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DISSEMINATING HUMAN ECHOLOCATION THROUGH PUBLIC ART

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Projeto de Mestrado em Arte e Design para o Espaço Público
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Abstract and Key-words

The master project, *Disseminating Human Echolocation through Public Art*, researches the phenomenon of echolocation through public art. Echolocation is the ability of evaluating an object's position by the reflection of a self-emitted sound. The most well-known mammals that master this skill are bats, dolphins, whales, and shrews. Humans also have this skill, but it is mainly asleep. Human echolocation can be a great improvement for blind people's mobility, empowering them on their independency and perceptions. Yet human echolocation is still not generally understood as one of the main blind mobility training worldwide and for so little has been developed. The purpose of this research is to contribute to the development of human echolocation ability through the experience of public art. The project consists in the temporary placement of three portable devices that encourage echolocation in public space, a work that I have named as *Itinerant spherical, flat and concave surfaces* (2021). The project targets sighted people but also hopes to reach blind individuals in the long term. In order to achieve this goal, concepts of performativity, conceptual art, and public art are being interwind with concepts of science and user experience design. So far, I realised that very act of studying echolocation in public is in itself a way of disseminating the ability among the various people I came across and that the resulting artefacts of the research have a hybrid status, i.e., they are simultaneously art objects and researching tools representing different stages of this interdisciplinary artistic experience.

Key words: Human Echolocation, Public Art, Blind, Design Thinking, User Experience Design

Resumo e Palavras-chave

Este mestrado *Disseminating Human Echolocation through Public Art* pesquisa o fenômeno da ecolocalização através da arte pública. Ecolocalização é a capacidade de avaliar a posição de um objeto através da reflexão de um som auto-emitido. Os mamíferos mais conhecidos que dominam essa habilidade são morcegos, golfinhos, baleias e musaranhos. Os humanos também têm essa habilidade, porém ela se apresenta adormecida. A ecolocalização humana pode ser uma grande melhoria para a mobilidade de pessoas cegas, capacitando-as em sua independência e percepções. No entanto, a ecolocalização humana ainda não é entendida como um dos principais treinamentos de mobilidade para cegos ao redor do mundo e por este motivo, ainda muito pouco foi desenvolvido. O objetivo desta pesquisa é contribuir para o desenvolvimento da capacidade de ecolocalização humana por meio da experiência da arte pública. O projeto consiste na colocação temporária de três dispositivos portáteis que estimulam a ecolocalização no espaço público, obra de arte que denominei *Itinerant spherical, flat and concave surfaces* (2021). O projeto visa pessoas com visão, mas também espera alcançar pessoas cegas a longo prazo. Para atingir esse objetivo, os conceitos de performaitvidade, arte conceitual e arte pública estão se entrelaçando com conceitos de ciência e design de experiência do utilizador. Até agora, percebi que o próprio ato de estudar a ecolocalização humana em público é em si uma forma de disseminar a habilidade entre as várias pessoas que encontrei e que os artefatos resultantes da pesquisa têm um status híbrido, ou seja, são simultaneamente objetos de arte e ferramentas de pesquisa que representam as diferentes fases desta experiência artística interdisciplinar.

Palavras-chave: Ecolocalização humana, Arte Pública, Invisuais, Design Thinking, Design de Experiência do Utilizador.

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Introduction

The master project, *Disseminating Human Echolocation through Public Art*, researches the phenomenon of echolocation considering public art as tool. Echolocation is the ability of evaluating an object's position by the reflection it produces of a self-emitted sound. The most well-known animals, that have mastered this ability are bats, dolphins, whales, shrews, and some birds. These animals are mammals on their majority and some of them are birds. Yet what all of them have in common is the necessity of seeing without the eyes, of having to trust not solely on the light. This can happen by living in environments where vision is not favored, like dark caves, deep sea and murky waters. Other situations that can favor the development of echolocation is nocturne behavior. By observing this skill in a variety of species it is possible to assume that it's not so uncommon in the nature. In fact, humans can as well echolocate. As the species described previously, some blind people have developed the same strategy to overcome the lack of vision, the echolocation.

Human echolocators developed a system very similar to bats and dolphins. They emit repetitive tongue clicks and read the echoes produced by this sound in the environment. By doing that, echolocators create sound images from static obstacles and moving objects, literally seeing by sound. Tongue clicks and sound emissions are not the only way humans can echolocate, some of them developed this skill by tapping their white cane (blind people walking sticks) on the floor or even by clapping their hands. Interestingly, the development of human echolocation occurs in different people, without any connections between them, as an independent phenomenon. The blind that developed human echolocation achieved unimaginable mobility standards. E.g. making trails between mountains without the aid of any sighted people or riding bicycle through obstacles. Inevitably, this empowering ability for the blind, caught the attention of scientists, becoming the focus of some research. Some of these studies proven that the skill is not that extraordinary, every human being can learn it. However, even with all its potential, human echolocation isn't being taught on blind training facilities as the average way for training the mobility of the blind. Some training places exist in some countries but just a few.

Considering all human echolocation possible benefits to blind individuals life experience, why is it not more disseminated and being taught everywhere? It's believed, as said by the human echolocation researcher and specialist Dr. Lore Thaler from the Durham University, that perhaps the ability is not so well spread, simply because it is completely unknown by the society's majority. A supposition that was proven to be true along my studies, as most people that I came across during this research, were hearing about the human echolocation for the first time.

This master research is an attempt to create a certain awareness to this situation and to contribute to the dissemination of human echolocation to blind and non-blind individuals. Although, I initiated this research with the aim to collaborate specifically with the blind. the challenges that I faced to work with blind people prevent me from achieving this goal. There are innumerous social and cultural barriers between blind individuals and the rest of the population that demand time and dedication to reverse. This initial aim was also aggravated by the spread of Covid-19 virus, identified in Wuhan, China, in December 2019, which lead to the massive worldwide lockdown during 2020 and early 2021. I still wish to collaborate with blind individuals, this aspect did not change, however it became a longer-term objective.

My research was adjusted to this new situation, to include the non-blind individuals, in the awareness of human echolocation. To achieve this, I developed the public art project, *Itinerant spherical, flat and concave surfaces* (2021) for triggering some collective consciousness of human echolocation in public space. I describe this project as an artwork and an artefact simultaneously due to its hybrid nature of working at the same time as an object in the context of public art and as a researching tool made for investigating effective ways of inducting human echolocation perceptions in human subjects. I first tested my idea in the city of Funchal, Portugal, during the pandemic months of March and April 2021. The public art project, *Itinerant spherical, flat and concave surfaces* (2021) consist in the temporary placement, in public space, of three different objects-surfaces — a concave, a spherical and a flat —3d printed on light grey biodegradable plastic (PLC). The three devices are lifted at customizable heights by three stainless steel tripods. These objects are accompanied by a sign, produced in the same material, explaining briefly what human echolocation is and how to start practicing it. The sign is written in Braille and in embossed Roman alphabet. It also has an embossed iconography to support the information.

Besides developing a professional career as a User Experience Designer, I have been working also as a visual artist with specific interests in the experience of art in the public space and its political consequences. With this research I aim to help fill the gap on the awareness of the benefits of human echolocation through public art. The research questions ahead guided my study pinpoint, what I wanted to find out and provided me clear focus:

- How does a public art device for temporary placement in public space may generate curiosity about human echolocation?
- How should aiding devices for human echolocation training be?
- How an echolocation experience in public influences its participants perception of minorities social life?

I believe that designing an experience that brings visibility to a phenomenon such as human echolocation might contribute to amplify the confidence of individuals of certain minorities in public space and bring more awareness to the diversity of the many individuals that integrate society and its specific life circumstances. Testing this possibility is one of the main objectives of this master research. The second one is to help spread human echolocation ability through temporary placement of an artwork/artefact in different urban settings.

Conceptual Framework

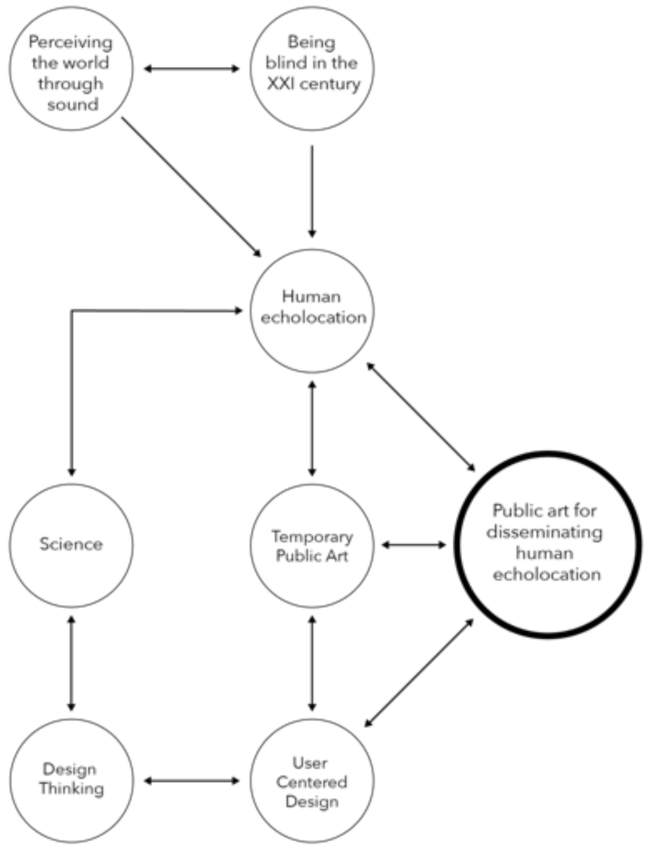

Figure 1: Conceptual framework.

The conceptual framework was structured and restructured along the research with the main objective of testing and developing ways for disseminating human echolocation in the public space. For doing so, I used the subjects "Human echolocation", "Temporary public art" and "User centered design" to sustain the main objective "Public art for disseminating human echolocation" and make it a reality. This tree mains pillars are sustained by their side, by other subjects. "Being blind in the XXI century" and "Perceiving the world through the sound" are connected to each other and sustaining the subject "Human echolocation". The "Science" subject is sustaining the subject "Human echolocation" as well and the subject "Design Thinking". "Design thinking" is sustaining by "User centered design".

Methodology

For addressing this complex challenge, various approaches are possible. Due to my background as an artist and user experience designer, the fields of art and design were interwind to tailor a possible solution to the area. *Disseminating human echolocation through public art* is a project about how to use the public space to strategically trigger human echolocation perception in public. As this field of study is still being explored by scientists, psychologists, blind individuals and other enthusiasts of the topic I have tried to engage my intuition and informal knowledge on the subject with a more objective and user centered approach. This is how I came to develop the concept of the artwork and the ergonomics of the artefact.

The method I applied in the knowledge building could be described as an iterative approach to problem solving. I initiated my experiments by creating suppositions based in previously generated data, I then tested my suppositions and used the test results to make new decisions and build new suppositions to be tested. This continuous cycle endured until I considered that a minimum valuable product was visualized. I have described and documented this process to be repeated by other researchers. In other words, I have tried to come closer to a research methodology that resembles to a “scientific approach” to problem solving. An approach that I consider may bring several positive aspects by generating decisions based in testing results.

In addition to this approach I also integrated a methodology for designing products based in data — a design thinking method that consists of an iterative process based in the user needs (User Centered Design — UCD). In this approach the user is central for the designer researcher. When working with digital products, this kind of designer has expertise in human computer interaction (HCI) and is commonly identified as User Experience Designer (UX Designer) or just, product designer. Usually, testing results generate new design decisions and new prototypes that bring new features to the product, in a continuously way. Therefore, a product after being implemented, keeps being tested and modified — a Minimum Valuable Product (MVP) is enough to make a product come to life, but not to keep it living. It must be improved. This also explains why from time-to-time famous applications like *Instagram*, *YouTube* and *Facebook* are renewing their interactions with users by coming up with new features. It is an endless developing process. This methodology became a powerful tool for designing better products and presently is the standard for developing complex software. In the development of this master research, I have applied aspects of this methodology, as you can see in chapter 2.

Along with my studies in MADEP - UP, during 2018, I attended a post-graduation in Human Computer Interaction (HCI), also in the University of Porto, where I deep in the study of human echolocation and designed digital and physical devices for the blind to train this skill. During this stage of the project, I could confirm the suppositions of the expert in the field Dr. Lore Thaler, that one of the motives for the human echolocation non-disclosure is because people are unaware of its existence. E.g. a sighted person would never encourage human echolocation training for a blind relative because of the lack of knowledge about the existence of such ability and its empowerment possibility to the blind. This also reinforced the change of one of the goals of my research: to disseminate the ability not only among the blind but as well among the sighted.

To frame the artwork/artefact I produced, I structured this document in two chapters. In the first chapter, *Perceiving the world through sound: human echolocation and some of it constrains*, I include information that contextualizes the problem that is being addressed. Human echolocation has an extraordinary mobility empowerment capacity for the blind, yet it is still unknown and consequently very modestly encouraged by blind training facilities or blind people families. This contextualization is made through an exploratory discussion about non-visual perceptions of the world and integrates some notes about being blind in the XXIst century.

In the second chapter, *Public Art as a Strategy for Human Echolocation Dissemination,* I contextualize my strategies for investigating the spreading of human echolocation through public art in four subsections**: a)** Public art as temporary art; **b)** Research for triggering human echolocation perceptions; **c)** Description of the *Itinerant spherical, flat and concave surfaces* (2021) working process and its enactment in the city of Funchal, Portugal; and **d)** Description of permanent public art projects for disseminating human echolocation that I have been developing.

In subsection a) I briefly reflect about three temporary public art projects with context-specific political relevance. The projects are *Following Piece*, 1969, by Vito Acconci; *Alien Staff,* 1993, by Krzysztof Wodiczko; and *The Green Line*, 2004, by

Francis Alÿs. These three projects were meaningful references while developing this research.

In subsection b), I explain the design-scientific approach that I implement to stabilize human echolocation experiences in public space. Considering that objects for triggering human echolocation still haven't a standardized ergonomics, I had to perform several research attempts to find out how such devices could be physically shaped.

In subsection c), I detail the working process and outcomes of the temporary public art *Itinerant concave, spherical and flat surfaces* (2021).

In subsection d), I detail permanent public art projects for disseminating human echolocation that were as well outcomes of the master research. One was submitted to an open call and the other is still being prototyped.

This document ends with conclusion notes that reflects on the research process, the outcomes of the work conducted and possible futures for this research.

1. Perceiving the world through sound: human echolocation and some of it constrains

The master project, *Disseminating Human Echolocation through Public Art*, researches the phenomenon of echolocation through public art. Echolocation is the ability of evaluating an object's position by the reflection of a self-emitted sound. This chapter contextualises the wicked problem (Horst Rittel and Melvin Webber, 1973) that is the focus of this research. Echolocation is a human ability that can improve immensely the life of a blind person, yet teaching this ability is still not integrated in the training of unsighted people. A wicked problem is a problem that does not have a straightforward solution or not even a final solution due to the complexity of the variables influencing it. Problems like climate change, poverty, health, education policy and geopolitical issues are examples of wicked problems. They do not have a final answer, like a math equation or even a precise right or wrong result, but depend on choices, decisions, and consequences. With that stated, this master research is not aiming to give a final solution to this subject but to develop a positive outcome into the direction of disseminating human echolocation as a more standardized possibility for training blind humans.

