VIRTUAL ACOUSMONIUM: A STUDY ON EXPRESSIVENESS OF MUSICAL GESTURES

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ABSTRACT

For the composer and the interpreter of acousmatic music, the ability to place a sound in space has become an essential element in the creative practice. Together with pitch, timbre, intensity and duration, the position of sounds in space determines its role as a whole. Even more, the movement of sound in space allows them to evoke, with the help of the interpreter, representations of physical environments and gestures. The gesture as a source of motion and the movement that follows, allows you to dive fully in the sound environments depicted. The relevance of this aspect has led us to study and to experiment the behavior of a virtual environment, more precisely a virtual Acousmonium, testing on it various gestures that are part of the tradition repertoire of acousmatic interpretation. The goal is to verify its effectiveness as a compositional tool, as a tool for studying, for the preparation of acousmatic music performances, and as a didactic support for interpretative practice.

1. INTRODUCTION

In the acousmatic compositional practice, the concept of *spatiality* has always been a central point: the representation of plausible or unlikely environments, the movement of sources within a physical or virtual space, the evocation of soundspaces, can bring an acousmatic work to a completely different dimension. In particular, the Acousmonium is one of the most used diffusion systems for acousmatic music: it is the so-called "loudspeaker orchestra", where a large number of speakers are strategically placed in space, each with their own frequency response. The performer of acousmatic music has access to the potential of the Acousmonium through the mixing console: with interpretative gestures, he can decide both the movement and coloring the sound, giving its own personal imprint on the music.

The idea of creating a virtual Acousmonium comes in the first place from the difficulty of using a real Acousmonium: it can be complicated to be able to test, perform and experiment on these system, given the size and complexity. This trouble in accessing the system reflects on artists, performers and composers: a work reproduced by an Acousmonium will be very expanded and enlarged. The composers will therefore have to understand, within the structure of the music, how this enlargement can be compatible with their ideas.

For example: if we have two very fast and short sounds in succession, how will they behave positioned in a space ten times wider, played ten times louder? Without the availability of an Acousmonium it is much more complicated for the artist to be able to relate to the space in which he will play, not to mention the fact of not being able to access the control interface.

The creation of a virtual Acousmonium compensates for this problem by making accessible a system that not always can be so. The use of modern spatialization technologies also make this system flexible and usable in different situations in the studio: Ambisonics, in particular, allows to spatialize sources both in binaural and in a multichannel environment. Developed by the engineer Michael Gerzon in the 70s, the Ambisonics system gives the possibilty to encode a sound field taking into account its directional properties [1]. In the case of a virtual Acousmonium, for example, each speaker is represented in the Ambisonics system through its coordinates in a virtual space, from which the physical characteristics of the acoustic field of that source are obtained. The decoding occurs according to the audio reproduction system, in which the number of components is proportional to the level of complexity used in the coding process (called *order*): this can take place in headphones (binaural decoing) or in a multichannel configuration [2].

Furthermore, the possibility of automating and programming gestures and movements for the machine to perform, is extremely interesting: in this way, many fascinating topics can be delved into, such as didactic applications (ear training and acousmatic composition) or performative applications (assisted spatialization, practice tool at the control interface).

2. BACKGROUND

From a non-musical point of view: "gesture is a movement that you make with your hands, your head or your face to show a particular meaning" [1]. Gesture and sound are two intimately related dimensions. The musical gesture is the movement that produces sound, which relates the

[1] https://www.oxfordlearnersdictionaries.com/definition/english/gesture_1?q=gesture

sound object - the object that "plays" - with the cause of the sound itself, inextricably linking music to physical activity [3]. The physical gesture as an "expression of a thought" is therefore linked to a sonic result, characterized by its tonal qualities. In the spectromorphological terms of Smalley, "A gesture is therefore an energy-motion trajectory which excites the sounding body, creating spectromorphological life" [3]. Consequently, the morphology of a sound will bring with it the gestures that produced it.

