Immersive sound / Immersive listening

Perception, consciousness, algorithmic composition

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Abstract

This dissertation is concerned with the immersive aspects of sound and listening. In indicating possible ways of entry to a definition that might seem abstract, a body of theoretical studies on perception and listening is used to provide a framework. In practice, the research implied algorithmic strategies focused on using behaviour as a central compositional tool for sound and music making. Immersive aspects of material and behaviour are framed together with the context of listening, the implied sound technology and the space of reproduction.

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Contents

1. Introduction

The current research was developed in its theoretical studies during the last two years, although my creative work has been centred around the concept of immersive experience for some time before.
It was a courageous decision to investigate sound and listening under this perspective since the adjective “immersive” embeds a framework that especially looks at multimediality and interactivity. It also might often become too abstract, or be too limited within technologies such as VR and multichannel audio formats (Dolby Atmos, Ambisonics and others). It’s, therefore, a relatively new term in its association with art and technology. In the main dictionaries, the adjective “immersive” refers exclusively to the aforementioned frameworks of media arts, but what I find specific is that its most used synonyms (surrounding, enveloping, overwhelming) define properties that are particularly inherent of sound.
The main inquiries that have driven this research path are: is immersiveness a property of sound/material? Or is it a property of a specific kind of experience of sound? How much is the role of audio technology in creating immersive material/experience? Is it possible to investigate on experience, taking into consideration the subjectivity of the listener?
The fundamental aspect that emerged from the research is that immersive technology and immersive art specifically focuses the attention on the space between the user / listener / “immersant” and the artwork, within the technological mediation. Digging into this space implies encountering many different fields of research. In choosing some points of focus, I took into account studies on human perception, investigations on the relations between listening and consciousness, research on entrainment and its implications on attention over listening. Reflections over the contextual implications on listening have been also included, together with some considerations over the role of the space of reproduction and of the audio technology.

The creative work originated from the choice to use Wind as the main sound source, driving the development of an algorithmic system of analysis and resynthesis of the source material. The focus was not to re-synthesize wind but to extrapolate its behaviour as a source of musical expression. Therefore, the compositional work was inspired by the idea of wind as a *presence* to be revealed through synthetic sounds that are not necessarily focused on wind's mimesis.
For the first months, the research seemed to be unfolding along two parallel lines: the theoretical studies and the creative work. Later, the two lines merged together, one informing and influencing the decisions of the other.

The thesis is structured in four chapters: Chapter 2 provides an overview on theories of perception. In particular Ecological Psychology is taken as a starting point for further considerations over the notion of Environment. Embodiment theory is discussed as providing insights into the role of the body in the experience. After this overview, two Virtual Reality works are described as presenting related aspects. A section regarding investigations over listening and consciousness is introduced as presenting conceptual similarities with the notions of environment discussed before, directing the focus towards listening.
Chapter 3 drives the reflections over the domain of sound and listening, presenting my idea of patterns of listening developed through the usage of wind's morphology. Reflections are made over acousmatic music and the implications of listening to the acousmatic environment. Studies on entrainment are analysed as showing the effects of prediocity and rhythmicity over listening.
Chapter 4 is dedicated to the technical and musical developments of the first year, describing the process of recording, analysing and composing with behaviour. The first outcomes are described and discussed: *Becoming Wind*, *Forma Volatile.* Chapter 5 is dedicated to the technical and musical developments of the last year, more focused on the development of the algorithmic system. The outcomes consist of four sound studies, two live coding performances and the code developments of the last two months, that are currently evolving towards a cycle of compositions entitled *Flow States,* which is still in progress.

2. Constituting the Environment

Introduction to the chapter

In this chapter, I will provide some theoretical background and references the questions addressed in this research. I will firstly look into perception, specifically referring to the studies on perception of ecological psychology (2.1). I will proceed with the discourse taking into consideration the theory of Embodiment of Merleau-Ponty (2.2). I will then describe two VR works presenting some related aspects. In continuing to define the research's environment, I will provide an overview of Ruth Herbert's studies on listening and consciousness (2.3).
In the last paragraph (2.4), I will summarize all the aforementioned topics and connect them to the focal point constituted by immersiveness.

2.1 The Ecological approach to Perception

The research on perception constitutes an extremely vast body of studies and works of art. As "immersiveness" is a property of the experience of contact between individual and environment, I found great enlightenment in the take on perception from the school of ecological psychology pioneered by J.J. Gibson (1904-1979) and E.J. Gibson (1910-2002).
Ecological psychology, in its very origins, aimed to offer an innovative perspective for understanding perception and perceptual learning that overcomes the traditional psychological dichotomies of perception/action, organism/environment,

subjective/objective, and mind/body[1]. These widely accepted ideas and dichotomies, sustained by experimental psychology for the first half of the 20th century, started to be challenged by the Gibsons and their collaborators from the 40s. Specifically, the work of E.J. Gibson focused on perceptual learning, ontogeny and reading, while J.J. Gibson (her husband), focused on perception. J.J. Gibson's main works, although focusing specifically on visual perception, gave a groundbreaking view on the mechanisms of interaction between individual and environment. His observations were inspired by different currents of psychology and philosophy such as Pragmatism, Behaviourism, Gestalt Psychology, Phenomenology (in particular the work of Merleau-Ponty, which will be introduced in the following paragraph). Gibson's main works are *The perception of the visual world* (1950), *The senses considered as perceptual systems* (1966), in which the Aristotelian account of the senses as channels changed to be defined as "active systems", and the most famous *The ecological approach to visual perception*, first published in 1979, a few months before Gibson's death.

Ecological psychology emphasized the active exploratory role of the agent perceiving the environment, breaking the behaviourist idea that the objects of perception are physical units with inner structure and meaning which are recombined in our head. Gibson indeed inherited the view of Gestalt psychology that experience is given to us by certain laws that shape it. However, he rejected the Getaltist idea that meaning or value is subjectively imposed on the natural world by mental processes, and the separation between mind and body. In rejecting the take on subjectivity of Gestalt, Gibson was influenced by Merleau-Ponty's phenomenology. Indeed Merleau-Ponty believed that the structures that allow for cognition are not purely cultural or mental, but bodily structures. Merleau-Ponty's idea of the "body-schema" is explained to be a "pre-conscious system that emerges by the combination of the bodily capacities of the agent and the complementing aspects of the environment"[2].Similarly, Gibson formulated the concept of "perceptual systems", individuating an intrinsic

[1] Lobo, Escribano, Travieso (2018) "The History and Philosophy of Ecological Psychology", Frontiers in Psychology, 1

[2] Lobo, Escribano, Travieso, 4

coordination between perception and action when one of these systems is functioning:

> [...]sense modalities should not be understood as subpersonal systems in which specialized receptors (photoreceptors, for example) are stimulated by a sensory stimulus (photons) producing a sensory impression that is enriched and transformed to form a representation. According to Gibson, animals evolved not only to be sensitive to sensory stimuli, but also to detect ecological information. What is needed for this is not only the subpersonal neural pathways and systems, but also a range of behaviours that are instrumental in revealing and picking-up ecological information: these behaviours extend to the eye-brain connection and include movements in the eyes, head and body that facilitate the detection of ecological information in the array. Thus, a sense modality is considered as a perceptual system when it includes this range of behaviours of the animal taken as a whole.[3]

Moreover, the organism-environment dichotomy is one of the most important dualities that ecological psychology aimed to overcome. Indeed in his last book Gibson recognised an essential reciprocity between perceiver and environment. He refused an account on the environment as described by physical metrics, since they are not useful to describe behaviour, which is indeed related to organisms. Rather, he described the environment in ecological terms, taking it as related to the organism's capacities, formulating the concept of *affordances:* "the possibilities of action that the environment allows for an organism".[4] Gibson claimed that perceiving affordances is perceiving ecological meaning, which is perceiving how the surroundings are related to the agent's capacities. This idea shows that an organism does not perceive an objective, value-free physical world in which meaning is imposed, as in Gestalt theory.

> We do not create affordances when we perceive them (Michaels, 2000), they already exist in the system as constant relations between organism and environment. The

[3] Lobo, Escribano, Travieso, 5

[4] Lobo, Escribano, Travieso, 7

> detection of information amounts to affordance perception, so affordances are meaningful objects of perception in an organism-environment system.[5]

Now, in framing this view on the organism-environment system in the context of this research, it's essential to include the technological mediation as an additional agent. As I will explain in the following chapter, technological media have the agency to shape substantially our experience.

In the context of acousmatic music, this view of ecological psychology has been adopted by Luke Windsor to formulate an analysis of the listening context and modalities in place when listening to acousmatic music. Although I will go in detail about that in the following chapter, it's important to say that Windsor, within this view, is able to define the importance of the *context* of listening as an essential agent in the environment. He defines listening as an exploratory activity of the environment, substantially shaped by the context. Within this view, it is not possible anymore to isolate music as a stimulus of which the experience is purely subjective. Rather it's an *originator* of an environment, of which the musical stimulus becomes one part.
In my opinion, a musical environment can therefore be considered as a *space of interactions* between the material, the listeners, and the context. I acknowledge that the word *interaction* claims a whole series of other contexts where an actual intervention or communication between the listener/observer/user and the artwork is tangible or observable. Indeed, talking about interactions between listener, music and context without implying actual interactive infrastructures can seem a bridge too far. The interactions considered here are for sure not tangible, but neither are they abstract nor metaphysical. Indeed, what emerges from the view of ecological psychology is that the act of perceiving already embeds a series of actions, happening at the cognitive level and sometimes embedded in the environment itself (affordances). These actions substantially shape the external stimuli, thus the listener responds to the music by perceiving it in certain ways and directing the attention to specific elements (or inwards). These internal activities are translated to behaviors and social behaviors that on a larger scale feed-back into the works of art. From this

[5] Lobo, Escribano, Travieso, 7

perspective, listening offers a space of interactions, without them to be specifically tangible (like in the case of interactive music and artworks).
With regard to that, Luke Windsor arrives at the assumption that listening is a way of *inhabiting* an environment, emphasizing the active and exploratory nature of listening, never passively experienced.[6]

In order to give a more extended view on theories of perception, I will continue in the following paragraph into the theory of Embodiment by Merleau-Ponty, being an important inspiration for Gibson and a milestone in the theories of perception.

2.2 Embodiment and *Habits* of Perception

> "Music, by way of acoustics, is inherently physical. It is a phenomenon experienced through the senses of the body, regardless of the media used to render it."[7]

The theory of Embodiment, or embodied cognition, asserts that many forms of cognition are shaped by mechanisms involving the entire body of the experiencer. Introduced at the beginning of the 21st century, this theory is rooted in Merleau-Ponty *Phenomenology of Perception,* in which the philosopher states that the body and the external world are a unified body of experience. Experience is where the making of knowledge resides, being not only a product of the mind but of the body as well. The *body knowledge*[8] is explained to be pre-cognitive and constituted by processes inherent in muscle memory, in the sensory-motor system and created by the process of perception. As explained in the article *Habit and Embodiment in Merleau-Ponty* by Patricia Moya, according to the theory of Embodiment, there is no

[6] Luke Windsor, "Through and around the acousmatic: the interpretation of electroacoustic sounds", "Music, Electronic Media and Culture" ed. Simon Emmerson (Ashgate, 2000), 20
[7] Corness, Greg (2008), "The Musical Experience through the Lens of Embodiment", Leonardo Music Journal, vol. 18, 21
[8] Corness, 21

hard separation between bodily conduct and intelligent conduct. Rather, there is a unity of behaviour that expresses the intentionality and hence the meaning of this conduct. In what Merleau-Ponty defines as *habits*, the body adapts to the intended meaning, thus giving itself a form of embodied consciousness.[9] In defining the role of habit:

> Habit bears a direct relation to this form of *dialog* between environment and subject. Its role is to establish in time those behaviors or forms of conduct that are appropriate for responding to the invitations of the environment. Merleau-Ponty, in establishing the etymological root of the term "habit," notes that the word *have* states a relation with what has been acquired by the subject as a possession, which in the case of the body is conserved as a dynamic corporeal scheme (Merleau-Ponty, 2012). Thanks to habit, the person establishes appropriate relations with the world that surrounds him or her without needing any prior reasoning, but rather in a spontaneous or immediate way.[10]

Moreover, Merleau-Ponty argues that our perception makes us both object and subject at the same time, referring to this reciprocal interaction between subject and environment with the term *reversibility* (being clearly of a big influence for Gibson's theories of organism-environment system).[11]

> We have to reject the age-old assumption that put the body in the world and the seer in the body or, conversely, the world and the body in the seer as in a box. Where are we to put the limit between the body and the world, since the world is flesh ? The world is not "in" my body and my body is not "in" the visible world ultimately: as flesh applied to a flesh, the world neither surrounds it nor is surrounded by it.[12]

The aforementioned view on perception and bodily cognition is indeed crucial for understanding the theoretical discourse on immersiveness, being largely investigated

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[9] Moya, Patricia, "Habit and Embodiment in Merleau-Ponty", Frontiers in Human Neuroscience (2014),2

[10] Moya, 2

[11] Corness, 21

[12] Corness, 22

by many multimedia artists. In providing a couple of examples of artistic investigations of this topic, I will describe in the next paragraphs the work *Osmose* by Charlotte Davis (1995) and the work *The Protagonist,* developed by my sister and I during the second half of 2020. Both of these works make creative use of VR technology and explore the physicality of the technologically mediated experience, focusing on mechanisms of communication between the human perceiving body and the technological media.

The concepts of embodied cognition and mutuality of relationship between individual and environment are also important keys for investigating musical experience, as said in the previous paragraph when framing ecological psychology. Following the last quote of Merleau-Ponty, a question arises: is it really useful to think of a clear perceivable separation between a musical sonic environment and what's outside of it?
Following what stated in the previous paragraph, I can reply to this question by further emphasising the validity of a view on listening to music as inhabiting an environment. The environment is constituted by a complicated net of interactions between the musical stimuli, the space of reproduction, the specific context of listening (including the technological infrastructure) and, most importantly, by the culture, the knowledge and the subjectivity of the listener.

Both ecological psychology and embodiment theory emphasize the importance of the pre-cognitive part of the process of perception as essential to constitute meaning, giving light to the unconscious as a space for meaning.
The intuition that drove me, during the first months of this research, in using wind as the central source of composition and sound making, can be observed as following a similar take on perception. Indeed, the idea was to attribute to sounds of wind, incorporated in a synthetic "abstract" soundscape (abstract in the sense of disregarding the morphology of wind or any other environmental sound source) the function of inducing different modalities of attention by evoking resemblances of everyday environments. Wind is incorporated in different ways in an algorithmic unfolding of behaviours that move gradually or abruptly away from the sonic

modalities of wind. Possibly initiating different hearing modalities and qualities of attention. I will elaborate more extensively on this idea in the following chapter.

2.2.1 *Osmose* by Charlotte Davies

Osmose (1995) is an immersive interactive VR installation with 3D computer graphics and 3D interactive sound. The interfaces utilized are a stereoscopic head-mounted display (HMD) and a real-time motion tracking interface vest. The latter tracks breathing and balance and allows the "immersant" (Davies coined this term to refer to the user) to navigate the virtual space. The movements of breathing in and out are translated to vertical navigation of the virtual space, literally giving the illusion to dive in and out, while balancing movements of the body serve to move horizontally. This navigational device constituted an innovation in the field of biofeedback for VR. This technical choice was supported by the artist's strong ideology and personal aesthetic. As analysed by Frances Dyson, Davies challenged the traditional VR interface (often constituted at that time by the HMD and a glove or joysticks) by offering a critique of VR as a medium based on Cartesian coordinates which privileges the eye and the mind over the body.[13] By offering an alternative interface that involves the totality of the body (although still relying, it has to be pointed out, on Cartesian coordinates), Davies aimed to problematize and challenge the supremacy of vision in modern society and the dualistic paradigm of eye-hand, proper of VR.
As explained by Davies herself:

> *Osmose* is a space for exploring the perceptual interplay between self and world, i.e. a place for facilitating awareness of one's own self and consciousness embodied in enveloping space.[14]

[13] Dyson, Frances (2009) "Sounding New Media - Immersion and Embodiment in the Arts and Culture", 112
[14] Dyson, 112

Moreover, the virtual environments proposed in *Osmose* are characterized by visual elements of a semi-transparent, blurred and semi-solid nature, thus criticizing the photorealism of computer graphics.

