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8. Design and Prototyping for Disability. E2E (EAR-TO-EYE) Case Study

by Alice Forestan, Camilla Antea Erba, Denny Roncolato, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the methodology applied for the development of "E2E (Ear-to-eye)", a lighting assistive open-source product for deaf people. The project was developed during the "Intelligent Products" Design Studio, of the Product Design Master Course at the Iuav University of Venice (Romero, Ferrari and Toso, 2018).

The hypoacusis is a disease caused by damages in the internal ear that reduces the hearing ability. The hearing aid and the cochlear implant are the main solutions to the hypoacusis (Nidcd, 2019), although they are removed or switched off in some specific situations which take place at home (such as studying, sleeping and relaxing) causing an uncomfortable feeling of total isolation.

After a desk research, we interviewed four deaf people and we identify as critical three situations that take place at home when the hearing aid is removed:

- someone rings the bell at the front door;
- the alarm clock sounds in the morning;
- someone from a different room is calling.

The purpose of the project is to involve the deaf person into events happening in the domestic environment when she/he might not wear the hearing aid in order to reduce the sense of uncertainty and isolation. To address this issue, we have designed E2E, a system of two or more devices positioned in different rooms and connected each other through radio frequencies. The devices are provided with three different LED lights: two of them activate when the microphone recognizes the sound of a bell/alarm and the acoustic signal is converted into a light feedback; the third one is used to communicate with a person in a different room. The interaction takes place through two different buttons, one to send a call signal and the other one to send an answering signal.

Keywords: *Design Open Source, User Centered Design, Learning Experience, Hypoacusis, Visual Feedback.*

8.1 Introduction

Hypoacusis is a disease that involves the reduction of hearing capacity due to damaged parts of the ear designated to the mechanical transmission of sound waves or the degeneration of one or more components related to the inner ear. Different typologies of damages may cause a wide range of shades in hearing loss (Mayoclinic, 2018) and they are named according to the levels (mild, medium, severe hearing loss).

People suffering from hearing loss have often difficulties to communicate: they tend to exclude themselves from social relationships and to group together with only deaf people. In addiction, they are not easily recognisable as deaf: in most cases they tend to hide their discomfort and underestimate their hearing loss, developing psychological-behavioral problems and social isolation. Because of the number of cases and degrees of hearing loss, we decided to focus the project on users suffering from medium-deep hearing loss who share the same daily use of the hearing aid, the most well-known and efficient assistive technology in the deafness sector (Apparecchi acustici Pontoni, 2019).

8.2 Methodology

The desk research has been indicative in the preliminary phase of the project because it has allowed to learn the state of the art of general assistive technologies and specific treatments addressing the hearing loss. The focus was on the following aspects: levels of hearing loss, existing hearing aids and other devices (Nidcd, 2018), ISL (Italian Sign Language, 2018), deaf social community (Affrontiamo la sordità, 2019) and forum (I sordi forum, 2019), associations and institutions.

The whole team did several interviews with experts (two graduates in hearing aid techniques from Padua) and deaf users: Luigi and Lucia, partners and parents; Michela, languages student; Ilaria, psychologist and Davide, Iuav master student.

These interviews took place at Iuav University and in different locations between Venice and Padua. All the interviews were organized to be a sort of informal conversation between the team and the interviewed, in order to make them feel comfortable in talking about themselves and what deafness represents for them: social relationships, daily life problems and critical aspects of hearing aids. After a general conversation with the interviewed about the disease, the team asked him/her some specific questions to deepen the knowle-

dge of deafness (symptoms, personal and shared experience). In this way, by analyzing and comparing the results of the interviews, the team was facilitated in recognizing possible situations and common patterns related to the daily experience of people wearing a hearing aid.

Finally the team was able to identify a final user, which ideally sums up the main characteristics and issues identified during the interviews and the desk research: people with a medium-to-deep hearing loss who wears the hearing aid every day. In addiction, through a daily timeline analysis, the team defined some specific conditions which need to be improved, specifically related to the user who is at home and does not wear the hearing aid.

