there is a greater trend not to listen to the sound. This happens more frequently with the right ear.

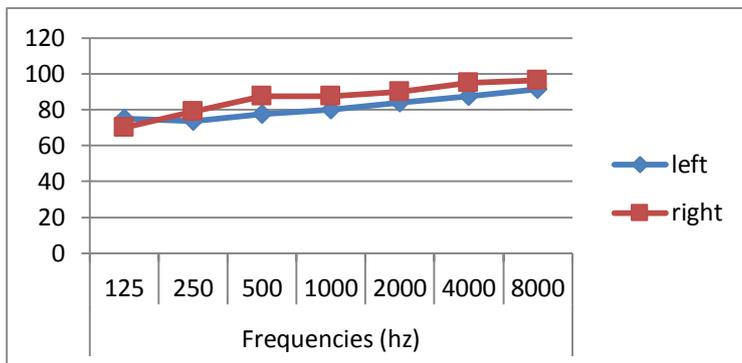
Graphic 51: Group 1 - PRESBYCUSIS USERS WITHOUT HEARING AIDS

The users start by a frequency of 125 Hz in the same way, both for the right and the left ear, and then the results split and rejoin at 2000 Hz. The sound perceived by the left ear is constant between 60 dB and 80 dB.

Graphic 52: Group 2 - PRESBYCUSIS USERS WITH HEARING AIDS

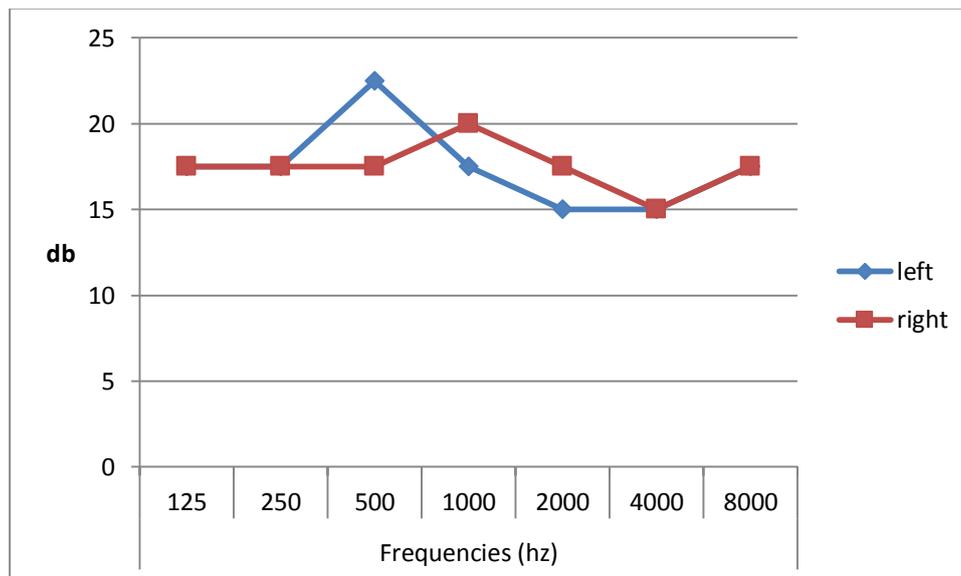


The data represent the 4 presbycusis users with hearing aids, who are asked to remove and turn off their hearing aids to perform the tonal audiometric examination with masked tone.



The graph shows that, at a frequency of 125 HZ, the users perceive the sound in the same way with both the right and the left ear, starting from 70 dB and this remains more or less constant for all the other frequencies (125 HZ to 8000 HZ). Both ears (the right and the left) perceive the sound in a constant way (from 70dB to 100 dB).

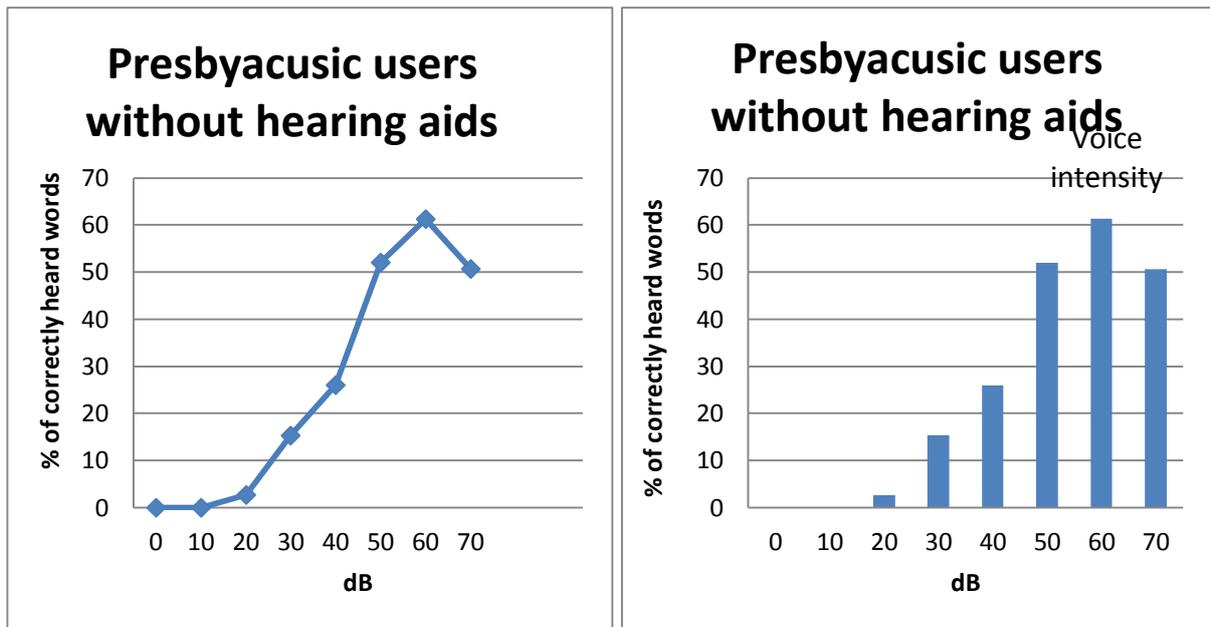
Graphic 53: Group 2 - PRESBYCUSIS USERS WITHOUT THEIR HEARING AID WITH MASKED TONE



Graphic 54: Group 3 - NORMAL HEARING USERS

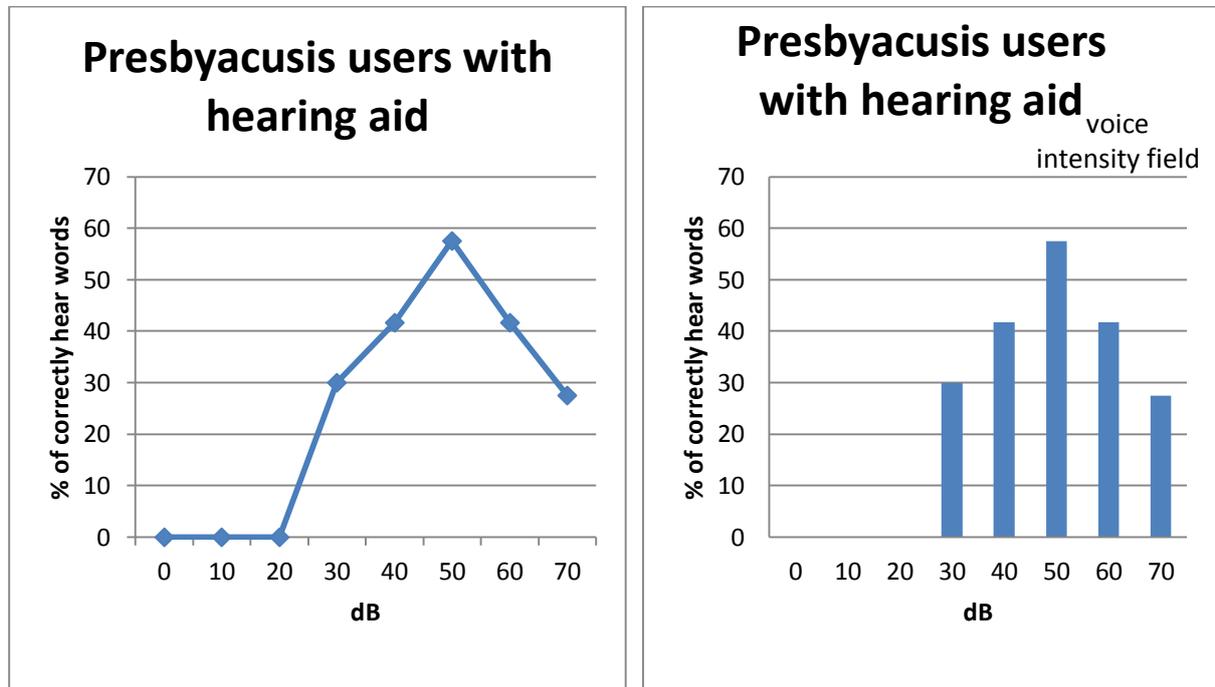
The graph shows that there is a difference in perceiving sounds between the right and the left ear, particularly at the frequencies of 500 Hz and 2000 Hz. The hearing perception at all frequency is not constant.