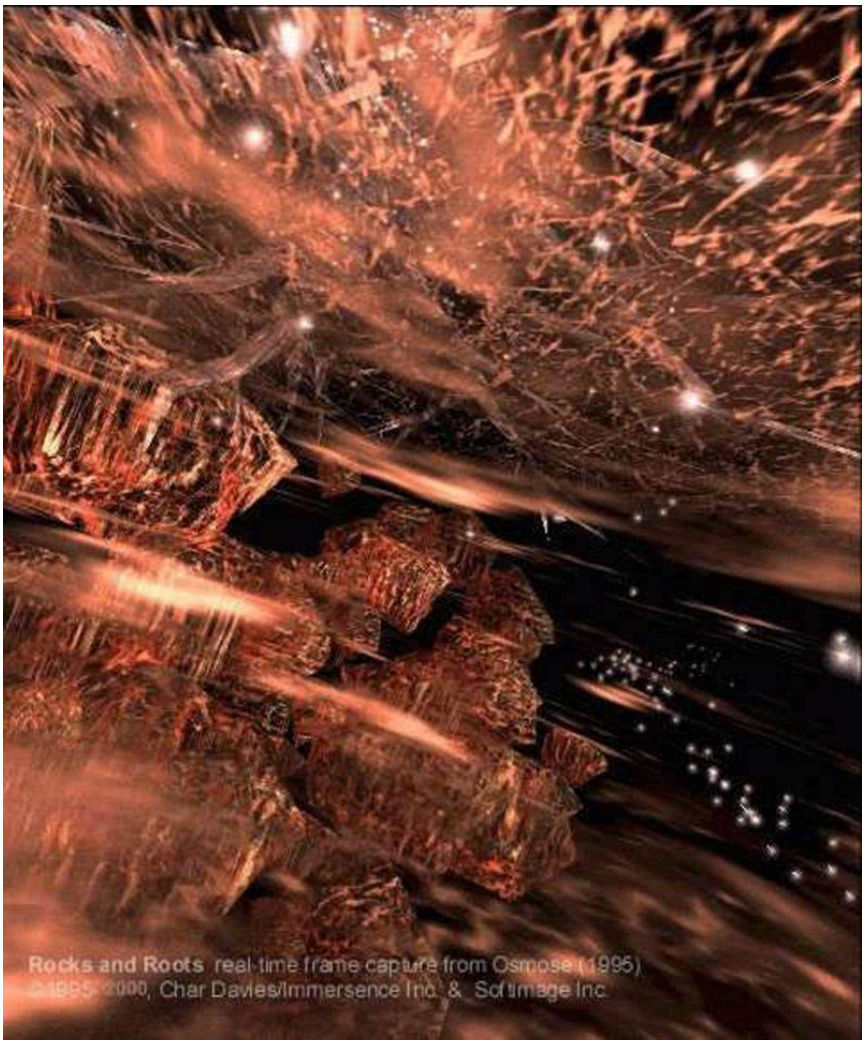

Figure a, real-time frame captured from Osmose (1995)

As analysed further by Dyson:

> Using breath to move up and down in the virtual environment, and balance to move left and right, the design of *Osmose* was intended to counter the frontality of vision with a sense of movement within enveloping space. This shift in perception, Davies hoped, would effect a shift in habitual modes of organizing the world – from

> hand-eye coordination to a focus on being-in, from the desire of forward movement[...]to an appreciation of being grounded in the here and now of the experience.[15]

Osmose has gained a lot of visibility and much criticism, being a revolutionary and unique work in the field. Indeed one of the big challenges was that the virtual environment remains still for most of the time, without many events happening. This irony presented to the user who experiences an uneventful environment while using a highly interactive interface gained a lot of criticism. Among the many, Richard Coyne remarked that " from a Heideggerian perspective, space builds on spatiality, which operates in a field of praxis, and if there is nothing to do that draws you in, then you become aware of the other sources of breakdown extraneous to the focus of the system: the heavy headset, the low image resolution, the noises in the museum, the time constraint, and so on…".[16]

Osmose is probably an extreme example in the reduction of the individual's agency over the environment, one that exposes all its infrastructure to the possibility of failure. It nevertheless made a tangible and strongly conceptual interconnection between embodiment and the possibilities offered by such technology. The work claimed the centrality of the body in the experience of the world, underlining the vagueness of the separation between body and environment. In order to do so, the body of the user is literally "locked in" the environment. The smallest bodily movements constitute the centre of agency for the whole of the experience.

> For Merleau-Ponty, the body is no longer *in front of* the world: "Being [is] no longer *before me,* but surrounding me and in a sense traversing me"[17].

[15] Dyson, 113
[16] Dyson, 115
[17] Dyson, 120

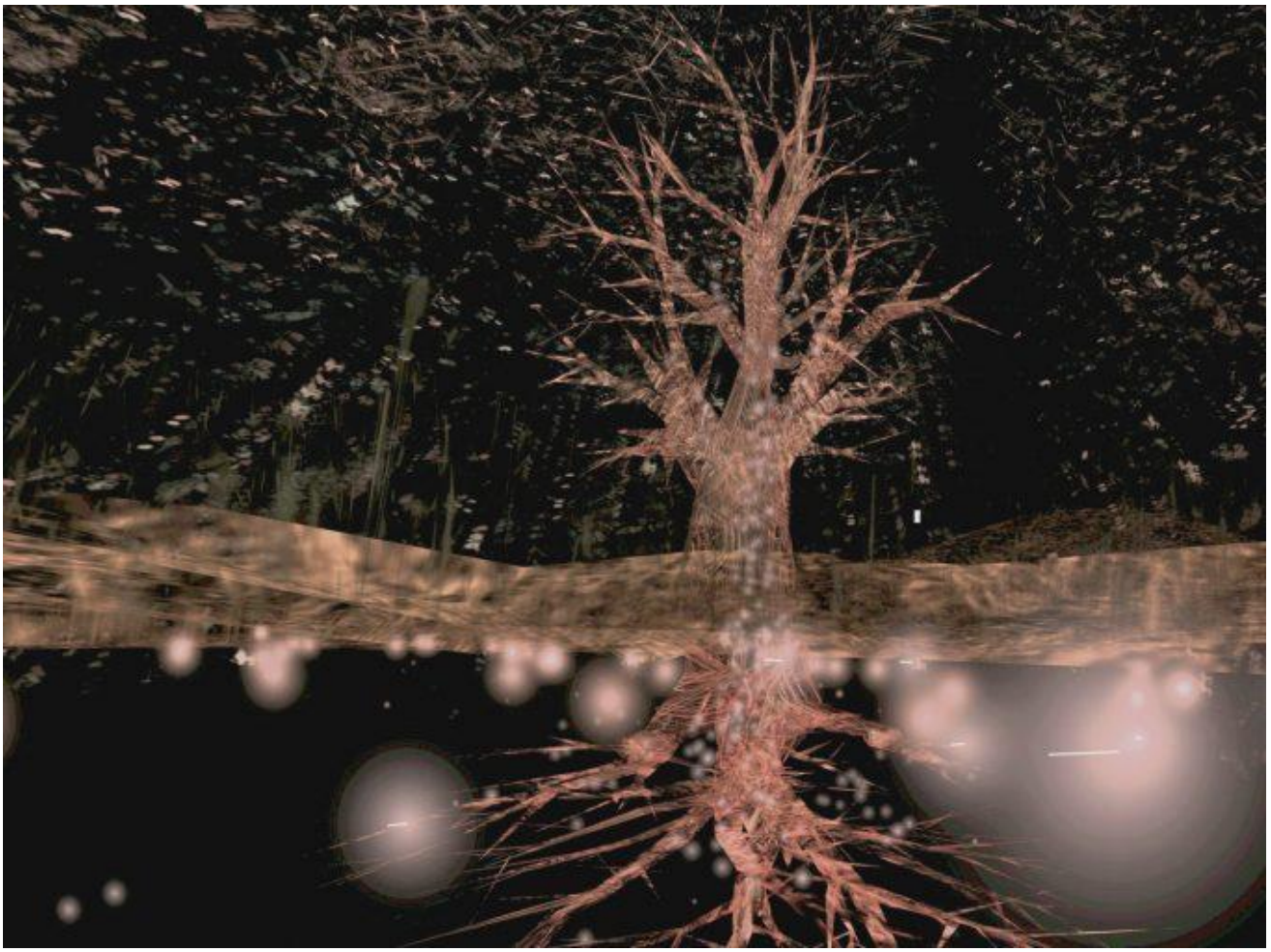

Figure b, real-time frame captured from Osmose (1995)

2.2.2 *The Protagonist* by Giulia and Anna Francavilla

The Protagonist is a project that I have realized with the collaboration of my sister Anna Francavilla during the second half of 2020. It consists of a 360° video with binaural audio (field recordings), to be experienced with a VR headset. The video represents a one-shot walk into a wood, shot with a camera placed on the head of the walker and recorded with a pair of binaural microphones placed in her ears. On the way, the walker incorporates all the audible sounds: the sounds of the body of the walker are at the forefront while the background is barely audible, giving a "subjective" aural perspective of the walk. This was possible due to the usage of the binaural technology and the choice to place the microphones in the ears of the walker. The recordings were subsequently processed (mainly with compression and

noise-cancelling) in order to bring the rest of the sounds to the far background. Moreover, every pause of the walker corresponds to an abrupt absence of sound, while the visual surrounding keeps living. The disconnection between visual and aural here is used to question the aspects of realism carried on by VR, especially by simulations of real-life experiences. By this approach to sound processing, the manipulations are not explicit but rather create a sense of subtle alteration of a sonic "real" situation. Indeed the work explores the simulation's starting point of deviation from being realistic. Moreover, through the aforementioned use of pausing, *The Protagonist* suggests a critique on the human egocentrism and supremacy of the visual, an approach that leads the individual to a condition of deafness towards what is external to the self while continuously exposed to visual stimulation.

figure c, real-time snapshot from *The Protagonist* (2020)

A specific interest is put upon natural environments: the shootings were made in a beechwood primary forest, a place of unspoiled beauty and rich biodiversity situated in the National Park of Abruzzo, Lazio and Molise, in central Italy. Here, Nature

pursues its cycles undisturbed, due to the minimal influence that humans had in this area. In such a place, the walker explores the unfamiliar, experiencing a state of disconnection from the surroundings.

The interactivity in this case is very limited: when wearing the headset, only the movements of the head are tracked, causing 360° rotation of video and sound (the sound is encoded to Ambisonics). This aspect shapes substantially the quality of the experience, differentiating this work from many VR applications focused on interactivity.
In this case, the user is asked to embrace the technological limitations and to experience what that implies.

Due to the circumstances, we haven't had yet the opportunity to expose the work to a group of users, although a few of our friends and relatives had the chance to experience it with a headset. What emerged for everyone was the strong sense of disbalance that comes when the walker is in movement and the user is not, a typical bodily effect of VR called "virtual reality sickness", related to "motion sickness". There are different theories that attempt to explain what causes it, one of the most accepted is the sensory conflict theory. This theory affirms: "sickness will occur when a user's perception of self-motion is based on incongruent sensory inputs from the visual system, vestibular system, and non-vestibular proprioceptors, and particularly so when these inputs are at odds with the user's expectation based on prior experience."[18]
At the same time, in the moments in which the surrounding is still, the effect could be an opposite sense of being trapped.
Most importantly, we realised that our aim to make the perspective of the body of the walker being to some extent perceptually incorporated by the user through the displacement of camera and microphones didn't work as we were expecting. This happened because the 360 camera produces a very distinct optical distortion. Due to that, the relationships between the dimensions of the objects at the foreground and those at the background result to be substantially different from how they are usually grasped by human visual perception. Therefore the user, looking at the ground,

[18] Virtual reality sickness, Wikipedia https://en.m.wikipedia.org/wiki/Virtual_reality_sickness

would see the feet of the walker from a bigger distance than the one that they would expect. The distorted image does not result to be realistic, as well as the audio.

figure d, real-time snapshot from *The Protagonist* (2020)

Besides the aspect of the spatial dimensions and the realism, the breaking of coherence between the visual and the aural stimulation increases the perceived alteration of the natural environment. Here, technology not only is a mediator of the present, but also a means for direct manipulation of the environment's behaviour. Yet, from our (still restricted) experimentation with users, it emerged that the main attention got focused on the perceptual aspects, underlining once again the strong connection to physicality and perception offered by this technology.
By its potential to create massive alterations of self and bodily awareness, this field gives, in my opinion, powerful tools for understanding human functioning, while expanding the boundaries of the "virtual dimension of human experience"[19]. In

[19] Dyson, Frances, "Sounding New Media – Immersion and Embodiment in the Arts and Culture" (University of California Press, 2009), 131

addition, as the main inspiration for the creation of *The Protagonist*, I feel the urgency for this technological field to focus on and problematize the defective relationship that humans have developed with their environment.

2.3 Listening and Consciousness

> Music emerges as an effective mediator between internal and external experience, affectively colouring and fusing together perceptual elements that could otherwise remain separated.[20]

In driving the theoretical perspectives on perception and immersiveness to the domain of sound and listening, I will present an overview of the studies of listening and consciousness by Ruth Herbert.
Modalities of listening and their reflections on configurations of consciousness have been largely investigated by many artists and researchers during the last half of the century (i.e. Pauline Oliveros). Among the many approaches that can be taken in consideration, I found interest in some aspects of Herbert's studies. In the book *Everyday Music Listening - Absorption, Dissociation and Trancing* (2011), Herbert takes into analysis everyday life's experiences of music listening, focusing on how the act of listening can be modulated by configurations of consciousness and vice versa. Listening is taken into analysis as a *mediator* for processes of change of self-awareness and perception. With regard to this, a line of continuity between these studies and the aforementioned approaches on perception can be traced.

Herbert collected an amount of data consisting of descriptions of first-person experiences adopting specific methodologies: participant's direct observation (witnessing participants involved in an activity), Experience Sampling Method (ESM), interviews and structured/free journaling of the subjects. Experience is therefore

[20] Herbert, Ruth (2011), Everyday Music Listening - Absorption, Dissociation and Trancing. Ashgate Publishing Limited, 147

analysed as a whole. This path can be seen as opposite to the approaches adopted by psychoacoustics based on indirect measuring of specific and isolated features, such as pitch or rhythm perception. Indeed with this phenomenological view, the situational variables of the specific context and the individual meaning and interpretation are taken into consideration as important elements of a complex picture, where context and subjectivity play important roles. Herbert observes the big influence that J.J. Gibson's theories had on recent studies on perception and listening:

> Drawing on J. J. Gibson's theory of ecological perception, the potential of an ecological approach to listening has been increasingly explored in recent years (Clarke, 2005; Windsor, 2000; DeNora, 2000). In this approach, it is recognized that listening is not an autonomous activity, but is instead *situated* within a context, i.e. dependent on the 'relationship between perceiver and environment (natural and cultural)'(Clarke, 2003)[...]Music is not seen as an unchanging stimulus that transmits immanent meaning and standard effects regardless of occasion or who is experiencing it. Rather, the combination of objective musical properties and capacities and needs of the listener give rise to what are termed affordances.[21]

I find it important to note that Herbert doesn't really consider in her analysis specific features of sound and music as modulators of listening, taking into account the act of listening *per se*. She adopts a quite generic definition of music that doesn't really resonate with this research. Besides this fact, some of her observations over perception and self-awareness can be informative for the sake of researching immersiveness.

An interesting perspective is given on the influence that listening can have over perception of the surroundings. This is explained to happen especially in situations where listening is in conjunction with other stimuli. In commenting on a specific case:

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[21] Herbert, Ruth (2011), Everyday Music Listening - Absorption, Dissociation and Trancing. Ashgate Publishing Limited, 17

> Music here enhances sensory awareness, contributing to a pleasant and effortless experience that fluctuates in intensity, with attention distributed between the music, surroundings, inner associations and tangential thought[...]. The affordances of the music and the wider environment blend together, suggesting a kind of performativity, in which the perceiver herself informally 'blends' together visual and aural.[22]

In this described case, attention is distributed between different stimuli, and this "effortless" condition seems to cause a change in the perceptual awareness of the surroundings, to the point that visual and aural "blend together".
As explained further, features of changing perception of surroundings seem to fall under the definition of Dissociation, as one of the main consciousness configurations that are likely to occur during listening. Herbert explains dissociation as an omnipresent feature of human consciousness, happening slightly on an everyday basis:

> Dissociation features as a characteristic of an unexpectedly large number of listening episodes in daily life. Detachment may or may not be perceived as a definite move away from a baseline state of consciousness. It is not generally perceived in terms of an 'unusual disconnection or disengagement' however, as Cardeña has asserted (1994: 23). At themes, experiences are spontaneous, arising as a coping response to immediate situations. On other occasions, dissociative experiences are deliberately sought, and participants describe what appeared to be established and well-rehearsed techniques of volitional detachment.[23]

Herbert indicates different modalities of dissociation, mostly divided in *external dissociation* and *self-dissociation*. The first is described as a cutting off from surroundings and external activities, where music can be a powerful mediator. She reports several cases in which the listeners describe feeling isolated from the rest of the surroundings, as inside an "auditory bubble".[24]
Herbert indeed elaborates on the features of listening to powerfully mediate the selective focus over the surroundings, from where it derives a sensation of being in a

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[22] Herbert, 57
[23] Herbert, 92
[24] Herbert mentions the definition of "auditory bubble", addressed in the work of M. Bull "Sound Moves: iPod Culture and Urban Experience" (p. 14)

bubble. She also indicates how sound technology can maximise this feature, taking into analysis the property of headphones to cut off the surroundings.
Self-dissociation is described to be concerning a move-away for the usual perception of self, where the sense of self decreases to give space to a dissociative state.