However, a sound gesture can also be a movement of sound in space. According to Roads [4] we, as human beings, not only memorize and reason in spatial terms, but perceive space. The same emotional charge that we can evoke from the perception of a sound gesture, can be obtained through the movement of sounds in space. The space as a compositional element was used by various composers, from the use of separate choirs in the 16th century in the Basilica of San Marco, to Mozart, Berlioz and Mahler, Stockhausen and Grisey. But it is undoubtedly in electroacoustic and acousmatic music that space comes to have the same relevance as pitch, rhythm and timbre [4]. From the potentiomètre d'espace created by Poullin in the 1950s, to the sound diffusion in electronic music studios of the same years, passing through the panning techniques of voltage-controlled synthesizers up to the potential offered by computers, the use of audio-oriented programming languages or to the implementation of plug-ins in DAWs, space has always been a compositional and performative element of this musical art [5].

Spatiality and spatial gestures have an enormous relevance in acousmatic music and especially in the Acousmonium, the diffusion system created specifically for this music genre. The term acousmatic is derived from the Greek *akusmatikoi* and describes the sound that is heard without identifying the cause. The adjective refers to the lessons of Pythagoras that the disciples had to listen without being able to see the teacher, hidden by a veil. It was the French composer Pierre Schaeffer who first coined the term acousmatic music in his "Traité des objets musicaux" [6]. By isolating the sound from the visual context, acousmatic music returns to the hearing the total responsibility of a perception that normally relies on other sensitive testimonies [3].

The Acousmonium, instead, was born from the idea of Francois Bayle and the Groupe de Recherches Musicales (GRM) after the experiences of concrete music in the 1950s and 1960s by Pierre Schaeffer: they needed to evolve electronic music, exploring all the problems related to listening and the little interest aroused by simple stereophonic reproduction in the early 70s. Inspired by the orchestra as a standardized and unified concept by Haydn, Bayle wanted both to create a predefined framework in which the acousmatic composers could express their ideas, and to define a reproduction system of great impact in terms of sound and timbre. Almost simultaneously, Bayle's first Acousmonium was born at GRM, premiered on February 12th, 1974 in Paris, while Clozier created the Gmebaphone for the Group de Musique Expèrimentale de Bourges in 1973. The latter separated the various audio channels by filtering the original source, sorting the timbrically modified signal to the various speakers; Bayle's Acousmonium, on the other hand, created its large timbral palette by positioning speakers with radically different frequency response in space. This made it possible to circumvent the problem of the signal's phase deriving from filtering of the source, which can lead to big problems of localization of sound and to sound artifacts. Today, compared to the 1970s, there are much more developed supports such as the computer and the possibility of editing channels directly on the mixer. In addition, there are Acousmonium configurations that provide a huge number of speakers, with different degrees of height compared to the listener, or with an impressive variety of speakers. With the creation of such systems, the importance of the spatial interpreters has grown considerably: they are performing musicians, require a certain degree of virtuosity (depending on the speaker system and the ergonomics of the sound projection instrument) and stylistic knowledge of the repertoire [7]. According to Vande Gorne, there are sixteen gestures (or spatial figures) that are applicable to the interpretation of stereo compositions at the Acousmonium: the spatial interpreter is responsible for binding these gestures together in order to reinforce the writing of the work [7].

In 2016 Barret and Jensenius [8] and Kermit-Canfield [9] present two different versions of virtual Acousmonium. However, the work presented here is specifically modeled after the Sator Acousmonium [2], and a number of gestures have been formalized and experimented on this virtual system in order to test its robustness.

3. THE VIRTUAL ACOUSMONIUM

The virtual Acousmonium was developed with the SuperCollider programming language [10] and relies on spatialization libraries based on Ambisonics [1]. The basic idea for the recreation of an Acousmonium was to emulate the desired number of speakers, place them in a virtual space and "color" the frequency response based on the position and type of speaker.

