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A MULTIMODAL SOUND INSTALLATION FOR EXPERIENTIAL LEARNING

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Sound is an evanescent phenomenon that can convey information about the world around us. Unfortunately, explaining the production, propagation, and perception of sound to non-experts through a theoretical approach can be a goal hard to achieve. In this paper we discuss an alternative way, based on an unmediated fruition of a multimedia installation originally conceived as an artwork. The idea is to use multiple sensory channels (i.e. hearing, touch and sight) in order to provide a low-level experience of sound-related phenomena through synesthetic experiential learning.

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1 Introduction

The production, propagation, and perception of sound are phenomena we are used to in everyday life. Basically, sound is generated by a source that creates vibrations in the surrounding medium in a range of frequencies that we can perceive. As the source goes on producing vibrations in the medium, they propagate away from the source at the speed of sound, thus forming the so-called *sound waves*. Sound can propagate only through a medium such as a solid (e.g., a metal plate) or a fluid (e.g., the air). The whole study of sound can be seen as a study of vibrations (Morse, 1948). The theoretical aspects of sound are well covered by a huge amount of scientific works, and a detailed discussion of this subject goes beyond our goals.

It is worth noting that – in normal conditions – we are not consciously accustomed to a tactile experience of sound, namely we are not used to "touch" a sound, even if we are surrounded by sound waves and only the physical contact lets us perceive sound. A clarifying counterexample is provided by the low frequencies produced by a subwoofer, that – due to their physical characteristics – can be more easily perceived as a haptic stimulus; for example, this happens frequently in rock or electronic music concerts.

The goal of this work is to present and discuss an artistic installation named *Parallel* focusing on sound production, propagation and perception. *Parallel* was conceived primarily as an artwork to show the multimodal facets of sound through personal experimentation (Morandi, 2015). In this sense, *Parallel* adds a further dimension to the senses of hearing and touch, including also sight in the global perceptual experience.

Multimodality describes communication practices in terms of the textual, aural, spatial, and visual resources used to compose messages (Murray, 2013). This approach presents a number of social semiotic implications, as discussed in (Kress, 2009). The ways people receive information may be divided into three categories, sometimes referred to as *modalities* or *modes*: *visual* – sights, pictures, diagrams, symbols; *auditory* – sounds, words; *kinesthetic* – taste, touch, and smell (Felder & Silverman, 1988). Consequently, on the basis of the preferred learning modality, we can recognize visual, auditory, and kinesthetic learners. Visual learners remember best what they see, auditory learners remember much of what they hear, and kinesthetic learners prefer physical activities, rather than listening to a lecture or watching demonstrations. Thanks to its intrinsic characteristics, a multimodal approach is able not only to catch the attention of young learners (Jewitt, 2008; Wolfe & Rosie, 2010; Morgan, 2013), but it is fundamental in adult education, too (Merriam, 2008). In conclusion, a multimodal approach addresses various kinds of learners, stimulating their senses, adopting reinforcement techniques and fostering the awareness of different facets of a problem. As explained below, multimodal aspects make *Parallel* suited to experiential learning in either an unsupervised or supervised educational environment. Even if theoretical aspects of sound can be hard to explain to non-experts, we believe that an auditory, tactile and visual first-person experience can be very effective.

Sound experiences that somehow recall the *Parallel* approach are already available: for example, the Audioversum museum of Innsbruck presents a number of multimedia installations to make sound either haptically or visually perceivable to the audience. The key differences are: i) the non-artistic goals of such installations, and ii) the absence of a unique, multimodal experience where different senses are simultaneously involved.

The paper is organized as follows: Section 2 will discuss the conceptual framework at the basis of Parallel, Section 3 will provide technical details about its implementation, Section 4 will focus on the experiential learning supported by this installation, and finally Section 5 will describe an on-the-field experience occurred during "MeetMeTonight 2015".

2 The Conceptual Approach

Parallel was originally conceived as an artwork, and thought as a glimpse on self-knowledge and the relationship with otherness, involving sight, touch and hearing. This section describes the conceptual approach of the installation through the words of its authors.