My next step is to elaborate on aspects of human sensation and perception. As echolocation is an auditory ability that in some situations can substitute vision, I believe it is relevant to bring some context to the way our senses work, emphasising specially our potential to listen. I will than, summarize a few aspects of the contemporary life of unsighted people, with worldwide data and historical examples of blind people that were able to excel in western society. In addition, I will finalize this chapter with some reflections on the scientific research regarding human echolocation and its current *status quo.*

1.1 How the human senses perceive the world: some aspects about sensation and perception

In order to receive information from the environment we are equipped with sense organs. Each sense organ is part of a sensory system which receives sensory inputs and transmits sensory information to the brain. Sensation is the process by which we receive information from the environment. This information is what we call stimulus, in other words a detectable input from the environment. For example, one is sensitive to light through vision. Visible light is part of the electromagnetic spectrum that has properties such as intensity (experienced as brightness), wavelength (experience as hue), complexity (experiences as saturation). One is also sensitive to a limited range of sound frequencies, another stimulus, and its properties such as intensity (loudness), frequency (pitch) and wave form (timbre). As described in the introduction paragraph, I will continue to use these two senses as examples for framing some aspects of the processes of sensation and perception because this research is mainly focused in the role of the experience of these two sensory modalities.

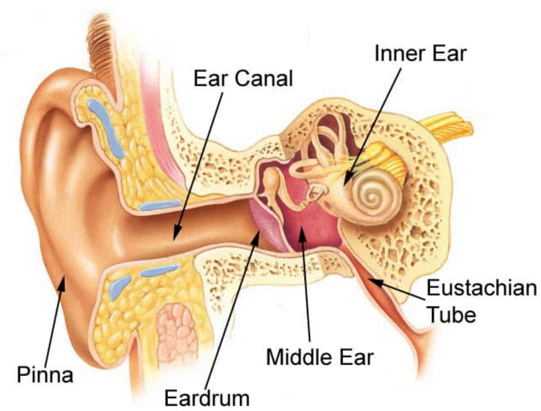

Figure 2: Inner ear scheme.

In accordance to Yi-Fu Tuan in his book *Space And Place: The Perspective of* Experience (1977), humans perceive the world through the organoleptic properties of sight, hearing, smell, taste and touch. However, this notion of the five senses, nowadays, is oversimplified (Young 2021). We also have sensory systems that provide information about balance (the vestibular sense), body position and movement (proprioception and kinesthesia sense), pain (nociception sense), and temperature (thermoception sense). Despite the concept of perception being traditionally related to the most common five senses: hearing, vision, touch, taste and olfaction, these categories seem to reflect the organs of sense, rather than the sensory modalities themselves. For example, the sense of taste is generally associated with the taste receptors in the tongue (sweet, salty, bitter, etc.). But what one refers to as taste in daily experience involves the tongue, including "taste" receptors (sweet, salty) but also "tactile" receptors (the texture of food), the nose ("olfactory" receptors), and probably also the eyes (color) and the ears (chewing sounds). This means that one is most likely to experience an event as a unified bunch of sensations from multiple senses, and therefore perception operates in the context of information supplied by multiple sensory modalities at the same time.

Human sensory abilities allow one to experience the most enjoyable and most miserable experiences, as well as everything in between. Everyday our senses are being challenged and affecting our perception. For the last few decades, perceptual research (Goldstein 2016) has pointed to the importance of events and objects in the world that are observed when there is information from more than one sensory modality. Some researchers, advocates that those responses to multimodal stimulus are typically greater than the combined response to either modality independently (Calvert et al 2004). In other words, if you present the stimulus in one modality at a time and measure the response to each of these unimodal stimuli, you will find that adding them together would still not equal the response to the multimodal stimulus. This is what I will be discussing further on in this subchapter. How the lack of vision affects one's perception of the world as a unified experience.

Considering that perception is a process with the aforementioned characteristics, the stimulation of one sense alone is not entirely responsible for what is perceived. What I mean is that perception is dependent in the information available in the external stimulus but also mediated by knowledge one already possesses about the situation. A knowledge that is based on past experiences and that allows one to form expectations about what one ought to perceive. The abstract interpretations of physical stimuli are an integral part of perception. Consequently, the symbolic world build by experimentation and external cultural aspects plays a major role on what is perceived. In other words, we humans do not only feel the world with our senses but as well with our cultural background and previously lived experiences (Gendler 2006). For instance, an adult can percept a dog barking at a distance just by hearing it. Yet, he or she only knows that the sound comes from a dog, by interpreting it with the assistance of previously build knowledge.

The fact that the senses are not pure stimulus, that their integration depends also on a cultural background can be, as well, illustrated by the struggles of humans relearning to use long time lost senses. Susan R. Barry, in her book *Coming to Our Senses: A Boy Who Learned to See, a Girl Who Learned to Hear, and How We All Discover the World* (2021), shares a few stories of people relearning to use a lost sense and tries to understand its complexities. In one of these stories, a blind man with the age of 52, gained vision after being subject to a cornea transplant but was not able to adjust to his new life. After the surgery he became depressed by the fact that, although seeing, he was not able to read, write and drive. This consequently accelerated his life decay and ultimately his death. Another case described by Barry refers to the difficulties of the young boy Liam McCoy. Blind during his childhood, McCoy started to see by the age of 15. According to Barry, he had a lot of difficulty to understand the new cues he was receiving through vision. It took a year for him to make sense of the lines on the environments around. It was difficult for him to understand that those lines could signify a sidewalk step up or down for an example.

In the book *Fixing My Gaze: A Scientist's Journey Into Seeing in Three Dimensions* (2010), Susan R. Barry describes her own experience from having to learn how to see three dimensionally after being healed of a cross-eyed and stereo blind condition that followed her since childhood. Through a vision therapy procedure, she was able to learn how to see with both eyes. It was a big effort for her to achieve this goal during the age of 48 years old, yet this proved that even in a relatively advanced age, is possible to learn how to use a sense and to develop new perceptions with this new learned sense. Both examples serve as evidence of how our perception demands a learning path that is not limited to our biological ability of sensing through our organ's receptors. Paul Rodaway, in his book *Sensuous Geographies* (1994), has a similar perspective over the process of perception. For Rodaway, perception is not merely the physical aspect of receiving a stimulus through the senses, but something also part of a mental cognitive process mediated by lived experiences. Putting differently, we humans have natural tools to perceive the world. However, we must build proficiency with them. This happens through educational training and cultural conditioning, which means that people build different ways of perceiving the world during life and as well distinctive ways of perceiving the same things. E.g., a blind person can perceive the sun by feeling it through its skin.

Adding to this, it is also relevant to highlight those different cultures tend to build different perceptions from the same objects and facts. Also, according to Rodaway (1994), humans do not use their senses in a naive way, but in various complex and subtle ways. Rodaway delineates five important factors to take into account: Firstly, sensing is a multi-modal phenomenon, in which we feel the same things with different senses at the same time, e.g. we can see a train arriving to the station, but as well we can hear it and even we can feel on the floor the vibration of its approximation; Secondly, the ecological concept of perception, which means that the mechanical way of receiving stimulus depends on the medium those signals are passing through. For example, the wind whistling on a window produces a vibration making you perceive it not only by its contact with one's skin. The geometry of the window influences the soundwave produced which is part of the ecological environment producing that perception; Thirdly, perception is a learned behavior, which means that is culturally specific and that it can be educated. So, for instance, a trained person can define music notes just by hearing a melody once. And fourthly, perception is corporeal, which means that the body and its extensions work as well as a medium to perceive. Body size, position, movement, and its extensions, like glasses, walking sticks, clothes and hearing aids work as well as mediums for perception.

Rodaway (1994) did not included in his analysis digital extensions, like smartphone, or personal computers, but through my one analyses of this topic | assume that those and other endothermic devices can work as mediums to perceive the world when connected to the human body. For instance, even cars can work as extensions of the body. While one is driving a car, he or she knows that a floor is smooth or rough, or if it is windy outside, just by filling pattern changes by holding the steering wheel. Nevertheless, digital devices that connect humans into a just in time digital public space are giving to the human being different ways of perceiving the world. The discussion about how the development of digital technology is creating new cybernetic human senses will not be elaborated in this project, yet I feel that the subject will guide my interests in the future.

The soundscape, a term coined by Raymond Murray Schafer, in 1977, in his book *The Soundscape: Our Sonic Environment and the Tuning of the World*, follows a similar principle to the term landscape used by geographers, yet it is related to the listenable sonic environment of a space. The soundscape of a place allows perceptions of the environment that sometimes are unreachable by vision. The opposite direction is as well truth, in a way that the vision allows perceptions of what is inaudible. In fact, the complete understanding of a place comes with the intertwining of all the sensual geographies, haptic, olfactory, auditory, visual and its learned interpretations, as described previously (Rodaway, 1994). Despite of the importance of sensual geographies to build complete perceptions of the environment, this research is interested in the listening capacity of predicting locations and shapes of objects, as so, the auditory ability will prevail. With that in place let's start by imagining situations in which the auditory sensory modality brings perceptions that would not be reachable by the sight modality, but mainly by listening to the soundscape.

Imagine that you are tired from a fulfilling workday. It is already late; your room is dark, and your apartment is silent. You are still not sleeping yet flashes of memories from your daily experiences come to your mind like a pre-sleeping daydream. Furthermore, acoustic stimulus from the real world, are still being generated. In the depths of the street you live, you can hear a neighbors' dog barking. You do not know this dog, but somehow, you know this dog. You know that the animal barks often during the time you are about to sleep. By the barking sound quality, you can assume that it's not a small dog, it's probably guarding a house and it's in a ray of distance approximately of 400 meters. By the position of the window in your room, in relation to the street, you realize as well from which part the sound is coming from and you can even guess, from which house it is possible coming from. In this case you were imagining a supposed situation that was being described, but it is easy to trace parallels with this experience on your real life. When you are riding a bicycle in the street, you can predict how far a car, or a bus is behind you just by hearing it. Even the vehicle's velocity you are able to guess. Or, when you are about to arrive on a metro station, yet you still cannot see the rails and the train, however, by hearing you can predict that one is coming and therefore, you fast your pace to not miss it. The car horns work in a similar way, calling for attention to something that is next, yet you are not seeing, at least not seeing with your eyes. Considering these supposed situations, it's possible to realize the importance of the auditory system for a sighted person to understand the involving environment. In parallel it is possible to assume that the auditory system is extremely important for a blind person comprehension of its immediate physical environment.

By not having the possibility of supporting on vision to perceive the world, blind people tend to rely on the other senses, touch, smell, hearing and taste. The smell is very connected to memory and feelings (Martin 2013). It can be used to identify smelly things on the environment, even do, it is difficult to precise positions considering only on the smell and less even in shapes. Smellable particles flow in the air medium depending on air currents, which cannot help to precise a source origin. Touch is very precise but limited to the area reachable by the body of the one who feels it. As well taste, that is connected to the smell, is limited to what is in touch with the tongue of the taster. Sound, however, navigates in the air without much interference, being able to provide information about an objects position and even its shape.

Considering that humans have the incredible ability to listen to various sound wave frequencies, how precise and magnifying is the information coming from sound feedbacks to a blind listener? In the book *Touching the Rock: An Experience of Blindness* (2016) by John Martin Hull, a professor of religious education that became blind during his adult life, the author reports his experience as an unsighted person. These reports are important not just because of the faithful documentation of reality but because, as well, the memories from the world when seeing helped this professor to co struct parallels between both worlds, and that are better understood by the sighted. In some excerpts of the book, the author explains how much rainy or windy days can be informative in the way one perceives the world. Hull explains that days with rain and wind, for him can be compared to a good sunny day to a sighted person and that opening his home door on a rainy day would magnify objects outside of it, as the sun light would do for a sighted person. The wind and the rain produce noise when touching on trees, walls and other objects on the landscape. These noises work for him as if they are "coloring" those objects, making them come to an existence at a distance. Something that would not happen on a calm sunny day, in which those objects would remain totally inaudible or better placed, invisible.

Through the descriptions of Hull (2016), it is possible to understand that he was producing a kind of "auditory vision" of the shapes and locations of objects by the sound made by the impact of the rain drops on or the wind on them. This means that by emitting sounds, objects turn themselves visible or better, "listenable" by a blind subject. However, those objects do not naturally produce sound, they depend on the impact of something on them, which consequently lead me to think that if a person is able to induce an auditory response on an object, perhaps this person will be able to see or listen to the object through his/her auditory system. In fact, this is true and already exists in nature. It is exactly what bats, dolphins and other echolocating animals do to navigate in dark environments. Some humans as well are using this skill to overcome the lack of vision and this subject will be elaborated in subchapter 1.3 *Human Echolocation*.

1.2 Some notes about being blind in the XXIst century

In 2018, the International Classification of Diseases categorizes visual impairment in several degrees: in distance vision impairment, mild (visual acuity worse than 6/12 to 6/18), moderate (visual acuity worse than 6/18 to 6/60), severe (visual acuity worse than 6/60 to 3/60) or blindness (visual acuity worse than 3/60), and near vision impairment (visual acuity worse than N6 or M.08 at 40cm). Yet, a definition that is better readable by non-specialists of the field would be the one made by Wendy Sapp, a PhD researcher specialized in teaching blind children and youth, published in the *International Encyclopedia of Education* (2010):

> "Blindness technically refers to a total absence of vision, although the term is often used to refer to severe visual impairments that result in a need for primarily using nonvisual sensory information. Low vision refers to visual impairments that are less severe than blindness but still impact a person's ability to complete daily activities to some degree. People with low vision may need to use tools and techniques to enhance their ability to use their limited

vision, or they may need to use nonvisual means for completing tasks.

It is important to note that, differently from the common sense, blindness does not mean solely the totally lack of visual response but also a very low visual acuity. Which means that some blind people can perceive light transitions and objects with 6 meters of distance (Sapp, 2010). It is also relevant to share that it was quite challenging to find precise and current data about the number of blind people worldwide. Perhaps this can be viewed as a symptom of the difficulties faced by the blind that I will be analyzing in the paragraphs ahead. The most recent document I found showcasing the visual impairment world data was produced during 2017. It works as an interactive atlas developed in a partnership between the International Agency for the Prevention of Blindness (IAPB) and the Vision Loss Expert Group (VLEG) (IAPB, 2020). This data is based on the VLEG publishing of regional and country-level estimates for blindness and vision impairment every 5 years (2010, 2015, 2020) in the *Lancet Global Health* and other journals. According to this map, in 2020, 1.1 billion people worldwide suffers from a kind of visual impairment, from whom 44 million are blind. It was estimated that, in Western Europe, live 32 million people with visual impairment of which 1.5 million are blind. In Central Europe, the estimation points to 18 million people with vision loss, of whom, 330,000 people are blind. In Eastern Europe, there was an estimation that 43 million people live with vision impairment and that 790,000 are blind. In Portugal the total number of visual impaired are estimated to be 780 thousands of which 33 thousand are blind.

In the world today, there are 7.9 billion people (Worldometer, 2021) which means that the 44 million blind people (WHO, 2021) is a minority. A minority to which the world was not build for. Imagine how much the vision is necessary for almost all of your daily tasks. Driving, cooking, reading, finding products on a supermarket, following signs, using public transport, among so many others. Accordingly, to the World Health Organization – WHO (2021) in a visual world build by the sighted, mainly for the sighted, a blind person struggles in many instances throughout his/her life. Blind babies take longer to build bonds with their parents and blind children have difficulties to develop their motor coordination, social relations and studying practice (Cavitt, 2013). Blind adults generally do not have the higher salaries or the best job vacancies available. This was referred by António Manuel Silva, a blind person that I had the opportunity to work with during this project and that was crucial for my research:

> "Gustavo, if you intent to make money with this project, forget about it. We blind people are not loaded, and we don't have the best jobs and salaries. Specially here in Portugal. Perhaps in a richer country like Germany you will find more opportunities, yet worldwide we are not a big market".[1]

Again, according to the WHO (2021) report, old blind people can experience a faster decay, appearing sooner into care homes. The blind condition can frequently lead to isolation and be accompanied by psychological problems like depression and paranoia at any age.