Vocal audiogramme - Results:



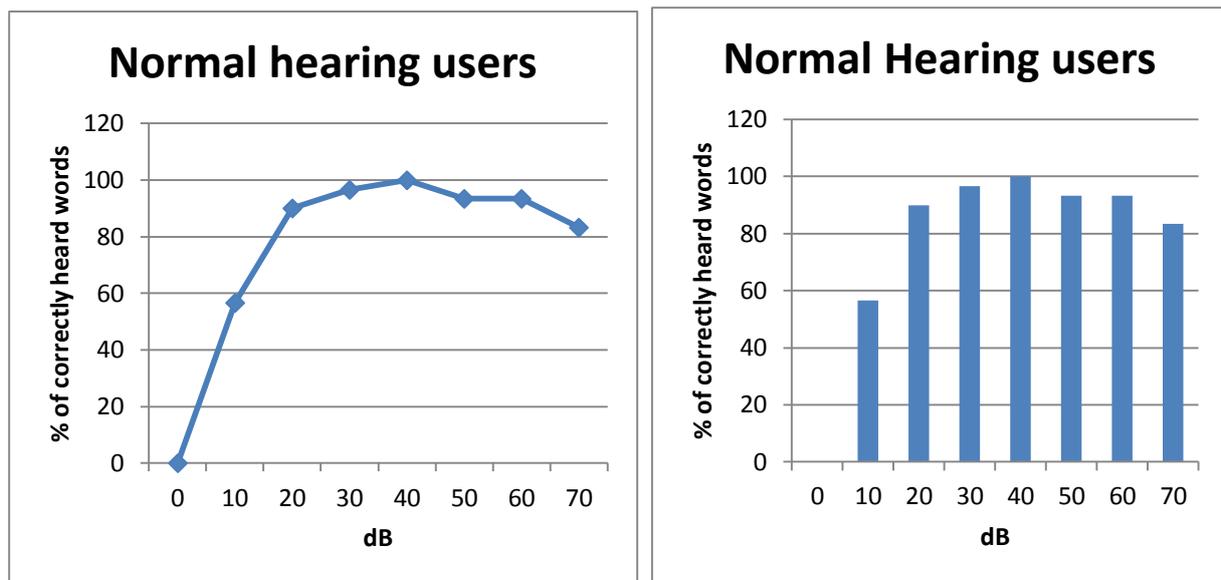
Graphic 55: Group 1: PRESBYACUSIC WITHOUT HEARING AIDS

Data obtained by the vocal audiometric test stipulate that, presbycusic patients without hearing aids perceive about 55% of the words pronounced in the interval ranging from 50 to 70 dB.



Graphic 56: Group 2: PRESBYACUSIC WITH HEARING AIDS

These users perceive the 45% of the words in a punctual way and, while frequencies rise up the words are perceived but in a distorted way due to the recruitment phenomenon.



Graphic 57: Group 3: NORMAL HEARING USERS

The vocal audiometric test in normal hearing patients allows to obtain the intelligibility “S” curve, thus the users perceive almost the 100% of the words they listened to from 20 to 60 dB.

There is no improvement above a threshold in the rate of understanding by presbycusics. That means that it’s not necessary to increase too much the level of the sound in station and cars for presbycusics and normal hearing persons.

5.3.2 Auditory filter measure.

This test consists on measuring the width of the auditory filter for impaired hearing person. As mentioned in [Gnansia 2009]⁸.The auditory filter varies depending on the age. This lead to a decrease of the frequency resolution. To measure the auditory filter we use a “masking tone by pure tone” as specified in [Zwicker&Fastl 2007]⁹. The procedure of auditory filter measure is similar to the tonal audiogram but in presence of a second pure tone in specific frequency and level.

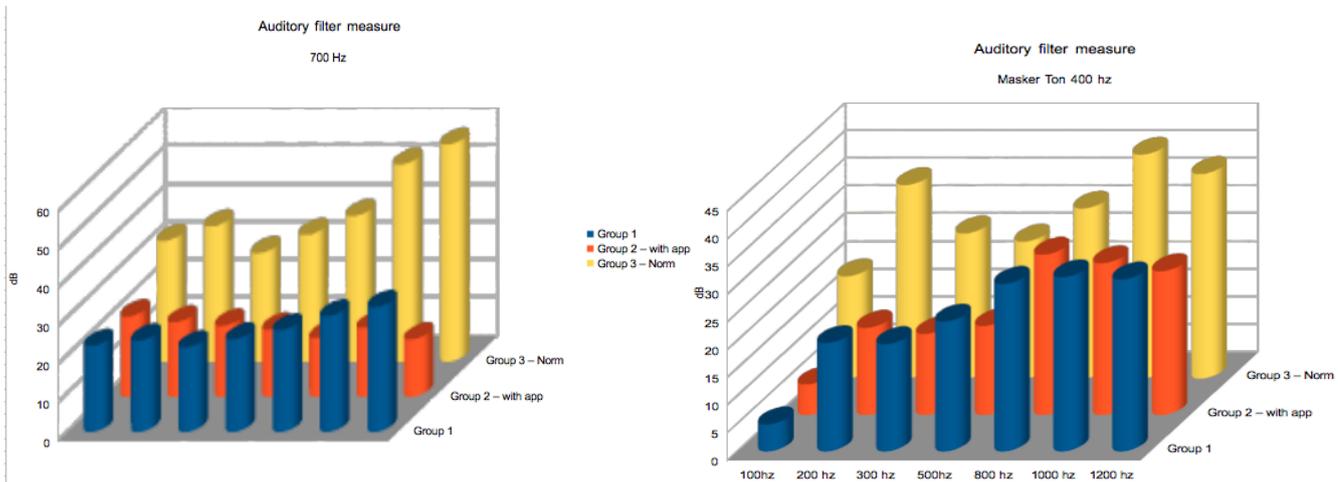
Procedure:

- Presenting simultaneously two pure tones: masker tone and masked tone.
- A masker tone is a pure tone with a fixed level of 60 dB in specific frequencies.
- A masked tone will varies in frequency and level like test tone in tonal audiogram.

⁸ [Gnansia2009]: D. Gnansia, “Intelligibilité dans le bruit et démasquage de la parole chez les sujets normo-entendants, malentendants et implantés cochléaires”, Thesis, 2009.

⁹ [Zwicker&Fastl2007] : Hugo Fastl, Eberhard Zwicker, “Psychoacoustics: Facts and Models”, Springer, P-80, 2007.

- The subject will listen to the masked tone in a presence to the masker tone and responds as soon as the presence of the masked tone produces a sensation in addition to the masker.
- The procedure will be repeated for a number of different test frequencies chosen to encompass the entire range of the tuning curve. More precisely, frequencies are chosen according to alarms frequency content ¹⁰.



Graphic 58: Auditory filter measure (700 Hz and Masker ton 400 Hz)

It is observed that presbycusics users generally need a higher volume difference than normal hearing users to perceive the two tones, even for presbycusics users with hearing aids and particularly when the masker tone frequency is closed of the masked tone.