I find it interesting to speculate on how immersiveness can be seen as an act of dissociation from the baseline of self consciousness, to use Herbert's words, allowing holistic experiences to occur[25].
I also think that, although all this remains highly dependent on the subjectivity of the listener, specific characteristics of the sound material can modulate the listener's attention to the point of suggesting specific approaches to listening. I will elaborate on this in chapters 4 and 5, where I will describe my compositional work.

2.4 Inhabiting the environment

> Immersion can be understood as a transitional experience where there are given sensory conditions that continuously transform reality"[26].

All these above-discussed topics show perspectives that do not specifically have the purpose to describe what it means to define an experience "immersive".
Although, they serve to constitute a structure of concepts that aims to disassemble notions of experience that would be otherwise taken for granted.
Elaborations on how human perception works, and on what listening implies to perception, served to shed more light to the implications behind experiencing a VR environment or listening to music (although more elaborations on listening will be presented in the following chapters).

[25] Herbert, 86
[26] Parada, "De-composing Immersion", 56

These studies helped to understand that immersiveness is not an immanent characteristic of material or of technology, but resides in the relationship between the material and the other agents in the environment.
"Immersive" defines a property of the experience, and, being experience previously described as a complex network of environmental interactions, depends on the mutual relationship between environment and individual. Indeed the aim of immersive art is to access the "space" between the individual and the material/environment and to find ways to modulate its properties.
Moreover, ecological psychology suggests that perception itself constitutes a way of participation to the environment, and not a mere re-elaboration of it. Similar emphasis is given to listening by Ruth Herbert, who explains how this activity contains so many layers of interaction with the environment that it can never be considered as passive. In adopting this view on perception and being-in, listening is an act of *inhabiting* an environment.[27]
Although I mentioned the separation between environment and individual quite often, these perspectives, especially Embodiment theory, suggest that this division shouldn't be so omni-present in our view of the world. I see the tendency to blur this border in many applications of VR technology (and in Char Davies' work, of course) and in general in immersive artworks, as mentioned before. Virtual Reality especially provides powerful tools for digging into aspects of incorporation, through "naturalizing" the technological interfaces[28]. Within my musical and sonic investigations, I couldn't access the levels of embodiment and perceptual alteration that I could have with the VR project. Nevertheless, my later works (especially *Flow States #1*) show how much potential sound has in alternating spatial perception and affecting the body when treated in its vibrational properties.

[27] This concept related to listening will be mentioned in the following chapter when providing the overview on acousmatic music by Luke Windsor.
[28] The concept of "naturalization" of interfaces is mentioned by Oliver Grau in his book "Virtual Art - From Illusion to Immersion" and will be expanded in the following chapter.

3. Listening to the Environment

Introduction to the chapter

In this chapter I will examine aspects of immersiveness in more detail. In particular I will take into account the concept of critical distance between artwork and observer/listener and how this relationship morphs during immersive experiences. In paragraph 3.1 I will address some of the critiques done over applications of immersive technology as massively influencing perception and therefore critical distance. From paragraph 3.2 I will enter the realm of sound and listening, gradually driving the theoretical reflections towards my personal approach to sound and composition. Here, the act of distancing is re-framed in the context of listening and the perspectives on attention and dissociation examined in Chapter 2 are contextualized. In doing so, I will prepare the ground for the subsequent two chapters, which will be devoted to the documentation of the creative work, including descriptions of the algorithmic system, the artistic choices and considerations over the musical outcomes.

3.1 Critical Distance and Immersion

> Immersion can be an intellectually stimulating process; however in the present as in the past, in most cases immersion is mentally absorbing and a process, a change, a passage from one mental state to another. It is characterized by diminishing critical

> distance to what is shown and increasing emotional involvement in what is happening[29].

In his work *Virtual Art - From Illusion to Immersion,* Oliver Grau examines the aspects of immersion characterizing visual arts throughout history, pointing out how forms of immersive technology such as VR can change the fundamental aesthetic relationship between artwork and observer. Namely, he observes the feature of immersive art that enhances perceptual awareness and, as a consequence, decreases critical distance. In doing so, he specifically refers to the work *Osmose* by Charlotte Davies (mentioned in the previous chapter) focusing on the implications of her custom interface on the user's perception and critical awareness.
He claims in his critique Theodor W. Adorno's view on critical distance:

> [...]distance is the primary condition for getting close to the content of a work. It is implicit in the Kantian notion of disinterestedness, which demands of the aesthetic stance that it should not seek to grasp the object [...]Distance is a phenomenon of works of art that transcends their mere existence; their absolute proximity would mean their absolute integration.[30]

Despite Grau's considerations specifically focusing on the domain of visual art, he points out that the main attempt of these art forms and applications is to produce a "totality" in the experience of the user by massively involving perception. According to his analysis, this would affect the aesthetic experience by enhancing sensory awareness, bringing to the extreme a sense of "illusionism":

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[29] Grau, "Virtual Art", 13

[30] Oliver Grau, "Virtual Art: from Illusion to Immersion" (The MIT Press, 2003), 202

> [...]by intensifying the suggestive image effects and through appearance, this can temporarily overwhelm perception of the difference between image space and reality. This suggestive power may, for a certain time, suspend the relationship between subject and object[...]The power of a[...]perfect medium of illusion to deceive the senses leads the observer to act or feel according to the scene or logic of the images and, to a certain degree, may even succeed in captivating awareness[31].

Grau expresses a critique on the above discussed "passage" of awareness as preventing the necessary act of distancing and therefore precluding a critical understanding of the piece of art:

> In virtual environments, a fragile, core element of art comes under threat: the observer's act of distancing that is a prerequisite for any critical reflection. Aesthetic distance always comprises the possibility of attaining an overall view, of understanding organization, structure, and function, and achieving a critical appraisal[...]Notwithstanding the longing for "transcending boundaries" and "abandoning the self", the human subject is constituted in the act of distancing; this is an integral part of the civilizational process[32].

This raises the question whether this polarization of thought (detached and critical VS immersed and a-critical) could comprise all the possibilities of fruition.
The author Frances Dyson elaborates on this critique by presenting some alternative views. Although without taking a clear personal position, she juxtaposes Grau's critique with an alternative view by Mark Hansen, who "regards the lack of aesthetic and proximal distance between the interface and the artwork not as a potential danger but as an aesthetic process in itself".[33] Hansen's point of view (specifically focused on the embodiment of technological interfaces in VR), implies that these applications of immersive art not only constitutes a means for expanding perception, but they also contain potential for producing "new affective relations". These

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[31] Grau, "Virtual Art", 17

[32] Grau, "Virtual Art", 202

[33] Frances Dyson, "Sounding New Media - Immersion and Embodiment in the Arts and Culture" (University of California Press, 2009), 124

relations constitute the "virtual dimension of human experience", which is specified by means of virtualization.[34]

The aforementioned discussion mostly concerns the implications of "naturalized" technological interfaces on the aesthetic experience of Virtual Reality. I don't pretend to take part in the debate but I can nevertheless provide my personal experience gained by working on *The Protagonist* (described in the previous chapter). Indeed the work, as already explained, originates from a deliberately critical take on human relation with technology and environment (similarly to Davies' critical approach behind *Osmose*). It also presents the intention to show some different shades of the technological infrastructure and their implications on perception, through deliberately uncovering the infrastructure's failures (bad video definition, extremely narrowed perspective on audio, absence of interactivity). This approach indeed aims to induce in the perceiver a reflective and critical take on the experience, rather than creating the illusion or the amazement that Grau talks about.
Having had a (restricted) opportunity to test it with a number of users, I can indicate that, among the differences in the reactions, I have received feedback of a quite critical nature. Most of the attention was nevertheless captured by the physicality of the experience, being VR so peculiar in involving the totality of the body. *The Protagonist* offers the possibility to experience a disembodied natural environment (disembodied because the environment visually surrounds the user without physically surrounding the user's body). It aims therefore to suggest an exploration of perception without the intention to create the illusion of a "real" experience in nature. I don't think, therefore, that the problem of critical thought VS expanded perception is to be found in the technology itself but rather in the reasons behind its applications.

I see in immersive art and technology a potential to expand critical thought and perception as two converging aspects of the same experience, rather than diverging. The topics of expanded perception and virtualized human experience are highly interconnected with the experience and contextual functioning of acousmatic music, as well as being some of the drives of the creative processes that I implied during

[34] Dyson, "Sounding New Media", 131

this research. On a theoretical level, I therefore correlate the notion of the "virtual dimension of human experience" proposed by Hansen with the notion of "inherent virtuality" of acousmatic music emphasized by Windsor[35] and explained in the following paragraphs.

3.2 Immersion and listening: investigating wind

This part of the chapter expands the above mentioned concepts taking into consideration the activity of listening. The considerations on perception discussed in the previous chapter are here framed in the context of listening to acousmatic music. Some dissertations are made over the inherent virtuality of acousmatic music and the possible implications of perceiving sources coming from the natural environment, such as wind. Moreover, it is questioned to which extent the musical behaviour influences attentional focus. Entrainment is taken into analysis in order to address the features of rhythmicity in driving attention during listening.

3.2.1 Patterns of Listening

After the previous considerations on critical distance and immersiveness, I find it necessary to direct the focus of the discourse towards listening.
In investigating the relationality between material and listener, I approached immersiveness by considering and reflecting on the influence of specific musical behaviours over the listener's focus. In doing so, I directed the practical investigations towards finding the evocative potential of some selected sound sources and defining specific aspects of musical behaviour to work with. At the same time, I have been taking into consideration the technologies in use and the space of

[35] Windsor, 17

reproduction in affecting experience. These elements are agents of the environment in interaction with the listener.

From the previous considerations on the aspect of "totality" emerging from experiences of VR a question arises: is it possible to refer to the experience of listening to acousmatic music in the same terms, considering the lack of interactivity and stimulation of the other senses? And what are the implications of perceiving behaviours of sound sources belonging to everyday environments—even when they are incorporated within synthetic sounds? Is there a continuity there?

J. J. Gibson's take on the senses was to consider them not anymore as channels but rather as perceptual systems constituted by a complexity of mechanisms. Consequently, we can avoid reducing the processing of sonic stimuli to the aural apparatus by considering the involvement of processes distributed in different cognitive areas. Moreover, the take on environment from ecological psychology considers perception as a continuous and embedded relationship between the organism and the environment. In respect to this, I find it important to emphasize that the sounds of our everyday surroundings and our sonic memories constitute an important body of influence on our ways of perceiving and approaching sound in musical contexts. It is therefore important to underline that, besides their complexity, there is a continuity in our fabrication of meaning between the everyday contexts and musical contexts. In this regard, I found inspiration from a consideration by Raviv Ganchrow found in an interview by Ariane Wilson dated 2016. Ganchrow here talks about the influence of our sonic "vernacular" on hearing, and how it sometimes reveals itself by "erupting" into music:

> Environments in general, and built environments in particular, are listening technologies. They haphazardly condition hearing. Vernacular sounds contain a multitude of latent meanings that are waiting to be explored[...]If you pay attention to the ways in which these vibrations manifest themselves, spatially, qualitatively, there is much more going on than just the collection of sound sources. We could call these rich configurations *vibrational contexts*. Most often they are not heard consciously until they surface in a social praxis. Certain types of music, for example, become possible because of these unconsciously absorbed contexts: our sonic vernacular

> tunes us in such a way that inherent aspects of its structure or signature erupt back into musical practice.[36]

It's nevertheless difficult to go further in detail in such a topic, since our personal history as individuals and our shared culture plays a big role in shaping our hearing. Wind, in the context of investigation of this research, is a source that crosses different environments: natural (where it originates from), urban (where I've listened to it the most and where I did some of the recordings), mechanical (where it has been transduced from air pressure to electrical signals), algorithmic (where it reveals its presence through synthetic sound). The wind is a sonic entity (even before than sonic, vibrational) originated in the natural environment. It crosses our built surroundings and it's deeply interconnected to our perception of space, since it is revealed in its qualities by the configuration of the space itself. Moreover, wind is perceived by humans in a multimodal way (visible through the movement of trees, perceivable on the skin, heard, bringing smell and maybe taste as well). What I especially find stunning about wind, listening to its presence in the urban environment (it is very present here in Den Haag), is that it can sonically *pervade* the surroundings in their totality. Wind embraces all the other sounds and transforms their qualities during its passage.
In respect to that, I wanted to bring into the context of algorithmic music and synthetic sound the qualities of wind's behaviour and to make them hearable *through* synthetic sound. Therefore, my aim was not to either represent or re-create wind, but rather to physically *transduce* it through the implied sound technology and make this transduction hearable in the space of reproduction. In attempting to do so, I have developed an algorithmic system of analysis of wind's behaviour by analysing field recordings of wind and/or live incoming signals, together with strategies for re-mapping the obtained data to parameters of (mainly subtractive) sound synthesis. I have implemented different types of mapping for applying the wind's behaviour to the sound material, creating a space between no-influence and big-influence, and therefore between no-presence and presence of wind. In such a way I was able to work on the edges of the wind's presence, with the attempt to investigate the *patterns*

[36] Raviv Ganchrow, "Sound Attention - Raviv Ganchrow in conversation with Ariane Wilson", interview (2012-2016), 14

of listening that such presence brings about. With patterns of listening I mean patterns of different *qualities* of listening, constituted by attentional focuses of diverse intensities, pointing at different directions.
Traces of the presence of wind could possibly recall the acoustic functioning of the source, revealing the presence of a behaviour coming from an environment which is external from the synthetic and algorithmic one, without the source having to be explicitly revealed (i.e. by playing field recordings). In this regard, the wind crosses different environments.

So, to come back to the initial questions: is it possible to refer to the experience created by listening to acousmatic music in similar terms to the ones of immersive art forms ?

I partially tried to reply to this question by investigating the potential of the wind's behaviour in stimulating perception. Indeed my aim was to find ways to recall embodied (and multimodal) experiences of wind through making it hearable through other sounds. During the course of the research and by the feedback that I have received along the way, I understood that it was not really possible to go so far in stimulating perception with only the tools of sound, sound technology and space of reproduction—at least with the tools and knowledge that I had. Nevertheless, as I will elaborate in the following chapter, I found potential in expanding the typical listening "canons" of acousmatic and performed music by experimenting the usage of other "mediators" such as blindfolds.

And then the second question: what are the implications of perceiving the behaviour of a sound sourced from the natural environment and incorporated in synthesis? Is there a continuity there?
As said before, the approach that I implied on sound sources and composition was of incorporation between sources that can be considered as belonging to real and musical environments, rather than the juxtaposition of the two—if we want to make this separation. However, in some of my compositions, such as *Forma Volatile* or *Becoming Wind*, audible traces of wind can be easily found in clear contrast with the behaviour of noise and other sound generators. Therefore, clear and juxtaposed

differences in the morphology of sounds can be found. In the works done over the second year, these morphological differences are not anymore juxtaposed, since the focus switched to the morphological micro-level. The coexistence of many different layers of behaviours have driven the research's concerns towards an integration of different morphologies, where recollections of wind emerge less explicitly. Within this approach on micro-level and multi-layering, a continuity of perception over a multitude of different behaviours is for sure suggested and probably facilitated. Although, at the same time, emerging elements of a radically different quality can contribute to breaking such continuity.

In regard to this, Luke Windsor's considerations upon acousmatic music constituted a useful reference, since, by looking at the same ecological perspectives by Gibson, they provided clarifications over some of the possible mechanisms of listening in the context of acousmatic music. I'll introduce some of them in the following paragraph.

3.2.2 Events perception and synthesized wind

In defining the context of acousmatic music as a living environment, Windsor states that the elements that characterize the fundamentals of acousmatic music (recorded sounds, synthesized sounds, sound processing, rediffusion of sounds over loudspeakers) become a source of "structured acoustic stimulus information about events for the perceiver"[37]. Moreover, the "structure acoustic stimulus information" doesn't only comprehend the information generated by the diffused sounds: Windsor states that "the listener[...]perceives acoustic structure originating from the loudspeakers along with a multitude of other sources"[38], meaning this multitude of sources also consists of stimuli that are external from the music. These external sources form the *context* as a fundamental part of the environment constituted by acousmatic music and are therefore deeply intertwined with the listening experience. From this perspective, listening to a piece means *inhabiting* an environment:

[37] Windsor, 20

[38] Windsor, 20

> The listener inhabits an environment rich in stimulation, rich in structure, and will perceive affordances not only through the pick up of structured auditory information from the piece but from the environment as a whole, whether acoustic or not.[39]

With a similar perspective, the listening experience is defined by Ruth Herbert as "a sum of a network of interactions"[40]. The interactions are here considered as occurring *in* the listener but nevertheless influencing the environment. They indeed constitute actions occurring during the time of listening intersecting together: interpretation coming from past experience and knowledge; mood and cultural background; perceptual modalities produced by evolutive processes; aspect of the specific context (aspects of the physical space and other situational aspects). These embedded actions constitute an exploration of the environment—an act of inhabiting the environment.