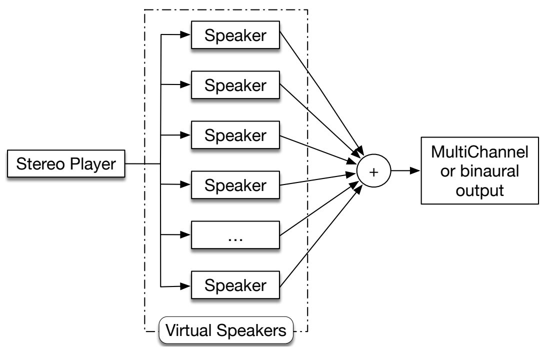

Figure 1. Audio flow diagram from a single stereo source.

Each of these speakers receives a stereo audio signal and,

[2] https://www.centrosanfedele.net/musica/

through a series of equalizations, delays, reverberation and spatialisation, it will emulate the speakers chosen in the virtual space.

The user will have an interface where the sliders of the relevant speakers (or groups of speakers) will be displayed, being able to manually control their amplitude, the buttons to activate the automations and the waveform of the stereo file being read.

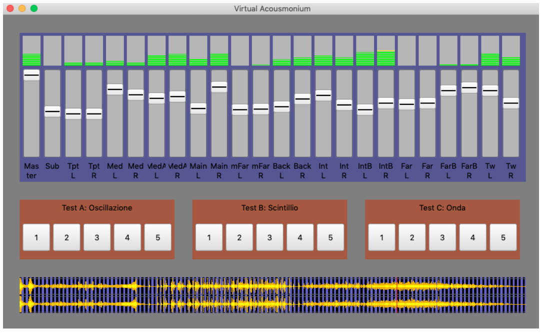

Figure 2. The Virtual Acousmonium prototype GUI.

Ideally it is useful to have MIDI or OSC controllers with a sufficient number of faders, in order to have manual control on the individual sliders and receive visual feedback in real time. In particular, a Korg NanoKontrol [3] and a 16n Faderbank (figure 3) were used for testing.

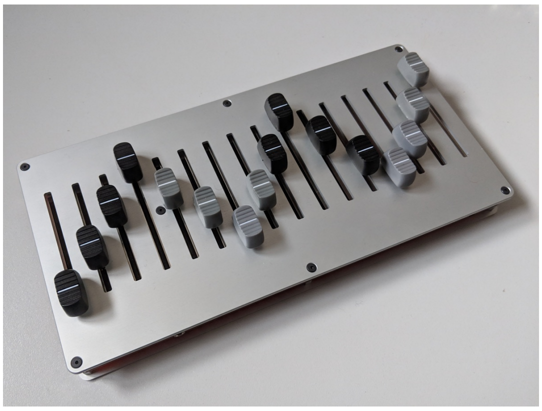

Figure 3. 16n Faderbank.

3.1 The Acousmonium Sator

The virtual Acousmonium implemented here is based on the configuration of the Acousmonium Sator of the Centro San Fedele in Milan [4]. Designed by Eraldo Bocca, the Sator system consists of different types of speakers distributed along three concentric crowns and an effects section which, controlled by a console consisting of a Yamaha LS9 mixer and a Yamaha 03D mixer for a total of 48 channels, allows the diffusion of acousmatic, electroacoustic and mixed music.

Different groups of speakers are already present in the room:

- an internal crown of 9 Nexo speakers + a Nexo subwoofer;
- an external crown formed by four speakers mounted in the corridor of the balcony which produce a reflected and reverberated sound;
- two Db speakers positioned on the balcony for rear reflected sound and eight JBL speakers for cinema surround;
- two JBL main monitor speakers on stage;
- a central JBL speaker on stage;
- a JBL subwoofer speaker on stage.

Speakers built and installed specifically for the completion of the acusmonium are also present:

- two front distance speakers positioned in the backstage;
- a front section of colored loudspeakers positioned on the stage made up of two loudspeakers for the reproduction of dipole emission mediums;
- two diffusers for the reproduction of medium-high dipolar emission;
- two hyperbolic horns for the reproduction of higher frequencies;
- six supertweeters are inserted in the auditorium sky;
- on the balconies four loudspeakers for medium and four supertweeters are installed.