Other critical problems for blind humans, in accordance with the *We Capable* organization, are mobility and access to reading materials. In western countries, in major urban settings, public transportation and public spaces have inclusive technologies that help blind people to handle their tasks — for instance by pressing the right button on an elevator through braille embossed letters, find directions through tactile tiled floors or crossing the streets with the assistant traffic lights sound signals. However, these technologies tend to be available only in big cities, not covering a great area and limiting the independent locomotion of the blind to various places. In poor countries, these materials are even more scarce.

Furthermore, it can take time for a new technology for helping the blind standardize. The Braille system, for example, took many years after its development to be accepted as the standard. As stated by Brian R. Miller (2014), Luis Braille (1809-1852), a blind student at the Royal Institute for the Blind in Paris during the 1820s, got interested on a raised-dot system invented by the French army to allow communication between soldiers in the dark. This system was never really used by the French army,

[1] Free translation from Portuguese to English from an in person interview with António that took place in 2019.

yet Louis Braille appropriated it, making improvements, and simplifying the system making it became what is the Braille letters today. Louis Braille brought this system to schools and after becoming a teacher in this same institute, starts using the technology to teach reading for his blind students. The system is probably one of the greatest developments in Western history for educating the blind.

Even though, Braille technology took a long time to become the standard way for alphabetizing blind people. The braille system proved to be more effective on giving unsighted people access to the written word than the embossed roman letter system in usage by the time Luis Braille was a student. To substitute the conventional system of embossed roman letters for the "Braille" system Louis Braille faced a big bureaucracy and political resistance on the university he was a teacher. Only after Braille's death, the system came to be accepted in his university as the standard way of alphabetizing the blind, thirty-one years after its invention. It is belied that the institute was struggling against the more effective Braille system due to the fear of wasting the resources user to develop the older system. I think that this political issue faced by the Braille technology helps to illustrate the relevance of my research. Into this direction, this master is an attempt to help human echolocation to thrive political obstacles that are possible preventing it of becoming the main way of training blind people mobility. Blind people mobility training institutes invested years and lots of resources on their specialization. Making the shift can be challenging and overwhelmed. I suspect that this can be a factor creating entropy on making human echolocation become more spread.

Also, the digital screens, that nowadays are more spread than ever, are still a challenging technology for the inclusion of braille letters on it. Screen readers are giving to the blind access to digitalized texts, but some modern digital devices that have touchscreens are not designed with the blind perspective in mind. António Manuel, for example, explained me during some of our conversations, some of the difficulties that he goes through when buying a coffee in an automated machine in the Faculty of Arts of the University of Porto, where he works as a technical assistant at the student Support Office with Special Educational Needs. He never knows what kind of drink— coffee, cappuccino, tea, — he will get. It is always a surprise. António Manuel mentions that braille letters on physical buttons works better for him. In addition, despite the great achievement that Braille technology represents, its use is decreasing and being disincentivized by new technologies like screen readers, as stated by Shelley Kinash and Ania Paszuk on their *Manual: Accessible Education for Blind Learners: Kindergarten through Post-Secondary (Critical Concerns in Blindness*) (2007).

Notwithstanding, all the life challenges blind people face, it does not mean it is impossible for an unsighted to achieve a higher educational and professional career. However, a blind person life will always be accompanied by the "being blind stigma" as described by Ronald J. Ferguson in his book *The Blind Need Not Apply: A History of Overcoming Prejudice in the Orientation and Mobility Profession* (2007). Ferguson advocates that the socially constructed beliefs about blind are based on wrong ideas, misunderstanding and misconceptions continues to be accepted as "truth". In other words, people following common sense ideas have a very fixed notion of what a blind person is capable of, or not, even without never meeting one. Ferguson advocates also that this pseudo "truth" guides the foundations in which the rehabilitation programs for the blind are based on. Perhaps this wrong idea is one of the reasons why human echolocation is still not spread as one of the main ways of training blind people's mobility. Perhaps it is also because of this that the rehabilitation programs of aiding institutions for the blind don't consider it either. For the common sense the blind is often seen, and several times treated, as handicapped people. Yet, considering the knowledge I built through this project, I would like to change this very simplistic perception of blind people. The brain of a blind person is in nothing inferior to the brain of a sighted person. As the sighted, they must be trained and oriented to find their passions and professions without having their possibilities atrophied and underestimated by prejudices (Scott 1981).

Considering all the difficulties faced by the blind and the quantity and diversity of blind people worldwide, it's possible to presume that brilliant brains are probably not being developed on their full by society's lack of capacity in including them into high stakes educational, professional, and even physical trainings systems. In my view, people are the most precious asset of a country and losing them have direct economic consequences that in would be overpaid by more attention on the education and training of the blind.

Societies benefit from having blind scientists, blind lawyers, blind politicians, blind teachers, blind designers, blind writers, blind artists and so on. The world has already a few examples of blind persons renowned and recognized on their fields of profession. For instance, as mentioned before Louis Braille was fundamental for the development of Braille technology; Helen Keller (1880-1968) was a deaf-blind political activist, in the USA, who campaigned for those with disabilities; Jacob Bolotin (1888-1924), who graduated from the Chicago School of Medicine, was the world's first totally blind physician fully licensed to practice medicine; Argentinian writer Jorge Luis Borges (1899-1986) suffered from a terrible myopia and became blind at the age of 55 years old; the famous piano player Ray Charles (1930-2004) with his talent helped to shape Soul, Jazz and Blues music in the USA; Stevie Wonder (b.1950) is another famous North-American composer and singer from the USA. In Brazil, for an example, there is a politician named Filipe Rigoni (b.1991) that is working towards the elimination of the "being blind stigma" by being the first Brazilian blind politician (Edson Sardinha, 2019), among many others. The success of these individuals symbolize how much we need to work towards the inclusion of the blind and of course of other disabilities on the working force and knowledge building of society.

1.3 Echolocation in Humans

As mentioned previously, Echolocation is the ability of evaluating an object's position by the reflection of self-emitted sounds. The most well-known mammals that master this skill are bats, dolphins, whales, shrews, and some type of birds. These animals are mammals on their majority, at least, the ones that were scientifically proven to have such skill. Yet, what all of them have in common is the necessity of seeing without the eyes, of having to trust not solely in light. This can happen because they live in environments where vision is not favored, like dark caves, deep seas, murky waters, or because such animals have a prevailing nocturne behavior. The discovery of such ability on animals dates the XVII century. Sven Dijkgraaf (1908–1995), a physiologist and professor at Ultretch University, wrote an article, in 1960, about the discovery of bats awareness of objects through sound. He argued that blind bats were probably first perceived as using sound for orientation by the Italian biologist Lazzaro Spallanzani (1729- 1799), in 1793. Spallazanzi did not discovered echolocation, but that bats got disoriented when flying with the ears covered. His works, about bats perceptions, were not fully published, but fragments of them remained. The remnants of the studies made by Spallanzani were as well examined by the North American neuroscientist Robert Galambos (1914-2010) and Donald Redfield Griffin (1915-2003) in 1940 and 1942. Galambos and Griffin by the time were making advancements on studies about the importance of the sound on bats guidance. They were able to prove that bats were emitting high frequency sounds while flying and hearing this sounds echoes to guide themselves. The studies made by Galambos and Griffin were the first publications regarding echolocation in bats. Further, sea mammals like dolphins, whales, and porpoises, were found by Winthrop Kellogg (1898 –1972) to be as well echolocating animals. This discovery was published on the book *Porpoises and Sonar by Winthrop Kellogg,* in 1961. Evidence for echolocation in screws were documented by Edwin Gould during the years of 1962, 1964 and 1965. Gould could prove that shrews were using a different technic than bats and sea mammals to echolocate. The screws were not emitting sounds by clicking and were using echolocation to study the space and not to find prays. In the case of birds, as stated by Signe Brinkløv (2013), 20 years after Spallazani, in 1817, Alexander von Humboldt got mesmerized by the constant chirping of dark cave oilbirds in Venezuela, yet just in 1953 the echolocation acoustic orientation was considered the navigation way in the dark for oil birds by Griffin; and in 1959, an article attaching the echolocation ability on swiftlets was written by the British zoologist Lord Medway (b. 1933). With all that explained, it is important to say that probably the most famous echolocation expert along the western science history is the zoologist and researcher Donald Redfield Griffin. He was the one that created the term.

The word “echolocation” was first recorded by Griffin, in 1944, in his article “Echolocation by blind men, bats and radar” written for the *American Association for the Advancement of Science - AAAS*. Griffin proposed to use the junction of the words “echo” and “location” to define all mechanisms using the interpretation of self-produced sounds reflection and self-produced radio waves reflection. As stated by the author, animal echolocation, human echolocation, artificial sonar systems and artificial radar systems would be understood as echolocation. However, a more recent definition of this concept, regarding the natural ability, was stated by John D. Altringham, and published in his book *Bats Biology and Behavior* (1996):

> “(…) is the analysis by an animal of the echoes of its own emitted sound waves, by which it builds a sound-picture of its immediate environment. A number of animals use the sound in this way, and many use the high frequency sounds or ultrasounds, beyond the range of human hearing” (p 79).

If further deepen the meaning of echolocation, one realizes that “echo” is a word related to sound waves and its meaning, according to the *Cambridge Dictionary* (2021), is: “a sound that is heard after it has been reflected off a surface such as a wall or a cliff”; the word “location” also accordingly to the *Cambridge Dictionary* (2021) is: “the act of finding the exact position of something”. I believe, that neither of the above words are a perfect match for what echolocation means today and for what is stated by Griffin. Without denying the existence of similarities, I argue that a radio wave has a different nature than a sound wave, because a radio wave reflection is not a synonym of an echo (sound wave reflection). Considering this, the evaluation of a position is included on the semantic of the word “location”, yet the evaluation of an object’s shape, size and material doesn’t overflow to this semantic. Even though, the capacity of making this analysis, the evaluation of an object’s shape, size, and material, through the interpretation of a self-emitted sound’s reflection, is included on the abilities of an expert human echolocator, or animal echolocator.

Accordingly, by being etymologically rigorous, the meaning of the word echo + location can’t comfort the interpretation of radio waves reflections. Additionally, it can’t comfort the other qualitative evaluations of an object made by an expert echolocator, namely the definition of shape, size, and material of an object through the interpretation of echoes. Perhaps the term “echovision” would be more appropriated, a vision through the interpretation of echoes. But even this term raises some doubts, as in fact, to evaluate objects through sound, a reflection of a self-emitted sound wave is not mandatory and not even a reflection is. It’s possible to precise an object’s position and its physical characteristics through the interpretation of the reflection of a secondary sound source, located in a different position than the subject interpreting its reflection. The video “Perceptual workshops: Thomas Tajo with Victor” (2017) exemplifies this last situation. Thomas Tajo, an expert echolocator instructor, uses a teaching technique in which he hits a book with his hand, generating a very characteristic sound emission to be interpret by his pupil. Tajo keeps varying his position but always positioning himself between a tree stalk and his human echolocation pupil. This technique allows the student to feel the massive presence of the tree stalk by interpreting the reflections of an external sound source emission. In addition to that, a blind person can also evaluate the size of a person, the age, and the persons position by the sound voice of the speaker as stated by António Manuel on one of or encounters. In this last case, no echo is necessary for an evaluation.

Figure 3: Perceptual workshops: Thomas Tajo with Victor by Thomas Tajo (2017).

What I am trying to suggest is that the already existing words "hearing" and "listening" — which means hearing with attention — would be enough to describe what today is considered echolocation. I even suggest the creation of a new word to express more intimately the meaning of what happens while an alive being is echolocating — auditoryvision. For me, "auditoryvision" describes exactly what an echolocator, or better, an "auditoryviewer" does: sees through his/her auditory system, not mattering if it is through a self-emitted sound echoes or an external sound source echo, a primary source sound, or the sound of a physical impact on objects made by the rain, wind or whatever produces a sound wave when getting in contact with a surface. One could say, that mixing the senses of audition and vision, would not be a perfect match as etymologically the vision is related to interpretation of light and the audition to the interpretation of mechanical soundwaves. Yet, a study made by Lore Thaler, Stephen

R. Arnott and Melvyn A. Goodale, intitled “Neural Correlates of Natural Human Echolocation in Early and Late Blind Echolocation Experts”, (2011), concluded that the part of the brain used by an echolocator to process and interpretate echoes is the same used to process vision and not, as would be expected, by the part of the brain that processes sound. This means that the brain of an echolocator is processing echoes in a similar manner, or at least in the same area of the brain, he/she is processing vision. This is one of the reasons why I consider the words “Auditoryvision” and “Auditoryviewer” more appropriate when describing human echolocation. Nevertheless, an echolocation experience happens when the echolocator is using sound to project an imaginative idea of the physical environment in his brain. With all that elaborated, although I had built this opinion along my studies, that the word “Auditoryvision” would be a more appropriate to apply to the study of the echolocation ability, for practical reasons, I decided to continue using the word "echolocation” in this study.

As explained previously in this subchapter, humans can behave as echolocators, but this skill is mainly asleep. Some blind people, due to the lack of vision, developed echolocation as strategy. A few studies and tests show that human echolocators developed a system very similar to the one present on bats and dolphins. They emit repetitive tongue clicks and read the echoes produced by this sounds on the environment around. By doing that, the echolocators can create sound images from static obstacles and moving objects, literally seeing by sound. To deepen this echolocation system and relate it with the way bats echolocate I include Altringham’s (1996) explanation about how a specific specie of bats perform echolocation:

> “Megabats of the genus Rousettus echolocate within their cave roosts generating sound by clicking their tongue. The pulses are short (1-2ms) of high frequency 10-60 kHz, at a pulse repetition rate of around 7 Hz” (p. 79).

Despite the direct similarity to the way some bat species echolocate, tongue clicks, and sound emissions are not the only way humans can echolocate. Some individuals developed this skill by tapping their white cane (blind mobility walking stick) on the floor, by clapping their hands or even by analyzing their own walking steps echoes.

Interestingly, the development of human echolocation occurs in different people, without any connections between them, as an independent phenomenon, which points to the fact that echolocation is a natural human ability that remain unconscious for the majority. This is also reported in the documentary *The Boy Who Sees Without Eyes (*2007) by Elliot McCaffrey, about Ben Underwood. Blind since the age of 3, Underwood developed a navigation skill like the one present in bats and other echolocating animals. By emitting repetitive clicks with his tongue and listening to its reflections on the environment, Underwood was able to achieve an unimaginable mobility standard for a blind person. The child was able to ride bicycles, participate in ball games and avoid obstacles while doing all those activities.