In fact there may be various situations in which the user may remove the device. The deaf person who is not wearing the hearing aid, live in a condition of deep isolation where he/she is not aware of what is happening around because he/she can not receive and process any sound information (Cappanera, 2012). The team identified the main reasons why the hearing aid is not worn: voluntary (fatigue, desire for isolation and/or concentration); induced (sleeping, places with high levels of humidity such as the bathroom and the gym); obliged (technical maintenance, cleaning of the device). Most of these situations usually occur when the user is located in a domestic environment and we analyze three of them: the morning alarm rings; a person rings the doorbell; a person wants to communicate with the user from another room in the house.

For the alarm function only one device is needed in the bedroom, located near the alarm clock on the bedside table or hung on the wall. The device does not replace the alarm clock but recognizes its sound and transforms it into a luminous feedback. One of the three lights is adjustable and can be directed towards the user's face so that the bright flashes wake him up.

For the doorbell function more than one device is needed. One of them must be located near the doorbell speaker and the others are positioned in the remaining rooms. Also in this case, the device does not replace the doorbell but it generates a luminous feedback. When someone rings the bell at the front door the specific colored light, associated to this function, turns on all the devices.

The third and last function allows family members to call the deaf user attentions when they are out of his field of view. Every room of the house can be associated with a different colored light, for instance red for the kitchen and blue for the bedroom: by pressing the call button on the kitchen's device, all the other devices will light up red, in the same way by pressing the answer button in the bedroom's device, all the other devices will light up blue. It is possible,

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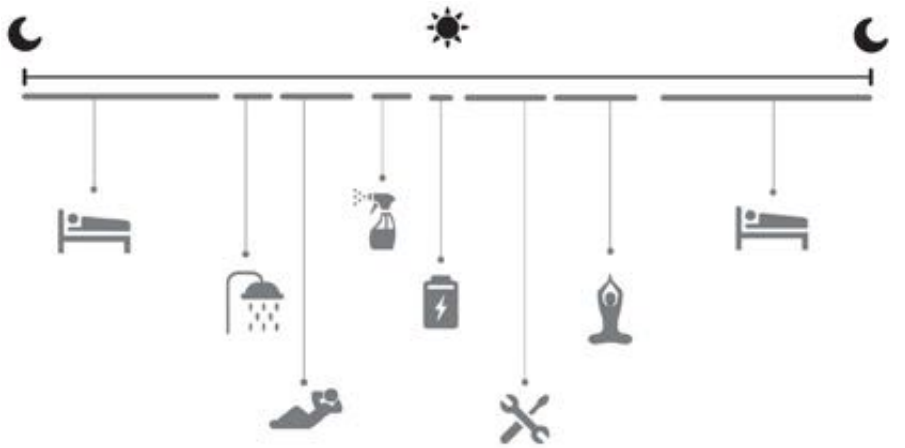

Fig. 8.1 - Journal timeline: specific situations when user doesn't wear hearing aids

