PhD in Bioengineering and Medical-Surgical Sciences

(Program UNITO-POLITO)

Research Title:

ECological protocols for inclusive Hearing Opportunities in LIFe Environments (ECHO in LIFE)

Short Title:

Ecological protocols for inclusive hearing

Funded by	Università degli Studi di Torino – Dipartimento di Eccellenza in "Scienze Chirurgiche"

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Context of the research activity	One of the main consequences of the evidence that population in western countries becomes older and older is the progressive increasing of pathologies, such as the hearing loss, that are directly linked to ageing. Nearly one third of people over 65 years of age are affected by disabling hearing loss. A main impact is on the individual's ability to communicate with others. This has effects on everyday life, causing feelings of loneliness and frustration. Unaddressed hearing loss poses an annual global cost of 750 billion dollars, including health sector costs (excluding the cost of hearing devices), costs of educational support, loss of productivity, and societal costs. People with hearing loss can take advantage from the use of hearing assistive devices, such as hearing aids, but the evidence is that 80% of adults who would benefit from them, do not use them, and from 4.7% to 24% of hearing impaired given a hearing device do not wear it, since they do not provide enough improvement and comfort. A reason for this is the low correspondence between the audiometric measures of the disability on which clinical audiology relies on so heavily and the self-assessment of the disadvantage.

	The main problems are the use of simplistic sound systems that cannot adequately represent the spatial complexity of real listening environments. With this premise, the research proposal ECHO in LIFE answers to the increasing need to have new diagnostic protocols to better assess hearing impairment and to optimize hearing aid fitting. Audiologists always face the critical phase to decide whether or not to recommend a hearing aid and, in the case of hearing aid prescription, they do not have tools and methods for a proper fitting on the different daily challenging listening conditions in the life environments (e.g. a noisy and reverberant office, day-care center, restaurant or public place). Through a multidisciplinary approach, the research aims to develop such protocols to be used in clinics for the vulnerable groups of hearing-impaired older adults, on the base of ecological audio-visual virtual scenes that reproduce their frequently attended environments (FAEs), derived from advanced multichannel audio in-field recordings and acoustical simulations. The diagnostic audiological protocols should include challenging auditory and visual scenes and supply results both in terms of speech intelligibility (SI) and listening effort (LE), thus accounting for the cognitive processes involved in listening. The gold standard test in traditional hearing evaluation is based on a pure-tone audiometry that allows degrees of hearing loss (HL) from “normal” to “profound” to be determined. The audiologists also assess SI, i.e. the rating of the proportion of speech that is understood, with standardized tests that are generally presented in quiet or with stationary noise, and in anechoic condition. The drawback of these traditional tests is that they fail to determine the degree of HL disability in the patient’s life, since they do not reproduce the auditory scenarios encountered in daily activities. Therefore, recent research has started focusing on the implementation of SI tests that provide valid measures under more ecological auditory scenes in FAEs, with different auditory stimulus conditions, addressing different types of complex listening environments [1]. In particular, a huge research project has been recently funded for assessing real-life impact of hearing disorders and devices [2], but no general conclusions have been settled yet. As background of the research group, a multilingual matrix sentence test has been recently validated by UNITO and POLITO for the Italian language [3]. The test allows for accurate SI results comparable in 14 mother tongues [4]. This has been done in collaboration with the Cluster of Excellence “Hearing4all” of Oldenburg (DE), that is one of the leading research networks among the international institutions in the fields of audiology and hearing research. Research will greatly benefit from the collaboration with researchers from this Institution.

Objectives	The research activity aims to develop ecological protocols (EPs) that more accurately represent real-world listening situations, which describe hearing-impaired listeners (HI) ability to engage real-life. New measures will be collected through these protocols to help audiologists doing hearing aiding (HA) prescription and fitting, and patients to be aware about their ability to listen in everyday conditions with and without acoustic devices. The EPs should: ○ comprise a number of complex virtual auditory environments frequently attended by older adults (OAs) aged more than 65 years; ○ include SI and LE tests, thus accounting for both hearing and cognitive processes; ○ be personalized according to the patient's age, needs and FAEs; ○ include the most challenging listening conditions in FAEs in terms of type of noise, target voice and noise positions, and room acoustics (reverberation and first reflections); ○ allow investigating the benefits of optimal acoustics in FAEs for hearing aided; ○ allow a better HA fitting in FAEs with the patient involvement, thus increasing the patient's satisfaction. Ecological auditory and visual scenes should be selected accordingly to the FAEs for OAs and should be as minimum a day-care center activity room, a restaurant/cafeteria, a home environment, a street environment, and a train station. The sources of data for the scene implementation could be: 1) multichannel audio and 360° video field recordings inside FAEs (real audio recording with the em32 Eigenmike® microphone array and video recording carried out with a 360° panoramic videocamera); 2) simulation of FAEs with Odeon® room acoustics simulation program (real video and simulated audio); 3) scenarios simulated with TASCAR which is a highly flexible scene-creator targeted to audiological applications (simulated video and audio). In order to produce realistic and ecological representations of the FAEs in the laboratory, a highly innovative audio-visual test bench has to be developed. The apparatus should consist of a silent virtual room, that is the Audio Space Lab of the Politecnico di Torino, equipped with a High Order Ambisonic (HOA) sound reproduction system paired with a 360° synchronized video projection. The audio-visual reproduction system should be driven by a server application, which also govern the whole test procedure including the collection of testers' responses. A smartphone or a tablet can be used to run the test application, which is connected as client to the server. The test material for SI mainly consists of matrixed-type tests available in the Italian language. Besides SI, also metrics

	informative on the construct of LE has to be collected with the same apparatus. In particular the response time could be taken as a behavioral index. In order to be able to tune the hearing aids according to the patient's needs, the "Master Hearing Aid" (MHA) of the University of Oldenburg has to be used with the advanced audiological tests (AAT) based on auditory and visual ecological scenarios. The aim is to obtain the best setting with MHA and AAT, so that the patient could be prosthesized in accordance with personalized clinical indications. [1] HAPPAA Project, https://uol.de/en/sfb-1330-hearing-acoustics [2] https://www.nal.gov.au/project/assessing-real-life-impact-of-hearing-disorders-and-devices/ [3] Puglisi GE, Warzybok A, Hochmuth S, Visentin C, Astolfi A, Prodi N, Kollmeier B. An Italian matrix sentence test for the evaluation of speech intelligibility in noise, Int J Audiol, 2015; 54(2):44-50. [4] Kollmeier B, Warzybok A, Hochmuth S, Zokoll MA, Uslar V, Brand T, Wagener KC. The multilingual matrix test: Principles, applications, and comparison across languages: A review. Int J Audiol, 2015; 54(2): 3-16.

Skills and competencies for the development of the activity	Some of the following skills and competencies are expected: ○ Background in applied acoustics (fundamentals, measurement and simulation procedures for architectural acoustics); ○ Knowledge of audio-visual software; ○ Knowledge of computer aided design software; ○ Knowledge of programming languages as C / C ++, JavaScript, HTML, Python.