Moreover, in regard to the aforementioned question between listening to real-environment and listening to music, Windsor takes a defined position, saying that we assume different behaviours when we listen to acousmatic music and when we listen in everyday life because the two different environments create different affordances. Nevertheless, we probably perceive the stimuli in them in the same way. Therefore, in following the analysis on the acousmatic music environment, it's not useful to use a distinction between real and virtual. Windsor states that the acousmatic environment is *intrinsically virtual*, since the events that are specified, being either synthetic or recorded, are products of technical elaborations (we could add that can be at the same time *intrinsically real*). Moreover, according to him, elements that originate from the interaction between machines and humans or from components of a machine(such as synthetic sounds), together with acoustic events recorded in the natural environment(such as wind), can be indeed perceived in the same way[41]. This reflection is clearly inspired by the theories of ecological perception (discussed in Chapter 2).

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[39] Windsor, 20

[40] Ruth Herbert, "Modes of Music Listening and Modes of Subjectivity in Everyday Life", ResearchGate catalogue

[41] Windsor, 15

In addition, Windsor takes the steps from some research on events perception by Warren, Shaw and Verbugge that, inspired by the concept of affordances, explains that events consists of a structure of *invariants*, which are the properties that make up a particular affordance structure[42]. The invariants can be classified in two groups: those that specify "style of change" and those that specify "persistence" or "permanence". An acoustic event is therefore explained as consisting of an acoustic structure that has permanent and changing qualities. During the development in time of an event, the acoustic structure undergoes transformation to a certain degree (depending on the specific case, of course). In changing the structure to some degree, the event changes its affordance, that is to say its relationship with the environment. Consequently, the listener, in perceiving the change in affordance, perceives an environmental change. This view on event perception tends to underline the fact that the listener is particularly sensitive to the causal relationships between the sonic events. The same approach can be found in the literature of physical modelling in sound synthesis.

Despite agreeing with the above discussed analytical approach, I find it problematic to rely on the assumption that sonic causality is continuously perceived, especially when referring to the listening experience of algorithmic music. With a high level of abstraction and high inner sonic complexity, a "causal" listening modality might not occur.

An alternative view on acousmatic and algorithmic music has been proposed by the artist Erik Nyström. In the article "Algorithm, Performance and Speculative Synthesis in the context of Spheroid" he argues that acousmatic music does not have to refer to acoustic properties prior to technological mediation. He proposes the concept of "speculative synthesis" which occurs when "sound with origins attributed to the performance-technology domain begin to invite imaginative speculation of causes in addition to what is taken to be technology or performance, or guides attention away from causes altogether".[43] Nyström affirms to dissociate from "the

[42] Windsor, 12

[43] Erik Nyström,"Algorithm, Performance and Speculative Synthesis in the context of Spheroid (eContact! 20.2, 2018)

notion of an essential, pure reality or nature, in which sounds are assumed to originate and in reference to which sounds are evaluated"[44]. In continuing to speculate on nature, he states:

> [...]I view nature fundamentally as a synthesis, not separated from technology or culture and speculate freely on the creative potential of synthetic ecologies, where unnamed organisms reposition categorical conceptions of species, nature and artifice.[45]

Despite being fascinated and attracted by the concept of an ever-synthetic nature proposed by Nyström, in framing my work I think that a negotiation between *natural* and *artificial* might be still applicable.
Most importantly, I find it essential to use the term *behaviour*, rather than sonic events, being it a lens through which I "refocused" my compositional point of view. In investigating behaviour, I have tuned my elaborations of wind in exploring the creative applications of its analysis through algorithmic music. As previously said, the wind has been considered not only as an originator of data to use for "driving" other sonic elements, but also as a source of inner sonic behaviour revealing an external presence. In using this source, I have created a space of action between wind's *mimesis* and *abstraction,* finding there an interesting opportunity for developing compositional strategies with creative programming.
Developing strategies to manipulate wind and working within the aforementioned creative space led me to concentrate on ways to develop processes of micro and macro sonic change. This approach on the micro-details of sound and on their degrees of transformation has driven me to reflect on how morphological aspects of sound can influence the attentional focus during listening, and the consequent sensations of being more or less immersed in sound.
As said before, if a differentiation between real and virtual doesn't apply to this context, a distinction between *natural behaviour* and *artificial behaviour* might be still applicable. Drawing this distinction in sound means individuating perceptual areas when the wind doesn't anymore afford its natural morphology, transformed into

[44] Nyström, article
[45] Nyström, article

something which is perceived as “more artificial”. I relate here with Nyström’s consideration on morphology:

> Morphology is where source appears and disappears: morphology generates “acousmaticity” by drawing attention away from the real, toward speculative domains and, as a result, creates an expanded environment within which sounds can colour and situate the performance domain.[46]

Through subtle or massive manipulations of sounds’ morphology, attentional focus can be indeed partially guided. As explained in the research by Ruth Herbert, during listening attention is likely to switch often between inward and outward focus. With respect to this, the presence of wind could contribute to induce resemblances of past experiences in the listener, contributing to switch the attentional focus *inwards*, giving the space for an imaginative mental activity. This configuration of consciousness could abruptly be shifted to another: being the musical behaviour internally moving towards artificiality through micro-sonic change, attention could be pointed outwards, focused on characteristics of the external stimuli.

3.2.3 Entrainment as an attentional drive

> Repetitive, automatic tasks function to either still the mind or change relationship with thought[...]suggesting a dissociation from self. The suspension of critical faculties that result, encourage in turn a heightening of the senses, as if the ‘volume level’ of experience had been temporarily increased[...]This selective attentional focus can either be very narrow (one-pointed) or more extensive (mindful), but in both cases the replacement of critical thought by an awareness primarily of sensation features a preoccupation with attributes, rather than meaning of stimuli, i.e *perceiving*[...] rather than *conceiving.* Interaction with music shows this perceptual process clearly[...][47].

[46] Nyström, article

[47] Herbert, Ruth “Everyday Music Listening - Absorption, Dissociation and Trancing” , 116-117

In the aforementioned quotation, Ruth Herbert attributes to repetitiveness a value for facilitating perceptual configurations of a heightened quality, at the expense of a decreased critical awareness. She also points out that this process of change in the relationship with thought is likely to be reached within the interaction with music. Although Herbert doesn't go deep in investigating repetitive musical stimuli, she points out the influence that repetition has on perception, as if it would recall some primitive functioning of human nature. In many of the examples that she reports in her studies, it emerges that repetitive stimuli have the feature to decrease emotional arousal, consequently driving attention to be "one-pointed" on features of external stimuli. This attentional configuration corresponds to a focus on sensation, and, depending on the specific cases, the individual would be more receptive and sharper in perceiving:

> As with experiences characterized by reduction of thought, critical awareness and lowered arousal, a focus on restricted stimuli, together with repetitive qualities - either of activity (e.g. digging) or of stimulus (circular patterns of an artexed ceiling) - provides an obvious source of involvement via selective, restricted attention[48].

I find this aspect of repetition as a drive for "the suspension of critical faculties" having a lot in common with the discourse on critical distance taken by Oliver Grau. Herbert indeed identifies repetitiveness of stimuli as a means for "suspension of critical thought" and "preoccupation with attributes, rather than meaning of stimuli". In a similar way, Oliver Grau mentions the decrease of critical thought caused by some modalities of fruition of immersive artworks and technology. It is important here to differentiate the nature of the two statements: Herbert doesn't indeed express a critique while Grau does. Anyway, I find it quite interesting that these two different spheres of research here orbit around the same inquiry: an enhanced quality of perception seems often to be paired with a decreased critical/rational processing.
If Herbert defines this configuration of listening in positive terms, talking about "heightening of the senses" and an increased "volume level" of the experience, Grau considers the decreased critical distance as a risk for aesthetic perception.

[48] Herbert, 130

It's not my intention to take sides but rather to contextualize Herbert's findings on repetitiveness and attentional focus. Indeed, in some of my compositional work, rhythmical and repeated stimulus has been investigated in its potential to modulate attentional and absorption. I will elaborate on that in Chapter 5.

Talking about repetitive stimuli and the consequences on human thought requires a digression on the concept of *entrainment,* a key phenomenon concerning the relations between bodies when involved in periodic movement.
Entrainment has a considerable history and it was first identified by the physicist Christiaan Huygens in 1665. To quote the basic definition of entrainment given in the study by Clayton, Sager and Will:

> Entrainment describes a process whereby two rhythmic processes interact with each other in such a way that they adjust towards and eventually 'lock in' to a common phase and/or periodicity.[49]

It is important to differentiate it from the phenomenon of *resonance,* where a still body can be put in oscillation by the influence of another, vibrating in sympathy with it.
In the case of resonance, if the source of oscillation ceases to exist, the other body will cease to vibrate, while entrainment occurs if the two oscillators are autonomous and still able to oscillate if they cease to interact.
Moreover, entrainment defines an interaction or *coupling* between two or more oscillating bodies that can vary between degrees of weakness and strength.
Also, there are two aspects of entrainment that don't necessarily occur together. As described in the aforementioned study:

> [...]we can distinguish two aspects of entrainment that need not necessarily co-occur. One is frequency or tempo entrainment, where the periods of the two oscillators adjust towards a consistent and systematic relationship. The other is phase

[49] Clayton, Sager, Will, In time with the Music: The concept of entrainment and its significance for ethnomusicology, 2

> entrainment, or phase-locking: where two processes are phase-locked[...], focal points occur at the same moment[50].

It has been also pointed out that "oscillators may entrain in *states* other than exact synchrony"[51], alternating for example states of synchronicity and asynchronicity, making this phenomenon further complicated to analyse.
To summarize, the core of entrainment stands in the establishment of an interaction between two or more oscillating bodies, characterized by a non-linear and complex behaviour—most of the time one rhythm is more dominant than the other. Nevertheless, entrainment can also involve parts of a single body, in the case of "self-entrainment" in the human body, where "two or more of the body's oscillatory systems, such as respiration and heart rhythm patterns, become synchronized".[52]

Being a fundamental mechanism of interaction between bodies, entrainment has had an important role in the development of social sciences, physics, mathematics, biology, and cognitive sciences, in particular for the studies on rhythm perception. In the context of cognitive studies on music perception, entrainment is used to investigate how the presence of perceivable rhythmicity can modulate qualities of attention in listening. One of the most relevant works on the topic is the one carried on by Mari Riess Jones and her co-workers between 1976 and 2002[53], pointed out in the above-mentioned study on entrainment. Jones formulated theories of "attending rhythms" which are driven by entrainment as an adaptive process capable of adjusting to widely different musical contexts and levels of rhythmic complexity. That flexibility has been explained to function both under a conscious direction and by the nature of the external stimulus. Jones indeed assumes that humans are *inherently rhythmical* and naturally inclined to synchronize their endogenous rhythms with perceived and expected rhythmic processes[54]. Besides this human inclination, she also points out how much importance individuality in its complexity has on shaping the experience:

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[50] Clayton, Sager, Will, 9
[51] Clayton, Sager, Will, 9
[52] Clayton, Sager, Will, 7
[53] Clayton, Sager, Will, 14
[54] Clayton, Sager, Will, 14

> In all, varying rhythmic contexts, stages of development, as well as physiological and psychological factors will cause people to have "different temporal experiences of the same event", meaning people will have different entrainment experiences even though they may be participating in the same musical performance[55].

The aspect of this approach on rhythmicity that I find relevant here, is that it takes into consideration musical situations in which the periodicity fails to accomplish the expectations. This failure of expectations can derive from the inner complexity of the musical structure or the absence of perceivable repeated events.
In explaining how that works in terms of expectations:

> Cues from events unfolding around the attender are taken as indicators of where to focus attentional energies in order to 'catch' upcoming events. Anticipation of future events is facilitated by the presence of highly coherent(i.e., regularly patterned) temporal events[...]If our expectations do not match what happens next, then synchronization has not occurred. It should be noted, however, that the discrepancies between our expectations and the actual unfolding of events can cause arousal that in turn heightens attention and results in learning[56].

In understanding further what happens when expectations are not necessarily accomplished, it's important to see attention as "partly intentional and goal-directed and partly controlled by the pace of an external stimulus"[57]. Jones defines two modes of attending, "future-oriented attending" and "analytic attending":

> Future-oriented attending tends to occur where the stimulus has a coherent time structure, which facilitates a shift in attention to higher referent levels(i.e., longer time spans). For this reason, future-oriented attending "supports anticipatory behaviours".
> Analytic attending tends to occur when the event stimuli are less coherent and more complex, such as where expectations are extremely difficult to formulate. In analytic attending, attention is switched to focus on shorter time-spans, which facilitates the

[55] Clayton, Sager, Will, 14
[56] Clayton, Sager, Will, 15
[57] Clayton, Sager, Will, 16

> comprehension of the grouping of adjacent elements rather than repeating structures.[58]

Although my work is not entirely focused on rhythmicity and entrainment, I experiment with sections of repetitive/periodic behaviour interfaced with behaviours presenting different degrees of irregularity (quasi-periodic, chaotic behaviours). In creating this contrast, I aim to understand if the attention in listening can be affected by rhythmicity. In Chapter 5 I will describe how I applied this idea on the sound material of my first live coding performance. I specifically applied layers of rhythmic pulses at the beginning of the performance, with the intention to create an entry point to a state of more active perception of details, required by the more complex and non-rhythmic material of the following sections.

[58] Clayton, Sager, Will, 16

4. Wind and Behaviour

4.1 Background

Some months before beginning to focus the research into immersive aspects of sound and listening, I started to have a fascination for *fluctuation* in sound and music. Surely this fascination stemmed from the work done for my bachelor thesis at the Conservatory of Turin, entitled *Encoder.* This consists of a series of two audio/visual pieces. Each piece originates from a pre-existing timelapse video (found on Youtube) which was analysed through a system of motion and colour tracking. These analysis processes produced data (not real-time) that were subsequently translated to time functions. These functions were then mapped to sound processes and on the development of the musical macro-form. Indeed sound process and compositional process are here seen as two faces of the same process, or better sound process constitutes the musical form. The data were also fed-back into the system and used to process the original videos, new data was extracted from the analysis of the resulting processed videos and added to the body of data for shaping sound. The videos represent two evolutions: *Encoder 1* is a blooming lotus flower, *Encoder 2* is a rose flower burning.
What led me to the creation of that work was a fascination for biological processes and their expressive and informative potential for music making.

4.2 Composing with Behaviour

To begin investigating fluctuation, I decided to implement some sound analysis strategies for understanding and further translating such movements into sound and formal development. Here my ideas started to probe the concept of “behaviour”. This concept has been floating around since the previous year when following the

classes of Algorithmic Composition taught by Bjarni Gunnarsson. In particular I was inspired by perspectives on sound and computer music coming from composers such as Agostino Di Scipio. Di Scipio stressed the point that in computer music it is fruitful to consider musical form as emerging from the process (or the material), rather than a separated architecture imposed on material. In doing so, Di Scipio developed a series of algorithmic systems for working with micro-sonic textures (using granular synthesis techniques). In working on such a low level of sound, he explains that composing *timbre* corresponds to composing *form:*

> When speaking of timbre composition, we recognise that timbre comes to be not only the quality of the sound material, but also the result, or the epiphenomenon of an underlying compositional process. As a consequence, the notion of timbre intermingles and overlaps with that of *musical form*. In micro-time sonic design, especially, the musical form is experienced in terms of *processes of timbre formation through time*.[59]

A view on musical form as "a process of timbre formation through time", it's quite inspiring when thinking of fluctuations in music as behavioural qualities of a process of multiple processes. I also found great inspiration by listening to the music of Bjarni Gunnarsson, in which I perceive a unique balance between organic unfolding of processes and "narrative" interventions. With this regard, Gunnarsson adopts an interesting point of view on material and composition:

> It is always an important choice whether the material should guide the process or if it should exist in the shadow of structural decisions[...]it should contain both features and thus be placed on a dynamic path in-between the two extremes. Material should be composed for, its qualities should not take over the compositional process. However, the material should also bring forward properties useful for structural development. From its creation additional attributes should emerge.[60]

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[59] Agostino Di Scipio, "Micro-time sonic design and timbre formation" (1994), Contemporary Music Review, 9

[60] Bjarni Gunnarsson, "Processes and Potentials - Composing through objects, networks and interactions" (2012) Master Thesis, Institute of Sonology

Within this framework of ideas and musical influences, in addition to the above described bachelor work, I decided to adopt a process-based approach on sound and music making. These influences and the above mentioned fascination for biological processes have been combined with the ideas mentioned in the previous chapter about perception and environment. This network of influences led me to the idea of experimenting with the Wind as the main source of behaviour and sonic investigations.
During the course of the research, I explored different techniques for sound analysis and synthesis to interface with the properties of wind's behaviour.

