STARTS Residency Public Report
Sensorium Audio Theatre

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Abstract

Within the framework of VERTIGO STARTS Artistic Residencies Program, we developed an environment for a new public aural experience. Entitled “Sensorium Audio Theatre”, the project originated in research on immersive educational environment to enhance students’ concentration.
The idea of “Sensorium" stems from numerous artistic and scholarly traditions. Intended to reveal interdisciplinary character, it is imbued with the spirit of holistic and integral perception of human emotions, intellect and physiology. It is supposed to merge well-balanced artistic, scientific and technological, as well as psychological aspects. “Sensorium” is an intimate, one-person experience of "anti-mass" character. It essentially consists in transposition of visitor’s emotional psychophysical reactions into musical structures in a direct “live” experience.
The objective was to create a musical environment to let one hear their psycho-physical reactions, experience (through composed music) their changeability, as well as comprehend the possibility of exerting control over them.
Work on the project consisted in testing biofeedback sensors, development of "The Bridge" data transfer application, designing Max/MSP patch (installation’s "engine"), composing the musical layer, as well as preparing public presentations of “Sensorium”. Educational workshops for young people made a separate stage.
Research was mainly carried out by the author Rafał Zapała (at the Telematics Workshop of the Academy of Music in Poznań), and staff at FutureLab Workshop of Poznan Supercomputing and Networking Center.
Upon completion of the residency, we plan further joint activity associated with the project: composing new pieces for “Sensorium”, preparing subsequent presentations, developing "The Bridge" program, as well as regular classes based on "SAMOUSPOKAJANIE" [Self-Appeasement] Young Person Psychological Workshop project.

Index Terms : data-driven-composition, biofeedback, immersive sound installation, sensorium, soundart for education,

I. INTRODUCTION

The report refers to artistic-scholarly residency held under the title **Sensorium Audio Theatre** within Vertigo Starts Artistic Residencies Program 2019/20. The project, which was developed by Dr Rafał Zapała in collaboration with R&D ICT Project FutureLab: Innovative Education Laboratory, had been proposed and produced by Poznan Supercomputing and Networking Center (PSNC).
The project continued an artistic idea which originated in 2014. The prototype of “Sensorium” was the effect of the author’s traineeship at Stanford University’s CCRMA Institute (Palo Alto, 2014). The first edition was developed on request from "The Castle" Culture Centre in Poznań

(Poland). The experience of this prototype installation combined with subsequent consultation with PSNC staff resulted in the emergence of a new, bolder vision.
“Sensorium” essentially consist in transposition of the structure and dynamics of visitor’s emotional psychophysical reactions upon musical structures in a direct “live” experience. The **artistic objective** was to create *a musical environment* to let one hear their psycho-physical reactions, experience (through composed music) their changeability, as well as comprehend the possibility of exerting control over them. The key technological-composing challenge was the development of the rhizomatic instrument’s "engine" to operate in the area between biofeedback sensors, hacked medical detectors, original software, and artistic aspects: timbral composition and ambisonic sound projection.
The second, educational objective was to design new tools to enhance students’ attention.
A civilisation disease, attention problems suffered by ever growing numbers of pupils and students remained in the centre of our attention. It is related to a new technological reality and new habits (domination of visual culture, multi-tasking, mixing of “real” and “virtual” reality, etc.). We come across these problems in our educational work; they also come under scrutiny at FutureLab PSNC. We opted for replacement of image with sound as a medium less conspicuous and more abstract than the dominant image, and, at the same time, still very attractive to young people. The immersive quality of the tools and bio-feedback technologies were intended to boost this attractiveness. For this reason we developed a structure of workshops intended for young people called SAMOUSPOKAJANIE.
Work on the project (25 July 2019 through 20 April 2020) lasted longer than initially assumed, which was partly due to intensity of project authors’ artistic and research activity in 2019, and partly to complications associated with COVID-19 pandemic.