5.3.3 Subjective intelligibility assessment.

The goal of the experience at CERTA was to design a protocol for subjective intelligibility assessment, using two types of sentences (Hint database and Vocal announces of railway station) and two types of distortions :

- reverberation (convolve clean sentences with typical impulse responses (IR) of railway stations with different reverberation times (TR60))
- noise: typical railway station noise at different levels (SNR: Signal to noise ratio) to the reverberated sentences.

The chosen SNR's and TR60 have been inspired from [Remy2001]¹¹ in order to have a real representation of railway station environment.

This test had been created in order to obtain, a database of subjective intelligibility scores to be used for validation and optimization of objective intelligibility assessment algorithms. This test could also be used like an ecological intelligibility test to help the patient to be aware of his deficiency.

¹⁰ A. Balastegui *et al.*, "New siren tones optimised for increased detectability distances of emergency vehicles", Elsevier, Applied Acoustics, 47, 803-811, 2013.

¹¹ N. Remy, "Maitrise et prédiction de la qualité sonore du projet architectural: Application aux espaces publics en gare", PhD Thesis, CRESSON, 2001.

- Impact of reverberation on the perception of a message

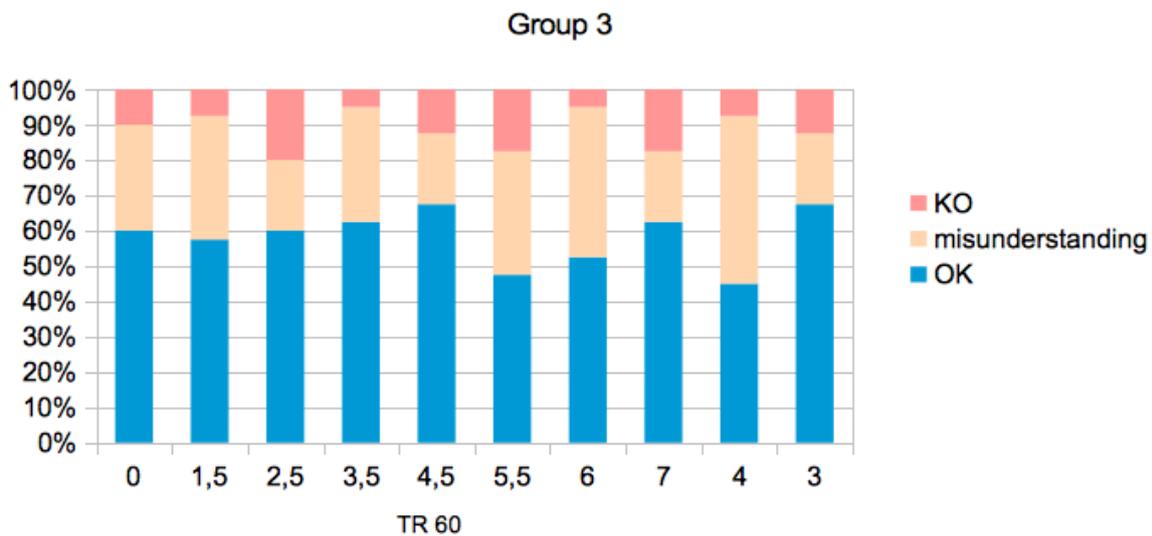
The audiologist ask the user to reproduce what he understood from the Hint sentence.

Definition of the intelligibility score: percentage of recognized key words per test-condition, with a noise at 50dB

Ko: sentence isn't heard

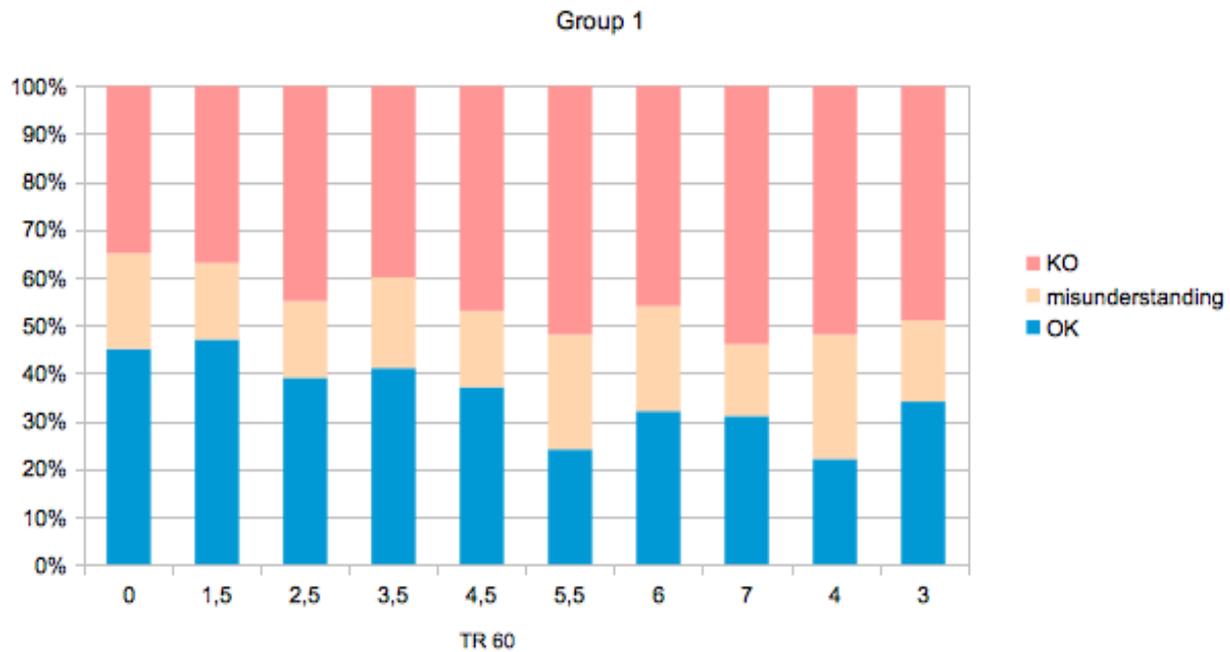
Misunderstanding: sentence is heard but not understood

Ok: sentence is heard and understood



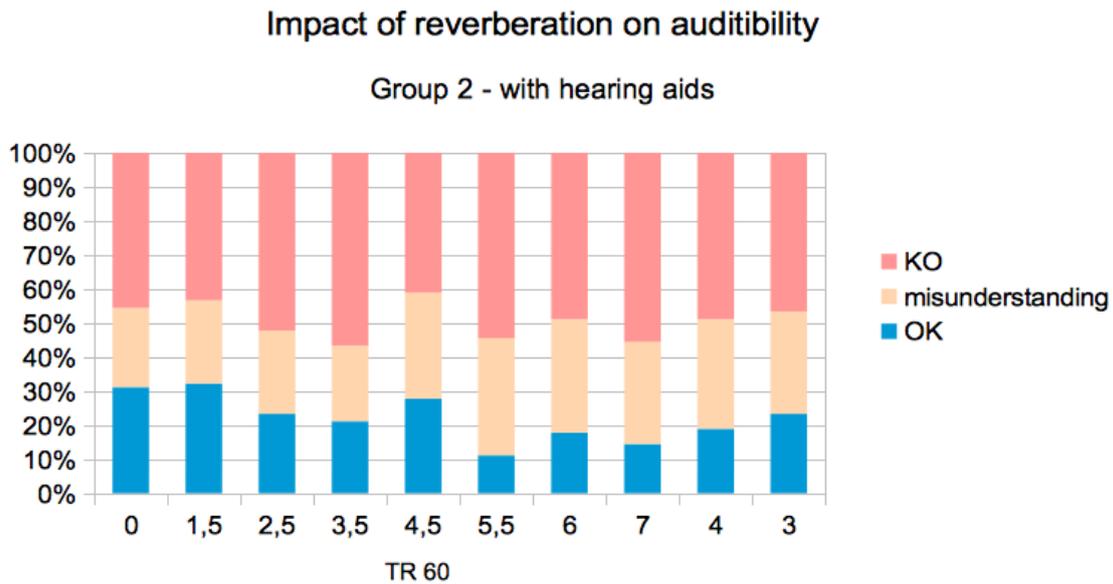
Graphic 59 : Group 3 : Normal hearing users:

- Understanding of the sentences from SNR >-4dB: 8% of the sentences are not heard.
- Significant impact of intelligibility: 24% of the sentences are repeated incorrectly.
- sensation perceived as unpleasant
- Important impact of mental substitution, allowing the overall understanding of the message.