The authors have chosen to emulate this configuration of the Acousmonium given their collaboration with the Centro San Fedele and its availability for testing.

Figure 4. The stage of San Fedele with the Sator's coloured speakers and the Yamaha console.

3.2 Implementation and structure

Given the configuration of the Acousmonium Sator, we opted for a narrower recreation than the large number of speakers actually on site. In total 27 virtual speakers have been created (plus control over the master):

[3] https://www.korg.com/it/products/computergear/nanokontrol2/

[4] https://www.centrosanfedele.net/musica/acusmonium-sator/

- 1 subwoofer;
- 6 coloring speakers: 2 trumpets, 2 medium, 2 medium-high;
- 6 full-range speakers: 2 front, 2 back and 2 front echo effect;
- 4 full-crown speakers: 2 sides and 2 back;
- 4 external crown speakers (echo effect): 2 sides and 2 back;
- 6 supertweeters.

These virtual speakers are placed in space in accordance with the arrangement of the Acousmonium Sator. In particular, to create the echo effect, a great distance from the listener is emulated through delay time, reverberation, and amplitude scaling (figure 5), just like in [11].

```
1  SynthDef(\src , {
2      arg x = 1, y = 0, lpf, hpf, amp, d, eq1, db1, eq2, db2, eq3, db3;
3      var sig, enc, dec, out, rev, del, eq;
4      //x and y positions between -pi/4 and pi/4
5      x = x.linlin(-1, 1, -pi/4, pi/4);
6      y = y.linlin(-1, 1, -pi/4, pi/4);

8      sig = In.ar(~srcBus, 2)*amp; //input signal

10     //speaker equalization
11     //low and high frequencies boundaries
12     sig = LPF.ar(HPF.ar(sig, hpf), lpf);

14     //3 bands parametric EQ with individual gain
15     eq = BPeakEQ.ar(sig, eq1, 0.5, db1);
16     eq = BPeakEQ.ar(eq, eq2, 0.5, db2);
17     eq = BPeakEQ.ar(eq, eq3, 0.5, db3);

19     //encoding and binaural decoding with x,y positioning
20     enc = PanAmbi3O.ar(sig, x, y);
21     dec = BinAmbi3O.ar(enc);

23     //delay and riverbero related to speaker distance
24     del = DelayN.ar(dec, 0.3, d.linlin(0, 5, 0.001, 0.3));
25     rev = FreeVerb.ar(del, 1, 0.8, 0.8);

27     //output stage
28     out = (dec*(1/d)+(rev*(1/d.sqrt)));
29     Out.ar(~revBus, out);
30 }).add;
```

Figure 5. SynthDef of a virtual speaker spatialized with binaural Ambisonics 3D reproduction [12].

To differentiate the virtual speakers, the most important aspect is equalization: in figure 5 (from line 12) the signal is firstly delimited in the high and low frequencies (with LPF and HPF) and then a 3-band equalization (BPeakEQs in line 15-17) with individual gain is applied. In particular, the extreme limits of the signal are important in order to denote the speakers: for example, the tweeters have a range from 4,000Hz to 20,000Hz. This is even more critical in the so-called "colouring" speakers: the trumpets have a range from 3.500Hz to 10.000Hz, the middle ones from 300Hz to 800Hz while the medium-high ones from 600Hz to 3.500Hz. To give the sound more liveliness, the frequencies and gains of the 3 parametric equalizers for each speaker are slightly randomized, creating a phasing effect also between the L and R channels for each family of speakers.

The subwoofer plays a separate role: for convenience, the virtual speaker dedicated to low frequencies is considered omnidirectional, therefore not spatialized. Furthermore, a convolution reverber is applied to the final mix: since the room of San Fedele has a very "dry" and little reverberant acoustics, the impulse response applied to the virtual Acousmonium is one recorded in a medium size concert room with a percentage of "wet" around 20%.

The spatialization of each virtual speaker is made with third-order Ambisonics, both for binaural rendering and for quadraphonic reproduction. These two solutions are particularly suitable in the studio, as Ambisonics is a technology that can quickly switch between the two decoding techniques but that requires the listener positioned in a very well-defined sweet spot [2] (in quadraphony).