> Knowing something involves being in relation with it, which is why knowledge is always incomplete when based only on the observer or the observed object. The roots of knowledge are as deep as clear is the relationship between self and the world. What ties us to the world are our senses and our rational abilities, which sometimes agree with each other and sometimes don't: logical patterns, precognition, prejudices overlap, agree or fight with symbols, allegories, stories. This is the richness where modern man is shipwrecked. The very mechanism of *Parallel* is based on such considerations: the intention of the observer to interact with the reflected image of himself is recognized by the interaction with an impalpable aspect of reality (the electromagnetic field). From the desire of exploring our own reflection arise tactile and acoustic stimuli: a network of parallel phenomena that surprisingly manages to meet, as if to emphasize the non-Euclidean nature of our universe. To experience an aesthetic phenomenon, we start from the suspension of belief, we start listening, in parallel. In fact, the word parallel comes from the Greek *parà allelois*, which means "facing each other". Concepts of frontality and interaction trigger a process of inner knowledge that

stimulates thoughts about the relationship between the self and the world. From Plato's cave until now, this relationship can be expressed as the inevitable tension to a hidden truth and the difficult quest for an ethical living that agrees with it. Can we get out of a narrow, damp cave full of echoes, where habits and false beliefs bind the man as a prisoner? If the answer is affirmative, this is in front of us.

3 Technical Details

From a technical point of view, *Parallel* is composed by the following parts:

- A vertically-suspended metal plate, sized 1m × 2m, able to conduct electricity and characterized by a reflective surface;
- An Arduino UNO, representing the programmable logic controller (PLC);
- A laptop computer running Max/MSP or Pure Data;
- An audio power amplifier;
- Electro dynamical exciters (EX).

Some details of the equipment in use are shown in Figure 1.

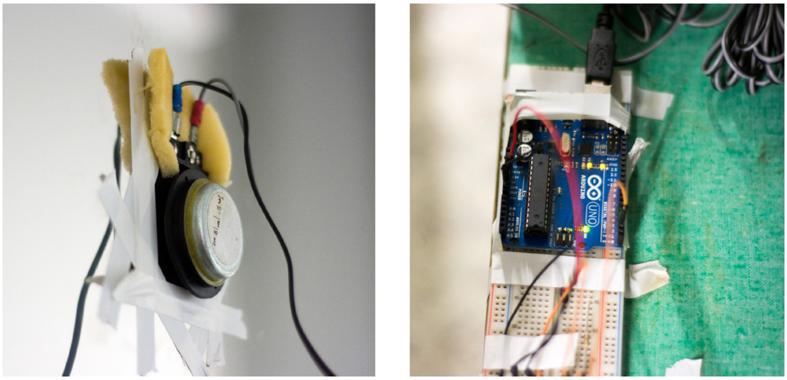

Fig. 1 - **Details of the equipment: an** electro dynamical exciter (left) and the Arduino UNO (right).

The metal plate is connected to a digital input PIN of the Arduino, which in turn is set to a high-level (i.e. a small current is applied to the plate). The metal plate acts as the face of a capacitor, disposing the charge to ground very slowly. Arduino measures the time needed to discharge the plate completely and communicates this value to the computer. The interaction among the elements of *Parallel* is shown in Figure 2.

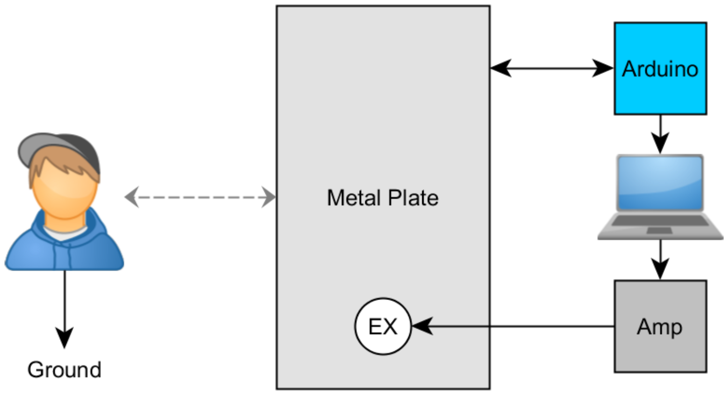

Fig. 2 - A diagram showing how the different elements of *Parallel* interact.