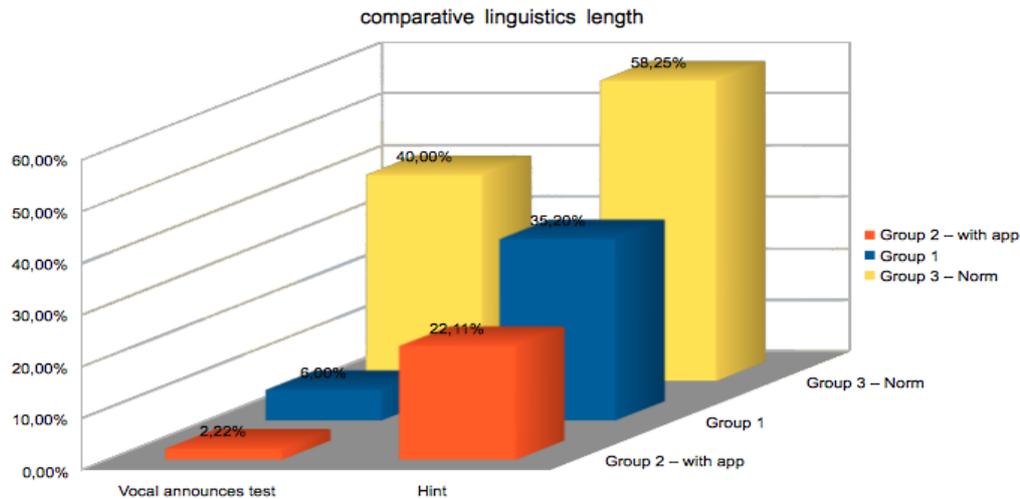
Graohic 60: Group 1 : prebycusics users without hearing aids

- Understanding of the sentences from SNR > 0 dB: 45,7% of the sentences are not heard.
- Significant impact of intelligibility: only 35,2% of the sentences are correctly repeated.
- Ecological test: 76% of patients expressed the same sensations in noisy situations.
- The mental substitution is not as efficient as the normal hearing group, which does not facilitate the correct perception of the message: 19.10% of the sentences are repeated with linguistic errors. The users are embarrassed by the lack of understanding of the verbal message: lack of understanding of a word prevents them to continue listening to the global message. This lack of understanding increase with the stress (waiting a train, for example).



Graphic 61: Group 2 : prebycusics users with hearing aids

- Understanding of the sentences from SNR > 5 dB: 49,7% of the sentences are not heard.
- Significant impact of intelligibility: only 22,11% of the sentences are correctly repeated.
- Ecological test : 80% of patients feel as in known situations. The users used to these situations and fear them.
- The mental substitution is not possible: 28,26% of the sentences are repeated with linguistic errors (between SNR +5dB and +10dB).
- In the same situations (railway station for example), users fear vocal announcements and try to find visual.



Graphic 62: Intelligibility of vocal announcement, impact of the length of the message

- Despite the fluidity of speech and the female voice, the vocal railway station announcements are not clearly identified.
- The length of the sentence significantly impact the understanding of the verbal message, especially in noisy environments:
 - group 1 -29.20% comprehension
 - group 2: -19.89%
 - group 3: -18.25%
- Important impact of mental substitution

Conclusions of subjective intelligibility assessment:



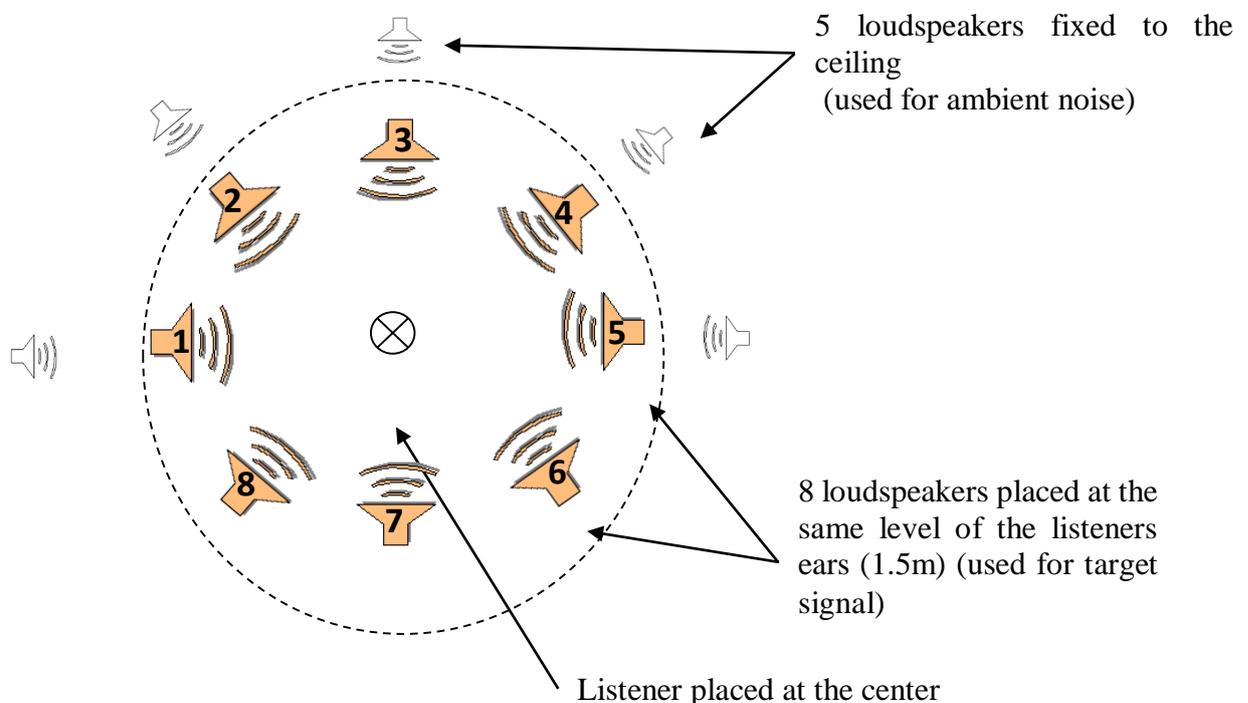
Graphic 63: Subjective intelligibility assessment –Hint in noise

- The reverberation has a significant impact on intelligibility, particularly for presbycusics users.
- The hearing aids don't facilitate understanding in noise. If they remove their hearing aids, they will have a worse understanding. The hearing aids facilitate understanding in noise, even if people with hearing aids have a low level of understanding in noisy environments.
- The SNR significantly affects the understanding of the verbal message, the length of the sentence prevents the mental substitution
- Notorious fatigability during the test

5.3.3 Localization assessment

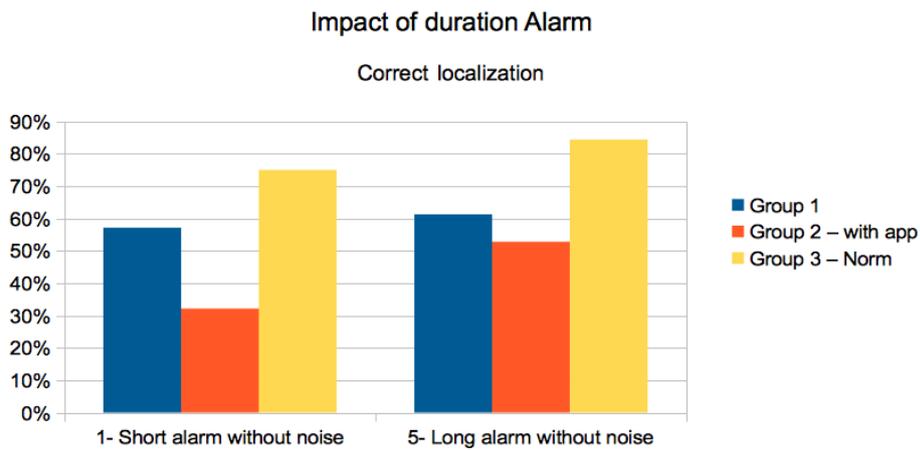
- Goal of the test:
 1. Evaluate the effect of the age related hearing loss on the localization accuracy of a car driver, particularly, in term of reversal errors (front-back confusion)
 2. Propose an ecological localization test to help the patient be aware of his deficiency.