The documentary reveals that Underwood's mother never told him that he couldn't see, but that he was able to see in another way, empowering the boy to not have his dreams atrophied by his condition. She realized during her son's early ages that he started to make some repetitive noises with his mouth and that this somehow helped him with space orientation. After observing that, she started to encourage her son to never stop making his noises and this helped him to develop and master the echolocation skill. By becoming a blind echolocator, Ben Underwood was able to study on regular schools during his childhood. The contrary was not so easy. During his teen ages he had difficulties to adapt to a school specialized in educating blind individuals. In the new school were no ball games and clearly no human echolocation training. In this "special" school the blind students were treated as handicapped, something that Ben Underwood, never felt he was. These facts inevitably raise a few questions:

- Is the regular way of training blind people able to unleash all the potential of blind individuals? What could be changed?
- Why is that human echolocation is not being trained regularly?

Figure 4: Ben Underwood riding a bike by Elliot McCaffrey (2007). Source: The Boy Who Sees Without Eyes. Firefly Film and Television Productions.

The psychological, neurological, and sociological explanation of the awareness of objects position by blind people can be new for most people reading this text, although, it has been rising curiosity along the history of science, being the subject of scientific research for a long time. Samuel P. Hayes (1935) made a compilation of studies about this phenomenon from 1749 until 1935. This compilation can be found in his article “Facial Vision, or the Sense of Obstacles”. In accordance, one of the first publishing regarding the theme was made by Denis Diderot (1713-1784) in his letter for the blind (1749). Diderot was mesmerized by the ability of a blind individual to evaluate his distance from objects. At the time, Diderot supposed that the face sensibility of the echolocator was responsible for it, working as a kind of air pressure antenna. Diderot stated that “he is so sensitive to the least atmospheric change that he can distinguish between a street and a closed alley” (letter for the blind, 1749). After that, other studies investigating the phenomena occurred. In 1872, William Hanks Levy published a book named *Blindness and the Blind* (1872) a compilation of statements about the “Facial Vision” phenomenon — how echolocation, or the perception of objects in distance by the blind, was called by the time. One of the reports made by a blind in this book, states the ability of a blind to differentiate, with a certain amount of precision, different materials and a line that separates a brick base from the upper rails of a fence while walking on the side of it.

140 years after the observation of Diderot, the first scientific research regarding the theme was published by the German scientist Theodor Heller in his book *Studien*

zur Blindenpsychologie (1890). Heller concluded that the perception of distant objects by the blind was due to a mix of sensations that included the hearing sense and the forehead sensibility to air pressure changes. To handle his experiments, Heller used a spacious empty room and a school chart (6,65x1m) as object to be found by a blind subject with “facial vision” capabilities. He concluded that the footsteps of the subject generated echoes responsible for guiding the blind to the objects position, yet that the precise objects position was being confirmed by the pressure change sensation on the forehead when the human subject gets near to it.

Also in 1890, three North American psychologists decided to investigate the phenomenon. Their supposition was that the tympanic membrane could be sensible to air pressure change. After that, many other research regarding the theme and many other cases of blind people with the capacity of building a sensorial perception of distant objects have been appearing. This ability was first called “facial vision” and it took some time until be proven that in fact the hearing sense, as proven on the experiments handled by Supa, Cotzin and Dallenbach (1944, 1947 and 1950), was in fact, the responsible for the ability. Kellog (1962) went further by testing the precision of the ability in blind people to identify texture, sizes, and distance of objects. Before that even Ammons, Worchel, Dallenbach (1953) proven that blind and sighted people can learn the ability. All those experiments prove that echolocation is not so exceptional, but that I just have been disregarded as a natural human ability that tend to develop on people with sight lost.

Daniel Kish, is a self-taught echolocator and echolocation instructor that nowadays is teaching the skill to other blind people through the non-governmental organization, founded by him, Visioneers. Some of his classes include a tour in nature, more precisely, a trail through the mountains. One of his alumni, Juan Juiz, has the world record for blindfolded cycling through obstacles and today, as some other alumni, is as well a human echolocation instructor. This is information I retrieved in Visioneers website.

Figure 5: Daniel Kish teaching echolocation.

Figure 6: Juan Ruiz (2011). Blind Bicycling Guinness World Record. Guinness World Records. (April 2011).

Despite of the knowledge that is being built about the theme during the last 270 years, the conclusion that echolocation is not for super humans, that it can be learned and taught for blind and not blind people, and that it has a great empowerment possibility for the blind; human echolocation is still, not being taught on every blind training facility. Some training places exist but just a few and it's believed, as said by the human echolocation researcher Dr. Lore Thaler from the Durham University, that perhaps, this is because the ability is completely unknown by society. So, if a sighted person has a blind relative for example, this person most probably will never encourage the echolocation training of his/her relative, simple by the total lack of knowledge about the existence of this ability. Addedly, the consequences of the lack of knowledge about echolocation can be even worse. The noise made by a beginner echolocator kid, that occasionally starts to develop the ability naturally, can become annoying for sighted parents that would perhaps disincentive the practice. This attitude would be the opposite of the one made by Ben Underwood's mother, that incentivized her child to master the ability. Possibly atrophying the young kid possibilities of becoming a new human echolocator and a more independent and self-confident person.

2. Public Art as a Strategy for Human Echolocation Dissemination

2.1 Public art as temporary art

After the Second World War, site-specific public art started to appear as a critical answer to the modernist statuary and the capitalist market pressure encompassing artwork as transportable commercial goods. This phenomenon became not just site-specific yet context-specific, becoming temporary and sometimes itinerant, depending on the cultural context and on the specific point in time it occurs. Miwon Kwon (2002) made a very complete synthesis of this transition in her book *One Place after Another: Site-Specific Art and Locational Identity*. As stated by the author, site-specific works awake in the emergence of the minimalist movement during the late 1960s and early 1970s. If a modernist sculpture with its pedestal is supposed to be removed from a place to another, it would not necessarily loose its primary iconographic meaning or symbolism. In a counterpart, a site-specific work of art (an object or an event), demands the bodily presence of a spectator and is shaped by its environment, having its context attached to the physical, social, cultural, and sometimes, momentaneous background for which the artwork was designed for.

This exchange between the representative characteristics of modern sculpture and the experiential characteristics of site-specific works was characterized as the "theatricality" of an artwork by the art historian and art critic, Michael Martin Fried (1998). Fried argued that the minimalist object had focus on the experience of the beholder and not on the symbolic relation exemplified by historical monuments. In this way, the object of art would not be differentiable from the phenomenological experiences from the real world, having its existential significance attached to its provoked experience, to its "objecthood".

One of the most famous site-specific work of art is *Tilted Arc* (1981) by Richard Serra (b.1938) and its notability raised not only by the experience evoked by it, but from the site-specificity issue its experience generated. Richard Serra designed a Cor-Ten Steel arc, with 36 meters long and 3,7 meters height, to be placed at the middle of Foley Federal Plaza in Manhattan, New York, USA. As synthetized by Robert Storr (1993), the object of art generated controversy and as well public petitions against it since its installation. The plaza has a heavy walking traffic from employees working on the surrounding offices. These users of the plaza disapproved *Tilted Arc* because of the noise it produced on the space. The artwork obligated a reconfiguration of the main architectural feature of a central square, a clear space between buildings allowing direct vision between them.

Figure 7: Tilted Arc by Richard Serra, New York, USA, 1981.

This site-specific artwork was considering the physical specificity of the place, yet not its social context. Symbolically the struggle faced by Richard Serra regarding the removal of his artwork from its original site, illustrates the necessity of including the social and community context into the site specificity of a work of art designed specifically for a place. A public space can have a big quantity of social context layers streaky one over the other and this context specificity is attempted to be addressed by temporary public art.

Considering what I mentioned above, I bring three temporary public artworks that I believe successfully expresses these new features of public art. *Following Piece*, 1969, by Vito Acconci (b. 1940); *Alien Staff,* 1993, by Krzysztof Wodiczko (b. 1943); and *The Green Line*, 2004, by Francis Alÿs (b. 1959).

In 1969, Vito Acconci produced the *Following Piece,* an artwork that consisted of a daily performance of following an aleatory stranger in the streets of New York, until this stranger enters a private space. These acts happened continuously during the approximately time of one month (October 1969). Acconci registered the daily performances through pictures and used them to build diagrams containing maps of the routes of these strangers around the city and some notes about the procedure. This temporary public art had all the specificity missing in *Tilted Arc* (1981), undoubtedly context specific, depending on a time slot and limited to the social layer of the ones being followed. The lack of a physical permanent change in the public space is as well a factor, in a way that the act of the artist itself during this certain period and specific geographical routes related to a stranger, are the artwork itself.

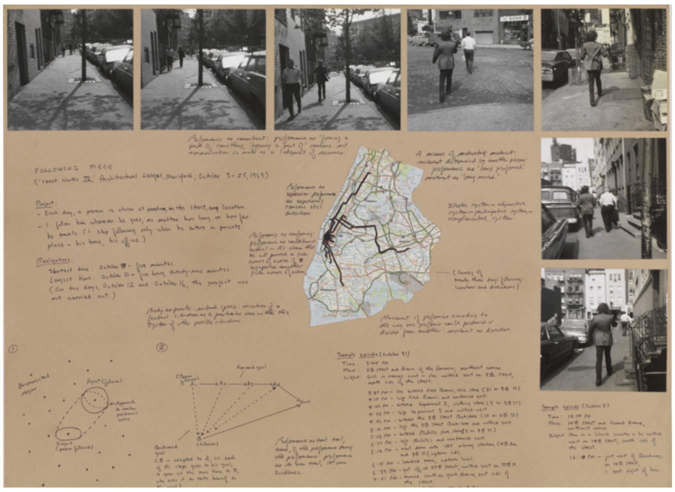

Figure 8: Following Pieceby Vito Acconci, New York, USA, 1969.

During the described process, Acconci was able to collect and study data about real people performing their daily locomotion tasks in the public space. This act is not tangible and became the work of art itself. I believe it is possible to share and disseminate knowledge about human echolocation with strange people in the publics space, by interrupting their daily tasks and using their natural curiosity as tool. In this supposed case, the performance of disseminating information about human echolocation would be the work of art itself.

Most probably, the artwork that inspired more in this research is *Alien Staff,* 1992, by Krzysztof Wodiczko. The device built by Wodiczko brought to the surface the silent voices and realities of immigrants. A staff like digital device, as tall as a person, with a futuristic appearance. The artefact displayed a small digital screen on the top of it and a middle part working as a transparent stash, showcasing the personal belongings of the staff holder. An immigrant generally has a diminished mediatic representation, e.g. a shampoo advertisement does not feature people with a foreigner appearance, showcasing shining beautiful hair in the wind. Similarly, immigrants lack of political representation on the state administration, TV programs, and on. It is like, immigrants have no digital existence, yet they are there, working hard, paying taxes and making their part on societies that do not see them and do not represent them as a part of it. The Alien Staff was designed to trigger conversations between an immigrant, the staff holder and locals. The digital screen is showing a digital image of the face of the same person holding the staff, creating as this, a symbolic digital existence for its holder. The intriguing appearance of the device itself added to the fact that the person using the staff does not have a local appearance, triggers the curiosity of the passersby that consequently start to see those immigrants and perhaps start talking with them.

Figure 9: Alien Staff by Krzysztof Wodiczko, Barcelona, Paris, New York, Stockholm, Helsinki, Marseilles, Warsaw, Rotterdam, Houston, Boston, 1992.

The *Alien Staff* works as a tool for giving visibility for a hidden layer of a society, a political reality that is there, but remaining invisible for some locals. With this master my plan is to use an itinerant futuristic like device as tool for disseminating the commonly unknown, human echolocation ability. By inducing a human echolocation experience in public, this device would generate discussions about its existence.

Another context-specific temporary public artwork I found very powerful in generating political discussions about the public space is *The Green Line* by Francis Alÿs. The artist once performed a walk with a leaking can of blue paint in São Paulo city, Brazil. The route left by the leaked ink marked a route in the city, coming out from a gallery and coming back to the same place. This action was called the leak (1995). In 2004 a similar act was performed in Jerusalem, this time with a leaking can of green paint. Alÿs followed a 24 kilometers trajectory that once was the "Green line" made with a pencil on map. In 1948 this "Green Line" dividing the city of Jerusalem into two regions, one controlled by the Arab Legion and the other by the Israeli force. This act was filmed and presented to architects, historians, activists, filmmakers, and other people invited by Alÿs to react spontaneously to the images during in person interviews. After that, various versions of the documented action were released. Each one with the sound of one of the interviews as background. A very poetic gesture made by Alÿs was able to trigger a deep discussion about power relations on the boarders of Jerusalem. Similarly, I believe that it is possible to generate political discussions about the importance of human echolocation for the education of the blind, by using temporary public art.

Figure 10: The Green Line by Francis Alÿs, Jerusalem, Israel, 2004.

2.2 Prototyping and testing for Human Echolocation

The ambition of this research is to disseminate human echolocation by triggering its perception in public space. Despite of the fact, that this field of study is being explored by scientists and other specialists that identify with this field of research, design ventures for sparking human echolocation perceptions are still rare. In this subchapter I will explain in detail the trials and experiments I have developed so far to test and explore my ideas for bringing human echolocation experiences to public space.

The scientific method applied in knowledge building could be described in a brief way as an interactive approach to problem solving by creating suppositions based in previously generated data, testing these suppositions, and using the test results to make decisions and build new suppositions to be tested. This cycle must be well described and documented to be replicated by other researchers. In other words, a scientific approach to problems is a powerful way to contribute to the understanding of certain phenomena's because a scientist is a data driven decision maker. Which, in a counterpart, does not mean that this method is perfect and immune to errors. Scientific experiments lead to opposing results, generating constructive intellectual conflicts. Taking out of the discussion the fact that the scientific knowledge building is not as democratic as it should and could be, having its centralization on rich countries. It is possible to affirm that the scientific knowledge is built collectively by humankind, like a wall made of bricks. Sometimes a broken brick must be substituted by a new one. Within time, it was proven that despite of its imperfection, this is a solid way for building knowledge. E.g., with this method some societies were able to start space exploration.

In addition, from the scientific method, a methodology for designing products based in data, and with the human subject in the center, was developed. This method is called design thinking. The design thinking approach to product design consists of an iterative process based on empathizing with the user needs. In this approach a human subject is central for the designer researcher and in the case of a digital product, this kind of designer has expertise in human computer interaction (HCI) and is commonly called User Experience Designer (UX Designer). This approach could be described as the scientific method applied to the unpredictability of a human subject. In a way, with this approach, product design decisions are made based in data generated during the researching process. Then, these decisions are prototyped and tested. The testing results generate new design decisions and new prototypes. This continuous cycle endures until a minimum valuable product is implemented. This minimum valuable product (MVP), after being implemented, keeps being tested and modified. This explains why from time-to-time famous applications like Instagram, YouTube and Facebook are renewing their interactions by coming up with new features. It is an endless developing process. This methodology became a powerful tool for designing better products and today is the standard for developing software.

With all that stated it is important to highlight that, the scientific method and the design thinking methodology were applied in this project.

As a scientific approach was made, I started with suppositions to be tested. Based on the analysis of the research described in the first chapter, it became possible to suppose that: If human echolocation can be learned by blind and non-blind people, its learning process can be enhanced and experienced by every human being able to hear. If it can be experienced by every human being able to hear, a human echolocation experience by itself is able to create awareness about its existence on a human subject that experiences it. Which would consequently, spread the knowledge about the ability. So, how to enhance the human echolocation practice and bring this experience to people in the public space?