II.ARTWORK

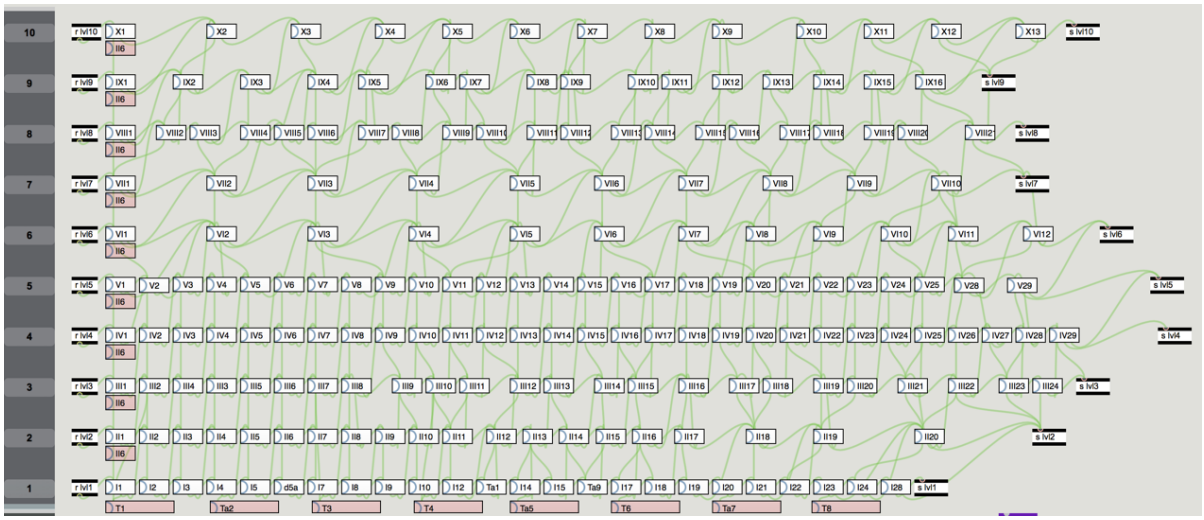
The idea of “Sensorium" stems from numerous artistic and scholarly traditions. Intended to reveal interdisciplinary character, it is imbued with the spirit of holistic and integral perception of human emotions, intellect and physiology. It is supposed to merge well-balanced artistic (composition of music, advanced sonification, sound art practices, acusmonium traditions), scientific and technological (bio- and neurofeedback, high order ambisonics projection), as well as psychological aspects (observation of psycho-physical reactions and emotions, concentration and meditation, non-linear narrative systems).
“Sensorium” is an intimate, one-person experience of "anti-mass" character. It will essentially consist in transposition of the structure and dynamics of visitor’s emotional psychophysical reactions (by means of biofeedback technology in the tradition of Alvin Lucier’s works) upon musical structures in a direct “live” experience. Excerpt from the description of “Sensorium”:

"(...) “Sensorium” is an instrument-music player which you operate with your brain, skin of the left hand, and heart (...). We have built an instrument, which does not operate without you; it is you to be the installation’s most real, non-metaphoric engine. Sounds surround you, yet they do so in a singular way: their character follows the state of your mind. The apparatus you are wearing lets you shape the character of the music that surrounds you. “Sensorium” is an intimate, single-handed experience of "anti-mass" character. An assistant guides you in silence along a complex route to the place of the installation. You enter a disturbing, austere space. You are surrounded by loudspeakers (around, above, and below you). The assistant puts on you the necessary apparatus – biofeedback sensors (pulse meter, GSR and EEG) – whereupon he starts the procedure. You begin to notice a relation between your reactions and changes in music. You learn the instrument. First, you learn how closely your thoughts, emotions, and

bodily reactions are interconnected. The division line between them obliterates. You control the changes of your emotions, which influences your body; which, in turn, by way of technology, influences the music. This, in turn, via the sense of hearing, influences you again."
The ultimate objective was to elaborate a complete Sensorium Audio Theatre system ready to be implemented in different locations, in different conditions, and with different musical content. The goal was to develop an environment for experiencing a new type of music – an "instrument" which would let one hear their psycho-physical reactions, experience (through organised sound) their changeability, as well as comprehend the possibility of exerting control over them.
The residency was a milestone towards accomplishment of this idea. A new, comprehensive system of Sensorium Audio Theatre was developed within the framework of the residency.
The installation is designed in such a way, as to make it possible to adjust it to various situations – by numerous visitors in varied spaces, and an option of designing various musical compositions is included.