Configuration of the test room:



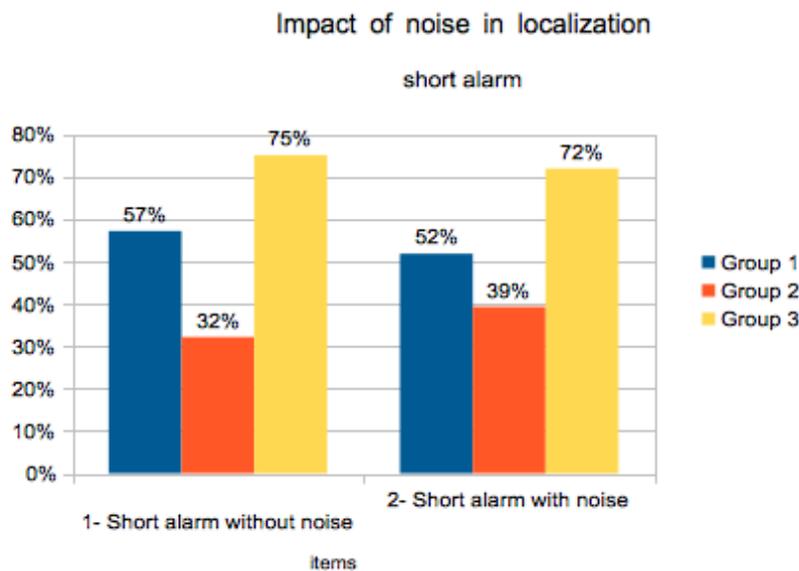
FiDisposition of the loudspeakers for the localization test

Loudspeakers are placed at 45 degree intervals around the participant, at 0 degree elevation along the horizontal plane. The user is placed in the center of the circle, 1m from each loudspeaker. The loudspeakers are visible and numbered. The target sound is diffused through one loudspeaker from the numbered loudspeakers placed around the listeners. The ambient noise is diffused through the 5 loudspeakers dedicated to this task. The user is asked to seat in the center, using a chair with headrest, as in a vehicle. The subject is asked to localize the direction of the sound.

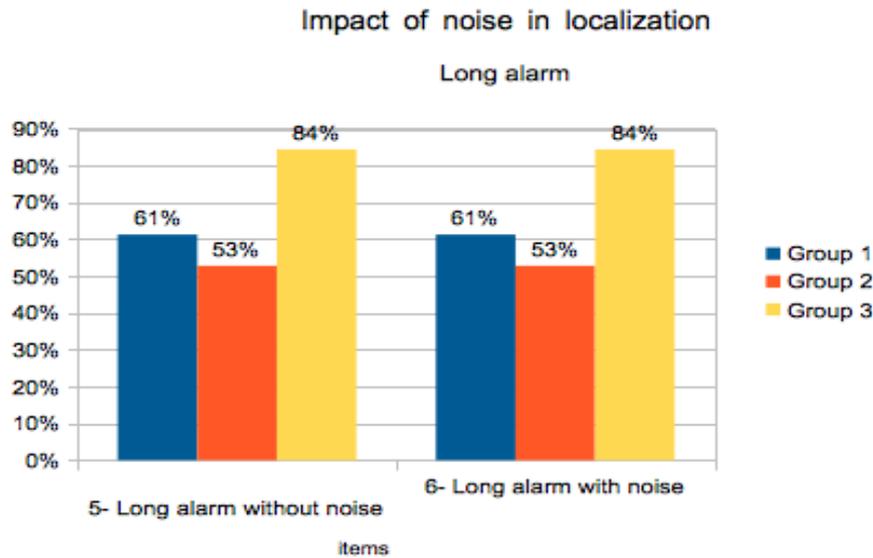


Graphic 64: Localization, impact of the length of the alarm

- Hearing aids disturb the localization of the target item.
- The localization of a long alarm is easier

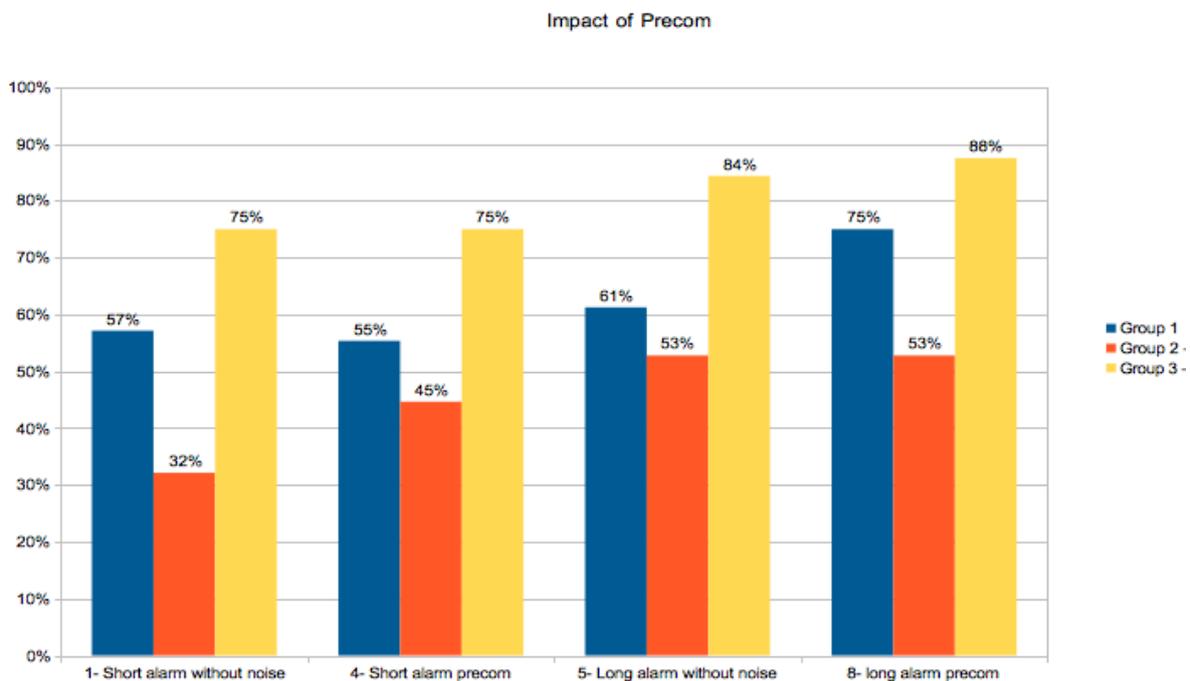


Graphic 65: Localization, impact of the noise:



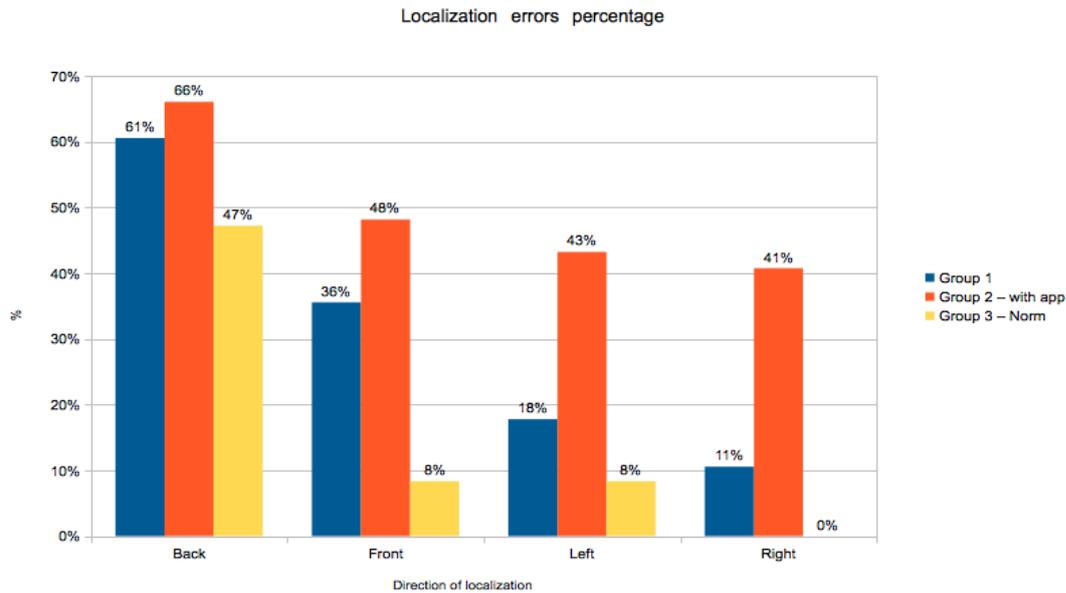
Graphic 66: Impact of noise in localization – long alarm

- No real impact of noise, but better localization in noisy environments with a long alarm.
- Sometimes discordant results due to a learning effect.



Graphic 67: Localization, impact of a precompensated alarm

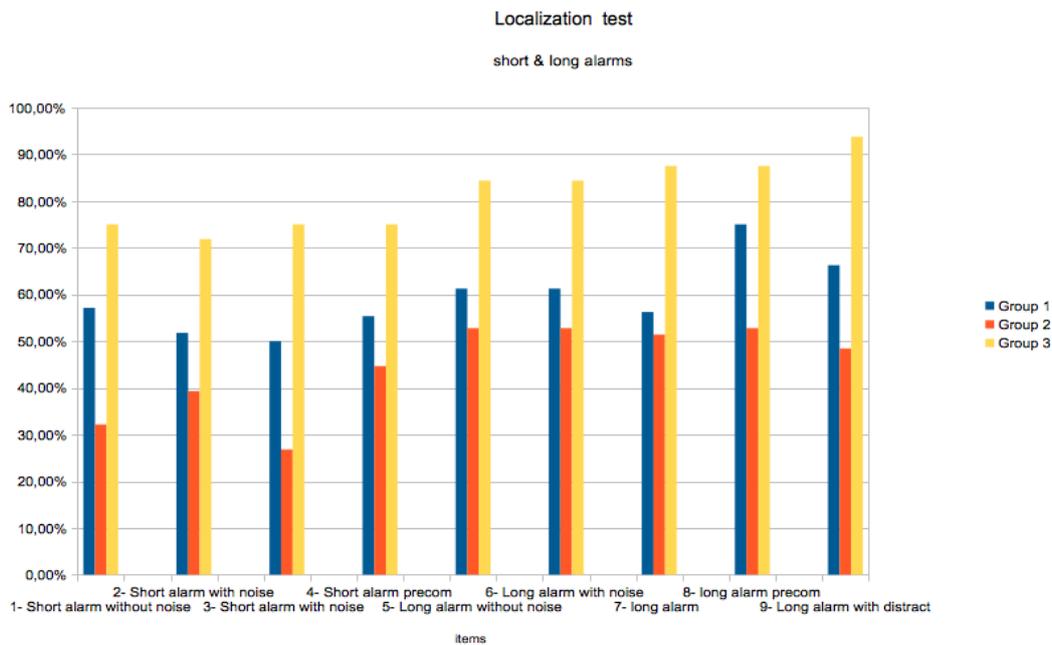
- The better localization with a precompensated alarm is not systematic, if a non-compensated alarm is heard, the pre-compensation does not facilitate the correct localization but the reaction's speed is increased.
- Learning effect.



Graphic 68: Localization, impact of alarm’s direction

- The front-back localization is harder than left-right for each groups.
- The back localization is really difficult even for normal hearing users
- Hearing aids clearly disturb the localization of the target item.

Conclusions of localization assessment:



Graphic 69: Localization test – Short and long alarms

This localization test generates an important learning effect. These results provide us a schematic view of user's needs. However, we can observe the very significant impact of the hearing aids on the difficulties of localization and the really bad back localization for the three users groups.

6 . CONCLUSION

This document describe the methodologies and tools developed and adopted to carry out the survey dedicated to user's requirements in terms of intelligibility, well-being and elderly safety, to better address the solution under elaboration by I City for All partners. This survey involves a cohort of 51 persons, older than 50 years, presbycusic or not wearing hearing aids or not, in Italy and France, between January and June 2013.

The survey evaluations were carried out in two stages. The first one enabled us to confirm the suitability level of cohort behavior to the existing literature findings:

- users are missing important information diffused in railway stations. Difficulties met in hearing and understanding information diffused by loudspeakers are mainly attributable to the bad quality of the loudspeakers.
- drivers wearing hearing aids have problems in localizing moving sound alarms. This explains the importance of the "I'city for all" project objective aimed at improving loudspeakers quality, particularly in railway stations and developing innovative localization solutions applicable in cars.

The objective of the second step of the survey was to identify user's needs, in more details. For this purpose, a new questionnaire focused on railway stations and cars where questions aimed at better steering the project solution under design had been proposed to the users. The users were also undergoing audiometric and audiologic tests aimed to scientifically assess their hearing capacities. Essential elements extracted from the second step of the survey:

Questions referred to the car

The majority of users with or without hearing aids often meet difficulties, in perceiving the different types of alarms coming from outside the car and in recognizing if an alarm is coming from the front or the back particularly at intersections and during lane change. This is more emphasized during high traffic and windows closed. However users generally prefer driving windows closed because of the noise, air currents and the use of air conditioning.

These observations are confirmed with audiologic test. The front-back localization is harder than left-right and particularly the back localization which is really difficult even for normal hearing users. We can also note that hearing aids clearly disturb the localization and the pre-compensation of an alarm doesn't facilitate the correct localization but increase the reaction's speed. Users generally prefer a visual indicator on their dashboard indicating the direction of the alarm with an arrow to locate an external alarm.

We can also note that any significant problem is observed in any of the three categories of users in perceiving in-car alarm bips (e.g. parking aid bip, safety belt undo bip, fuel gauge bid, other dashboard alarm, etc.) when windows are closed. This is due to the fact that noises are

inside the car and thus they are more easily perceivable. Presbycusic users with and without hearing aids have more difficulties when windows are open.

Questions referred to the railway station

The majority of presbycusic users with or without hearing aids have half the time or more difficulties to hear and understand a voice announcement in the main hall of a rail way station while normal hearing users generally have no difficulty. During peak hours, presbycusic users with and without hearing aids capacity to hear and understand the vocal announcements greatly reduced, they are also most commonly generally hurt by noises and loud sounds either in the hall or on the platform. The user's majority note that noisy conversations are more annoying in a closed space. This observations are confirmed by audiologic tests, the reverberation has a significant impact on intelligibility, particularly for presbycusic users, the hearing aids don't facilitate understanding in noise and the SNR significantly affects the understanding of the verbal message.

Presbycusic users with hearing aids believe mostly that the time duration of the vocal announcements is in general satisfactory. Presbycusic users without hearing aids and normal-hearing users are more divided even if half the time or more they feel that the time duration of the vocal announcements is satisfactory. Audiologic tests show us that the length of the sentence significantly impact the understanding of the verbal message, especially in noisy environments. We can also note that the length of the sentence prevents the mental substitution. The presbycusic users are embarrassed by the lack of understanding of the verbal message: lack of understanding of a word prevents them to continue listening to the global message. This lack of understanding increase with the stress.

The tonal audiogram shows that the curve of presbycusic users when they wear their hearing aids is quasi similar to that of presbycusic users without hearing aids. But when comparing the vocal audiogram, the intelligibility and localization assessments, we realize that the ability to understand a word or a sentence and to locate a sound, of presbycusic users with hearing aids, even when they wear their equipment, are lower than those of presbycusic users without hearing aids.

