THE PALLOPHONE

Eleftheria Manta, Hugues Genevois
Institut Jean le Rond d'Alembert, équipe LAM
Université Pierre et Marie Curie

ABSTRACT

This paper describes the "*Pallophone*", an instrument conceived and developed by the researchers of LAM[1] that is designed to enable deaf people to *feel* selected sounds from their surroundings (noise, natural sounds, music and voice). The instrument is based on the principle of transforming acoustic waves into vibrations that stimulate the acoustic nerve directly by bone conduction or tactile sensation. The portable instrument is comprised of three elements - an acoustic sensor, an amplifier and a tactile transducer – and its small size, light weight and adjustable features allow it to be used unobtrusively in a wide range of social situations.

An exploratory workshop in Athens with the group of comedians of the deaf theatre with the participation of Sophia Roboli, interpreter in sign language allowed a number of experiments to be conceived for laboratory testing. The experiments subsequently conducted in the laboratory involved testing different types of tactile transducer with the objective of discovering and understanding the multiple types of cognition associated with deafness and sensitivity to tactile stimuli (threshold, sound colours, variations, etc…).
We are currently working to improve the sound selectivity, vibration quality, size and ergonomy of the *"Pallophone"* (an important consideration since deaf people are in need of their hands for *signing*; thus our system has to be hands-free and easy to place).

INTRODUCTION

Does sound create an Image? Can an image evoke a sound? Does listening/hearing involve the form of say a scream/cry[2]? Or is it simply the image of that scream? Is it a mirror of itself? Could it become a witness of existence? Historically, sound and image - image and sound - are associated with strong/severe mental representations.

Senses have always played a leading role in the understanding of our environment and our own being within it, and play an important role in our creative negotiation within it.

Where should one look for a definition of *sound* and *image* - image and sound? Are they both sides of the same coin? Or traces of something else? Are they transmissions, or perhaps just emanations of a sign? Is it a manifesto? And if it is, what does it show? This may be an intense manifestation of human identity, the form in which it affirms itself or disappears.
Sound and image comprise these stimuli, the vital elements through which we can achieve self-determination. The link with sound might be unconscious, but it is nevertheless transposed on our being.

There is no single model available to study its expressions, understand happiness, pain, or anxiety? Whence the question: how can we define our perception of sounds? Is it we who are hearing? Or is it the sound, or the beyond of its absence, that is hearing us? When we are hearing a sound, we are watching it; or is it sound that which hears us, is it that which watches us?

---

[1] Laboratoire d'Acoustique Musicale

[2] « Oh my god, the dishes make noise and they "scream". And the door is screaming also »
Cf. Annexe - Transcripts

HYPOTHESIS

Do deaf people have the ability to hear?

Apparently, the answer is yes since there is no individual who is entirely devoid of sound experiences. Even the congenitally deaf « do not complain of living in "*silence*", as such a term corresponds to nothing in their experience »[3].

Today we know that sound perception is also a function of the left hemisphere in professional musicians and experienced listeners who understand its grammar and syntax, and for whom it has become a complex formal structure. Among the deaf or the hearing impaired, due to non-existent or weak hearing, the cortex's functioning is reorganised, with consequent and observable cerebral diversification. Visual perception is substituted in some way for auditory perceptions: the visual cortex then assumes verbal communication functions, through sign language, whose structure has a very precise grammar and syntax. Thus, the right hemisphere is responsible for a significant part of the language processing.

According to linguists Scott Liddell and Robert Johnson: « signs are not a succession of instantaneous configurations "*petrified*" in space, but a language continuously and richly modulated in time, punctuated by "*movements*" and "*thoughts*" similar to those of music »[4].This quote, putting both the question of the object and sound structures, goes in the same direction as the intuitions of Wittgenstein on the nature of sound and music and its structural value , for whom it would not have any meaning/sense, but would make sense. Sound and music has an affinity with homologous structures, beyond its own form and its own image. On this point, the contribution of Wittgenstein was decisive to free us from closely "*acoustic*" vision of music. This hypothesis is legitimate to the question of how these analogies and structural homologies could result in a world where the perception of sounds is weakened or non-existent?

Indeed, in the hearing world, not only the acoustic part but also the structural one of sound and music manifests itself through dance, which exists in all the cultures of the world. The dancer responds with an analogy gesture - more or less structured - the musical idea or « *Musikalische Gedanken* »[5] he perceives.