Key elements of such a system are:
1. The Input Suit – a set of state-of-the-art biofeedback sensors.
In the opening stage of the work, we tested all possible methods of acquiring affective data from the human body which were available at PSNC. The EEG (G-tech Unicorn, Emotive Epoc, Emotive Insight, E-Health), Galvanic Skin Response (E-Health, Shimmer) systems, heart rate systems and so on were the starting point.
Input system was selected with regard to:
– ability to operate "live,"
– reading adequacy,
– responsiveness,
– ease of donning.
Finally we decided to focus on:
– as an EEG/EMG sensor: Emotive Insight
– as an GSR and Pulse Sensor: Shimmer equipment
2. The Bridge.
During the residency a problem emerged related to simultaneous use of a number of biofeedback devices as sources of data. Each device communicated with the artist's computer in its own specific way. Each also required separate adjustment, "hacking" to make transmission and translation of its data to Open Sound Control (OSC) possible. OSC is a communications protocol developed by CNMAT Berkeley for open programming environments for artists, mainly – though not exclusively – for musicians. The standard gradually gains popularity and substitutes the outdated MIDI protocol. The problem emerged when a number of devices were plugged in at the same time. An idea germinated to develop an instrument to gather data from a number of devices and send it in a standardised format to the artist's computer (or a different recipient). We labelled the instrument simply "The Bridge". A computer program to collect data from various sensors was developed in collaboration with PSNC programmers. The program also formatted data to the predetermined 0-100 range of values, and to continuous frequency of transmission (0.5 s). The values are convenient for various types of use, and yield a stream of data useful as e.g. data with which to control music processors. We placed the Bridge on a separate, external microcomputer, which additionally relieved the processor of the artist's device. Data can be transferred by means of Ethernet cable, or through the web, which opens up "Sensorium" to a wide variety of telematic experiments.
Even though originally unplanned, the Bridge is an interesting outcome of work on the project during the residency. Jointly, we decided to continue work on development of the already

separate idea, to furnish it with extra sensors, not necessarily associated with the idea of "Sensorium", e.g. motion or weather detectors etc.
For the first time, the Bridge was employed in the presentation during Starts Residency Days.
3. Concert Machine.
The key technological-composing challenge here was the development of a rhizomatic instrument's "engine", which had to operate in the area between sensors, hacked medical detectors, original software, and artistic aspects: timbral composition and ambisonic sound projection. The work of composer of such an installation poses a considerable challenge, for it does not concentrate on a traditional linear musical form. What it does focus on is creation of a generative instrument able to sound differently depending on the changing listeners. It had to take into consideration the possible sets of emotions, the non-obvious combinations of various streams of data: the pulse, breathing, muscle tension, electrical charge of the skin, or the brainwave frequency. For obvious reasons, it had to be structured rhizomatically, i.e. take into account the possibility of musical parameters' multi-directional change and mutual influence.
The Concert Machine took form of a network of elements (patches) designed in the Max/MSP environment.



4. Music.
In "Sensorium," it is difficult to separate artistic aspects from those of technology and psychology. Rather than to separate them, we intended to merge these contexts. Rhizomatic structure of the composition and computer software, a set of sensors perceived as a musical interface, biofeedback as an interactive musical installation, data-driven composition as a sophisticated form of sonification – all these challenges also concern art. Invariably, I treat the musical content of "Sensorium" as an autonomous composition, a musical piece.
During the residency a piece taking into consideration specific character of the new instrument was composed. Generally, it is a composition for flute and live electronics. The sounds of the flute were composed in the form of a score, and later recorded in a particular manner. It was already at the piece composition phase that the specific character of "Sensorium" had to be taken into account.
The visitor's affective states, which range from this of relaxation to this of arousal, are crucial for the piece. The range was divided into eight levels. Music material had to be composed in such a way, as to represent particular levels (e.g. calm, static sounds for the level of relaxation; intense, busy granular clouds of sounds for the levels of greatest arousal). Acoustic material was enriched with granular electronic transformations, also operating differently at each level.

The process of recording the flute part was held in a specific way. We recorded very short fragments of the piece, which yielded a collection of the composition's micro-fragments. Such atomised sound material was then arranged in the Max/MSP patch in the form of two-dimensional template.
This made seamless transition between different levels of the composition possible, depending on the dynamically changing data acquired from the visitor's body.

Presentations.
Two **public presentations** of the piece have been held:
15 Oct. 2019 – GMEM, Marseille, 14th International Symposium on Computer Music Multidisciplinary Research (CMMR). EEG Emotiv Insight was the basic sensor during the presentation.