There is not just one answer for this question. Different strategies could be applied, urban planning regarding dedicated places for this ability training, obligatory educational human echolocation programs at schools, blind children parenting introductory training, online remote learning, obligatory human echolocation training for blind people and endless more ideas that will keep appearing if this brainstorming continues. Despite of the fact that I believe a mix of all these strategies would be the best approach for spreading the ability, the chosen approaches that will be presented here are based on my professional fields of knowledge. Human Computer Interaction (HCI) and Public Art. Human computer interaction is the field responsible for improving digital ergonomics through software development, combined with physical aspects of a product. And Public Art is a field that covers many cultural, social, and political issues related to the access and usage of public space. The proposals ahead naturally converge to the interlacement of these two fields. Therefore, bringing new functionalities to the public space is used as a strategy for generating political discussions about the human echolocation theme and possibly generating transformations on the individuals that experience it. Still, the iterative process of design thinking applied investigates possible paths for enhancing the human echolocation learning practice through a possible future digital product.

2.2.1 Sonar Application

My work started with assumptions to be tested. The main assumption to be tested in the beginning of the project was based in a soundwave. A soundwave is a physical phenomenon. Despite the difference between speeds, a soundwave propagates in a medium in a similar way than light. Which means that it reflects on surfaces following similar laws of physics as light. As well, accordingly to the fact that every sound is a mechanical wave propagating on a medium, it is possible to assume that the nature of this propagation should be the same for sounds emitted from different sources, natural, mechanical, or digital. I suppose that it is possible to practice echolocation using not just natural sound emissions, but digital sound emissions and mechanical sound emissions. Part of this was stated in the article written by Dallenbach (1944), where it is referred to blind people using footsteps noise or the white cane impact on the floor as sound emissions source for echolocation. Within the context of human echolocation training, not everybody knows how to make a tongue click and it takes time for developing an effective one. Based on that, it is supposed that a repetitive digital sound with equal characteristics between each bounce could be helpful for a human echolocation introduction training. A digital sound source with those characteristics would guarantee that the differences between the echoes and the original sound would be coming from the characteristics of the surface echoing the soundwave. Accordingly, the first supposition to be tested is if a digital sound emission would work for humans and an echolocation aiding toll and an introduction for the ability. This sound emission could work as a button that when pressed by a person, a sound is emitted. To prototype this device, not even a fancy hardware would be need, as nowadays we have smartphones able to have different software installed in it. Every mobile application is a software that brings a new function to a smartphone, so in this case, the software to be prototyped and tested, would be an application to enhance the human echolocation training by allowing self-emitted repetitive digital sounds.

To investigate the possibility of creating a digital product for enhancing human echolocation training, the first step was to empathize with a blind person and understand how she/he was interacting with digital interfaces on their mobiles and computers. I had this opportunity through Professor Bruno Giesteira from the Design Department of the Faculty of Fine Arts from Porto University, one of my teachers at the time. He intermediated the contact with the blind person that was crucial for this project, António Manuel Silva. António was very effective on his help for the knowledge building about a blind user and the perfect kick start for the research and brainstorming about the product. Yet, not only that, but the perfect human subject for the previous prototype evaluation and testing.

When I met António I conflicted with my own prejudices about blind persons. All the time with him I was being obligated to reevaluate my perceptions by analyzing his impressive cognition about the world. Every moment with António made me understand the importance of my project. This importance in my opinion is not regarding the aid of the blind for them to face the being blind stigma, but to aid the sighted to build knowledge about what they simple don't know. I see this project not as an altruistic action towards the blind but as an altruistic action towards the sighted about a blind person.

My first contacts with António were through emails. António agreed on helping with the project and invited me to meet him in his office, on the library of the Faculty of Arts from Porto University. By the time, I got curious to understand, how, he was being able to handle this task, writing and reading emails. Further I understood by António's explanations that there are screen reading software on modern hardware, that allow blind users to read texts in a pace as fast as sighted person does. Still, computer keyboards had an embossed line mark on the letter "F" and on the letter "J". António told me that those marks allowed him to understand his fingers position over the keyboard, making passible for a blind person to type whatever is necessary. In addition, they count as well with just-in-time audio description about the buttons they are pressing on a mobile or can even use voice recognition software to type a text just by speaking. I arrived on the library secretary and as I was instructed through the digital media we were using to communicate, asked by António. António arrived and called my name. When I arrived next him and said hello, he looked into my eyes and extended his hands for a handshake. António with this hello could instantly calculate my size and where my eyes were, as well where I was and that my hands would be able to reach his. After that, he guided me to his office and gave me a chair to sit around a round table and sited on the opposite side. He was not using a white cane. I don´t know if it is a pleasure for him, to show in a first glance how the cognition of a blind person can be, however from my side I can say that, at this point I felt the weight of the lack of knowledge about blind people that I was sharing with the biggest part of the society. I got super impressed and exited by analyzing his cognition, yet this should rather be a shared knowledge by the society than an impressive experience.

At this first meeting, I made an interview with António, and explained about the project and about human echolocation. He, as most people that came across me during my studies, was hearing about the ability at the first time. After this meeting we made some others, in which we brainstormed and refined ideas for a possible digital product for aiding human echolocation training. Ideas about how this product should be, how he as a blind person would expect to have access to this digital bounce though a mobile. We talked about other applications that help the blind to know from where light sources are coming from or that allow a blind user to take a picture and have a just-in-time verbal description of what was photographed and on. This iterative process is part of the design thinking methodology applied to the project. After many iterations, design decisions for the first digital prototype were made. The first digital prototype of what until today is being called the "Sonar application" would consist only of a sound emission reachable by pressing the screen of the smartphone and on the possibility of changing this sound emission type through a settings page. It is important to state that the development of an effective verbal explanation on how to start echolocating, a tutorial, is relevant as integral part of this possible future product. However, during this research only the prototyping of the digital sound bounces was covered. The verbal explanation became a part to be researched and developed in the close future. For making this digital prototype I used a prototyping tool called Flynto application. Flynto application by the time was one of the few digital prototyping tools allowing sound feedback inclusion after a button being pressed. In the end this sound feedback after a pressed button, became the prototype itself, working on an IOS mobile device.

Figure 11: António Manuel Silva explaining how he uses a mobile. Porto, Portugal, 2018.

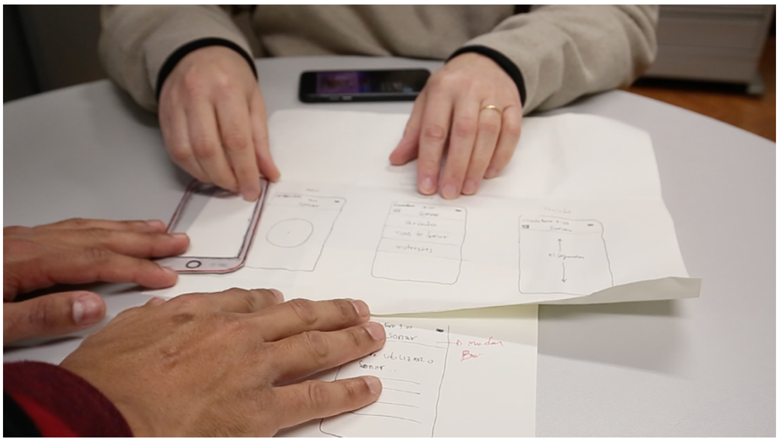

Figure 12: Iteration and ideation from the *Sonar Application* prototype with António Manuel Silva explaining how he uses a mobile. Porto, Portugal, 2018.

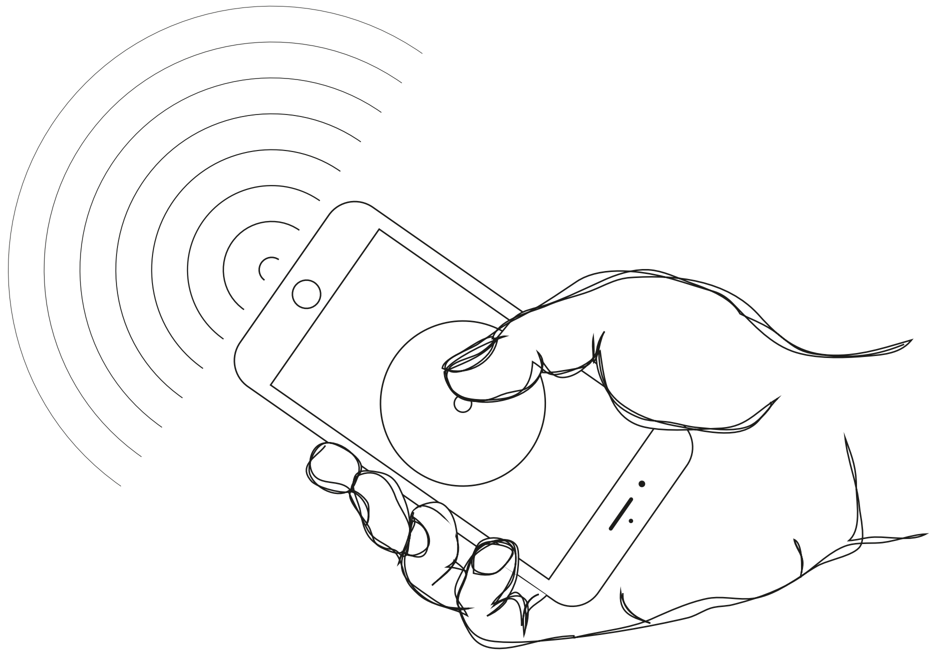

Figure 13: *Sonar Application* ideation Scheme.

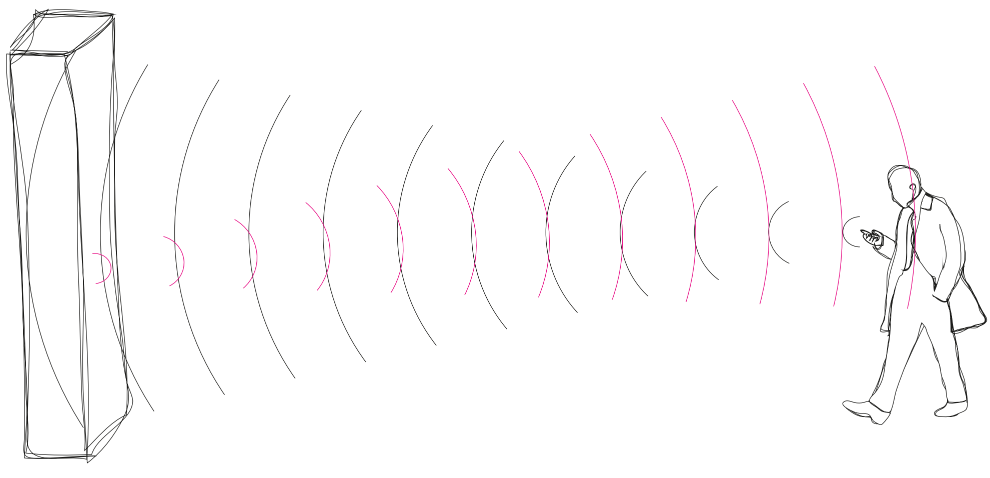

Figure 14: *Sonar Application* ideation Scheme.

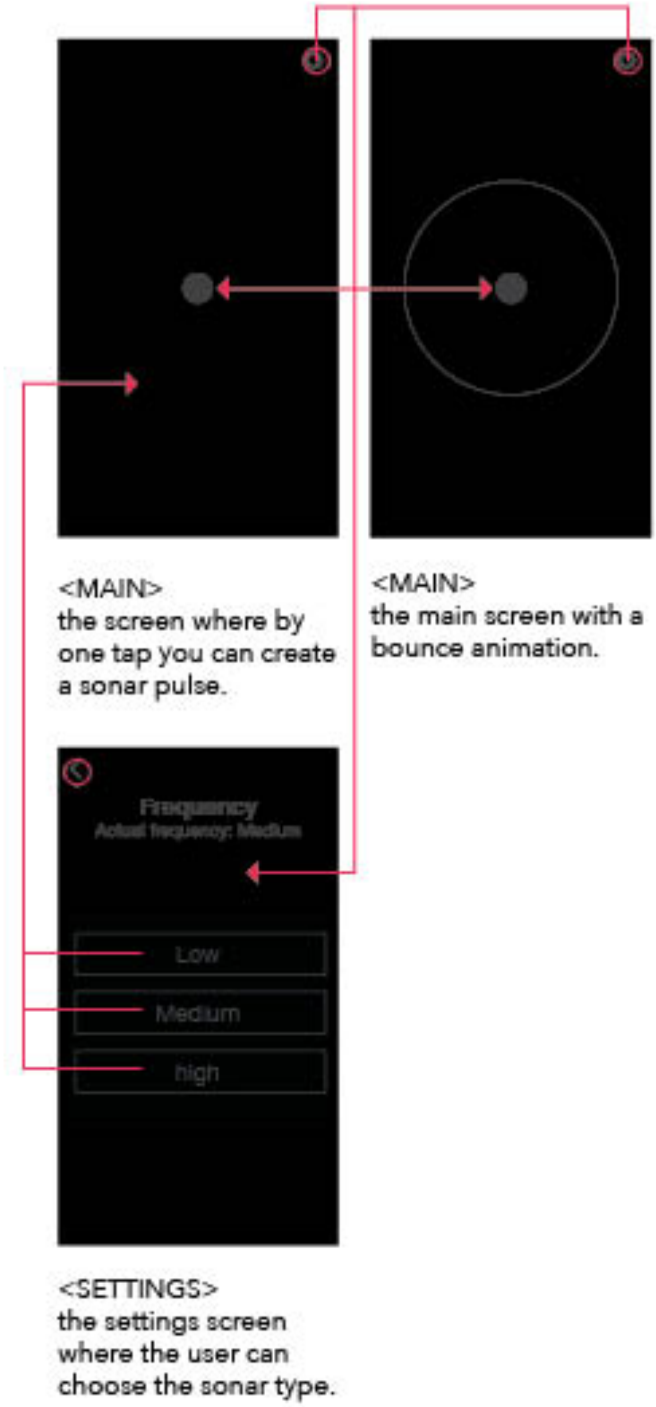

Figure 15: *Sonar Application* wireframe

2.2.2 Listening dimensions through echoes produced by a hand-held digital sound source

After this first iterative process, the first test to be made with this digital prototype was to see if António would be able to experience human echolocation by using exclusively the digital bounces coming from the smartphone with the sonar application running on it. I called this event as "*Listening dimensions through echoes produced by a hand-held digital sound source*" (2019). The test was made with António, a blind user, and it was handled in António's office. A Braille typewriter was put in the middle of the round table I described before, and the human subject seated in a chair in front of that table. An iphone 5 smartphone model with the sonar application prototype running on it was given to António. It was requested for him to find the object over the table and to measure approximately its dimensions solely by listening the echoes produced by the digital sound bounces coming from the smartphone on his hands.

Figure 16: *Listening dimensions through echoes produced by a hand-held digital sound source*. Usability test with a blind subject held in Porto, Portugal, 2019.

The result of the test was effective. António was able to handle the task with apparent ease. He was able to find the object over the table without touching on it, just by listening the echoes feedback of the digital sound source. In addition, he was able as well, to define the height and the width of the object, not precisely in numbers, but by understanding where the object starts and finish in a vertical axe and in a horizontal axe. Despite that he was involved on the conception of the digital prototype, he was using the device for the first time and never had an echolocating experience before. This test confirmed my supposition that a digital sound source would be enough for triggering human echolocation perceptions. As well that having the digital sound bounces coming from the hands of the user, like a kind of "Sonartorch", would work as a sound emission source for human echolocation.