A person getting close to the plate behaves like the other face of the capacitor: the closer to the installation the person is, the easier charges are disposed. When someone touches the surface, the discharging becomes really fast, and can further accelerate as the person increases the contact area. By knowing the discharge time, the computer can thus infer the behavior of the user and react accordingly, by generating different sounds that are amplified and transmitted to an electro dynamical exciter (EX). The EX is a device very similar to a loudspeaker, whose purpose is to make the plate oscillate in order to produce sound. People can move their hands around to explore how the plate vibrates.

The software component of the installation can be described as a finite-state machine composed of the following states:

- IDLE – The plate is almost still, a very low-frequency humming sound is propagated into the room thanks to another EX and makes the walls vibrate. This should catch the attention of visitors and add a sense of owe while approaching *Parallel*;
- PROXIMITY – When the user protracts a hand toward *Parallel*, even before touching it, the plate begins vibrating and wiggle consistently thanks to a low-frequency rumble which resonates through the natural vibrating modes of the surface. This should increase the sense of magic pushing involvement up;
- ACTIVITY – When the user touches the plate, the rumble suddenly stops and the software chooses a random sound from a library to be played through the metal plate. Some sounds can be modulated in pitch, others can be modulated in amplitude, proportionally to the

amount of touched surface. The user can thus experience the sound as an acoustic phenomenon, but also as a tactile experience (he/she is physically touching the surface) and a visual experience (the reflective surface quivers as the vibrations deform the plate). After some seconds of hands-off, *Parallel* goes back to the IDLE state.

Within the installation, the metal plate plays two roles: on one side, it is part of an *actuator*, since it represents the vibrating diaphragm which propagates the vibrations to air, similarly to the membrane of a stereo speaker; on the other side, it is part of a *sensor*, being sensitive to human presence and touch and influencing the sound to be produced both by the underlying system and the physical interaction with the plate.

4 Experiential Learning through Parallel

Parallel allows visitors to explore sound not only through listening, but also through touch and vision, in order to make them understand the physical properties of sounds without any need for math, physics, or music knowledge. Acting like a "microscope" for sound waves, the installation shows how human eardrum vibrates when exposed to different sounds.

In scientific literature there are many categorizations of the various types of learning styles. A very comprehensive review of the subject can be found in (Mangione, 2013), that mentions at least 6 widely-used models and many research works. For example, the Fleming's VAK/VARK model includes hands-on, visual, auditory, read/write, and kinesthetic learning (Fleming, 2001). As explained above, the kind of multimodal interaction expected for *Parallel* covers many of them, however in the intention of the authors kinesthetic and hands-on learning styles should be privileged.

Kinesthetic learning, also known as *tactile learning*, is an educational style based on physical activities (Lengel & Kuczala, 2010), where learners are commonly known as "do-ers" since they have to use their body to do something, thus stimulating the so-called kinesthetic intelligence (Gardner, 2011) and facilitating the kinesthetic memory (Posner, 1967). If on one side *Parallel* aims to stimulate different senses simultaneously, on the other the main interaction as well as feedbacks are conveyed through a physical activity, i.e. getting closer and closer and finally touching the surface.

Recalling the Fleming's model, *Parallel* also fosters a typical hands-on learning style, where the educational process occurs through experience. Moreover, learners are invited to reflect on their actions, even in an unsupervised environment, thanks to the feedback provided by the installation: in this sense the hands-on learning style becomes a form of *experiential learning* (Young, 2002).

Finally, it is worth underlining that *Parallel* lets learners achieve further educational results. For example, it supports social interaction and peer review, since the surface can be touched by different persons who may cooperate in the generation of a unique feedback. Besides, the explanation of the technological background provides the opportunity for discussing interdisciplinary issues. These aspects were investigated on the field thanks to the experience described in Section 5.

5 Use Case: MeetMeTonight 2015

Parallel was exposed at the stand of the Laboratorio di Informatica Musicale (LIM, Music Informatics Lab) of the University of Milan during the 4th edition of the European Researchers' Night,[1] called "MeetMeTonight 2015".[2] This event took place at the Giardini Indro Montanelli of Milan on September 25–26, 2015. The event addressed a wide and heterogeneous audience, ranging from primary school children to older people.

The research theme chosen for the stand was the gestural control of virtual music instruments. A number of activities was offered to the audience in order to show how new technologies can be applied to music and multimedia through installations to be individually enjoyed.