28 Feb.-1 March 2020 – 104 Centquatre, Paris, STARTS RESIDENCIES DAYS – for this presentation a different device was chosen. As the event's underlying assumption was a large number of frequently changing visitors, a quick and relatively simple technique of data acquisition was required. We opted for this of galvanic skin response, for which we used Shimmer sensors.

5. Workshops based on the installation

A special version of the composition intended for educational purposes was also developed during the residency. In the final stage of the residency we focussed on designing psychological workshops to boost focus in school-age youth. Collaboration with psychologist Joanna Zapała (Integral Psychotherapy Center, Poznan) and Karolina Karpowicz yielded workshops for young people, whose aim is to employ “Sensorium” as a therapeutic tool.

Brief description of "SAMOUSPOKAJANIE" – focus-on-emotion workshops for young people.

The workshops are intended for school-age youth aged 12-15, and involve ten-person groups. The psychological background for the proposed educational strategy is the DBT (Dialectical Behavior Therapy) approach. The aim of the meetings is development of the ability to identify emotions, name them, and handle them. We focus on three basic problematic emotions frequently experienced by young people: anger, sadness and fear.

Installation “Sensorium” and participants’ own work shall be used as experimental educational tool. The workshops consist in three meetings run by a therapist and group’s supervisor.

Meeting 1. – during a short lecture, pupils get familiar with three problematic emotions: anger, sadness and fear. They learn about physiological reactions typical of these emotions. 10-15-minute sessions of “Sensorium”, which is used here as a musical meter of the strength of an emotion, constitute the remaining part of the meeting. Pupils are assigned homework, which consists in recognising and memorising situations, in which the discussed emotions emerged.

Meeting 2. – pupils share the memorised emotional everyday-life situations. They learn that they can influence their reactions, and that emotions can be controlled.

In the latter part, they use “Sensorium” to try to exert influence upon their states. The objective-game is an attempt to influence the reactions of “Sensorium”, an effort to achieve conscious "self-appeasement". At home, pupils continue to discern emotions in everyday situations.
Meeting 3. – pupils learn basic methods to manage negative emotions. We are going to focus on purely physical techniques, e.g. calming one’s breath, concentration and relaxing tense muscles, etc. Next, the newly-acquired techniques can be tried with “Sensorium”.
Workshop performance will concern emotion and sound. However, the hidden (and for us, critical) goal is practicing concentration. All stages of workshop performance require focussing, a phenomenon extremely rare in the lives of modern-day young people. Both the awareness of emotions, and techniques of handling them require concentration. We believe that music installation “Sensorium” is a very good tool to practice this skill.

III. METHODOLOGY and IV. CO-CREATION PROCESS

The opening stage of work was the testing of selected biofeedback sensors. We focused mainly on EEG (electroencephalography) and GSR (galvanic skin response) sensors, which are key for “Sensorium”, as well as on EMG (electromyography) and pulse sensors. We also paid attention to facial expression recognition and eye tracking techniques, which, however, were abandoned as they were found excessively difficult to adapt to a situation of an artistic installation.
The main goal of the tests was to comprehend data dynamics (how fast these change, in what ranges, etc.). From the point of view of the composer, this information is absolutely crucial; it is tantamount with familiarising oneself with a new instrument, which “Sensorium” , as a matter of fact, is.
This stage of work involved the author Rafał Zapała, Jan Skorupa, Damian Niemir, PSNC biofeedback specialists: Mikołaj Buchwald and Adam Bykowski.
Tests were carried out at the seat of FutureLab, Poznan Supercomputing and Networking Center, at 20, Zwierzyniecka st., Poznań.

The Bridge: throughout the process of sensor testing, we realised a need to develop an application responsible for collecting data from a number of sensors at the same time, averaging their readings to a uniform range (0-100), and relaying it to the artist’s computer via OSC (Open Sound Control) protocol. Upon development, the application – a new, additional effect of the residency – was named The Bridge.
This stage of work involved Jan Skorupa and PSNC programmers: Damian Niemir and Mikołaj Węgrzynowski.
Work was performed at the seat of FutureLab, Poznan Supercomputing and Networking Center, at 20, Zwierzyniecka st., Poznań.

Development of Max/MSP patch, which we label Concert Machine, was a separate stage. The starting point were previous versions of “Sensorium”; eventually, the patch took the form of a template ready to seamlessly play very short fragments of the composition. Playback is controlled by means of changeable biofeedback readings.
As this area of work directly concerned Artwork, it was performed by Rafał Zapała (in collaboration with Jan Skorupa), and was held at the artist’s studio (Telematic Workshop, Academy of Music in Poznań).