One of the main problems of Ambisonics is also the poor directionality. Ambisonics of the first order encodes each sound field as an omnidirectional microphone (zero order microphone) or as a microphone with 3 figure-eight (first order microphone). It is possible to improve the directional sound of the spatialized sound by using higher order microphones: these techniques are called HOA (Higher Order Ambisonics) [2].

4. THE MUSICAL GESTURE IN SPACE

In musical research, movement has often been linked to the concept of gesture. The reason is that many musical activities (performance, conduction, dance etc.) involve body movements that evoke very precise meanings: these movements are called *gestures* [13].

There are many ways in which body movements related to musical contexts can be treated, measured, described and applied. Consequently, there are many ways in which the musical gesture can be meaningful. Musical gestures can also be recognized within a context of spatial interpretation at the Acousmonium. The authors propose two categories of primary gestures:

- Compositional gestures: the musical gestures within the work that can be observed spectromorphologically, that is, by studying how the sound is articulated over time timbrically, dynamically, rhythmically;
- Interpretative gestures: the musical gestures and spatial movements produced by the acousmatic interpreter during the performance.

These two categories are closely correlated: compositional gestures very often correspond to an interpretative gesture aimed at accentuating or highlighting certain intrinsic movements in the work. To these categories can be added other types of secondary gestures: for example physical movements of the performer as an aid to memorization.

It is also important to note that the term *spectromorphology* is not to be considered as an objective and scientific concept, as a scientific analysis of sound is not very interesting, although the latter can help in discovering some details of the sound itself: it is much more interesting, from an artistic point of view, the sound as perceived by the human ear. This is because the listener instinctively responds to body energy and the spectral qualities of sound: this is what happens also during tonal music performances, as it is not only a matter of pitches, harmonies and rhythms, but also of timbre or spectromorphological qualities [3].

4.1 Gestures in acousmatic music and gestural sonorous objects

Although Pierre Schaeffer is more commonly associated with the concept of *concrete music* and *acousmatic listening*, one of his great successes was the idea of the *sound object*. The sound object is a fragment of a sound, typically of a few seconds or even less. It allows to have a vision of an entire fragment of sound represented with a shape, therefore an object, with different characteristics simultaneously evolving between the initial and final points of the latter (timbre, dynamics, texture etc). These objects are raw fragments of sound, some of which can be chosen and used within musical compositions, and therefore elevated to the status of musical objects.

Schaeffer, in his monumental "Treatise on musical objects", observes how the sound object is an intentional unity, constituted in our consciousness by our mental activity [6]. The sound object can be inspected, explored and progressively differentiated through its own characteristics, which evolve or have different envelopes that can be traced, becoming, according to Godøy [14], the gestural object. Godøy says that there is a continuous mental sound tracking in the musical perception following the onsets, contours, textures, envelopes etc. with hands, fingers, arms or any effector organ (capable of responding to nervous stimuli) whenever we listen to or imagine music. This means that from listening or continuously tracking the sound we can recode musical fragments into multimodal gestures based on biomechanical constraints: in short, we move our body according to the type of sound to which we are subjected. The opposite can also happen, that some gestural images can generate sound images: it is therefore a two-way process.

In the case of acousmatic music, the listener cannot see what the gesture that produces the original sound is: one of the key concepts in the theories of listening to acousmatic music is precisely the fact of putting aside the anecdotal causes or meanings of sound, but focusing only on the intrinsic characteristics of the music. In any case, it is quite clear that Schaeffer, in his studies, made great use of gestural and metaphorical concepts in qualifying the sound objects. Again according to Godøy [14], Schaeffer's use of gestural concepts and metaphors can relate to an idea of embodied cognition, in which virtually every domain of human perception and thought (even the most abstract ones) can be connected to images of movements. The concept of sound-gestural objects can be introduced, an extension of the sound objects in relationship to the gestures that it is transmitted to us during the acousmatic listening. In Schaeffer's works, gestures can be divided into three caterogies of components concerning sound production:

- impulsive or discontinuous type;
- sustained or continuous type;
- iterative type;

Schaeffer also defines other categories of gestures, called compound (where multiple sounds start simultaneously) and composite (multiple objects merged together into one). Furthermore, these gestures relating to the production of sound match the different spectromorphological categories (always defined by Schaeffer) like, for example: changes in mass or harmonic timbre, but also in dynamics, in melodic profile (general changes in pitch) or in mass profile (changes in the intrinsic spectral content), all caused by changes in speed, pressure, direction of the original production gesture. The gestures concerning the modification of the sound are also combined with these morphological categories: modulation gestures such as the application of vibrato or tremolo at different amplitudes and speeds, but also changes in mass, dynamics, profile of pitches etc. previously mentioned. The point is to show that there are gestural components incorporated in Schaeffer's conceptual apparatus and inside his compositional works.

These gestural components can be applied to different sounds interchangeably: a tremolo can be applied to both a violin sound or to the sound of the pouring rain. We can therefore say that they have a certain degree of abstraction: they are transferable from one "domain" to another, both at the physical and at the musical level. In this case, all the characteristics of the sound-gestural object can also be applied to the concept of space and spatiality, in particular to the acousmatic interpretation and to the Acousmonium, as it is strictly related to the spectromorphology of sound and its projection in a diffusion space.

5. EVALUATION OF THE VIRTUAL ACOUSMONIUM

5.1 Tested gestures

To test the virtual Acousmonium, some of the gestures that Annette Vande Gorne [7] identifies were used. Through the automation of the faders, two gestures have been coded in order to test the system:

- **Le fondu enchaîné** (crossfade): slow or imperceptible transition between two pairs or groups of speakers. The gesture must be carefully performed in order not to dig a "sound hole". Between the two groups of speakers, begin to gradually increase the first one, decrease the second one finding a balance point. Musical function: reinforcement of a crossfade already pre-existing in the work. Change depth plane. Trace a path through successive crossfades if, for example, this sound evokes a moving object (ball, car, plane, etc.);
- **La vague** (wave): round trip that crosses, through cross fades or subsequent unmasking, a series of in-line speakers, for example from the backstage towards the front stage, all sides, the back. Musical function: moving mass effect and predictable unidirectionality. This movement has the advantage of joining a known agogic archetype.

5.2 Interpretations

The tests were carried out by automating five chosen interpretations of each gesture in the Virtual Acousmonium with binaural spatialization: these automations are generated through different combinations of fade movements that closely approximate the desired interpretation of the gesture.

The tested gestures are *Crossfade* and *Wave*. The interpretations, described through macro areas of the Virtual Acousmonium, are as follows:

Crossfade (crossfading areas reported):

1. back left, near right - back right, near left;
2. far right - far left;
3. sides far - sides near;
4. back left, near back right - back right, near back left;
5. front near - front far.

Wave (paths reported):

1. front far, front near, sides near;
2. back, all sides, front near;
3. far back, back, near back;
4. far, sides near, above;
5. left, front, right;

5.3 Preliminary evaluation

In order to collect data for future developments, we run a preliminary evaluation with five students in electronic music composition, one Bachelor's and four Master's. They have various degrees of experience with acousmatic music, but all can be effectively considered as expert listeners.

Every tester run the evaluation with their own equipment. They were sent three of the five interpretations for each gesture, six audio files in total, and a questionnaire. The audio files were labeled with the name of the gesture and an incremental number (e.g. Crossfade 1). The questionnaire reported the gestures' descriptions, as in Paragraph 5.1, and a list with the five descriptions of the interpretation as in Paragraph 5.2. For each audio file, we asked them to *i)* pair it with one of the interpretations, and *ii)* evaluate their confidence in matching the audio with the description through a Likert scale from 1 to 5, where 1 is the minimum and 5 is the maximum of confidence.

