Constructing a Ludic and Acoustic Environment for the Deaf; the Technology as a Tool in Music Education of the Deaf

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Abstract

Can music become perceivable to an extent that it can constitute a learning process, when the sense of hearing is absent? In which ways is the music education of the deaf carried out? Can technology be a contributor to the music education of the deaf? In which ways is the music education of the deaf carried out and can technology be a contributor? These questions led to the development of the system:"Immersense; step into the world of sound" which consists of an experimental tool under development for the music education of the deaf, through gaming technologies.
The research for the construction of the system is based on three main axes. The first one focuses on the utilization of the ways through which the sound can be perceived when the sense of hearing is absent. The second axis explores the emergence of the importance of music education for the deaf while the last one investigates the ways through which this research can be imprinted in a digital environment. The ultimate goal for this system is to become a comprehensive educational tool and also to integrate digital technology, and particularly low-cost virtual reality systems in the process of music education of the deaf. An additional aim is to offer a novel form of contact with sound through a ludic and interactive environment. An important feature of this effort is the use of technological means as a flexible and an affordable solution, which can easily be used by music institutions, schools, cultural places or even at home. The interactivity in such an application will result into two more benefits. Due to the active participation of the user, the experience itself becomes more effective and interesting. Additionally the system of interaction is able to produce valuable data that with appropriate statistical and mathematical analysis can result to further development of the system itself.

1. Introduction

Despite of the initial skepticism, the use of digital technology and interactive games for educational purposes is increasingly being integrated in the educational system. One of the most important reasons for this has been the use of these tools in the area of special education, particularly in the areas of general knowledge or main school subjects through specialized software and peripheral computer devices. What is happening though in the music education of deaf students? Can technology be used to educate the deaf in music? So far, technology has established its presence through peripheral systems, especially analog ones, such as chairs or accessories transmitting vibrations focusing only on music appreciation but not for educational purposes. Music education however is particularly important, since through this process someone may develop abilities such as synchronization and harmony, be developed emotionally and mentally, cultivate new skills, improvise, create, and be given the opportunity to leave his imagination free. Moreover, music helps in language skills development and in socialization.
Especially in the case of the deaf, music should be treated in a particular way because it is a learning process directly associated with the sensory sensitivity of the body. So far the music education of the deaf is limited to specially designed classrooms and in many cases music is being used as a therapeutic tool rather than an educational tool. The contribution of technology may be particularly helpful, because with it we are able to analyze in depth the structure of sound and its characteristics, to decode a musical sequence and reconstruct all of these elements into a new custom-built structure

2. Historical review

The engagement with music and music education of the deaf has been addressed by the scientific community since 1848 and specifically in America. In the section entitled "Music among deaf and dumb" [1], Turner and Bartlett wrote about teaching music to the deaf, citing the example of a deaf woman who learned to play the piano, arguing that not only hearing can help in correcting harmonic errors during a music performance, but also vision can do the same. Specifically, Turner mentions that

"*A practised eye may as readily detect any irregularity of fingering, or departure from the proper movement of the piece, as a cultivated ear*".
Searching through the history of music we come across several artists with profound or partial hearing loss who have managed to either compose music or play a musical instrument or even create sound installations, showing no deficiency compared to artists with no hearing loss. An important example in music history is Ludwig Van Beethoven, who at the age of 26 (1796) started gradually losing his hearing, when after four years he was considered completely deaf. However, he continued composing and created one of his most important works (the 9th symphony), which is, until now, considered a masterpiece of music history mainly because of its innovation. In the recent history of music we meet Evelyn Glennie, a virtuoso percussionist, who has been profoundly deaf since the age of 12, having started to lose her hearing from the age of 8, but she continued studying music and perform at an international level. In both cases, of course, we should recognize the fact of the advanced age when the loss of hearing occurred, resulting in a certain degree of aural memory established at a younger age. As far as the modern music scene is concerned, Signmark (M.Vuoriheimo), profoundly deaf, born in a signing family, has now obtained an international music career. In the domain of visual arts. Christine Sun Kim, also profoundly deaf, uses sounds as a tool to create interactive installations [2]. As she mentions in an interview about the perception of sound «*I often feel loud sounds through my chest because it is hollow. Air bass is what I dig the most, not through surface*»
The aforementioned examples, combined with the efforts that are being made to translate lyrics of several tracks in sign language and the performances by choirs of deaf people, lead us to the conclusion that the involvement of the deaf with sound and music is not strange or insignificant. Sound and music are a part of a deaf's daily life and culture as much as hearing people's, despite of the fact that the perception of the sound itself is achieved through a different process.
So far the methods of teaching music to the deaf are being realized through the physical presence, in specially designed music classes, using the vibrations produced by percussions and transmitting them through special materials in space (thick curtains, carpets / plastic floor, covering hard surfaces with soft material) [3]. In many cases this process of teaching music turns into a therapeutic process helping the people involved to improve their communication skills and provide an aid to socialization as well.
These research findings suggest that the process of music education of the deaf should be treated in a different way, in order to adapt to non-verbal and acoustic communication. One could argue that music is a different language of communication like the "visual-language of signs" [4]

3. The Project "Immersense: Step into the World of Sound"

Taking advantage of the research data and the conclusions reached, the construction of a prototype system is proposed, using low-cost virtual reality systems. The result is an experimental tool, which uses, combines and adapts this technology with the ultimate goal to become a comprehensive music educational tool for the deaf.