4.3 Field recordings

The first step of the practical research was to do some field recordings focused on capturing the movements of the wind. The main concern was to record its sound with as little disturbance as possible and limited mediation from objects in the landscape. Just air. Moreover, I experimented with different configurations of input gain and windshields in order to prevent distortion without losing too much sensitivity. The wind continuously changes in its intensity and often manifests sudden dynamic peaks— even disappearing for a while.

The recordings took place in Den Haag in different sessions during the time of these two years. The chosen places were the dunes area close to Oostduinpark and some spots close to my house in the city centre. The recordings featured different techniques:

- Ambisonics B-format, using Soundfield ST450 MKII microphone
- Ambisonics B-format, using a Zoom H3 VR recorder
- Stereo recordings with XY configuration, using a Zoom H6 recorder

- Stereo recordings with Omni diagrams, using a Zoom H6 recorder

Choices on the placement of the microphones were made according to the specific qualities that I wanted to capture. For the recordings in the dunes, the aim was to capture the fluctuations of air without having obstacles around. Therefore the microphones have been placed at the highest possible positions.
For the recordings made in the urban environment (mainly in the courtyard of my house with the Zoom H3 VR), I explored the sonic mediation of the architectural space on the movements of wind, moving the microphone in different places to explore the obstacles around.

4.3.1 Isolating the wind's sound

In order to isolate the wind's dynamic fluctuations, it was necessary to isolate it from the other sound sources present in the recordings: birdsongs, the rumble of the sea, the rumble of the city, the sounds from the people passing by.
This cleaning process took into account different techniques: compression, expansion, filtering, spectral stretching in CDP. The latter provides the possibility to warp vertically the spectrum of a sound, accentuating the spectral movements at the high and low extremes of the spectrum[61]. Consequently, the inner timbral movements caused by wind's fluctuation can be accentuated (having in the output, as the counterpart, added partials coming from the FFT process). Besides removing the "undesired" sounds, these processes have been used in order to accentuate the dynamic and spectral movements and served to understand more about the characteristics of wind's morphology.
Indeed, one aspect that soon came out after listening to the recordings and that became more accentuated with the aforementioned processes, was that an increase in amplitude can be rapidly followed by a movement of the fundamental frequencies higher in the spectrum with a narrowing of the frequency band. This specific

[61] "The STRETCH SPECTRUM process is a means to warp the spectrum of a sound. For example, a harmonic sound may become inharmonic, in a controllable way[...]The stretching operation expands or contracts the frequency gap between partials."
http://www.ensemble-software.net/CDPDocs/html/cstretch.htm#SPECTRUM

behaviour can be therefore imitated using a resonant filter of which the Q factor is guided by a tracking system of these movements. These fluctuations in the upper spectrum can be observed in figure a. So, in the case of wind, the changes in the dimensions of amplitude and pitch are always correlated in time and sometimes directly proportional to each other.

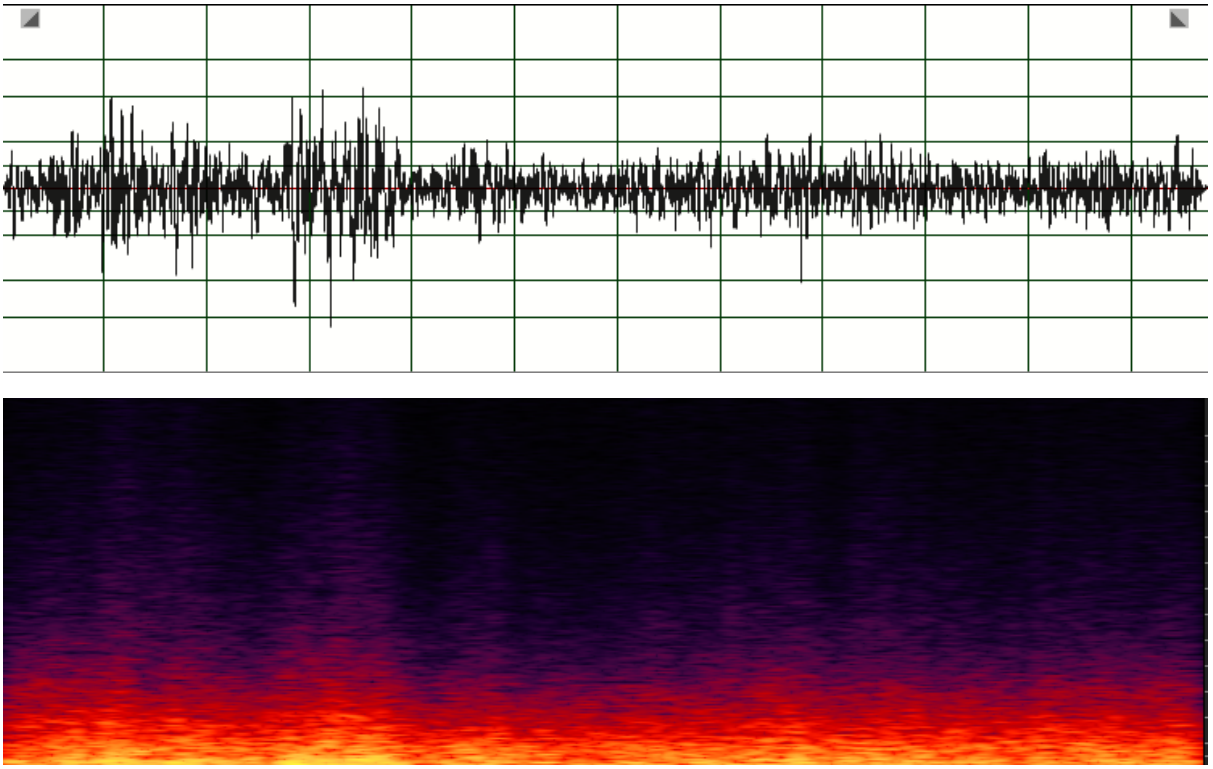

Figure a: visualization of a sample of recorded wind as a waveform(upper) and on the sonogram(lower). This shows the correspondence between the rising of amplitude and the rising of pitch and vice versa.

4.4 Real-time analysis and data mapping

From the previously described processes I obtained a number of samples. The following step was to implement the analytical strategies for investigating amplitude and pitch profiles. I decided to have an empirical approach: rather than collecting numerical data from offline analysis techniques, I wanted to be able to listen to the analysis data when applied to other sounds while changing the analysis parameters, therefore choosing to use real-time analysis only. This implied assembling some tools for real-time analysis and consequent strategies for mapping

the data to modulate parameters of synthetic sounds. Specifically, I implemented an Amplitude Follower and a Spectral Centroid Tracker in SuperCollider, which analyze respectively the amplitude and the centre of mass of the spectrum of the samples while providing continuous streams of data.
These data were rescaled individually for the specific parameters to control and mapped to them. The first sound sources to be modulated were noise generators and granulators. The control data were modulating the following parameters: global amplitude, frequency of oscillators, frequency of filters processing noise generators, grain density of granular synthesizers, panning position in the stereo image.
After this phase of "hands-on" sound, I noticed that the movements of pitch and amplitude of the wind, behaving in such a variable way, provided many expressive possibilities if mapped in different ways for the specific sound parameters to modulate. A schematization of the first algorithmic system can be seen in figure b. Such a real-time analysis system makes the integration of the analytical and the creative strategies possible: modifying the parameters of the analyzers in real-time (such as the cutoff frequency of the low pass filter of the amplitude follower or the input gain of the analyzed signal) becomes a musical gesture itself.

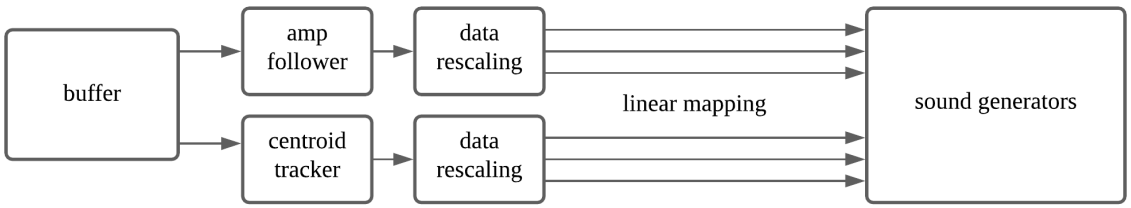

Figure b: block diagram illustrating the basic functioning of the system

4.5 First processes and *Becoming Wind*

The first outcome took the form of a solo live performance. I had the chance to play with the initial materials in a space dedicated to performances and exhibitions called MAMA, in the centre of Rotterdam. I played a solo set (with a 2.1 speakers setup) of 25 minutes using sampled materials from the first SuperCollider

experiments, layered and looped in Ableton Live, using a midi controller for balancing the dynamics and providing some filtering. The performance has been recorded and formalized as a live piece entitled *Becoming Wind*.

4.5.1 The sound processes and the musical structure

At the time, the code consisted of some sound synthesis blocks, specifically implementing granular and subtractive synthesis, together with fragmentation processes implemented in CDP and applied on some of the original field recordings. The data coming from the spectral centroid analyzer and the amplitude follower were mapped linearly to some parameters and rescaled differently according to the ranges of the specific parameters to modulate.

See code in the Appendix.
Generating sounds with a similar or identical spectral character and playing with different degrees of influence of the wind's data (by changing the scaling factors and the input gain of the analyzers) led the musical structure to be developed through transitional changes between micro sonic characters, in particular between stillness and dynamism of amplitude and timbre.
The musical form has been conceived as a translation of the same micro-transitions to a macro level, with the aim to make the micro and macro dimensions of sounds perceptively continuous. The musical structure was consequently developed through a live-oriented approach and took the form of a continuum, characterized by slow musical transitions between different areas of timbre and of inner movement rather than from different definite sound sources. The composing process has been done through Ableton Live. The samples generated from the SuperCollider patches were initially distributed in the software without a predefined order. By looping and layering the samples during a number of studio sessions, a continuous sonic and musical development between the layers was found. Entirely formalized only on the occasion of the live performance in Rotterdam. The compositional process itself was gradual and distributed over the rehearsing sessions.

4.5.2 The blindfolded audience

MAMA, the place of the performance, is a space surrounded by transparent walls, very exposed to the crowded street and to the city lights, where the visual stimuli are pervasive (figure c). Considering these characteristics, I have decided to provide blindfolds for the audience. This served as a means for isolation from the visual hyperstimulation coming from outside. More than that, I wanted to experiment with it as a listening mediator. I was happy to see most of the audience wearing them, and I felt trusted. Moreover, I soon realized that within blindfolds, the listening experience would have been probably sharper and richer than if without. This induced me to feel more responsible for my sounds, specifically more careful on the dynamics and on the transitions between the layers. This situation created the possibility not only for the audience to be in a relatively different position than usual, but also for me as a performer.

Using blindfolds provided a means for isolation from the outer stimuli, facilitating the emergence of the inner space for the listeners. The intention was to experiment with the features of listening to partially isolate the listener and affect the perception of space, even more when the visual stimuli are taken out. The speakers' setup was a 2.1 and was proportioned to the size of the room, the audience was around 20 people.

After the performance, I noticed from the audience a positive attitude in sharing the personal listening experience: using blindfolds created a relatively unusual situation in which the individual experience emerged as deeper and more detailed, yet still being part of a collective participation.

This sense of difference in the nature of the participation of a blindfolded audience is also mentioned by Francisco Lopez, a media artist and composer who have made an extensive use of blindfolds during his long performative experience. In an interview dated 2015 he says:

> [...]My blindfold technique for live performances has to do with the natural immediate surge in the non-visual senses but, more importantly, with the crucial question of commitment to the experience. Being voluntary and optional, the blindfold becomes in this context a tool for *transformative* listening through

> acceptance, surrendering, dedication, trust, engagement. And if we are even more resolute and ambitious, a tool for spiritual expansion[62].

When collecting the feedback by informally talking after the performance, I indeed noticed the same increased commitment mentioned here. Among the different experiences shared by the audience, some were concerning progress in concentration: L. described an initial state of active intertwining of thoughts and distant memories, slowly followed by a state of relaxation which led her to a clearer attentive focus on sound. She described one of the inner/outer focus shifts frequently mentioned by Ruth Herbert in her research. Other feedback was concerning "unusual" sensations of space: C. and K. both mentioned to have perceived the sounds arriving from many different directions rather than from the speakers, explaining to have happened "in a radically different way than usual". Moreover, in the middle of the performance, some people entered the room from outside and started asking the people at the entrance what was happening: not only didn't most of the audience realize the actual situation (of course mainly because of the blindfolds), but some of them perceived that voices as part of the same musical space.

[62] Francisco Lopez. "Expanded Listening: An Interview with Francisco López" (2015), Sonic Field https://sonicfield.org/expanded-listening-an-interview-with-francisco-lopez/

Figure c: photo taken during the performance

By the received feedback on the sound material, I came to the assumption that its continuous and slowly evolving shape and the absence of clear and repeated events, possibly created the mental space for “wandering” in and out of the sound, as well as in and out of the distracted mind. Moreover, the initial presence of low frequency droney sounds facilitated (not for everybody, of course) a state of relaxation. This condition, as mentioned in the previous chapters, can favour a stronger focus on the sonic stimuli and a consequent stronger isolation from what’s outside of it. But, again, the isolation was especially influenced by the exclusion of sight.
Indeed, the blindfolds favoured and amplified the aforementioned listening conditions due to the absence of visual distractions. Moreover, the absence of visible physical boundaries let the sound perception be less influenced by the visual surroundings. It blurred the localization of the sound sources (the speakers) and expanded the sense of directionality (therefore the descriptions of “sound coming from all the directions” by some of the listeners). Hence in this condition, the

intrinsic qualities of sound *surrounding* and *pervading the space* emerged more clearly. Together with these perceptual configurations, I believe that the aspect of collective commitment mentioned before played a crucial role. To mention other words by Francisco Lopez on the topic:

> We know that the visual component of our perception dominates, or obliterates sometimes, the hearing. But there's something else that happened that I didn't predict or plan. That is, when this happens in this way collectively and voluntarily, there is something else, which is a sense of collective commitment and voluntary acceptance of this very unusual way of following a performance[...]To me, that's perhaps even more important than this aspect of not seeing and therefore listening better[63].

Figure d: blindfolded audience during the performance

[63] Francisco Lopez. Lecture at Red Bull Music Academy (2011), https://www.redbullmusicacademy.com/lectures/francisco-lopez-technocalyps-now

Moreover, the aforementioned moment in which a group of people entered the room and their voices were perceived by someone as part of the music, or not perceived at all by someone else, served to reflect on two important aspects of listening.
On one hand, it strongly emphasized the feature of the listening self to be able to isolate from the stimuli that are external to the focus. On the other hand, the mediation of blindfolds served to decrease the ability to categorize the sounds coming from outside the "musical bubble" as external or "non-musical". This created the possibility to perceive sound as a whole, opening a door to witness the continuity of our environments. This is what the composer Pauline Oliveros calls "the whole space/time continuum of sound":

> Compassion and understanding comes from listening impartially to the whole space/time continuum of sound, not just what one is presently concerned about. In this way, discovery and exploration can take place. New fields of thought can be opened and the individual may be expanded and find opportunity to connect in new ways to communities of interest[64].

4.6 Composing with behaviour: *Forma Volatile*

4.6.1 Code developments

After *Becoming Wind*, I started to work on a multichannel piece. Having reflected on the strengths and on the weaknesses of the previous experience, I wanted to address the compositional work towards a more evident integration between sound process

[64] Pauline Oliveros "Deep Listening - A composer's sound practice" (iUniverse Inc, 2005), XXV

and musical form. In order to do that, rather than concentrating on relationships between different sources or elements, I focused on exploring inner characteristics of synthetic noises, implementing coding strategies to achieve gradual processes of inner transformation. I wanted to "mirror" these gradual modulations and movements from the inner qualities of sound to the overall form of the piece, by applying the same process to shape micro and macro aspects of the material.
I therefore implemented a spatializer that receives in input the data coming from the amplitude follower (analyzing the same samples) and translates them to movements in an 8-channel array of speakers. This means that, with an increase in amplitude in the input signals, the spatial movements get wider and vice versa. This allowed for a quite peculiar spatial behaviour.

See code in Appendix.

At this point, besides having this level of automation, I could tweak some parameters by hand while the synth and the data were running: namely the input gain of the amplitude follower, the panning center and spread in the 8 channels.
As mentioned before, by changing the gain of the amplitude follower, the level of influence of the wind over the sounds can be amplified or excluded, allowing to play between dynamism and stillness.
In this designed system (schematized in figure e), the player can anytime decide to intervene, however the range of intervention is quite limited: when the control from the data is taken out, few actions can be executed by hand and most of their effective results consist of changes in the degree of influence of the data.
Despite the little possibilities for live intervention, the natural flowing behaviour of the wind's data provided interesting spatial movements, effectively shaping an acousmatic space characterized by lively and unpredictable plasticity. I decided, therefore, to focus on a few sound spectres, and to expand their inner characteristics during the piece without needing to have many different sounds sources and many processes. The subsequent experiments were focused on processes of granulation and spatialization applied on filtered pink noise, and other noise generators found in SuperCollider.