Work on the said elements yielded, in effect, the installation prototype. This, in turn, made composing music material possible. This involved rehearsals with flautist (Paulina Graś) and recording of samples.

Recordings and mastering were made by Robert Gogol at the Telematic Workshop at the Academy of Music in Poznań (with participation of Rafał Zapała and Jan Skorupa).
Recording sessions were partly held at the Academy of Music in Poznań, and partly at Future Labs.

Preparation of two public presentations of "Sensorium" constituted a separate stage of work:
15 Oct. 2019 – GMEM, Marseille, 14th International Symposium on Computer Music Multidisciplinary Research (CMMR)
28 Feb. – 1 Mar. 2020 – 104 Centquatre, Paris, STARTS RESIDENCIES DAYS
The whole team (Rafał Zapała, Jan Skorupa, Damian Niemir, and PSNC programmers) took part in the preparatory phases. In Marseilles, the work was presented by the author; in Paris – by the author and Jan Skorupa.

The final area of research was adaptation of "Sensorium" to serve as an educational tool, whose aim is to support focus development in young people. Here, an important element was a workshop project for young people "SAMOUSPOKOJENIE" elaborated by psychotherapist Joanna Zapała in collaboration with Karolina Karpowicz.

Workshops have not been held within the time frame of the residency owing to COVID-19 pandemic. It is, however, a fully developed tool which we plan to permanently introduce into FutureLab's educational offer (as soon as lockdown is discontinued).

V. IMPACT

During the Vertigo residency at PSNC, we noticed that our previous experience in ICT projects can be successfully used as part of typically artistic projects, not necessarily based on technological innovation, but rather on new scenarios for the use of research equipment and techniques. These are completely new forms and tools intended for practicing art. Both the development of "The Bridge" and interdisciplinary meetings in FutureLab allowed us to redefine the priorities of our "PSNC Media Lab" and thus introduce its new name and new activity as an "PSNC Art&Science Lab". The results of the Vertigo residence, together with the developed "SAMOUSPOKOJENIE" workshop, will become part of the permanent laboratory agenda in the second half of 2020.

"The Bridge" helps with using many types of sensors. Data can be transferred by means of Ethernet cable, or through the web, which opens up "Sensorium" to a wide variety of telematic experiments. "The Bridge" will continue to be developed, especially since the pandemic situation has shed new light on the technological, remote element of our cooperation. As we were forced to move a large part of the activities online, the jointly developed interface will allow us to take on new tech and artistic actions remotely. Therefore, we could add one more element to our existing videoconferencing and remote work solutions - a virtual laboratory tool that allows to undertake creative art meetings remotely, not only for epidemic reasons but also for logistical difficulties, when the composer and biosensor-co-creator cannot meet in person.

VI. ART-SCIENCE INTER-RELATIONSHIPS

From the onset, "Sensorium" has been an art&science project. Imbued with the spirit of holistic and integral perception of human emotions, intellect and physiology, the installation is an

interdisciplinary endeavour. It is supposed to merge in well-balanced proportions artistic (composition of music), scholarly and technological (biofeedback, Max/MSP programming), as well as psychological aspects (observation of psycho-physical reactions and emotions, concentration and meditation).
We treat all the said contexts of work as artistic material, while operations involving sensors, data, software, or physical reactions are simply approached in terms of an artistic process – composing.

VII. FUTURE DIRECTION AND ACTIONS

“Sensorium” is a long-term artistic-research project. We find the Vertigo Starts residency an extremely important stage of the process. Owing to the Residency, “Sensorium” gained a powerful ally in PSNC. Further collaboration is planned:
– development of "The Bridge": a program to collect data from numerous sensors, average it to common ranges, and transfer in the form of OSC stream,
– further tests with biofeedback sensors,
– joint preparation of new versions of the installation. The next demonstration planned is the joint presentation of “Sensorium” at Ars Electronica festival in Linz in 2020.
– Rafał Zapała plans further compositions dedicated for the instrument,
– He also intends to continue work on composer-convenient environment (labelled as Concert Machine during the residency). The nearest opportunity will be the Visiting Scholar residency at the invitation of CNMAT Berkeley (autumn semester 2021).
– based on “Sensorium”, "SAMOUSPOKOJENIE" workshops will be a permanent entry on FutureLab’s offer for young people.