In general way, for tonal audiogram test, we can see « normal hearing » group can hear the different frequencies with decibels level including in the interval [0;20]. What are happen for the others groups: Presbycusis users without and with hearing aids? For the others groups, we can see that they need much more decibels than the « normal hearing » group to hear different frequencies. Those people cannot hear the same sounds in the street than the others people.

The second test was a vocal audiogram. The four groups need more decibels than the "normal hearing" group to hear the words. However, we can see something strange for the Italian "normal hearing" group. We suppose that this fact is due because in this group we have people that they thought that they haven't hearing problems. But after the tests, some people have been diagnosed « presbyacusic ».

The third test was a localization assessment. This test was realized in France but not yet in Italy. We made four evaluations: Impact of duration alarm; Impact of noise in localization; Impact of noise in localization; Impact of pre compensated alarm.

For each evaluation, we can observe that "normal hearing" group is better than the other groups. The other groups are quite close in their results, but the group without hearing aids had better performances than the group with hearing aids. The both first groups encounter more difficulties than the "normal" group.

The group with hearing aids does more errors than the other groups. Back localization seems to be difficult for all the groups. We can imagine the difficulty for this people (with or without hearing aids) to localize an ambulance on the road.

We have to consider the learning effect in this type of test to take in account the results. Thanks to these results we can more understand the needs of users. This study shows us that it exist security problems for the people with hearing troubles. They can feel more vulnerable and frutrated than the others with the same age. It clear that "I city for all" can be a solution in their daily life.

Now, most of the users involved in this survey, and new users will be asked to test the innovative solutions that are under development in the project. These "in-vivo" tests will be organized in railway stations and on cars both in Italy and in France, thus contributing to their validation.

7. GLOSSARY

APHAB model¹²: The Abbreviated Profile of Hearing Aid Benefit

BUCODES Surdi France: French national association for hearing impaired users (**SURDI 49** is the local association in Angers)

CERTA: Centre d'Evaluation et de Réadaptation des Troubles de L'Audition (evaluation and rehabilitation center for hearing impaired users)

CERCAT: Centro di Esposizione, Ricerca e ConsulenzasugliAusiliTecnici (Centre for Exhibition, Research and Advice on TechnicalAids)

CENTICH: Centre d'Expertise National des Technologies de l'Information et de la Communication pour l'autonomie(National Expert Center Of Information And Communication Technologies for Autonomy)

DEAFNESS¹³ is defined as a degree of impairment such that a person is unable to understand speech even in the presence of amplification. In profound deafness, even the loudest sounds produced by an audiometer (an instrument used to measure hearing by producing pure tone sounds through a range of frequencies) may not be detected. In total deafness, no sounds at all, regardless of amplification or method of production, are heard.

ENS: Ente Nazionale Sordi (Italian National body for deaf users)

GLASGOW model¹⁴: GLASGOW HEARING AID BENEFIT PROFILE (GHABP)

HEARING IMPAIRMENT⁸, or hard of hearing, is when your hearing is affected by a condition or injury and, consequently, there is diminished sensitivity to the sounds normally heard. More specifically, users suffering from hearing impairment have relative insensitivity to sound in the speech frequencies.

HEARING AID¹⁵: A hearing aid is a battery-powered, electronic device that makes listening easier for users with a hearing loss. A hearing aid consists of a microphone, an amplifier and a receiver. The microphone picks up sounds in the acoustic environment and turns them into electronic signals. The amplifier selectively amplifies the acoustic electronic signals. The receiver is a very small speaker that changes the electric signals back to sounds and delivers the sound to the ear. It typically fits in or behind the wearer's ear but there are many types of hearing aids which vary in size, power and circuitry.

PRESBYCUSIS¹⁶ is a progressive loss of ability to hear high frequencies (above about 2 kHz) with increasing age. Although genetically variable it is a normal concomitant of aging and is distinct from hearing losses caused by noise exposure, toxins or disease agents. It usually occurs after age 50 and is

¹² Cox, RM and Alexander, GC. "The Abbreviated Profile of Hearing Aid Benefit (APHAB)". *Ear and Hearing*, 16, 176- 186 (1995)

¹³ <http://www.answers.com/topic/hearing-impairment-1>

¹⁴ Gatehouse, S (1999) "Glasgow Hearing Aid Benefit Profile: Derivation and validation of a client-centered outcome measure for hearing-aid services", *Journal of the American Academy of Audiology*, 10:80-103.

¹⁵ http://unitron.com/content/unitron/global/en/consumer/hearing_aids-c/what_is_a_hearingaid.html

¹⁶ <http://medical-dictionary.thefreedictionary.com/presbycusis>

<http://www.nidcd.nih.gov/health/hearing/pages/presbycusis.aspx>

<http://www.uptodate.com/contents/presbycusis>

caused by structural changes in the organs of hearing. Initially, changes in the inner ear, such as degeneration of hair cells and changes in the basilar membrane, lead to decreased hearing at higher tones and a decline in pitch discrimination. As hearing continues to be lost, even lower pitch tones become harder to hear. Thus, over the time, the mid and low frequencies (0.5 to 2 KHz), associated with human speech, also become progressively involved. The low and mid frequencies of human speech carry the majority of energy of the sound wave. This includes most of the vowel information of words. It is the high frequencies, however, that carry the consonant sounds, and therefore the majority of speech information. These consonant sounds tend to be not only high pitched, but also soft, which makes them particularly difficult for patients with presbycusis to hear. As a result of their hearing loss pattern, patients with high-frequency hearing loss will often report being able to hear when someone is speaking (from the louder, low-frequency vowels), but not being able to understand what is being said (due to the loss of consonant information). Hearing deficits are exacerbated in the presence of competing background noise. The missing high frequencies are essential to allow the inner ear to focus on sounds of particular interest and pick those sounds out from competing ambient noise. Patients with presbycusis will often perform quite well in one-on-one communication in a quiet room, but the ability to hear will decline when there is even a small amount of competing noise. This experience is often referred to as the *"cocktail party effect,"* which emphasizes the difficulty that patients experience with communication in social settings. Patients also will often complain that they have more difficulty hearing women than men, which is the result of the inherently higher pitch of women's voices. Patients will often complain that sounds become too loud at levels that would easily be tolerated by persons with normal hearing. This is the result of *"recruitment,"* a disordered processing of sound in the inner ear. The simultaneous elevation of the threshold needed to hear quiet sounds, and the reduction of tolerable loud sounds, results in a narrowing of the individual's dynamic range. This can complicate fitting hearing aids for affected individuals, where careful upper output limits must be set to maintain comfort levels. Recruitment explains why shouting at patients with presbycusis is often quite counterproductive, since it is primarily the low vowel frequencies that are amplified by shouting, which carry little of the missing speech information and can be quite uncomfortable to the listener.

Annex I – Informed Consent delivered in France

Formulaire de consentement

Evaluation de la perception des annonces sonores dans les lieux publics et de la perception des alertes en voiture par les personnes déficientes auditives

Dans le cadre du projet Européen l'City for all, nous menons une étude, dont l'objectif est d'évaluer la perception des annonces sonores dans les lieux publics et la perception des alertes en voiture par les personnes déficientes auditives,

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 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 »

(suite) Les phases de mise œuvre de l'étude

1. Courrier d'information et de recueil du consentement adressé aux usagers.
2. Contact téléphonique, recueil d'un consentement oral à la participation à l'étude, proposition d'un rendez-vous à domicile.
3. Rendez-vous à domicile pour passation du questionnaire, recueil du formulaire de consentement signé. Conservation d'un exemplaire du questionnaire par l'utilisateur.
4. Durant deux semaines l'utilisateur peut être amené à compléter ou modifier le questionnaire.
5. Deux semaines après la première passation du questionnaire, retour de l'exemplaire laissé à l'utilisateur, par enveloppe pré-timbrée
6. Au cours de l'année 2013, proposition d'une date de rendez-vous au CERTA pour la passation d'une évaluation audiolinguistique.

abbiamo bisogno della collaborazione e della disponibilità di persone di età superiore ai 50 anni che ricadano nelle seguenti casistiche:

1. Persone non affette da problemi di udito;
2. Persone affette da problemi di udito che non utilizzano protesi acustiche;
3. Persone affette da problemi di udito che utilizzano protesi acustiche.