Obviously this analogy between noises, sounds and music, on the one hand, gestures, images and movements, on the other, involves a transliteration, which is not automatic, but in reality is a creation and invention. This aspect of creative transliteration is inevitable in any attempt to transpose music in the non-hearing world. Because by using images, movements and gestures « What *can* be shown *cannot* be said »[6] (4.1212).

In addition, it is well known that « the profoundly deaf *hear* noises of any kind and it is not rare that they are very sensitive to vibrations of all kinds »[7].
Nevertheless, it should be reminded that there are several types and levels of deafness; pre- and post-lingual deafness, conductive deafness, sensori-neural deafness or mixed. This means that, as for the hearers, there is a huge difference in sound perception.

---

[3] Sachs, O. (1996). Des yeux pour entendre, voyage au pays des sourds.(pp. 35) Paris : Seuil
[4] Johnson, R. , Lidell, S. , in Sachs, O. (1996). Des yeux pour entendre, voyage au pays des sourds. Paris : Seuil
[5] Wittgenstein, L. Tractatus logico-philosophicus (1993). Paris : Gallimard
[6] Ibid
[7] Sachs, O. (1996). Des yeux pour entendre, voyage au pays des sourds.(pp. 36) Paris : Seuil

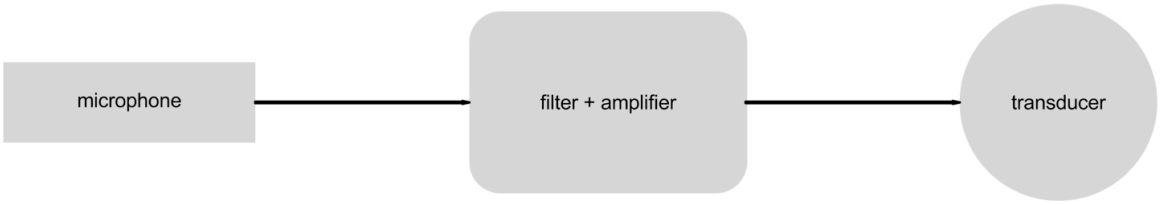
For example, prelingual deaf have « no auditory image, no idea of what actually looks like spoken language, or correspondence between sound and meaning »[8]. Contrary, the post-lingual deaf have *sound memories*. And that's exactly those memories that help them create a bridge between sound and image. The fact that in both cases, they can *hear* with their bodies as well as with their eyes, is absolutely not negligible. A deaf person becomes mute when he can no longer sign with his hands.

For all these reasons, we wished to pursue a research by experimenting new methods and instruments to study these cognitive questions.

CONCEPTION

Our first trials consisted in testing purely mechanical solutions to transcribe acoustic or sonic events into vibrations. Indeed, a sensing membrane can be used for this purpose, as we know, according to a lot of previous experiments with balloons, empty plastic bottles, etc. These solutions are simple and relatively effective, but are not adapted to some of the constraints we aim to address (size, weight, adjustment in order to fit different body parts, etc.). Because we know that it's possible nowadays to find non-expensive transducers to produce vibrations, we quickly opted for the development of an electronic device.

Our first prototype included in a little box a classic cardioid microphone capsule, an amplifier and an output to feed a small vibration transducer.



schematic diagram

After performing series of electro-acoustic measurements to determine the characteristics of the whole system, we tested it by putting the transducer on our skull. We observed that acoustic perceptions were clearly felt through the body even when our ears were equipped with noise-cancelling headphones.

From a purely functional point of view, the first results were consistent. But, of course, the most important question remained unanswered: is our instrument compatible with the expectations of deaf or hearing-impaired people?

EXPERIMENTS

A workshop was organised in Athens by our laboratory during three days in June of 2012, with the participations of the group of comedians of the Greek deaf theatre (Θέατρο Κωφών Ελλάδος). All activities and exercises/tests were held in the Greek Sign Language with the guidance and support of Sophia Roboli, an interpreter.