2.2.3 Listening obstacles through echoes produced by a hand-held digital sound source

The second assumption to be tested was if a human subject would be able to avoid obstacles by using the sonar application prototype on a smartphone. This kind of tests I named *Listening obstacles through echoes produced by a hand-held digital sound source* (2019). More than one test regarding this assumption was made, but at this time with sighted subjects. During 2019, two tests were made at the public park Quinta do Covelo in Porto, Portugal, and seven other tests were made at the campus of the Faculty of Fine Art of the University of Porto. On the first two, distinct human subjects received the task of avoiding solid tree stalks in a woodland with their eyes closed and using solely the *Sonar Application* prototype working on a smartphone. And on the seven remaining, distinct human subjects were requested to avoid walls and solid concrete pillars following the same criteria on the first two tests described, with their eyes closed and using solely the *Sonar Application* prototype working on a smartphone. The outcomes were less positive than the ones on the first test *Listening dimensions through echoes produced by a hand-held digital sound source* (2019). Some subjects were able to find the walls, the solid pillars, and the solid tree stalks. Yet, others got confused by the sound and were not able to be sure about the echoes feedback. The wall was always perceived, but sometimes the pillars and the tree stalks not so perfectly. By observing these trials, I supposed that these inconsistent results were probably happening because of two main reasons:

- Firstly, people being calmer and more attentive in the tests, achieved better results than the ones moving the hand-held digital sound source constantly and frenetically into different directions. By the time I supposed that having the possibility of changing the position between the sound emissions (the hand) and the echoes receptors (the ears) constantly could be influencing in this apparently confusion. Echolocating animals have a fixed position between the sound emission and the receptors. Generally, in a constant triangular structure with the source being always in the most forward point of this triangle in relation with the receptors. E.g., dolphins and some bats emit the sound from their mouths and collect the echoes with their ears. Some bat species emit the sound through their noses and even have physical characteristics that apparently influence on the sound emissions direction (Big nose leaves that apparently converge the sound emission) and as well big sound echoes receptors (Big surfaced ears). Bats were chosen for this physical analysis since they are mammals echolocating on the same medium as humans, the air.

- Secondly, the pillars and the tree stalks have a round shape, which physically diverge soundwaves that enter contact with them. Which in a certain way diminish the quantity of a soundwaves that echoes back to the sound emitter. Still regarding this second reason, I realised that is not that easy to find the perfect physical environment for triggering human echolocation perceptions. Perhaps a good one could be built having this purpose heading the design.

Both perceptions lead me to make new decisions to be prototyped and tested:

The first decision, based on the first supposed reason, was to fix the digital sound emission into the head of a human subject, respecting the triangular structure, between the sound emissions and echoes receptors present on echolocating animals. For that, a kind of glasses carrying a small cubic bluetooth speaker in the middle of it was prototyped and tested connected via bluetooth with a smartphone running with the

Sonar Application prototype on it. In other words, the sound emissions fixed on the forehead of the human subject were being reached by touches in the smartphone screen. This device I called the *Sonar Glasses*. In addition, to assesses if add on the human body would enhance the human echolocation experience, namely extensions of the human ears and as well the creation of converging leaves around the sound emissions, sketches of what until today I call the *Sonar Mask* were made. Still into this direction *Ear extensions* made of wax were prototyped and tested simultaneously with the *Sonar Glasses*. Two new tests were the outcome of these two new prototypes. These experiments were an attempt to test the tree suppositions ahead. First: that it would be possible to perceive differences on the echoes of surfaces with different shapes. Second: that the ear extensions would enhance human hearing and echolocating capacity. And third, that the *Sonar Glasses* would work for locating and avoiding obstacles in a place with flat surfaced obstacles, and to listen the difference between shapes. These two new tests I named as *Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead* (2020) and *Listening obstacles through echoes produced by a digital sound source fixed on forehead* (2020). Nevertheless, it is important to state that the *Sonar mask* was not prototyped during the time of this research but prototyping and testing it will be part of the continuation of this research in the near future.

Figure 17: A young woman interacting with a solid tree stalk using the Sonar Application working on a IOS mobile device. *Listening obstacles through echoes produced by a hand-held digital sound source*. Porto, 2019.

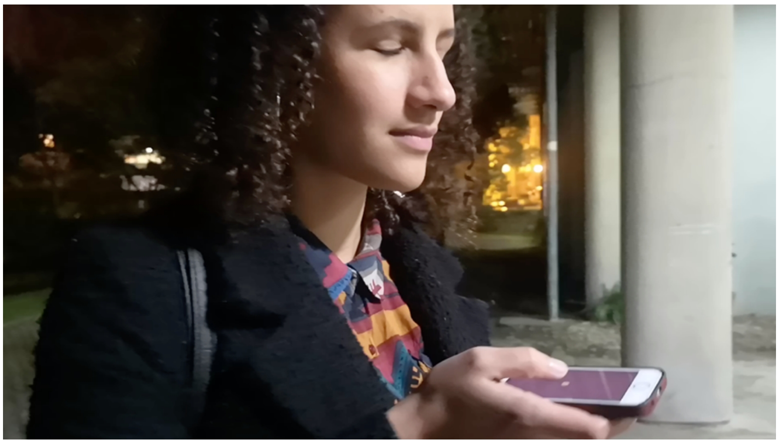

Figure 18: A young concentrating on the sound bounces of the Sonar Application working on a IOS mobile device. *Listening obstacles through echoes produced by a hand-held digital sound source*, Porto, 2019.

Figure 19: A bat image with prominent ears and nose leaves used as reference for the project.

Figure 20: Sketches from bats anatomy and *Sonar Mask* ideation.

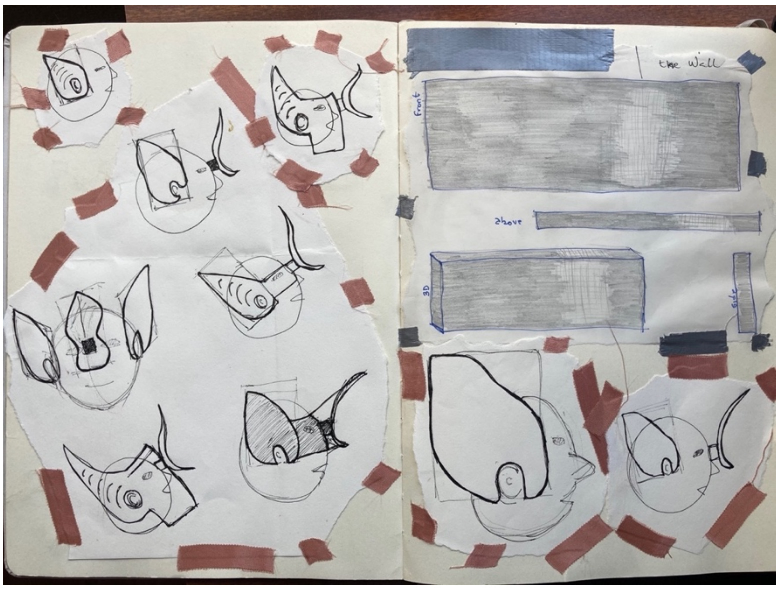

Figure 21: Sketches from *Sonar Mask* ideation.

Figure 22: *Sonar Glasses* version 1. A bluetooth speaker poorly attached on a sunglass.

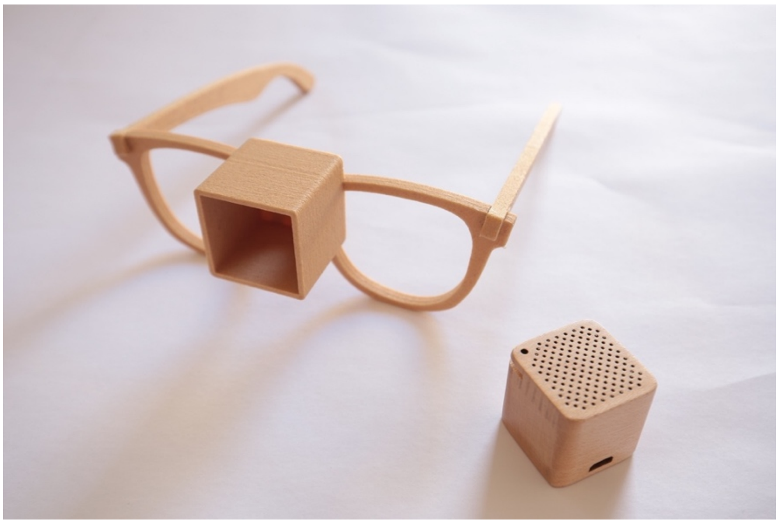

Figure 23: *Sonar Glasses* Version 2. 3D printed wood filament.

The second decision, based on the second reason - it is not so trivial to find good places to test devices for triggering human echolocation perceptions – was to project places with physical characteristics ergonomically favorable to trigger human echolocation perceptions. These spaces would be designed with the premises lifted during this research. In the case of a place with obstacles that reflect soundwaves in a more precise manner than round pillars and round tree stalks for an example. A place with solid obstacles, without sound diverging round shaped obstacles and in which the echolocator would be able to navigate by avoiding obstacles through echolocation. This fixed public art projects did not come to become a reality during the time of this master, but I will explain a little about them in the end of this chapter.

2.2.4 Listening obstacles through echoes produced by a digital sound source fixed on forehead

As shown on the pictures of the *Sonar Glasses* the first approach to fix the sound source on the forehead of a user, was to develop a glass like device able to carry the smallest bluetooth speaker I was able to find in the market. The first version was made in a rudimentary way and was tested by me. The second version was a 3d printed model in 3d print wood filament material and 3d print biodegradable light grey PLC. To test this new hypothesis, I decided for a place with very favorable architectural aspects, the *Memorial to the Murdered Jews of Europe*, Berlin, Germany designed by Peter Eisenman and Buro Happold in 2004.

The memorial itself, as all public monuments is passive to critics, as the one made by Richard Brody (2012) in an article written for the New Yorker. For Brody, the name of monument is too vague. He criticizes the fact that there are no names of people on the repetitive concrete structures and that apparently there are not information about who killed the Jews, when and how much were killed. This information can be accessed in an underground space of the monument, containing a permanent exhibition with documentation on the atrocities of the Nazi regime during World War II. As Brody, what annoys me about this monument is that is very common to watch the guards complaining with tourists climbing on the structures or playing with the structures. This happens because the tourists, apparently have no respect with the meaning of this memorial. By watching the described scenes of the struggling guards over and over, I started feeling that there is a clear error on the project. With that stated, now I will come back to the "*Listening obstacles through echoes produced by a digital sound source fixed on forehead*" (2020).

I made tests with two Belgian colleagues, Evy Van Hoey and Michael Duval, that were passing by Berlin during the winter of 2020. They did not know nothing about the project before and nothing about human echolocation either. I brought them to the memorial and explained the project in the way. There I requested for them to walk through the solid obstacles present on the space, with their eyes closed and using the bluetooth speaker connected to the *Sonar Application* prototype and attached on the *Sonar Glasses* to navigate and predict the location of objects.

Results: both human subjects were unbelievers of the project in the begging, yet after trying for a while they started to feel that they could build cognition about the structures solely by reading the echoes produced by the repetitive digital bounces. They did not become experts human echolocators in the one and a half hours long that the tests took. Yet, they gave some important feedbacks. They said that it took a while to concentrate and understand the sound feedbacks, which is evidence that there is a practical learning curve for the ability. Another important feedback is that they were not able to feel the obstacles solely by sound, yet as well by the air currents between the pillars and even by the luminosity touching on their faces when they were breaking through the shadows produced by the structures. This happened even on a cloud day. This feedback made me think that somehow the facial vision idea, referred by the first researchers of the awareness of distant obstacles by the blind can in some instance, make sense. An interesting fact about these tests, is that the young man tested had a better hearing on one ear than the other, yet this did not conceal his capacity of reading the sound bounces feedbacks. I would suppose before that this would make impossible to echolocate, but apparently, he was able to do it in a similar way to the young woman. Las but not least, the users complained that the "*Sonar Glasses*" does not fix so perfectly on the face, falling sometimes. That it could be better fixed.

Figure 24: A young woman interacting with solid squared pillars using the Sonar Glasses. *Listening obstacles through echoes produced by a digital sound source fixed on forehead*. Memorial to the Murdered Jews of Europe, Berlin, Germany, 2020.

Figure 25: A young man interacting with solid squared pillars using the *Sonar Glass*. *Listening obstacles through echoes produced by a digital sound source fixed on forehead*. Memorial to the Murdered Jews of Europe, Berlin, Germany, 2020.

2.2.5 Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead

The test *Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead* (2020), consisted in a human subject seated in a chair, wearing the *Sonar Glasses* and carrying with his own hands the *Ear Extensions* behind his ears. In this case, as the subject had no freehand, I, as the researcher, was responsible for triggering the digital sound emissions on the forehead of the human subject by pressing the smartphone screen. This decision was made because prototyping fast to make decisions is part of the design thinking methodology and the idea was to be sure that, would be productive to invest in a *Sonar Mask* containing a better developed built-in *Ear Extensions*. So, less time was used to be sure that the *Ear Extensions* would work, or not. With that stated, while I was triggering the sound emissions, I was lifting in front of the subjects' face, in approximately 0,6m distance, objects with radically difference surfaces: object A, a volleyball (a spherical surface); object B, a cubic wooden box (a flat surface) and object C, a kitchen metal bowl (a concave surface).

The experiment happened firstly with the objects in a static position in which the subject was informed about what object was in front of him, A, B or C. A time was given to the tested user to understand the difference between the echoes in this static position. In a second trial, I tested the same objects, yet with movement. I moved the objects into different directions in front of the subjects' face. I was changing from one object to another often and randomly without informing the subject. I requested the subject to try to describe the differences between the echoes from each object, as well as the direction of the movements the objects were performing. With the experiment results I could realise that the object A (a spherical surface) was more difficult to be perceived than the objects B and C. I suppose, this is due to the fact that the angles of impact of the sound-wave on a spherical surface tend to diverge the sound-wave and in a counterpart, a flat surface reflects the sound-wave back with the same angle of impact and, a concave surface converge the sound-wave back with a focal point related to the nature of the surface curvature. The subject was able to recognize that the echoes of the object C were stronger and was, as well, able to define the material of the object.

He said that the sound that was coming back was metallic and that for sure I was raising in front of him an object made of metal. Interestingly, horizontal movements made with the objects were described as a kind of laid eight shape movement, the infinity symbol.

This discrepancy between the real movement and the perceived movement was very interesting for me and is a subject that I intent to investigate deeper with more trials of a similar experiments. Regardless of that, from this last experiment my first art project for the awareness of human echolocation in public space was developed and tested in the city of Funchal, Portugal. This artwork/artefact will be described on the paragraphs ahead. I am calling it an artwork/artefact due to its hybrid nature of working at the same time as an artwork and a researching tool.

Figure 26: Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead, 2020.

Figure 27: Figure 29: Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead tests. Langenargen, Germany, 2020.

Figure 28: *Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead* tests. Langenargen, Germany, 2020.

Figure 29: *Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead* tests. Langenargen, Germany, 2020.