La partecipazione a questa indagine consentirà di acquisire elementi essenziali per lo sviluppo dei sistemi tecnologici che potranno contribuire al conseguimento dei seguenti benefici per l'utenza di riferimento e la collettività in generale:

- Miglioramento della percezione di segnali di allarme durante la guida di un'automobile, quindi maggiore sicurezza per sia per gli occupanti il veicolo, sia per gli altri attori del traffico;
- Miglioramento della intelligibilità di messaggi informativi e segnali di allarme in spazi pubblici rumorosi (come aeroporti e stazioni ferroviarie) contribuendo a rendere gli stessi più accessibili e sicuri anche per persone con problemi di udito.

Per questo Le proponiamo di partecipare alla presente indagine, illustrata dall'ing. Michele Bellosguardo, Responsabile del Centro CERCAT, 0885/425370 responsabile della stessa e del consenso informato.

Prima però che Lei prenda la decisione di accettare o rifiutare di partecipare, La preghiamo di leggere con ulteriore attenzione queste pagine e di chiedere chiarimenti ed informazioni nel caso lo ritenesse opportuno.

2. Scopo della indagine

Questa indagine si propone come obiettivo di rilevare la percezione uditiva dei soggetti indicati al punto 1. in spazi chiusi ed aperti, nello specifico in stazioni ferroviarie, aeroporti e automobili. I dati rilevati attraverso la presente indagine saranno utilizzati con lo scopo di fornire elementi essenziali alla realizzazione delle altre attività previste dal progetto. In particolare, consentiranno di sviluppare sistemi tecnologici in grado di migliorare:

- l'intelligibilità del parlato attraverso l'uso di innovativi altoparlanti intelligenti da collocare negli spazi pubblici confinati come ad esempio stazioni ferroviarie ed in automobili;
- il riconoscimento automatico degli allarmi ed una loro efficace localizzazione attraverso la progettazione di specifici allarmi sonori.

L'introduzione di questi sistemi potrà migliorare la fiducia in sé stessi, la mobilità ed il senso di sicurezza delle persone affette da presbiacusia in particolare e, più in generale, il benessere sociale.

3. Procedure dello Studio

Nel caso Lei acconsentisse a partecipare a questa indagine, Le sarà chiesto di firmare questo **modulo di Consenso Informato**.

Il disegno sperimentale di questa indagine prevede la somministrazione di questionari ai quali Le sarà chiesto di rispondere. A distanza di tre settimane circa, sarà ricontattato dallo Sperimentatore per apportare eventuali modifiche e/o integrazioni alle risposte fornite,

sulla base dei dati che avrà rilevato nelle situazioni descritte nei questionari (all'interno di un'autovettura, di un aeroporto e di una stazione ferroviaria).

Le sarà chiesto, inoltre, di sottoporsi ai seguenti esami audiometrici:

a) esame audiometrico tonale che sarà effettuato a cura dell'audiologo di riferimento operante presso il Centro CERCAT;

b) esame audiometrico vocale che sarà effettuato presso il Centro CERCAT o presso lo studio medico privato dell'audiologo di riferimento.

Infine, sarà effettuata una sperimentazione sul campo (in stazioni ferroviarie e su automobili) dei dispositivi tecnologici che saranno sviluppati nell'ambito del progetto.

Se accetta di partecipare all'indagine dovrà rispondere alle domande poste dallo Sperimentatore e dare la Sua disponibilità ad essere ricontattato nelle tre settimane successive all'intervista per introdurre eventuali modifiche ed integrazioni alle risposte fornite. Dovrà, inoltre, sottoporsi agli esami audiometrici nonché partecipare alla sperimentazione sul campo di cui sopra.

La Sua partecipazione alla presente indagine non comporta da parte Sua alcuna spesa. I costi della indagine sono a carico dei partner di progetto.

4. Indagini cliniche/strumentali previste nel Protocollo di Studio

L'indagine potrebbe prevedere la ripetizione degli esami audiometrici di cui sopra o l'esecuzione di ulteriori esami audiometrici nell'arco dei tre anni di implementazione del progetto

5. La Sua adesione a questa indagine è completamente volontaria e Lei potrà ritirare il **Consenso** alla partecipazione in qualsiasi momento.

6. Ai sensi del Decreto Legge n. 196/03 (Art.7 e 13) relativo alla tutela delle persone per il trattamento dei dati personali, La informiamo che i Suoi dati personali verranno raccolti ed archiviati in modo adeguato e saranno utilizzati esclusivamente per scopi di ricerca scientifica.

Lei ha diritto, se lo vuole, di sapere quali informazioni saranno archiviate e in quale modo.

L'accesso a tali dati sarà consentito solo a personale autorizzato. I partner di progetto e le Agenzie responsabili del finanziamento del progetto potranno ispezionare l'archivio senza però poter risalire alla Sua personale identità.

Firmando il **modulo** di **Consenso informato** Lei autorizza l'accesso a tali dati, che potranno

essere utilizzati e accorpati a dati provenienti da altri Centri/Istituti. I risultati della indagine a cui Lei parteciperà potranno essere oggetto di pubblicazione, ma la Sua identità rimarrà segreta.

7. Se lo richiederà alla fine dell'indagine potranno esserLe comunicati i risultati dello studio in generale ed anche in particolare quelli specifici che La riguardano.

8. Per ulteriori informazioni durante lo Studio sarà a Sua disposizione il seguente personale Michele Bellosguardo, cell.393/9601483, e-mail: info@cercat.it

Alessandra Brescia, cell. 348/4060741, e-mail: escoop-italy@escoop.eu.

2. DICHIARAZIONE DI CONSENSO

Modulo per il Paziente

Questa Dichiarazione deve essere firmata e datata personalmente dal Paziente, a cui sono state lette e spiegate tutte le pagine qui allegate della Scheda Informativa.

Io sottoscritto.....(*nome e cognome per esteso del Paziente*), nato il / / dichiaro di avere ricevuto dall'ing. Michele Bellosguardo esaurienti spiegazioni in merito alla richiesta della Mia partecipazione all'indagine sopra descritta. Copia della presente scheda informativa mi è stata consegnata.

Dichiaro di aver potuto discutere tali spiegazioni, di aver potuto porre domande e di avere ricevuto risposte in merito soddisfacenti.

Dichiaro inoltre di aver avuto la possibilità di informarmi in merito ai particolari dell'indagine anche con altre persone di mia fiducia.

Accetto quindi liberamente di partecipare all'indagine, avendo perfettamente compreso tutte le informazioni sopra riportate.

Sono consapevole che la Mia partecipazione all'indagine sia volontaria e che ho la facoltà di ritirarmi in qualsiasi momento.

Sono stato **informato** del Mio diritto di avere libero accesso alla documentazione relativa all'indagine.

Sono inoltre consapevole che secondo il rispetto della normativa vigente i Miei dati personali saranno utilizzati esclusivamente per scopi di ricerca scientifica.

Data

Firma del Paziente

Data

Firma dello Sperimentatore.....

Annex III – Aphas+Glasgow V1 English Excel file

Annex IV a - Aphas V1 French PDF file

Annex IV b - Glasgow V1 French PDF file

Annex V – Aphas+Glasgow V1 Italian Excel file

Annex VI – Aphas+Glasgow V1 French results Excel file

Annex VII – Aphas+Glasgow V1 Italian results Excel file

Annex VIII a – Aphas V2 English PDF file

Annex VIII b – Aphas V2 French PDF file

Annex VIII c – Aphas V2 Italian PDF file

Annex IX – Aphas V2 French results Excel file

Annex X – Aphas V2 Italian results Excel file

**Annex XI – Ecological protocol for Interelligibility and localization test _
LinkLab PDF file**

Annex XII – Audiologic tests results Excel file