3.1 System description

The system consists of a combination of mechanisms approaching fundamental principles in order to understand sound and musical structures, through a virtual environment. These mechanisms are represented as conceptual virtual spaces divided in three categories: a) sound b) music c) music composition. In each space the user has the opportunity to navigate and interact with the visual objects through a hand motion detector or by changing position in the virtual space. The content evolves gradually, starting from the notion of sound and leading to the structural elements of music.

Fig. 1. Sound transmission. Spherical sound waves

The introductory space evolves around sound transmission. The user can see schematically the transmission of sound in space, by selecting the sound source he wants to activate (via virtual touch) (Fig.1). This visualization is based on the physics of the transmission of a sound wave in a three dimensional space (spherical sound waves [5]).
The following three virtual spaces are dedicated to structural elements of music (frequency, rhythm and timbre). In order to understand the meaning of frequency we are using three main categories of the frequency range (low, medium and high frequencies) as well as the theory of music instruments related to their size and their frequency response. Based on that, in the virtual space there are three similar objects of different sizes, each of them representing a frequency range. While playing a sound there is also a movement of each of these objects according to the frequencies that are produced. The rhythm is explained through selected rhythmic patterns according to music theory. Their visual representation is given through the movement of a group of objects that are activated by the user. The notion of the timbre is represented through various textures such as metal or wood. The user can activate any of them via virtual touch. Each of these objects reproduces the same sound but with its own timbre. This result is also represented visually and acoustically. The last space is dedicated to “free composition”. In this area the user can choose from the objects he had met before in order to create his own music composition (visually and acoustically). Every chosen object can be put in a predefined place. During this process, apart from the visual representation of the sound itself, there is an acoustic reproduction of the result at high volume from the speakers surrounding the user, enabling the user to feel the vibrations in the physical space. This element is an important part of the process for the user to be fully immersed in the virtual space.

3.2 System Functioning and Architecture

The system “Immersense; step into the world of sound” consists of a composite immersive visual and sound vibration system. For its realization, the Oculus Rift DK2 was selected, combined with the Leap Motion for the hand movement tracking. These technology systems were chosen because of their accuracy and low-cost. Additionally, there is a special construction consisting of low frequency speakers which surround the user at a certain position and at a certain distance in order to transmit the sound vibrations properly. These virtual reality systems enable the user to navigate and interact in the virtual space in the same way as in the real world. The Oculus Rift DK2 is able to transfer and adjust the user’s movements from the real to the virtual world, since it is integrated with a position tracking system. The Leap Motion detects the movement of the hands and allows the user to use his hands so that he is able to touch or move virtual objects. Overall the system enhances the immersion and is free of other peripheral navigation systems which might distract the user's attention and eventually force him to be a priori educated in how to use the system itself. The user starts from point zero, where he comes in touch with sound transmission, and moves on to the final space, where he can create and compose music (Fig.2). The structure evolves gradually, having sound as its reference point. Finally, the system enables the recording of data related to the user's interaction timespan in each virtual space aiming to further develop and upgrade system itself.

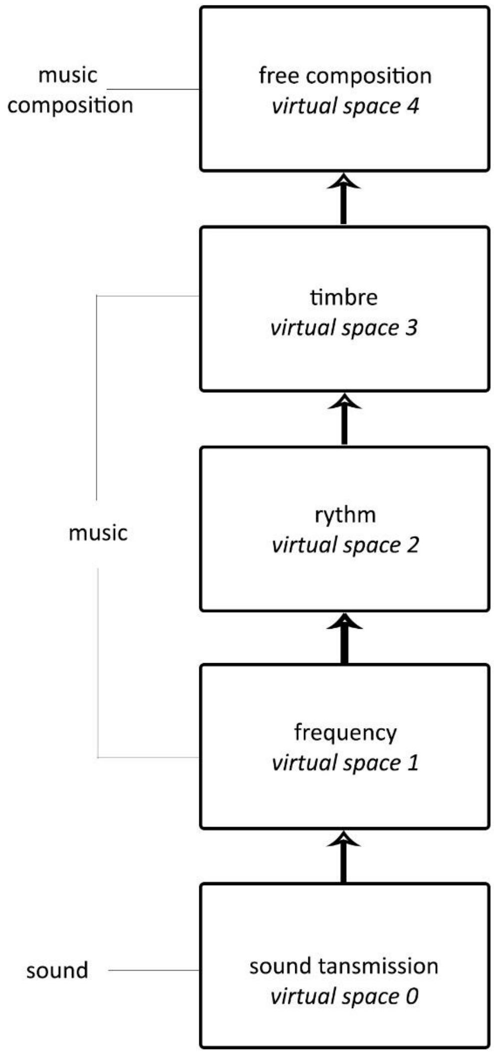

Fig. 2. Structure of the space

4. Conclusions and Perspectives

This work describes the development of a tool dedicated to the music education of profoundly deaf people. At this moment, due to the limited number of results, it is difficult to evaluate its effectiveness Nevertheless, the proposed system is a flexible tool because of the adaptability of the content to its operation and usage. This system could be developed in a wider experimental procedure in collaboration with scientific teams from the field of special education and psychology, in order to be able to become a comprehensive educational tool dedicated to the music education of the deaf.

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