In that context, we brought a re-scaled version (0.7m × 1m) of *Parallel*, originally presented during the 10th edition of "Meccaniche della Meraviglia", held on May 17 – July 26, 2015 in Brescia, Italy.[3] The need to produce a small-size version was forced by the limited space available and by logistic issues related to the handling and transport of the original installation. Figures 3 and 4 show the full-size and the small-size versions of *Parallel* respectively.

1 http://ec.europa.eu/research/researchersnight

2 http://www.meetmetonight.it/

3 http://www.provincia.brescia.it/cittadino/cultura/evento/meccaniche-della-meraviglia-10

Fig. 3 - The original, full-size version of Parallel installed at "Meccaniche della Meraviglia

Fig. 4 - The resized version of Parallel installed at "MeetMeTonight 2015".

Hundreds of people visiting the stand were involved in a multimodal experience of sound, based on auditory, visual and kinesthetic stimuli, being able to interact with the vibrating plate and influencing its behavior through their body.

The main research questions (and the corresponding answers) for the use case were:

- *understanding if an intuitive interaction with Parallel could engage a general audience*. The answer was affirmative: many users of all ages wanted to interact with the installation, and their engagement was high and prolonged in time. For example, often parents had to insist to make their children leave the installation, and we also registered a number of cases of young students that came back with their parents and friends after visiting the stand with their classmates;

- *investigating if this multimodal experience could effectively explain the phenomena related to sound*. On-the-field observation lets us positively answer this question, even if a supervised fruition was often necessary – sometimes required by the audience – to investigate the phenomenon in depth;
- *exploring the different interaction styles in a heterogeneous audience*. It was particularly interesting to observe the interaction of children, more inclined to haptically explore than adults, moving their hands around the surface, using either single fingers or both hands, and sometimes touching the plate together in small groups (see Figure 5). Adults have captured the artistic aspects of the installation instead, approaching the vibrating plate with a more cautious approach, as if to preserve the sanctity of the artwork. Since *Parallel* was designed for close interaction with the audience, typically adults needed to be encouraged in their experience;
- *measuring the ability to generate scientific and technological curiosity beyond the artistic fruition of the installation*. From this point of view, many users of all ages wanted to know how *Parallel* worked, and after a detailed explanation they tried to tweak the installation, thus demonstrating a good level of comprehension of the mechanisms behind it.

Fig. 5 - An example of explorative and collaborative interaction with *Parallel* typical of children.

The basic knowledge we wanted to convey through *Parallel* regarded the physical experience of sound properties, including pitch (high vs. low register), dynamics (piano vs. forte), and timbre (waveform and spectrum). The experiential learning path went beyond these goals and the multimodal interface of *Parallel*. In fact, an experienced or particularly curious audience, including a considerable number of children, wanted to explore what was "behind the scenes", peeking the other side of the plate where sensors/actuators resided. This approach allowed to face other aspects of sound production and propagation, e.g. how an electric signal can drive the generation of vibrations, in accordance to the behavior of loudspeakers. Moreover, it was possible to discuss with non-experts advanced technical and scientific subjects such as the exchange of electric charges, the measurement of electric values, and the theory of electromagnetism. It is worth mentioning the case of a teenager that used *Parallel* to check if different objects can conduct electricity by putting them in contact with its surface.

Finally, another part of the installation could be unveiled to a selected audience with specific competences and interests: the computer-based framework that made sound production possible, also as a feedback to specific actions by the audience. The Max/MSP patch under execution on the PC could be modified in real time, in order to provide an experiential counterpart to the theoretical explanations by the experts. From the point of view of Max/MPS, sound generation can be seen as a process evolving in time rather than a static event, and this consideration can pave the way to new insights.

Please note that, although the experiences proposed at LIM's stand were expected to be unsupervised, lab researchers were present on site to provide theoretical explanations and technical details.

Conclusion

The work presented in this paper shows a possible point of contact between artistic creation and scientific divulgation. The keystone is experiential learning, which is adequately supported by the former and is at the service of the latter.

Unmediated enjoyment, sense of surprise, curiosity become a push towards the knowledge, understanding and deepening of non-trivial topics, sometimes conducting educational activities on an unexpected land.

From this point of view, the experience with *Parallel* at "MeetMeTonight 2015" was really satisfactory, because the heterogeneous audience demonstrated a great interest and a high involvement in a scientific subject otherwise hard to convey to non-experts.

These are the characteristics that make experiential learning an effective way to reach educational goals.

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