Novel 3D games for people with and without hearing loss

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***Abstract*— Over 90 million people in Europe currently suffer with hearing loss and with an aging community this is expected to rise significantly. Digital Hearing Aids (HAs) offer real opportunities to enhance hearing capability in different acoustic contexts, however understanding functionalities and calibration can seem overly complex. The 3D Tune-In project has developed a 3D toolkit including a sound spatialisation algorithm and hearing/hearing loss simulators as the basis of five novel digital games addressing challenges of hearing loss and hearing education for children and older adults. Early evaluations have demonstrated the opportunities for hearing impaired groups, as well as the digital games community.**

Keywords—3D games, 3D sound, participatory design, formative evaluation, hearing aids, hearing loss

I. INTRODUCTION

Since the introduction and commercialisation of the first digital hearing aids (HAs), there have been huge advancements with regards to functionalities and calibration options provided [1]. However, many useful features are under-used or not exploited to their full potential, in part due to inefficient or lack of training on their use. Over 90 million people in Europe currently suffer from hearing loss, and this is expected to increase due to an aging population, therefore it is timely to consider novel approaches to support people in the understanding of hearing loss and in the calibration and use of HAs in different contexts.

II. THE 3D TUNE-IN PROJECT

The 3D Tune-In (3DTI) project is a three-year European funded project introducing novel approaches to using 3D sound, visualisation and gamification techniques to address challenges of hearing loss in different target groups from children and older users with and without HAs. The main outcomes include (i) technology transfer between traditional SME game developers and broader research and industrial communities in 3D sound and virtual reality (VR); (ii) 3DTI Toolkit for development of further HA-related technologies; (iii) 3D game applications (apps); and; (iv) guidelines on the effectiveness of 3D and digital games on hearing loss and HA technologies.

III. 3D TUNE-IN (3DTI) TOOLKIT

The 3DTI Toolkit provides the digital apps with the sound spatialisation algorithms and hearing/hearing loss simulators to be included in their apps. It includes the following functionalities [2][3]:

- 3D audio engine for (binaural) rendering comprising a novel Head-Related Transfer Function (HRTF)-based binaural audio algorithm, with HRTF selection, adaptation and individualisation functionalities and an Ambisonic-based binaural reverberator.
- Hearing loss simulator comprising frequency filters (eg. parametric and graphic equalisers), dynamic range compressor/expander, non-linear distortion and degradation of the temporal and spatial resolution.
- HA simulator comprising functions such as selective amplification, directional processing, dynamic range compression/expansion and non-linear distortion.
- Full integration with VR and gaming development environments (eg. Unity) and with currently available video and haptic rendering engines.

The 3DTI Toolkit is expected to be released with a non-commercial open-source license via the project website (http://3d-tune-in.eu) by May 2018. Five digital apps are being developed which address different target groups and challenges related to hearing loss and hearing education. These are described as follows.

A. *Musiclarity*

"Musiclarity" developed by Reactify, UK, is a web app which aims to improve HA users' experience of listening to music. A database of music tracks can be tuned and adjusted (at an individual instrument level) to enhance the sound and make it more pleasing. The lyrics of the track and visual representations of instruments can be displayed. These settings can then be applied to other tracks to optimise the sound quality, as well as shared with an Audiologist to improve calibration of hearing aid settings.

B. *Play& Tune*

"Play&Tune" developed by Vianet, Italy, is an Android-based app designed with older HA users to support their

understanding of basic parameters that influences quality of sound. The app consists of a series of hearing related tasks such as locating a mosquito in a room or identifying what someone has said in a loud restaurant. These enable HA users to begin to understand how making changes to their HA can improve their day-to-day communications in different contexts. This can be shared with Audiologists to help define sounds and words which the user may find challenging and therefore can assist in the better calibration of a person's HA.

C. Dartanan

"Dartanan" developed by XTeam, Italy, is a traditional platform game in the style of Nintendo's Super Mario and consists of a main game with levels that can be played by any child, and a series of mini-games designed specifically for children with HAs. The main game has a boy or girl character who jumps over platforms, fights with enemies, avoid traps, and collects coins following a quest to retrieve a stolen flower. The mini games are also in levels of increasing sound complexity. For example, there is a "whack-a-mole" style game where players identify where an enemy is coming from by the direction of the sound. The levels become more varied by changing background noises. In this way, the child would be able to learn how to adjust features of their HA to complete certain tasks, and the able to discuss any issues with their Audiologist.

D. Darius Adventure

"Darius Adventure" developed by Nerlaska, Spain, is a PC-based game which aims to educate people without hearing impairments about the challenges of hearing loss, raising awareness and empathy for people who experience difficulties. In this adventure game, players take on the character Darius who is an angel with hearing loss who needs to return to heaven. He can only get to heaven by collecting wings as a prize for completing tasks, yet he cannot complete the tasks without hearing other characters. He must keep his HA battery topped up, and learn behaviours that will facilitate his hearing, such as speaking face-to-face with characters.

E. AudGam Pro

"AudGam PRO" developed by XTEAM and GN Hearing, Italy, will enable the Audiologists of GN Hearing to demonstrate specific functionalities of their digital HAs with older users. Through a series of simulated realistic virtual environments, reproduced through a large screen and an 8-channel 3D loudspeaker, users are able to perform hearing related tasks in different contexts (e.g. house, office, restaurant, noisy street) to see how their HA could perform outside of the confines of the clinic. A variety of audiometric tests can be carried out while the user is engaged with the environments to explore different HA functions and optimize sound quality.

IV. Formative Design and Evaluation of 3DTI Apps

A participatory design approach has been applied in the development of the apps, involving iterative design and evaluation cycles with relevant stakeholders within the consortium across Europe (UK, Italy, Spain); from small-to-medium enterprises (SME) in traditional leisure games; academic institutions; a large HA manufacturer; and hearing associations. We have so far completed two cycles of design, development and evaluation [4]. Evaluations have considered feedback on the following aspects of the apps: **audiological elements**, focusing on whether the hearing challenges are appropriate; **game play**, e.g., the challenges users encounter to score points, the game's storyline and characters; **game mechanics**, e.g. the procedures and rules of each game (goals, player actions, levels, rewards, etc.); **game usability**, focusing on the interfaces/elements required to interact with the game; and **accessibility**, considering the suitability of the design for older adults and those with hearing loss. The findings highlighted that although the games and apps were fun to play, the audiological and game play aspects needed some fine tuning.

V. Conclusions

One of the main outcomes of the project was to provide technology transfer between traditional SME game developers and the broader 3D scientific, and hearing impairment communities, in order to address the challenges of hearing loss and hearing education. Through a participatory approach involving relevant stakeholders, including younger and older HA users, as well as Audiologists and the technology development team, we have developed five novel approaches to support the understanding and calibration of HAs in different contexts. These apps are currently being refined through iterative cycles, with the final versions of the apps expected to be released in early 2018.

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