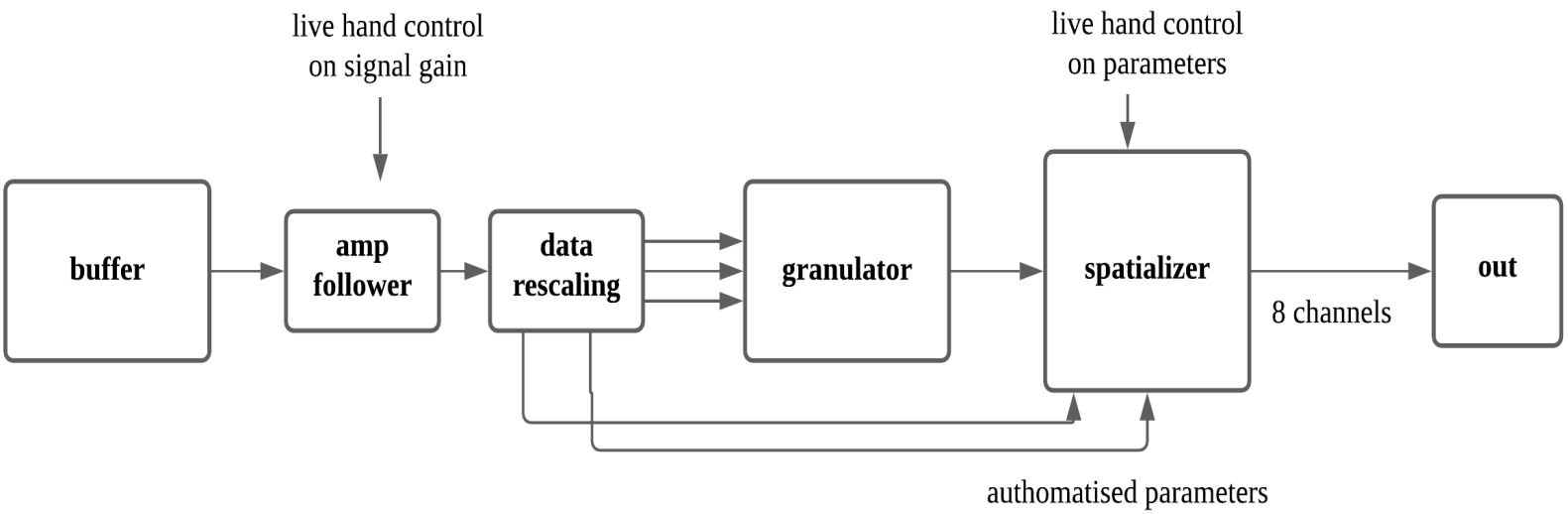

Figure e: global functioning of the patch used for *Forma Volatile*

4.6.2 Composing *Forma Volatile*

As mentioned before, the range of possible sound sources was narrowed down to synthesized noise only. This decision was driven by different reasons, mainly a need for coherence and simplicity, and an interest in *composing wind*, instead of composing with wind. At the time I was indeed interested in the process of wind's *mimesis* in order to experiment with levels of *abstraction* of such simulation, therefore the decision to use synthetic noise as a source where to "sculpt" wind from.

These ideas finally took form: *Forma Volatile* ("Volatile Form" in english).

This 8-channel fixed media piece was the result of the implementation of the previously explained algorithmic system, influenced also by my live interventions: by manipulating the control data by hand while the sound generators were running and recording the result, multichannel tracks were generated from SuperCollider and organized later on the timeline. Due to the level of control provided by the system, the work on the timeline took a relatively short period of time, since the recorded tracks were already unfolding as desired, up to a certain extent. Moreover, since the focus was on behaviour, it was my intention to intervene as little as possible on the recorded material with actions such as cuts or montage, and rather to let the sound reveal the behaviour of the system.
Following the steps from *Becoming Wind* by expanding the real-time control possibilities, it was therefore possible to manipulate the analysis data modulating the parameters of the synthesized sound so as to intervene in amplifying or reducing their influence on the inner dynamism of the noise generators. This led me to focus on creating transitions between moments of still and dynamic behaviour. These two extremes, dynamism-stillness, mark a creative space in which abstraction and mimesis occur: resemblances of typical behaviours of wind (very fast fluctuations in amplitude, high frequency fluctuations following amplitude peaks) can sometimes appear and soon after be abstracted by modulating the system's response over the data.

My aim in composing *Forma Volatile* was to make the continuous unfolding of sound a structural aspect of the form as well. I decided to articulate a transition from stillness to dynamism as a global aspect characterizing the first half of the piece. The piece starts with a slow densification of still streams of filtered pink noise, gradually becoming dynamic over the space and in their inner qualities by presenting inner fluctuations in amplitude and spectrum. This transition can be visualized in the waveform of the piece (figure f). After this transition between an initial motionless state to a dynamic condition, the continuum is broken with an explicit gesture: a gust of fragmented noise takes place, marking the presence of the human gesture behind the system (min 04:11).
After this moment, the homogeneous noisy texture starts to fluctuate similarly as before, but very dynamically. Slowly, a stream of noise of a different timbrical

character starts to emerge, very different in its dynamic behaviour, but still resembling the influence by the same control data. The two parallel streams of behaviour continue enfolding, challenging the listener's focus and contrasting the initial linearity of the process. The streams collapse together during the second moment of break at minute 7:07. After this moment, the coda appears from a segment of a field recording of wind, looped and distributed in space. The repetitive unfolding of the recorded segment is here used to underline the virtuality of the whole: even an element resembling "reality" such a field recording doesn't break the continuity of listening of the acousmatic context.

In balancing a process-based unfolding of sound and form with explicit human gestures, I wanted to emphasize the different tensions driving the creative process of this piece: a hierarchy between the algorithmic system and the composer's interventions was not predefined by rules nor formalized, but was rather based on a fluid relationship. This could be subjected to improvised and spontaneous interventions emerging during the time of playing with the patch, which was indeed the time of creation.

The two moments of break served also to model the spatiality of the piece: with the first break (04:11) the sounds are suddenly drowned by a gust of fragmented noise which "clears" in a moment the previous sensation of space, although the sounds reform similarly soon after. With the second break (7:07) a louder mass of distorted noise suddenly pervades the space, collapsing it at the center, and marking the end of the process.

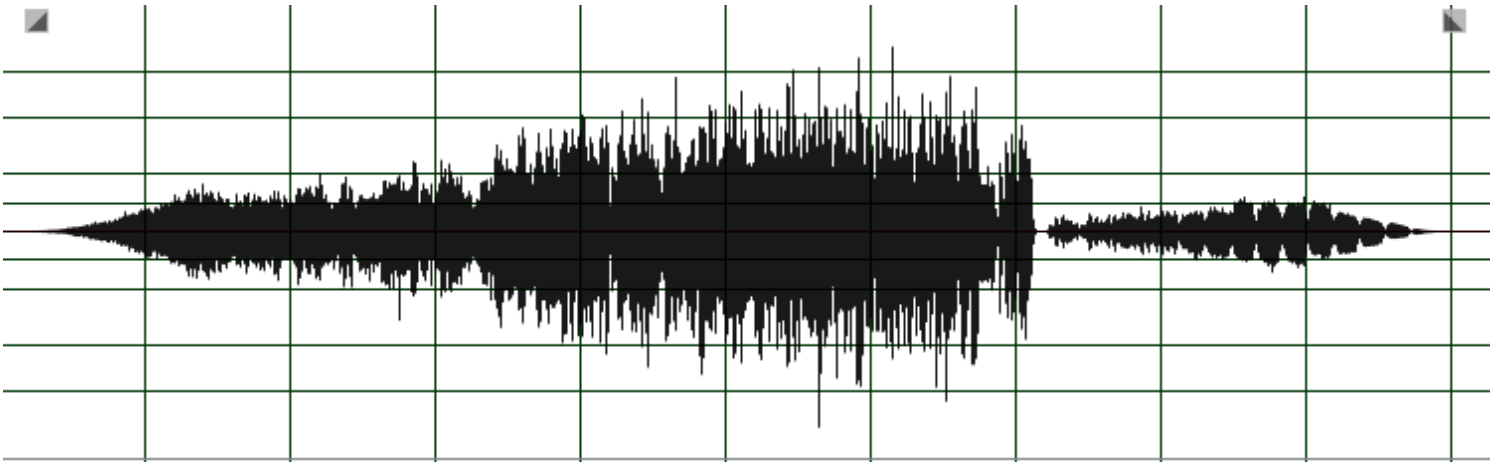

Figure f: waveform of the binaural mixdown of *Forma Volatile*

4.6.3 The binaural version

Covid-19 started to spread right after I finished composing *Forma Volatile*, therefore, due to the imposed restrictions on live concerts and social gatherings, me and my fellow students were invited by the teachers to create binaural versions of our multichannel pieces to be published online.
In order to realize the binaural mixdown of the piece, I have used the Sennheiser VST plugin AMBEO Orbit. The mixdown process consisted of placing the 8 mono tracks on 8 positions in space representing the virtual speakers. The plugin would then encode the material to binaural, thus giving the possibility to export the mix as a stereo track.
I found this binaural version of the piece quite problematic, since the homogeneity of the sounds enfolding in space created phasing effects. Besides the technical aspects, I believed that listening to this piece in headphones provided an experience of a substantially different character from the one that I remembered from the studio.
In the work, indeed, I wanted to challenge the concept of Embodiment by presenting timbres and behaviours which resemble sonic mechanisms of wind. By simulating wind (and contrasting it with the field recording at the end of the piece) I

wanted to see how much can the simulation of such a sound source recall multimodal sensations, considering that we experience wind deeply within our body (see Chapter 3).

I later had the chance to play the piece in Schönbergzaal during the Sonology Discussion Concert of 14th October, with a small audience.
In the hall, the sounds assumed a very interesting spatial character. It seemed to me that a big mass of air was just outside the hall, pressuring the walls and making the room vibrate.
I nevertheless realized that expecting to induce such a specific listening experience (embodied perception of wind) was problematic. Indeed the variables in place are too many to be able to define if a sensation of "real" wind occurred during listening and why.

Figure g: screenshots of AMBEO Orbit Binaural Encoder VST showing two of the 8 positions of the sound sources in the multichannel array.

5. Deeper into the algorithmic system

5.1 Sound studies I-II-III-IV

After the experience of *Forma Volatile,* I developed the algorithmic system to deepen and expand the level of agency of the control data over the sound generators. I also aimed to create better strategies for the real-time manipulation of the control data and the parameters of the sound generators together with widening the range of sounds to play with. The decision, therefore, was to keep the wind's analysis system while expanding the analysis strategies. Also, I aimed to widen the mapping possibilities and the influence of the control data over the unfolding of different events over time, and not only over the inner sound's behaviour.

To progressively manage the aforementioned system development, I composed 4 studies.

5.1.1 Code developments

The first actual code developments consisted of implementations of more types of noises and impulse generators. They were integrated in the system in order to be modulated by the control data coming from the real-time analysis blocks. As described in Chapter 4, the analysis blocks consist of an amplitude follower and a spectral centroid tracker, of which the output data are rescaled according to the specific parameters to which they're mapped.

Besides the implementation of new sounds from sound generators embedded together in one or two synthesizers (SynthDef), the system was developed in order to give the possibility to generate events.
A useful way to generate events in SuperCollider is provided by the Patterns library. A Pattern generates a Stream, which is a sequence of values obtained one at a time. In order to generate an event where more sequences are embedded together, SuperCollider has the pattern class Pbind. A Pbind responds to a specific synthesizer and allows embedding in one single event different sequences of values modulating parameters of the synth simultaneously. For each event, the next value of each sequence occurs. Since my interest was to be able to manipulate aspects of the events while they were running, the architecture of Pbind was not ideal, since it doesn't allow live manipulation. I therefore used another pattern class called Pbindef that admits to change values of the patterns independently while the event is running. Still, it applies the change to the next coming event per each sequence.

Within the designed Pbindefs, some of the parameters of the synthesizers (two implemented synthesizers) were modulated by the control data coming from the amplitude follower and centroid tracker, while some other parameters were defined by fixed numbers. Those fixed numbers were defined either arbitrarily or by controlled randomness.

Another important development was the expansion of the interventions over the control data produced by the analyzers by adding, in addition to rescaling, other manipulations: flipping data, applying offset, delaying and interrupting the data flow. Each manipulation provided in output a different set of data. This substantially expanded the possible behaviours of the control data.
The control data were at the time contained in one single module (a SynthDef) but each of these manipulated sets of data was assigned to global variables. Global variables refer to specific parts of the code that can be recalled easily in different areas of the patch (therefore the definition “global”). By having global variables, it was therefore possible to recall individually the specific sets of control data outside of their original module. In this way, it was possible to rescale them further and to recall them in the Pbindef. In order to send the control data from the Server (where

the data were generated) to the Language (where the Pbindef operates), each data set was sent over a control bus. Through this simple network from Server to Language, it was finally possible to recall them in the Pbindefs. By doing that, it was possible to map the control to the events instead of to the synthesizer, having an increased mapping flexibility. Moreover, a global variable mapped to a specific parameter of the Pbindef could be replaced by another or by other values while the events were running.

5.1.2 The musical output

Studio 1 (2 channel, 2'54") represents the first result of these developments.
The sounding output consists of a cluster of different noises and pulses, where is possible to perceive simultaneously a rich inner variety of behaviours (due to the different mappings of the global variables) together with a coherent and global unity of dynamic behaviour (the amplitude profile of the cluster is globally driven by the amplitude follower). Two global resonant filters (high-pass and low-pass) are applied to the cluster and modulated around their resonant frequencies and Q factors by fixed numbers, causing a distinct pitch quality. There are therefore local and global modulations happening at the same time. The local modulations consist of amplitude modulations of each layer independently, each controlled by a global variable (in this case only rescaled and flipped data were used). The global modulations are the filtering and the global amplitude modulation of the cluster (global amplitude of the SynthDef). This co-habitation of local and global modulation created a quite interesting contrast between micro and macro behaviour. This sound study presents the unfolding of a single event, highly influenced by the dynamic behaviour of the wind's analysis data. Therefore the wind here constitutes a clear and constant presence.

Studio 2 (2 channel, 1'38") sounds similar to the previous one in terms of behaviour, temporal unfolding and types of modulation. It nevertheless presents a wider spectrum because of the introduction of local high and low-pass resonant filters

applied to each of the layers (yet the frequency and Q of the filters are all modulated by the same fixed numbers).

Studio 3 (8-channel, 3'18") came with some further developments: another cluster was implemented (in a new SynthDef), constituted by the same noise and impulse generators but enriched with distortion techniques obtained by using binary operators. This new SynthDef was anyway designed to be modulated by the wind's data or the fixed numbers in the same way as the other. Although it was possible to trigger the two clusters individually, there wasn't yet an implemented system of relationality between the two. They could only be activated or deactivated by hand. Moreover, a multichannel expansion was implemented, indeed this sound study is 8-channel, while the previous two are stereo. This was achieved by assigning each of the layers contained in the SynthDefs to specific output buses and recorded separately. The recordings were subsequently layered in a DAW.
The multichannel expansion substantially improved the quality of the work on micro-change and behavioural differentiation. Indeed, having each layer assigned to a different speaker extensively expanded the sonic space. The widening of the listening space corresponded to a widening of the composer's possibilities of intervention to the micro details of sound. Moreover, the differences in behaviour between the layers became more easy to grasp. This increased the immersivity of the sonic space, making the sound's *surrounding quality* to emerge.
Another important change presented by this studio is that the control data are at times switched on and off while the events are running. These switches cause the sonic behaviour to drastically change: control data-off corresponds to a still micro and macro movement, control data-on make the inner movements occur, according to the dynamics of wind. I find it quite interesting to listen to these moments of change, observing a musical unfolding that doesn't remind me of any composed sound or behaviour that I previously heard. The organic movements of the sounds in space and the inner changes between the layers remind me of the swarming of mosquitoes coming together in dense groups. The distribution of the layers in the 8-channels array contributes highly to the spatiality of the sounds, giving the impression of being inside of the swarms.

Studio 4 (8-channel, 3'19") doesn't vary so much from the previous, the same switching happening in *Studio 3* is performed. It nevertheless brings a new development: the two clusters are related by their amplitudes (if one plays, the other don't and vice versa). This provides an increased global dynamic and sonic variety.

5.2 Live Coding

After these gradual steps, the technical and compositional developments took quite a steep curve when I started implementing live coding techniques.