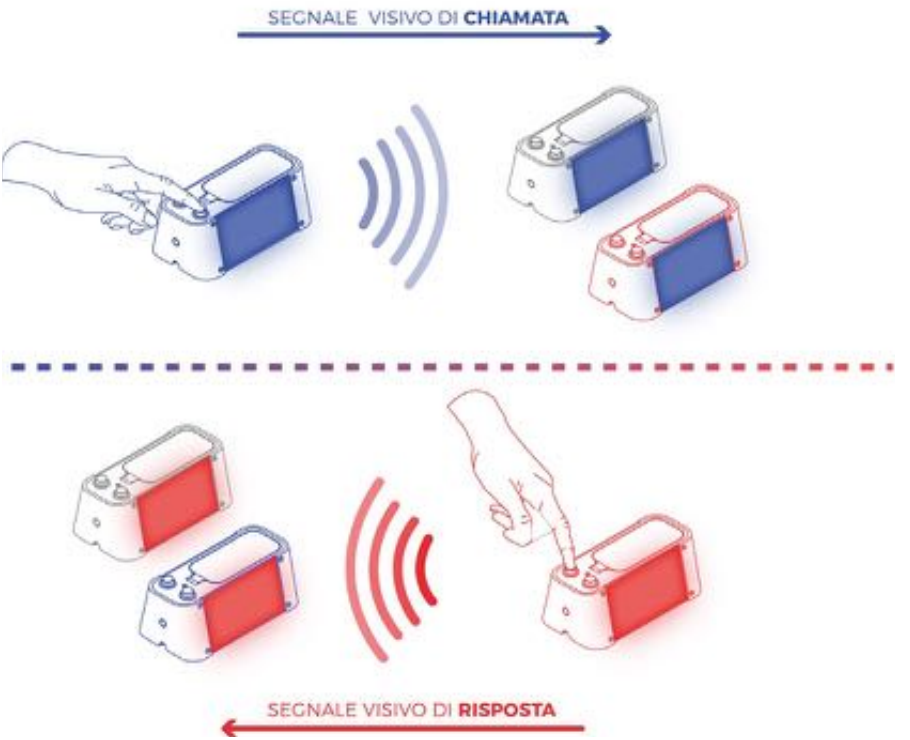

Fig. 8.2 - Colored light feedback scheme of interaction (third function)

through the answer button, to send and receive a luminous feedback that communicates the call reception.

The project development consisted in the elaboration of the feedbacks elaborated from the device (respectively the sound of the bell and alarm, and the pressure on the button) which is given back to the user as visual stimuli. In addiction the team worked on the definition of formal and functional details, such as materials, electronics components, dimensions, position, testing the prototype functionality and usability.

8.3 Results

E2E (Ear-to-Eye) consists in a open-source product that can be reproduced autonomously by the user and allows the deaf user to get feedback from the domestic environment when, for various reasons, the hearing aid is not worn or is switched off.

The project focuses on communication and interaction based on light signals in order to decrease the feeling of isolation and to facilitate social dynamics in the domestic environment. The user can have one or more connected devices that communicate each other through radiofrequency between the various rooms of the house. The devices must be positioned in a visible area of each room and through visual stimuli, the user is warned of three situations:

- the alarm clock sounds in the morning;
- someone rings the bell at the front door;
- someone from a different room is calling.

Prototype. E2E is a lighting device which can be hanged on the wall or placed on a horizontal surface. It consists of two lateral diffused lights and one central orientable light. There are two different buttons, one for the call function

Fig. 8.3 - Assembling the case components (work in progress)

Fig. 8.4 - Testing electronics and prototype functionality (work in progress)

and the other one for the answer function. The external shell has two small holes,one for the microphone and the other one for the antenna.

Downloadable and editable stickers can be used to identified the different devices and functions. Whatsmore the Leds' colour can be easily modified from the Arduino programming code. Electric components have been controlled using an Arduino Uno programmed shield and connections have been made using common instruments and material easily available on the market.

The main internal components are:

- arduino;
- electronic;
- power button;
- RF module (receiver and transmitter);
- monochrome alarm LED;
- monochrome doorbell LED;
- RGB LED for call function.

The optimization of the 3D model has concerned the following points: degree of inclination of the geometries; complete absence of printing supports (all components can be printed without waste material); minimization of thicknesses and juxtaposition tolerances.

Shared material/Instructions. An arduino code has been written to set radio frequencies communication and coloured LED emissions. E2E shell has been 3D printed because it is the best choice for a DIY open-source production. 3D files (stl and iges) and electric diagrams are available for download and can be freely modified. All the produced materials (video, photos, coding informations, various files) will be available for free in the Posta open-source platform.

8.4 Conclusion

E2E is designed for a wide range of users: from those suffering from mild to deep hearing loss. The reference context is the domestic environment but the product is designed to be modified and customized for public or work spaces thanks to the shared materials (Arduino code and 3D file).

During the design process, the team recognized some critical aspects which could be improved: the Radio Frequency module, characterized by a low receptivity, can be replaced with a wifi connection module that allows both a greater range of the signal and IOT implementations; on the microphone it is possible to set a single threshold that does not allow the device to detect sounds with different amplitudes so a voice recognition module would be a bet-

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ter alternative to create a personal library of sounds. These two aspects could improve the performance and expand the adaptability of the product.

Fig. 8.5 - Opened and oriented central light

Fig. 8.6 - Communication between devices

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E2E is a product designed by Alice Forestan, Camilla Antea Erba, Denny Roncolato, Juan Teruel Tera and Sebastiano Cicero, product design students at the first and second year of the Master at Iuav University.

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