These gestures have been tested on an acousmatic composition of one of the authors. The binaural audio of each of the interpretations is accessible on GitHub [5].

Every interpretation has been evaluated by three testers. In Table 1 and Table 2 we report the number of correct matches for each interpretation (min = 0, max = 3), and the average confidence for the correctly matched ones (min = 1, max = 5).

The results obtained from the virtual implementation of the Acousmonium can be considered moderately satisfactory: in particular, the movements that include the side speakers (internal, external crown and far/near effect) are very effective and have been recognized consistently by the testers.

[5] https://github.com/StefanoCatena/VirtualAcousmonium/tree/master/Audio

Crossfade	Correct	Confidence AVG.
1	1/3	2
2	2/3	4.5
3	1/3	2
4	1/3	4
5	1/3	4

Table 1. Evaluation of the five interpretations of the gesture *Crossfade*. Correct matches (0 to 3), and average confidence (1 to 5).

Wave	Correct	Confidence AVG.
1	1/3	5
2	0/3	//
3	0/3	//
4	0/3	//
5	3/3	3.7

Table 2. Evaluation of the five interpretations of the gesture *Wave*. Correct matches (0 to 3), and average confidence (1 to 5).

Gestures that include a front/rear movement, instead, have been confusing for the testers, as shown by the results of their questionnaire. The unclear distinction between back and front, however, is typical of binaural technology: this confusion is often a problem of these renders due to ambiguous interaural cues and therefore relying only on monoaural spectral differences [15]. Moreover, given the individual morphological difference in pinnae, each tester would experience the front/rear movements differently: this problem can be minimized by choosing the correct binaural render for the corresponding pinnae's shape. Some testers have pointed out how it is harder to recognize certain movements at first glance, while it takes some time to get used to the binaural rendering. This is especially true for the front/rear movements: while the directionality of the movement has been easier to identify, it was much harder to recognize the difference between front and back. This is also shown by the fact that all testers have misidentified Wave 1 with Wave 4 and, in fact, nobody has correctly recognize Wave 4. This can be attributed to the similarities in the gestures, but also on the fact that both rely on frontal movements and are prone to confusion with rear movements. It is also noticeable how all the testers have recognized correctly Wave 5, where only lateral movements are present.

6. CONCLUSIONS AND FUTURE WORKS

This paper presented the development of a virtual Acousmonium and a first approach to the study and automation of musical gestures in space applied to this system. This tool is not intended in any way to replace the Acousmonium, but to be a tool to help students, teachers and acousmatic composers interested in this area of interpretation.

In addition to interesting compositional applications, the possibility of automating gestures allows the system to be configured also for educational purposes. In particular, it can be effective for:

- training in the listening of gestures, in the form of ear training;
- the possibility of imitating and practicing gestures, displaying them through its GUI, with the aim of acquiring them for later use in performance.

In this sense, the use of this system by students who wish to learn more about the practice of acousmatic performance may be desirable, especially if they are unable to access the physical Acoumonium. In this case it is extremely important to configure the virtual Acousmonium with its control console as similar as possible to the real life performance situation: the arrangement of the faders and which speakers they control, the desired spatial configuration, the amount of reverberation etc.

From an implementation point of view, the use of Ambisonics to replace real speakers is a significant limitation: it is difficult to simulate the irradiation diagram and the directivity of the individual speaker. Physical speaker cabinets have nonlinear radiation pattern, which are impossible to reproduce in a virtual environment with Ambisonics [9].

In the future other improvements will be introduced: the implementation of a spectrogram and general improvement of the GUI, the implementation of a unified system for the creation, editing and use of virtual speaker configurations, a tool for visualizing the speakers in the space for visual feedback; the possibility of recording a performance, or parts of a performance, so that it can be objectively listened back to; possibly to intelligently automate a whole performance.

In addition, a more thorough testing of the system will be performed: a larger number of testers, different binaural renders and new gestures and movements. It will be of relevant interest to realize these tests with quadraphonic or octophonic reproduction systems, in order to evaluate the Virtual Acousmonium's efficiency in more diverse situations as well.

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