5.2.1 Code architecture and live approach

Around October 2020 I started converting the system of synths and patterns to the JITLib paradigm in SuperCollider, specifically using the Ndef class. Within this class, it is possible to create audio and control data generators that can be manipulated and routed differently in real-time through quantized interpolation.
I, therefore, created a modular system of blocks divided into three groups: analysis data blocks, sound blocks and sound processing blocks.
The following diagram represents a schematization of the system (not containing all the blocks) showing the possible connections between the blocks. Since the system is completely modular, not all the connections are traced here, for sake of graphical clarity.

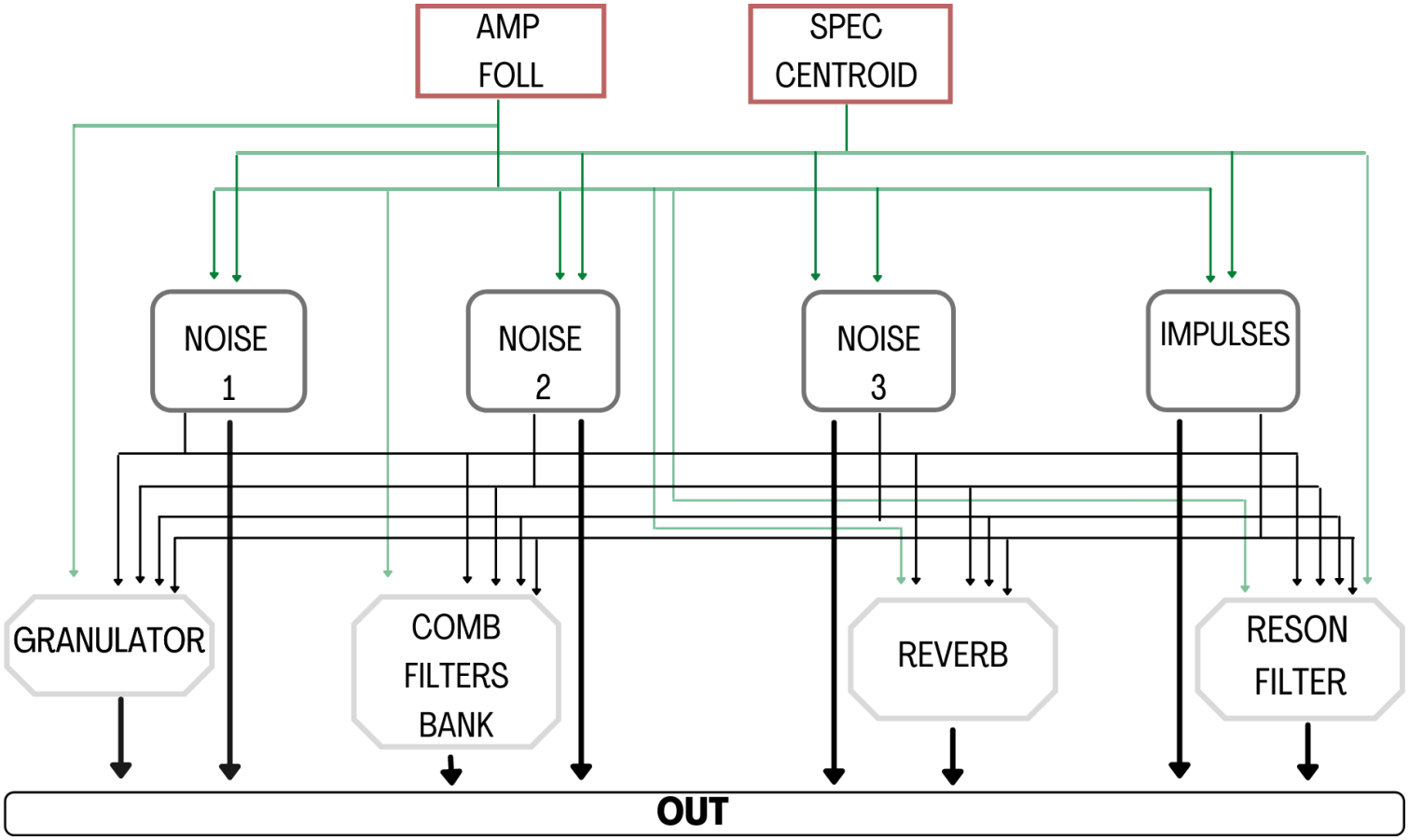

Diagram of the architecture of the system. At the top of the diagram the control blocks, at the middle the sound blocks, at the bottom the processing blocks. The lines in green represent control signals, the lines in black audio signals.

Data blocks

The analysis/data blocks have the function to analyze the wind's samples or eventually live incoming audio. During this period, the only implemented analyzers were still the amplitude follower and the spectral centroid Tracker. Later I would implement an Onsets Detector and a Threshold Detector, sending trigger signals both to the Server and to the Client, opening the possibilities for sequencing events through the control data (see paragraph 5.3). In addition to the analyzers, the blocks

contain units to rescale and manipulate the data (flipping, delaying, interrupting data) that can be chosen.
Each block can be activated, deactivated, rescaled and manipulated in the output, mapped and unmapped to different sound generators independently.

Sound blocks

The sound blocks consist of different types of noise (GrayNoise, PinkNoise, LFDNoise1, LFDClipNoise) and impulse generators. Each block can contain different processing techniques, according to the specific character or set of characters that the blocks are designed to have. Though the sound blocks are not thought to be "simple" units like single oscillators or noise generators, they already present a more or less complex sonic character, due to the embedded processing. The processing can consist of resonant filters, reverb (GVerb), binary operators, single or multiple delay lines, different kinds of oscillators (sine, saw, chaotic) modulating parameters of the filters, trigger generators that trigger specific parameters.
Of course, each block has to be activated and deactivated by the player and can receive the data coming from the control blocks through mapping. The control data can be mapped and unmapped fluently while the Ndefs are running, thus producing dramatic or subtle changes in the sound's behaviour without having to change the internal structure of the sound blocks. It is indeed possible to apply any change externally of the blocks, mapping and unmapping different Ndefs into other Ndefs and changing parameters while leaving the structure of the blocks untouched.

Processing blocks

The processing blocks are devoted to processing any of the sound blocks that they receive in input. The processing units have also been designed to respond to specific sound characters, therefore sometimes exclusively chained to specific sound generators. Some other times they are designed to receive any signal. They consist of granulators, pitch shifters, filters guided by chaotic oscillators, reverbs, comb filters guided by either sine oscillators or the control data.

The great flexibility and modularity that this architecture gives both to the mapping actions and the sound manipulation, improved the functionality of the system, orienting it specifically to the performance domain.
Moreover, in this case, while the inner behaviour of sound can be massively influenced by the control data, the organization of sounds in time is not driven by any means of automatisation and depends fully on the gestures and decisions of the player/composer. The gestures happen entirely by typing on the keyboard: numerical values are changed, Ndefs are mapped and unmapped, envelopes are triggered. Each action can happen individually or simultaneously within other actions, by selecting and evaluating single or multiple lines together.

I consider this approach to coding and live coding quite close to a modular synthesis approach since every block is designed to maintain its structure untouched during the performance. Indeed each block is designed to be independent and, while being modulated in its parameters and routed to other modules, still its original character can come back to sound. I acknowledge, looking at this architecture, that few things are left to chance in the space of the performance: the main structure of the code is fixed, the control data are quite predictable if buffers reading samples are used and are less predictable in the case of using live incoming audio (but still framed inside the possible behaviours produced by wind's fluctuations). One could say that, within this specific framework, the gestures and the compositional decisions can constitute the less predictable link of the chain, but I would argue that this depends on the specific attitude of the composer. During this path of implementation and discovery, I have maintained an improvisational and performative attitude, perpetrated during the working sessions in the studio and at home. Indeed I never start working by applying hierarchical structures or pre-defined ideas on the sound material, but I rather let ideas emerge from the process of making sound and discovering relations. Moreover, it often happens to discover sonic possibilities by code mistakes, where I find it exciting to reproduce or re-arrange mistakes in a functional way. In this regard, I acknowledge that this approach is not only facilitated by the available live coding tools, but more than that, these tools deeply shape the composer's ideas and mindset. As discussed by Collins, McLean, Rohrhuber and Ward:

> Yet there is undoubtedly a sense in which the language can influence one's frame of mind, though we do not attempt anything so ambitious as to track the influence on artistic expression of a language's representational mindset.[65]

In regard to this, fundamental flexibility and mutuality of relation between tools and creators are two of the main aspects characterizing the live coding practice and culture.
In the same article, Julian Rohrhuber, in describing his reasons behind the implementation of JITLib (just in time programming library) states:

> My reasons to introduce the just in time programming library (jitlib) was to make an interface to write code while playing that removes the distinction between preparation and action[...]Probably it has emerged from my own habit to change things up until the last moment before the performance and in many cases even during playing.[66]

I can't say I have the same attitude on performing, even if using similar tools. Indeed I always wanted to communicate a quite specific temporal unfolding of sound in the moment of performing in front of an audience. Therefore I usually rehearse the gestures I'll perform to a certain extent.
To this regard, according to Thor Magnusson, there aren't specific canons emerging either from the live coding practices or from the thoughts of the pioneers of live coding that define what is live coding and what is not, in terms of amount of live manipulation of code.[67] Although he reports the fact that both the live coding pioneers Nick Collins and Alex McLean reasonably stated that true "liveness" and deepness in the coding act are directly proportional to the amount of confrontation between the player and the algorithms.[68] In following these thoughts, Magnusson states that the practice of changing the structure of the algorithms while they are

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[65] Nick Collins, Alex McLean, Julian Rohrhuber, Adrian Ward, "Live coding in laptop performance" (Organised Sound Journal,2003), 321
[66] Collins, McLean, Rohrhuber, Ward, 328
[67] Magnusson, Thor, "Herding Cats: Observing Live Coding in the Wild" (Computer Music Journal, 2014)
[68] Magnusson, 9

running in a performance seems to be the prerequisite of live coding.[69] He therefore considers that, from this perspective, only weak and strong definitions of live coding could be defined. Consequently, for him, simple interventions on pre-written code could result to be closer to operating code with control interfaces (such as MIDI controllers or GUIs) than to live coding.

Considering the aforementioned discussion, I sometimes hesitate in naming my performative approach "live coding", since the amount of change that I imply on the algorithms while performing is not vast. Or better, the blocks are not modified in their structure, while what is modified is the structure of the connections between them, in addition to changing some specific parameters of the blocks. To draw a line from this domain to the analog, modules are plugged and unplugged into other modules, switched on and off and some of their values are changed by typing new numbers, instead of tweaking the knobs. Since I don't use MIDI controllers or GUIs, there's no interface, the code itself constitutes the interface. Moreover, the system doesn't have to deal with the limitations imposed by an interface such as a MIDI controller. One of these limitations derives from having to map knobs over specific values: this type of control, unless tweaked in the software, imposes a style of change on sound which is necessarily continuous, often translating in clearly hearable gestures. Here instead, the values are changed instantly by typing the values and evaluating the lines, and the actual change is achieved through a temporized interpolation, defined independently per each module. It is possible to change the duration of this interpolation anytime, thus translating the typing gesture to either instant or slow changes. Therefore, in this specific case, the absence of the control interface brings more flexibility and modularity to the control strategies.

I nevertheless acknowledge that the definition "live coding" does anyway comprise a "fuzzy concept", to use Magnusson's words.

From the words of Nick Collins:

> Because of the danger of running very complicated new code live, in practice most composers would content themselves with modifying pre-tested snippets. They'd go

[69] Magnusson, 10

> to a gig with a library of prefabricated and tested code. Certain functional aspects of their engine will already be in place[...]This is not to say that in advanced code one cannot make a massive change to the sound synthesis structure just by changing a few characters.[70]

5.2.2 *004 Rae*

On the 28th of November 2020, I was invited by fellow sonologist Hilde Wollenstein to do a performance in her studio, with a small audience.
This was the first occasion to perform within the live coding system in front of an audience and it turned out to be a very positive and insightful experience.
The live performance was recorded and subsequently released (31st January 2021) under the new-born label Ovaal, which is focused on live performed music and is run by Hilde. The release is entitled *004 Rae*: 004 because it is the fourth release of the series and Rae is the name of my solo project. For the release I was asked to cut the recording in four parts. In this cutting process, I haven't removed much, although it turned out to be well articulated in 4 different parts. These parts could almost seem to be 4 different pieces, while still being part of a continuum.
As mentioned in the previous paragraph, although having the flexibility of the code, I gave a specific articulation to the performance, finding in the studio sessions leading up to the concert a quite specific articulation of events that I wanted to reproduce in front of the audience.
The performance lasted 35'35" and, in my opinion, it had a clear narrative character, while maintaining a perceivable "liveness". It articulates as a slow and gradual process of unfolding sound. Each sound was conceived entirely as a stream, and the counterpoint between the different layers is managed to the microlevel of change. The graduality and continuity are nevertheless contrasted by a lively inner behavioural movement, due the presence of the wind's data in addition to the live manipulations by hand. Indeed, if the development of the relationships between the sounds is slow, the hand gestures sometimes generate dramatic or fast changes.

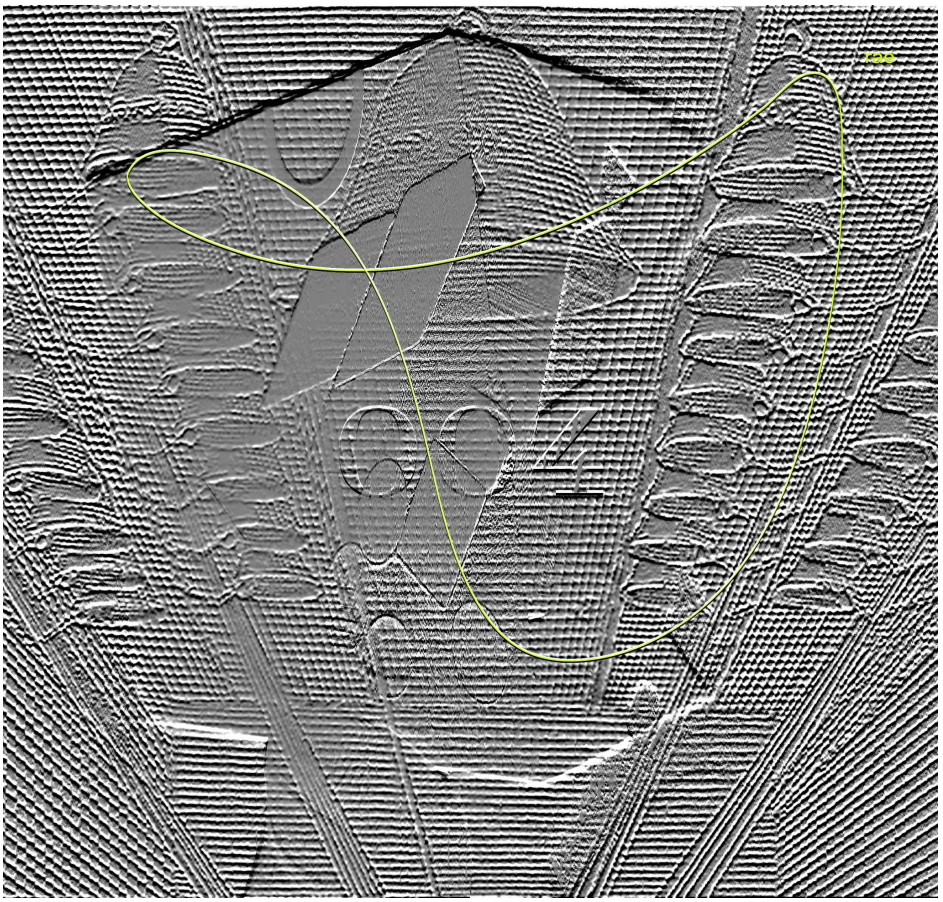
[70] Collins, McLean, Rohrhuber, Ward, 322

For this occasion, the control data were generated by the analysis of a looping buffer reading an excerpt of a field recording, the same used for controlling the synthesizers in the making of *Forma Volatile*.

As said before, even though the continuity, the soundscape changes drastically during the course of the unfolding of the events.
The first 10 minutes consist of the gradual addition of streams of periodic pulses, interlocking to the periodicity of each other due to a specific temporal subdivision. This first section has been thought to introduce the listener to a rich and detailed sonic world by using rhythm and periodic pulsation as a way to enhance a state of relaxation. In following the discourse on entrainment, following rhythm often can cause a decrease of density of thought. In regard to this, here I wanted to experiment with periodicity and rhythmicity through sounds of a simple spectral character (impulses passing through resonant filters and reverb). The intention behind this choice was to slowly *prepare the space* for the listeners to be able to focus the attention later when it would have been required by the sound complexity. I received quite positive feedback from some of the audience: apparently, this section felt to be hypnotic and helped to reach a more relaxed mental condition. I would add that, from the point of view of the listener, musical material of this kind *requires* a relaxed approach to listening, by inducing a decrease of expectations. Material of this kind approached with a listening attitude characterised by a dense mental activity and expectation would just result to be boring and monotonous. Also, this was an experiment on how entrainment (discussed in chapter 3) could be a strong driver of attentional focus.
After 9 minutes I gradually introduced some sonics streams, to start to change the picture. The following section gradually unfolds from subtle streams of noise to a loud and dense cluster. After that, the sounds become subtle again opening the space for a multitude of micro-changing layers. After a while, the sonic space is pervaded by a distorted stream of noise taking the presence of wind to the forefront. During the unfolding of this section, the filtered impulses of the initial section started gradually to appear again, transformed to high pitched streams. Their presence introduces the last section of the performance, in which the pulses, infolding

chaotically, gradually slow down, reaching a state similar to the beginning, yet never completely periodic (because of the wind's presence influencing their behaviour).