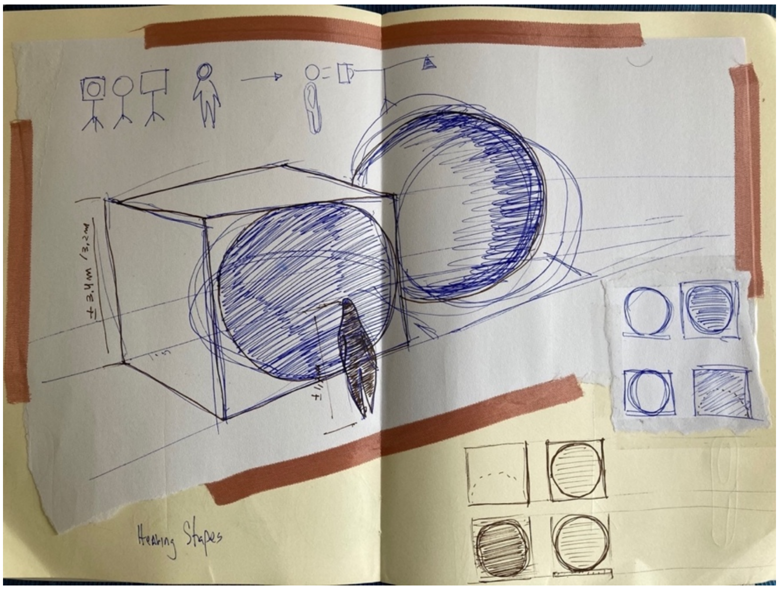

Figure 30: Sketches of the *Itinerant concave, spherical and flat surfaces*. Funchal, Madeira, Portugal, 2021.

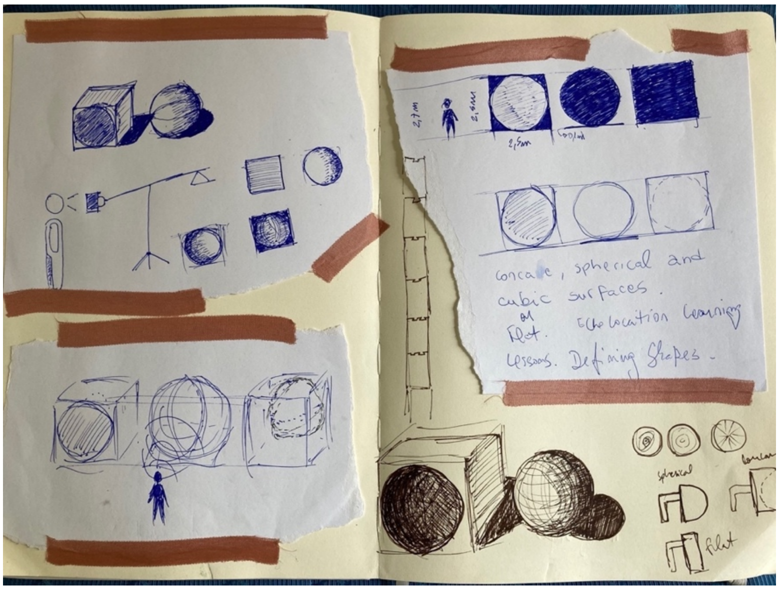

Figure 31: Sketches of the *Itinerant concave, spherical and flat surfaces*. Funchal, Madeira, Portugal, 2021.

2.3 Itinerant spherical, flat, and concave surfaces (2021) – a temporary public art installation for disseminating human echolocation

Artwork name: “Itinerant concave, spherical and flat surfaces” (2021). Dimensions: Customizable space of 12 to 24 cubic meters approximately. Materials: Biodegradable plastic (PLC) and stainless steel. Three different surfaces, a concave, a spherical and a flat one. All made with the same material and lifted in customizable heights by tripods made for supporting the photography equipment. The intervention is accompanied by a sign explaining briefly what human echolocation is, how to start practicing it naturally and the possible usage of the objects. This explanation is written in Braille letters and in embossed Roman alphabet. An embossed iconography is as well supporting the usage explanation. Last but not least, the sign presented as well as QR code leading to a link in which the spectator would be able to download the “*Sonar Application*” prototype and use it as an option to experience echolocation within the objects. This sign was made with the same material as the geometrical surfaces and was lifted in a lower height than the surfaces by the same kind of supporting equipment. Ideally the surfaces should be in the face height of the human subject using it. The artwork is not site-specific, nut context-specific, being able to be installed into different places. This itinerant capacity feeds the intention of spreading the human echolocation ability by allowing its installation on different cities around the world. Until the present moment the intervention has taken place in three different sites at Funchal city, Madeira, Portugal.

Figure 32: A young woman interacting with the *Itinerant spherical, flat and concave surfaces* installed in São Tiago beach, Funchal, Madeira, Portugal, 2021.

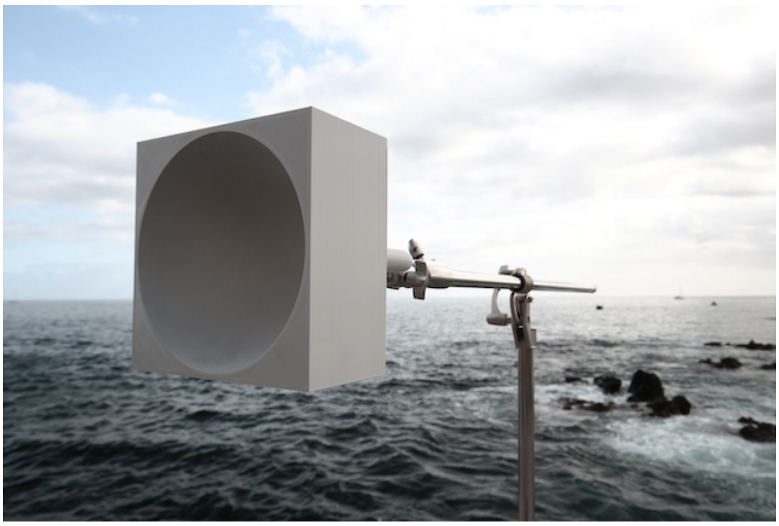

Figure 33: The concave surface - *Itinerant spherical, flat and concave surfaces* installed in São Tiago beach, Funchal, Madeira, Portugal, 2021.

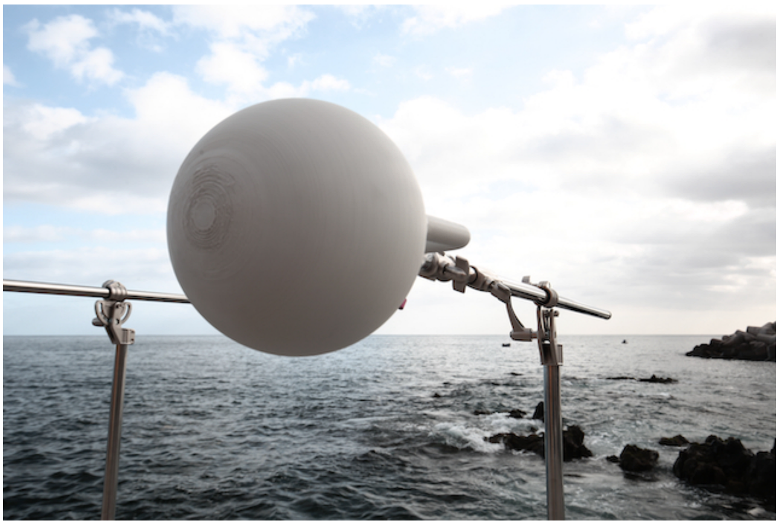

Figure 34: The spherical surface - *Itinerant spherical, flat and concave surfaces* installed in São Tiago beach, Funchal, Madeira, Portugal, 2021.

Figure 35: The flat surface - *Itinerant spherical, flat and concave surfaces* installed in São Tiago beach, Funchal, Madeira, Portugal, 2021.

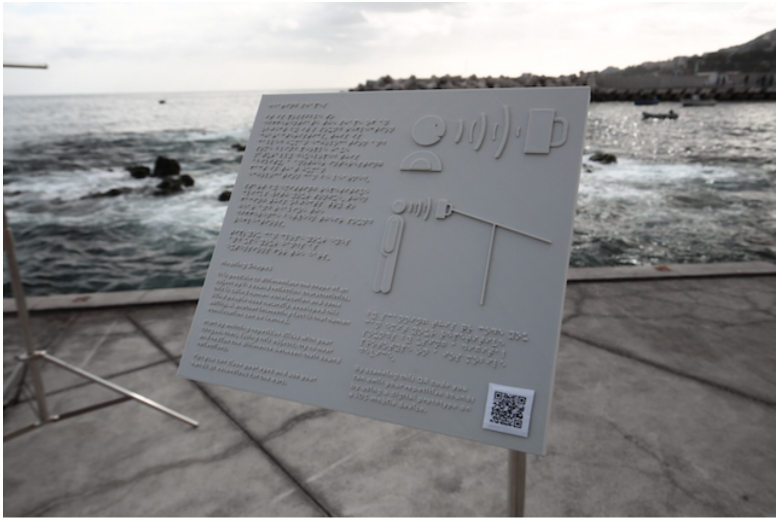

Figure 36: The sign - *Itinerant spherical, flat and concave surfaces* installed in São Tiago beach, Funchal, Madeira, Portugal, 2021.

I mostly live in Porto, but I am often in Berlin, Germany, because of professional reasons. During the period of this research the worldwide covid-19 pandemic took place. Because the city of Porto was under restrict lockdown, it was not possible to organize a public intervention there. So, I planned to stay for some months in Berlin and make this part of the investigation there. However, meanwhile I traveled to Madeira, which coincided with Europe's second wave of the covid-19 crisis getting more restrict. This obligated me to stay in Madeira Island for some months, because Germany decided to close the boarder for Portugal, allowing just native Germans or people living legally in Germany to cross the boarders. So, I got locked in the island and had to make the intervention on its biggest city, Funchal. Luckily, Funchal was never under a super restrict lockdown as Porto or Berlin.

Somehow, during my two months stay in the Island, I had the opportunity to build empathy and friendship with people around. This was very valuable. I was staying in a local residency in Funchal city, the main town of Madeira. This led me to meet other foreign travelers that were staying in the same place. These foreigners became interested in my project, and I had time to help them with some personal issues they were involved by the time. E.g., one of them was needing new portraits for his Curriculum Vitae and another was needing some shrimp-based food photography to feed his parents business website. In exchange, they; Jannik Weidinger, Tibor Lange, Hugo Avalon and Tim Thiele; were my friendly backup during the first intervention day and were very enthusiastic on triggering the art project and calling the attention of spontaneous users.

While I was in Funchal, I had to remotely 3D prints the surfaces and the sign. These four objects were materialized in Porto and sent to me by mail. I have as well search and buy suitable supporting tripods and clamps.

To find the right place for the intervention was itself a challenging. Which would be the best place to activate an itinerary experience of human echolocation perceptions? As I use photography to study the public space, this inevitably makes me stroll around cities and indirectly figure out good spots for making interventions. Another thing that helps on deciding good spots is the fact that I enjoy running regularly. Running is way of exploring unknown places. By doing this both activities I found two places that I initially thought would perfectly work for making the intervention. Places that in the end proven not so perfect as appeared in the first glance.

Still, as the intervention was being made during covid-19 pandemic times and since it demanded people interacting with objects. The uncertainty of how much this would inhibit spectators to interact demanded a sanitary security planning. Accordingly, during the installation of the objects in the public space I also placed disinfectants sprays and cleaning towels for cleaning the objects regularly.

Finally, now I will elaborate on the intervention and on the lessons learned on each one of them. The first chosen place to install the objects was a public concrete beach called São Tiago on the east side of Funchal, and next to a yellow fortress called São Tiago as well. The place has a bar with a privileged view of the beach. I decided that this could be a good spot for the intervention because I believe people sunbathing and swimming are more open to explore new experiences as they are out of their daily tasks and in a more relaxed mindset. Another fact is that groups drinking beer on a bar are always suitable to try new experiences. To reach to the place with all the necessary equipment to make the intervention I hired an Uber car and driver through the Uber application. On all the further interventions that will be described, I used the same transport method.

At this day I had as well the help of my new friends of the residency, Jannik, Tibor, Hugo and Tim. My friends started to interact with the objects and tried to differentiate them by making their own tongue clicks and following the instructions on the sign I left nearby. Soon, aleatory people start appearing and interacting with the objects. Some of them, just read the sign and started to test the objects, and some of them even after trying it, looked around for the responsible by those objects in the public space. The expected result contemplated less verbal interaction with the spectators, yet the interaction happened very often, and the project proven to be very well succeeded on triggering contacts with people interested in science, art and social concerns. Another interesting fact is that people interested by the objects on their majority had a higher educational background. I would like to make other trials among different cities to validate if this will be a constant factor, I suppose, not. A hundred per cent of the people that used the objects and after came to talk with me, were hearing about human echolocation for the first time on their life. Some of them got really interested about know this cognitive capacity of blind people and of all humans, and some others developed an overestimation about what I was doing. As I was a kind of illuminated mind by trying to help the needy. I personally do not feel this is the case, I am simple very interested about the human capacity of developing such skill naturally and I believe the world must know that.

The second trial was not so well succeeded. The chosen place was as well a concrete beach, but this time a half-public one. The site is called Lido Poente and is a part of the Lido Bathing Complex. The place can be viewed by people walking in a seaside path but does not make part of the regular walking path. At this second time I was alone and intending to research legitimate ignitions, solely by unknown people. The place is beautiful and perfect for the documentation of the intervention. I arrived very early and chose a beautiful spot near the ocean, to install the objects. It took a time for the first spectators to arrive, but soon they started interacting with it. A person that was doing his morning walk, a man around his 60s, read the sign and tried to understand the differences between his own tongue clicks echoes feedback at the spherical surface and at the concave surface. There were not so many people around, and by curiosity, he came to me and asked what where those objects. I explained a little about the project and that I was interested on using the public space and normal people for my research and for disseminating the knowledge of human echolocation ability. He said to me that he changed his walking route just to make a closer examination on the devices that he was being able to see in approximately 70 meters. He said as well that he would like to see more initiatives like this one on his hometown, Funchal.

Figure 37: A young man interacting with the Itinerant spherical, flat and concave surfaces in Lido Poente beach, in Funchal, Madeira, Portugal, 2021.

Other people came by to analyze the objects in this day, a young man for an example triggered the object more than three times, with swimming ventures between them. However, after some time, a woman, a Portuguese citizen from Funchal started complaining about the place in which the devices were installed. She demanded to sunbath exactly on the place they were. She called the lifeguard that looked for the responsible for the object. He found me and asked if I had authorization for doing that installation. I said that I didn't and that as the place was public, I thought it would not be a problem. Yet as a figured out, not so public as the name suggested. I didn't want to discuss with the women and the lifeguard, and I just said that my objective was not to generate this controversy but just to analyze the reaction of the public to the functionality of those objects. So, after this conversation, I decided to disassemble the installation and took it to a less noble place on a beach just in the side of this one. I stayed there for a while and at this time nobody came to interact with the objects. After being tired and emotionally confuse after the Funchal's citizen complaint, I decided to end the intervention on that day. This problem made me think about how to plan better the intervention site in a near future. Perhaps I install it on more open and less noble sites. The next steps are as well to make this intervention in different cites than Funchal. Probably Porto and Berlin as the main plan was before.

I did still a third intervention in Funchal, in an open area, next to a museum called CR7. The place is famous and visited by tourists by having a public sculpture of Cristiano Ronaldo, the famous Portuguese soccer player on its surroundings. I decided for this place because it was spacious and as well a touristic route from the city. The objects this time triggered the attention of a lot of people that were walking by. Many of them read the sign and some even downloaded the “Sonar Application” prototype by scanning the QR code on the sign with their mobiles. However, none really activated the devices. A young girl had her mom screaming on here after touching on the objects. I suppose the in this case, differently from the ones described previously, the covid-19 pandemic inhibited the spectators of really triggering the objects. Yet, this is just a supposition. After leaving the devices there for 3 hours without any real activation, I decided to abort the innervation and uninstalled the objects.