We have started our explorations, testing various ranges of natural sounds - such as sounds of nature, meteorological phenomena and ambient sounds. Our first challenge was, how would it be possible to spread these sounds and make them *visible* by actors. During our previous clinical experiments, we have noticed that sounds can be *heard/felt* in direct/live by using microphones, followed by a strong amplification as to power transducers. We have

[8] Sachs, O. (1996) Des yeux pour entendre, voyage au pays des sourds. (pp.61) Paris : Seuil

used these same principles/methods and urge the participants, to search and explore their proper sonic sensibility - based on vibrations, haptic sensation and bone conduction - using as a medium all parts of their body. We have noticed/realised that each one them preferred/chose a different part.

We have pursued our experimentations using a wooden bench, on which we have placed bigger and more powerful transducers. The principle is similar to a tactical table already used in a workshop which had taken place at the “Pantheon” monument in Paris during a week dedicated to "Handicap and Accessibility” in 2010. For this test, we tried to introduce a sort of *rythmique game*, using a software called Méta-Mallette[9], with repetitive sound patterns managed by actors. The results were not satisfying, as their expectations were different; *discover, feel, “hear / listen”* to sounds of the environment and everyday life such as : sirens of fire brigade, airplanes, cars and motorcycles, body sounds (snoring and coughing), etc...

For the last exercise, we dedicated the whole day to the “*Pallophone*”. Among this exercise, Sofia and the comedians experimented with their proper voices. In the first place, they “*heard*” through the instrument their voice and the voice of Sofia ; she turned her back to them to assure that they did not see her lips. The result was very satisfying as most of them managed to distinguish and recognise sounds and words.

RESULTS

These experiments, and also the work done with young deaf children, are very promising. We noticed that it is possible to build perceptual categories based on tactile stimuli only. Of course, it doesn't mean that we hear vibrations as we hear sounds, but one can learn to recognise them and link vibrotactile sensations to acoustic sources or events.

During these workshops, many observations have been made. It would take too long to detail them all in this paper. We will mention only two, which must be taken into account to improve our device.

First of all, inter-individual differences in susceptibility and perceptibility to sounds and vibrations are important. These differences have variable potential causes due to:

- physiological situation (partial or inexistent cochlear sensibility)
- psychological involvement (concerning the personal story of each person : for instance, the learning of oralisation techniques more or less, the family environment, the kind of deafness, the person’s mother tongue, etc…)

For each individual, corporal reception of vibrations is different. Therefore, the instrument must be easy to handle, move and pose, according to the needs and desires of the user.
Compared to the existing listening devices by bone conduction, generally designed by hearers for hearers and adapted for use in a specific position (e.g. headband), the device should be adaptable for use on different parts of the body (e.g. neck, wrist, palm).

As deaf people need their hands to sign to communicate, the instrument must be hands-free (both for capturing sounds and vibratory restitution). Thus, the microphone’s part should be also hands-free.

From these experiences, we can concretise and redefine the specifications of the “*Pallophone*”. These required changes and evolutions can be classified in three categories:

- functional enhancements:

[9] Music software developed by Puce-Muce

connectivity: adding an extra input (for a piezo sensor)

- technical improvements:

  selectivity (spatial and frequency)
  bandwidth and linearity (transducer)

- design and ergonomics of the device:

  miniaturization
  hands-free usability
  rechargeability

CONCLUSION

Today, encouraged by our first results, we decided to improve our "*Pallophone"* as described previously and to continue the experiments for a better understanding of the "mechanisms" that allow us to feel the sounds by other means than our ears. To attain these goals, we are actually looking for partner universities, laboratories or companies.

By attending this congress and presenting our work, we hope to identify such complementary collaborators interested in vibrotactile perception of sounds. We are not the first and not the only ones to imagine that sounds can be perceived by the sense of touch, but we are convinced that there are still a lot of things to understand and discover.