Figure 38: The Itinerant spherical, flat and concave surfaces installed at the surrounding of CR7 Museum, Funchal, Madeira, Portugal, 2021.

2.4 Permanent Public Art projects regarding the dissemination of human echolocation in the public space

2.4.1 Convex and concave cylindrical surfaces (2021) – a fixed public art project for disseminating human echolocation

In 2021, I decided to participate in a site-specific sculpture open call that was handled by POLDRA – Public Sculpture Project, Viseu, Portugal. The artwork I projected is based on the premises lifted by this project. In the fact that concave surfaces converge back the echoes and convex surfaces diverge the echoes. These characteristics would produce different echoes perceptions on the spectator and would work as human echolocation perception triggers. Consequently, disseminating the human echolocation ability among the spectators activating the objects.

The artwork consists of two identical mirrored half steel cylinders, rising from under the soil, and placed 1.1 meters of each other in opposite directions. The two objects would (distortedly) reflect everything that surrounds them including the Fontelo forest (site made available by the Poldra for the proposals). Despite of its aesthetics, these objects were not made to be primarily seen but instead to be heard. Because different surfaces produce different echoes, the nature of these half steel cylinders would allow visitors to play, experience and perceive the environment around by the echoes of nature or self-emitted sounds. Together with the artwork, a sign in the same material of the half cylinders, would be placed providing instructions on how the experience should be activated.

The artwork would be constituted by nine CorTen steel sheets (4 - 6x3000x1500mm, 4 - 8x3000z1500mm 1 - 6x3000x750mm) and eight polished steel sheets (2,3000,1500mm each). Each half cylinder will be composed by two of the less thick CorTen sheets rounded with radius of 0,95mm. These rounded sheets will be welded on each other forming a 3m height half cylinder. This structure will be welded on a base made by two of the thickest CorTen sheets welded side by side and forming a 3x3m squared base. On the four surfaces of each half cylinders, two concaves and two convex, the four polished steel sheets will be placed creating the reflective surface. The remaining ns smaller sheet will be user to make the activation sign.

The objects have 3,008m height in total, however only 2,6 meters height are visible to the visitor. The remaining part of the half cylinders would be under soil, in

0,408 meters deep. The width of each half cylinder will be of 1,9 meters and the distance between each other will be approximately 1 meter. The idea is that the objects rise from under the soil, as a natural structure would.

The half cylinders and the sign plate would be assembled at Pirra metallurgy in Estremoz, Portugal and would be transported by truck to Viseu. In Viseu a hole will have to be dig, with the size of 6000x3000mm and 312mm deep. The trucks will have the necessary machinery to install the objects in place. In the end soil will be put back into the hole, making the half cylinders bases disappear. A similar process but less bulky will occur for the installation of the activation sign.

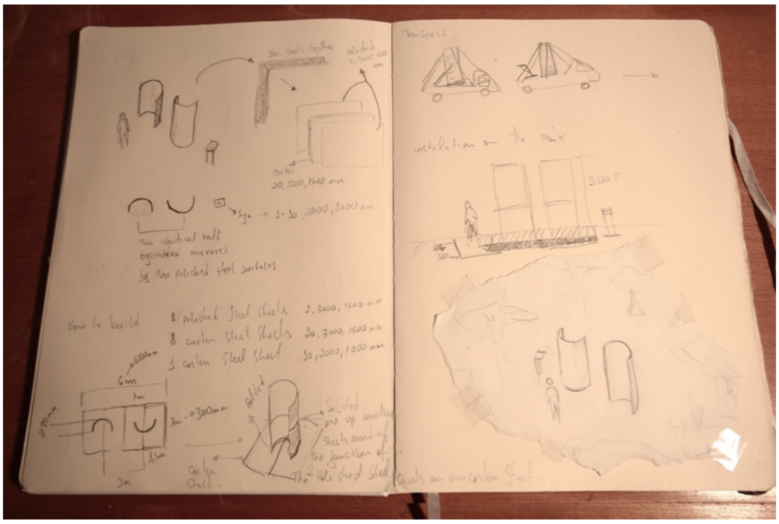

Figure 39: The *Convex and concave cylindrical surfaces* sketches, Berlin, Germany, 2021.

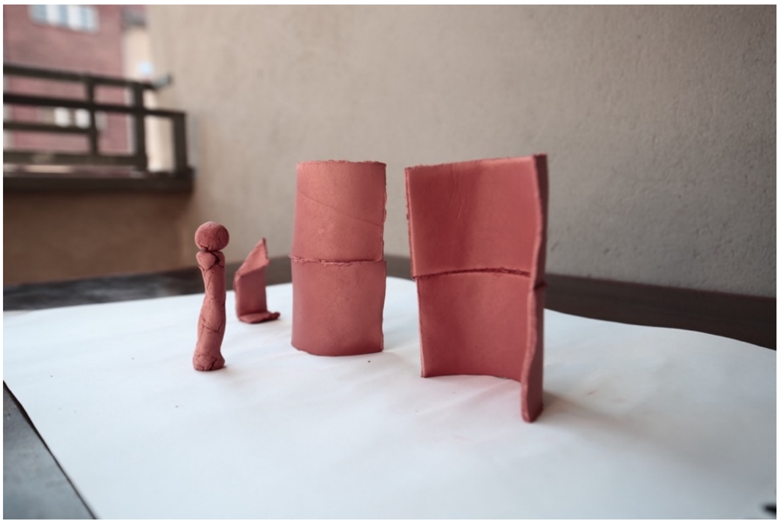

Figure 40: The *Convex and concave cylindrical surfaces* clay model, Berlin, Germany, 2021.

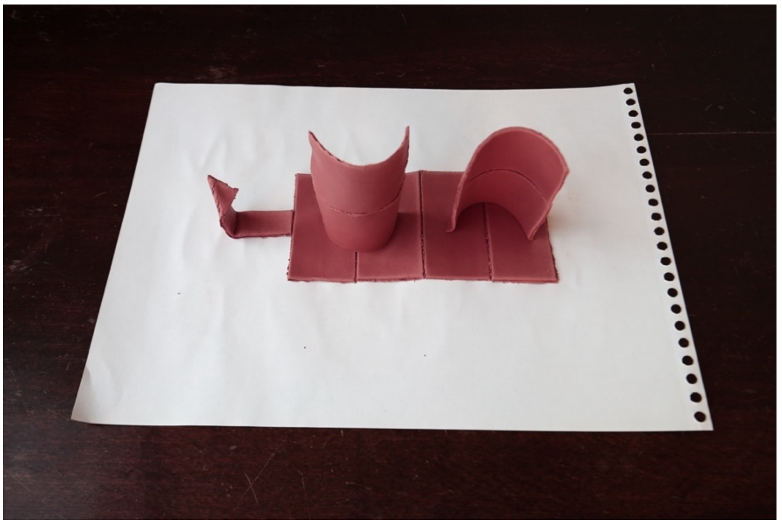

Figure 41: The *Convex and concave cylindrical surfaces* clay model. The full structure, including the base that would be invisible, under the soil. Berlin, Germany, 2021.

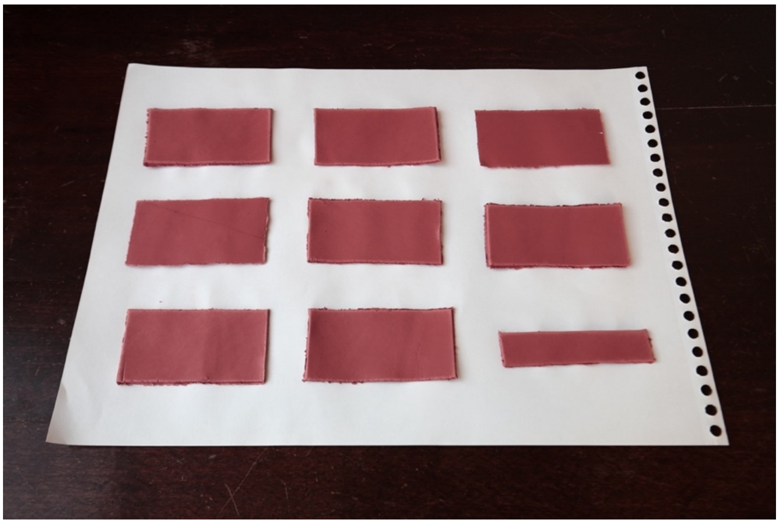

Figure 42: The Convex and concave cylindrical surfaces clay parts. Separated pieces of the full structure, showing that that the full structure would be made by elementary pieces of steel sheets with average cuts easily findable in the steel sheets market, Berlin, Germany, 2021.

Unfortunately, the artwork proposal, the “*Convex and concave cylindrical surfaces*” (2021), was not accepted in the site-specific sculpture open call that I handled in. I believe, due to its elevated production price, or simple and most probably due to the lack of fit for this specific open call. Despite of that, I plan to continue sharpening this project and to subscribe it into future opportunities. One thing that I believe, that was missing there, is a realistic image of the project in the middle of the forest. Something that can be reached in future, with modern architecture 3d rendering software. This is one of my next objectives regarding this project.

2.4.1 A Maze to be listened – a permanent public art project for disseminating human echolocation

A maze to be listened (2019) is a fixed public art project that raised just after my second supposition tests, *Listening obstacles through echoes produced by a hand-held digital sound source* (2019). After these tests, I concluded that round pillars would work for triggering human echolocation perceptions, yet, that pillars reflecting sounds more efficiently, by being concave or flat, would probably work better to achieve this objective. Some of these suppositions were confirmed with tests I did after the *Listening obstacles through echoes produced by a hand-held digital sound source* (2019) test. E.g., *Listening obstacles through echoes produced by a digital sound source fixed on forehead* (2020) and *Listening shapes, with ear extensions aid, through echoes produced by a digital sound source fixed on forehead* (2020).

A maze to be listened (2019) would be a maze made of solid pillars or walls, allowing a walking circuit between them that would be achieved by echolocating its obstacles. I decided to not limit the maze space with walls, yet with grass. I judge this would be enough to create awareness on a blind echolocators about the limits of the maze. If you analyze, on the sketch that you will see ahead. The maze would have a way to enter and a way to exit and allows the spectator/echolocator to make any circuit inside of it until reaching its exit.

If I had a maze like this for an example, would be easier to test my suppositions and devices and I discovered a place with similar characteristics. The Memorial to the Murdered Jews of Europe in Berlin, Germany. As described before, this site was used to handle test with the *Sonar Glasses - Listening obstacles through echoes produced by a digital sound source fixed on forehead* (2020).

The project is still ongoing, and will be changed in the future, but the idea to make this maze material with a relatively translucent material, to make clear that it was made to be seen, but to be listened.

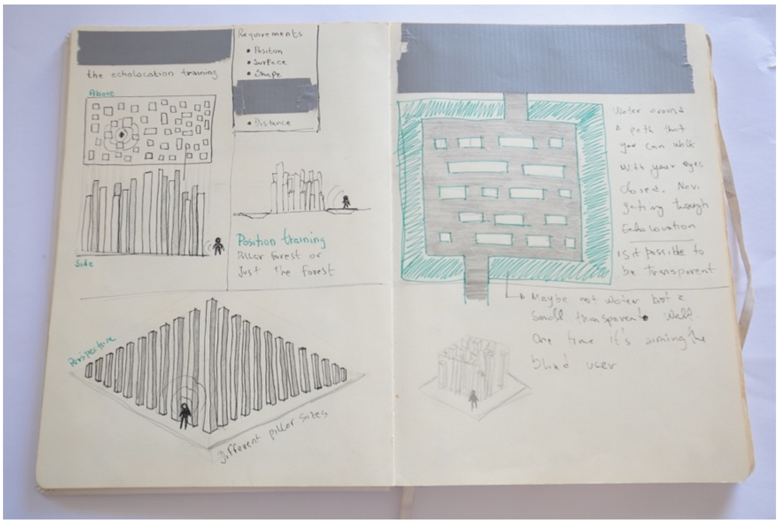

Figure 43: Sketches from the *Human Echolocation Maze* ideation. Porto, Portugal, 2019.

Figure 44: *Human Echolocation Maze* 3D printed model. Porto, Portugal, 2019.

Conclusion Notes

This master project, *Disseminating Human Echolocation through Public Art*, investigated the phenomenon of human echolocation through public art. I come to realise that the ability is not spread simply because of the lack of knowledge about it. Most people that I came across during this master research, between 2018-2021, were learning about it for the first time. I suppose that there are very strong political barriers preventing the fast standardization of human echolocation ability as the main mobility training for the blind. As reflected in chapter 1, it was also due to political reasons that it took more than 30 years until Braille technology became the standard for alphabetizing the blind. I wonder, how much time it will take for human echolocation to be taught as the standard for blind mobility education? Is it possible to develop strategies for fasting the dissemination of this human skill? Sighted people are more accessible in the public space and can act as valuable transmitters of human echolocation. Helping to spread this ability and to create awareness about it. Perhaps allowing the average people to experience echolocation may help spreading the phenomenon. I believe this research is critical because it is facilitating the acceleration of this process.

In the introduction chapter of this document, I listed three research questions that I feel that I am now able to answer:

1. How does a public art device for temporary placement in public space may generate curiosity about human echolocation?

The *Itinerant concave, spherical and flat surfaces* (2021) temporary public art project was able to reframe the site in which it was installed. Its uncanny appearance attracts passersby, that occasionally follow their curiosity into the activation of the artwork/artefact. This leads the users to became aware of an ability of their own that they didn't know before. This strategy can be repeated for spreading other subjects.

2. How should aiding devices for human echolocation training be?

Designing devices for aiding the blind continues to be my ambition for a mid-term future and disseminating human echolocation through art and design, seems to be becoming a long-term ongoing project for me. The research I did helped me to build some guidelines for these possibilities. A digital sound source works. *Ear Extensions* work. Fixing the sound source on the forehead of the emitter works. Yet, still a lot of research should be done to build more solid premises about how these devices should be. My aim is to keep exploring this and to enter in contact with other researchers exploring the field.

3. How an echolocation experience in public influences its participants perception of blind individual´s social life?

Although an echolocation experience in public changed some of the user's perception about human ability to develop space recognition through sound, I think I was not able to change the perception of the sighted users about the benefits of human echolocation for the education of a blind person's mobility. I feel that people in general create a superficial understanding of my intentions – a stranger trying to aid "unfavored minority" — instead of a person trying to amplify the potential of public space and public art for learning more about humans and nature. I don't feel comfortable with this outcome.

My purpose is to build awareness about the capacities of a blind person to have more control on his/her life. I plan to investigate strategies to deep in this message in the future. I intent to keep working with temporary public art, to investigate the possibility of designing entire places with physical aspects dedicated to the human echolocation training. I believe that a public space with those characteristics may have a remarkable aesthetics and a strong symbolic power that will, by itself, generate important political discussions about human echolocation. Consequently, bringing more awareness to its existence. I also think that it may prompt significant discussions about the current barriers in public space when considering blind minority.

I come to understand with my research that I just gave the first steps of my path towards human echolocation subject of study. I still have few ideas that I would like to test, rehearse, and prototype. Ideas that emerged from this master research and that haven't been explored yet. I suppose that by studying deeper the physical characteristics of bats, the most specialized animals to echolocate using the air as a medium and integrate that knowledge with art and design strategies will help trigger an even stronger perception of human echolocation in blind and in sighted people.

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