BIBLIOGRAPHY

Atkins, W. & Donovan, M. (1984). A workable music education program for the hearing impaired. Volta Review, 86(1), 41-44.
Carré, A. (2008). Musique et surdité, Éditions Fuzeau, France
Darrow, A. A. (1989). Music and the hearing impaired: A review of the research with implications for music educators. Applications of Research in Music Education, 7(2), 10-12.
Darrow, A. A. (1985). Music for the Deaf. Music Educators Journal, 71(6), 33-35.
Darrow, A. A. (1992). The effect of vibrotactile stimuli via the SOMATRON (tm) on the identification of pitch change by hearing impaired children. Journal of Music Therapy, 29(2), 103-112.
Darrow, A. A., & Goll, H. (1989). The effect of vibrotactile stimuli via the SOMATRON (tm) on the identification of rhythmic concepts by hearing impaired children. Journal of Music Therapy, 26(3), 115-124
Harvey Porter S. (1912). Musical Vibrations for the Deaf, Pupils of the N.Y. Inst. for the Instruction of the Deaf , New York
Johnson, M. S. (2009). Composing music more accessible to the hearing-impaired, Master Thesis, University of North Carolina, Greensboro
Rileigh, K. K., & Odom, P. B. (1972). Perception of rhythm by subjects with normal and deficient hearing. Developmental Psychology, 7(1), 54-61.
Sandberg, M. W. (1954). Rhythms and music for the deaf and hard of hearing. Volta Review, 56(6), 255-256.
Levanen, S. *et al*. (2001). Feeling vibrations: enhanced tactile sensitivity in congenitally deaf adults. Neuroscience Letters 301, 75 - 77
Sachs, O. (1996). Des yeux pour entendre, voyage au pays des sourds. Paris : Seuil
Wittgenstein, L. Tractatus logico-philosophicus (1993). Paris : Gallimard

ANNEXE

The following extracts are some of the comments made by the comedians during and after the end of the workshop. They are transcripts, corresponding to audiovisual sequences, extracted from videos shot during the three days of work with the troupe. In many cases, the comedians used the sign "*hear/hearing*" to define the sense of sound.

Magda - « What I feel is completely different from what I've "*heard"* so far. I feel that, maybe it's what I "*hear"* in a bar in general...I feel (compared to) low frequencies that is the same as if I was in bar, but there the sound is compact and here is everywhere. I really liked the differences between the examples of different sounds. I thought that hearing a stone falling was not important, but it is. You have a lot of different sounds to describe it. This is the first time in my life that I realise that. At first I said to myself: « Ok, it's nothing, it does not interest me ». But now I understand why hearing people get tired so much. And me too, I have a headache now ».

Apostolos - « I was not aware at all of all these sounds and elements. I tried to understand better how I could be « connected » to the instrument (note : the transducer). With my eyes closed, it was difficult for me at the beginning to guess the correspondence between sounds, but watching and hearing at the same time, I really understood what it was. I loved seeing the "*subject*" of sound and listen to it. If I looked elsewhere, it was imperceptible to me. If I have a visual perception it's much easier ».

Dimitris - « What I want to say, has to do with the instrument. I grew up in a deaf family and I did not understand at all the sounds I was provoking around me. I was dragging the chair, I was knocking the pan, I was leaving the faucet leaking. Two years ago, I have bought and used a hearing aid for the first time and I started thinking when I was doing the dishes: « Oh my god, the dishes make noise and they "*scream"*. And the door is screaming also ». All these noises stressed me (..) It was very tiring for me and for this reason, I dropped my hearing aid. Sound is a detail. But afterwards, I have understood that there were thousands of different sounds. Today, the instrument reminded me of my hearing aid and I have felt the same thing. For instance the stone, the steps. I can not understand which is each one, I can not distinguish, but there is something different in it. Stones are stronger, they "*cry*" differently. I only understand frequencies, I can not distinguish, but I understand if it is high or low ».

Evanthia - « I grew up without a hearing aid, totally deaf. And sometimes they (parents) were making noise for me to hear and perhaps I could turn, and I did not make the distinction. I said to myself: « Ok, I'm going to try ». And I tried an old technology hearing aid. And I realised that I could hear classical music, realised that I can hear the voice of my dad and my mom, I realised that there is a difference and after I bought the device (I was convinced). The first sound I heard with the hearing aid, it was the keys « click, click, click ». And it bothered me a lot, it was very annoying. But little by little, I began to distinguish more and more different sounds. Now I've learned to live with sounds. Just now, with Panos, we had a disagreement: He told me it's the same with the hearing aid and I told absolutely not, it's not the same thing. It is (transducer) stronger, deeper, bizarre. I feel as if the sound comes, beats and makes an oscillation. With the device, the sound comes, goes and leaves. With it (transducer), the sound beats, it makes an oscillation and beats again and again. It's an odd sensation ».