See Appendix for code.



Cover of the bandcamp release

5.2.3 *Moving Downstairs* 24/04/21

The second live coding performance happened at the Grey Space in the Middle on the 24th of April 2021, for the *Moving Downstairs* series of streaming concerts.
For this occasion, I wanted to use a "reduced" version of the system, reduced in terms of sound material and development. Indeed I have used only two of the sound blocks, and two or three control data blocks. Also, I was providing some post

processing in Ableton (grain delay, reverb, filtering, gain control), though sending the output from SuperCollider to Ableton and controlling a few parameters in the DAW with a MIDI controller. Meanwhile I was of course controlling the code by typing, as usual. Therefore the live coding here took probably an even more hybrid shape than the one previously described.
I structured the overall performance (29') by making different periodical patterns unfold and happen one after the other. The sound blocks in use were filtered impulses and a noise generator distorted by a binary operator modulated within a low-frequency oscillator, thus rhythmic.

By changing the range of values of the control data applied to the frequency and delay of pulses, I was producing drastic shifts in density and speed and vice versa. The periodicity of the noise was used as a rhythmic counterpoint to the pulses, and changed in frequency by hand. This sound block wasn't indeed modulated by any control data, only subjected to the hand gestures. Changing the density of the noise (the frequency of LFDClipNoise) was causing it to come to the foreground in gusts to then come back to rhythmical shapes.
The processing done in Ableton served to add two more layers by granulating, reverberating and pitch shifting the incoming pulses.
This reduced setup allowed me to concentrate more on micro-change, thus giving a sense of a very slow unfolding.

See Appendix for code.

5.3 Flow States

In the last months, I kept developing the code in order to add the possibility for the system to trigger certain actions depending on the characteristics of the input. Also I started working on architectures for allowing the system to respond back to certain events by triggering single or sets of actions.

5.3.1 Code developments and Locus Sonus project

The introduction of other two analysis blocks served to create trigger generators responding to characteristics of the incoming input signal. These triggers at the beginning served to trigger impulse generators. The two new analysis units consist of an Onsets Detector and a Threshold Detector. The Onsets Detector tracks the presence of new elements by recognizing their onsets (specifically designed for tracking percussive sources) and gives back a control rate trigger (1 when onset is detected, 0 when not). The implemented Threshold Detector detects in the input sound when a certain threshold is passed for a specific amount of time and gives back a trigger, similarly to the Onsets Detector.
Being the wind recordings not really containing onsets, the Onsets detector has been partially used. The threshold detector's functioning is very sensitive to the input due to the fact that, if the input doesn't reach a certain level, the detector doesn't give back anything. I, therefore, choose to change the threshold and time values quite often, in order to tweak its response over the system, depending on the situation.
A schematization of the system with these new implementations follows:

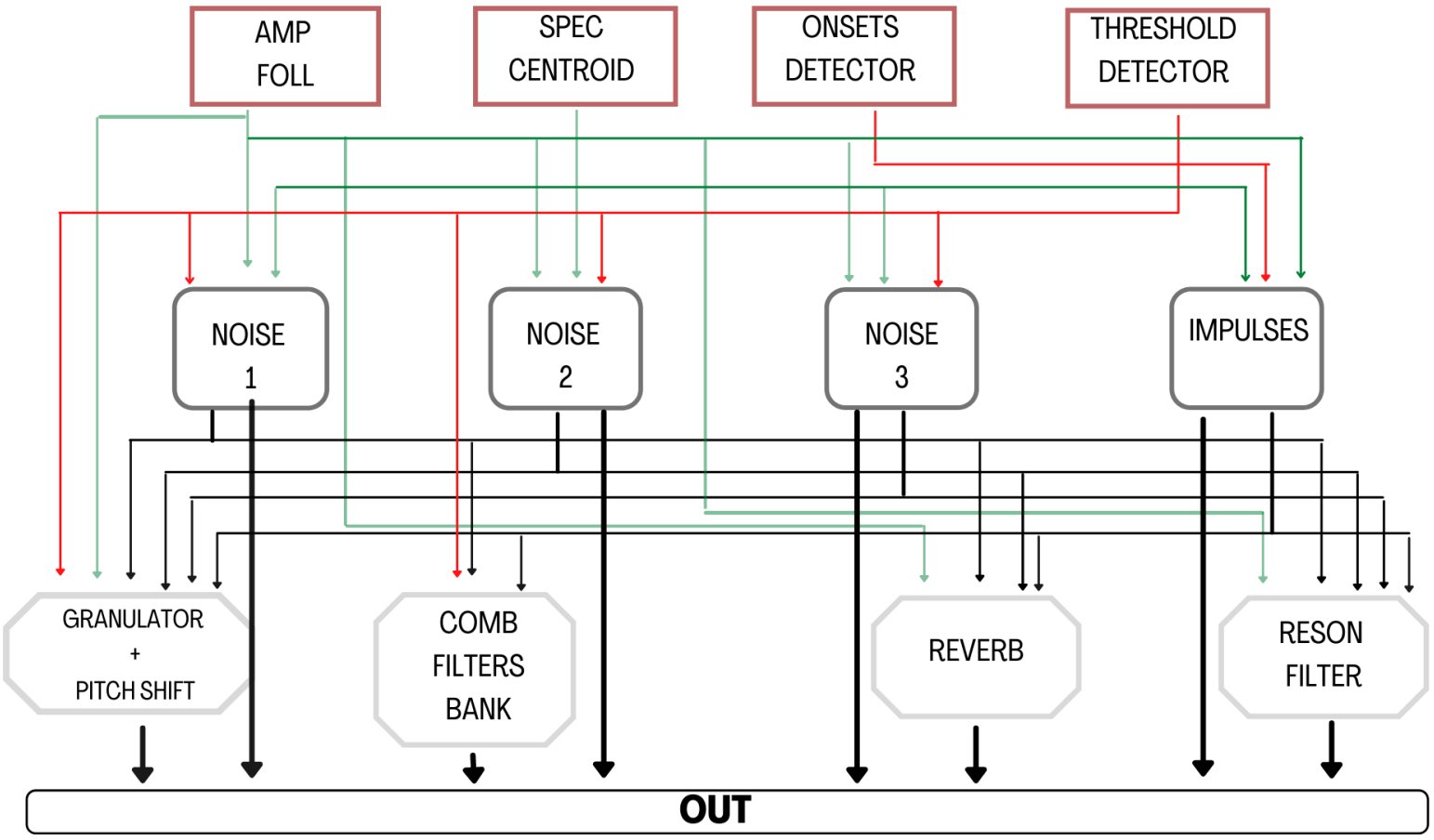
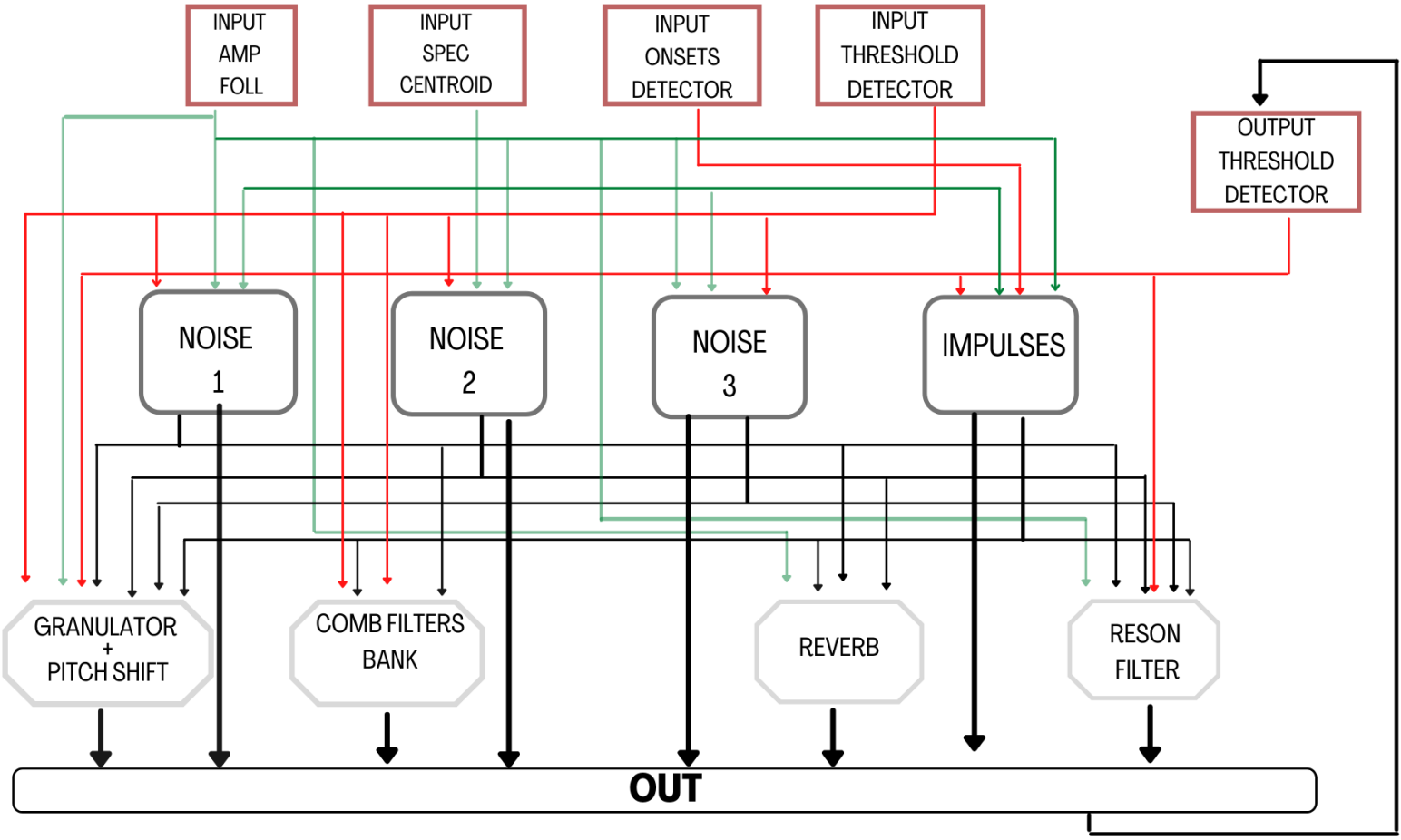


Diagram of the architecture of the system with the onsets detector and threshold detector. The lines in green represent control signals, the lines in red trigger signals, the lines in black audio signals.

This architecture was used on the occasion of an ensemble performance that I was involved in. The project consisted of building a live performance together with other three fellow students from Sonology and Art Science faculty, for the occasion of the REVEIL 2021 festival on 1-2 May 2021. The ensemble was constituted by 4 laptop players, using SuperCollider. The rule was to take in input live streamed audio from a web map called Locus Sonus soundmap, which provides a network of open microphones placed in different locations of the world and streaming audio 24/7. Since my incoming audio was not anymore constituted by wind only but it included a wide range of environmental sound sources (from natural soundscapes to people talking) the Onsets detector was used quite a lot, since the input could present new elements.

5.3.2 Code developments and *Flow States*

Further developments (the last presented in this thesis and still under construction) consist of allowing the system to take actions after "hearing" its output. This adds a recursive aspect to the system that can "hear itself" and, by taking action, can start to respond back to the gestures of the player.
In order to do so, another Threshold Detector is routed to receive in input the master output of the system and, after detecting the audio passing a certain threshold over a period of time, it responds by sending triggers to the system. These triggers are used to switch on and off processing blocks and sound blocks, so they are sent inside the Server or from the Server to the Client, through OSC communication.



The Output Threshold Detector block takes the audio signal from the output and sends triggers to the system.

Flow States is a series of multichannel compositions that represent the actual state of the system and some of the compositional ideas.
The series will be constituted by 4 pieces (work in progress), each of them exploring one configuration of the algorithmic system and its dialogue with the player.

Flow States #1 (8 channel, 8'32") was presented at the Sonology Discussion Concert of the 15th of May. It presents almost no influence from the wind's input data on the system, except for a section at the very end, where values of density of 4 noise blocks are modulated by rescaled data coming from the amplitude follower.
The piece has been fully generated from a live coding session, done using the 8 channel setup in the studio. Four stereo tracks were recorded separately and layered in a DAW. The original recording lasts 18 minutes, but for the concert I made a compressed version of 8'32". The compression consisted of cutting out some sections at the middle of the recording and anticipating the high pitched sounds of the ending section. The first 6 minutes remained untouched from the original version.

The piece consists of a very slow and gradual development of low frequency pure tones (around 50 Hz), gradually presenting higher frequency layers coming from distorted versions of the same sounds. The distortions were made by using binary operators that were switched between 3 different types during the recording.
The gestures implied during the recording were very few and consisted of: gradual introductions of the sound blocks, increasing amplitude values, switching between the binary operators, introducing modulations from the wind's data at the end. All was done by typing. Since the fade in and fade out times of the sound blocks were quite long (15 seconds), the gestures implied the activation of quite slow changes.

Within this piece I wanted to explore the physicality of sound, or better, to make the physical vibrations of sound hearable through the ears and through the body. Since the usage of low frequencies, within the right conditions (presence of subwoofers, good amplitude levels and right placement of the speakers according to the space of reproduction) it's possible to feel the vibrations all over the body.
Due to the specificity of the material, which is clearly separated between low and high frequencies, the sound assumed a peculiar spatial configuration both in the

studio and in the concert hall. Indeed, it's possible to clearly perceive a spatial separation between low and high-frequency sounds: the low frequencies felt especially with the body, are spatially perceived at the same height where the body of the listener is; while the high frequencies are perceived outside of this section of space, higher towards the ceiling. Although the piece works very differently according to the specific space of reproduction (in the studio the bodily vibrations were much more present than in the concert hall due to the dimensions of the space and the placement of the subwoofers), this spatial separation between the sounds remained hearable. Moreover, thanks to the specificity of the sound material, the work explores the mechanisms of vibration of the specific place of reproduction. The specificity that I refer to consists of the clear separation between low and high frequency sound sources, and the feature of low sounds to produce pressure waves of the necessary length to induce resonance of bigger objects and bodies.
Moreover, the aspect of simplicity and minimalism of movement of the sound material, allows for the listener to focus on slow and micro-changes of sound and on the corresponding vibrational responses from the space and the body.

See Appendix for code.

The rest of the series is under construction. My intention is to articulate the series over this conceptual structure : after Flow States #1, which doesn't present, if not just at the end, the influence of the wind's control data, Flow States #2 will feature the above described system of triggers with the system listening to its output and responding by triggering blocks of actions. Flow States #3 will present the control data as a continuous flowing, and the wind's behaviour will be revealed more clearly through masses of synthetic sound. Flow States #4 will be influenced by the same data that ultimately will follow more chaotic behaviours (more manipulation on the control data will be added). The sound material will be constituted by filtered impulses.

6. Conclusion

Although at times challenging and overwhelming, the approach adopted in this research has driven my compositional ideas towards rewarding results. The challenge indeed was to include in an already formed creative mindset a body of speculations and considerations that come from quite distant contexts, not always concerned with sound or electroacoustic music. In doing so, I kept the idea to explore a diversity of points of view, at the same time being not able to deepen the investigations on specific topics, due to this diversity. Nevertheless, this wide spectrum of research showed a strong net of interconnections that emerged by sustaining and inspiring the creative developments. Although I just started to scratch the surface of many of the discussed perspectives, I hope that these interconnections could serve to nourish the research on sound and its inherent immersive aspects.

This path opened a diverse spectrum of possible artistic outcomes and provided plenty of inspiration for new music to be composed and performed.

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Appendix

The Protagonist 360 video (headphones recommended):

https://www.youtube.com/watch?v=H8aB7aVaITI

Forma Volatile binaural mix:

https://soundcloud.com/sonology/giulia-francavilla-forma-volatile-binaural-mix

004 Rae Ovaal release:

https://ovaal.bandcamp.com/album/rae

Moving Downstairs live coding performance:

https://www.youtube.com/watch?v=m4fHDu0MUcY

SuperCollider Code

All the following code has been updated on github.
You can access my code repository through the following link:
https://github.com/GiuliaF999/Master-Research

1. Code of Becoming Wind
   see folder: Becoming Wind - patches
2. Code of Forma Volatile
   see folder: Forma Volatile - patches
3. Live Coding examples

- *004 Rae* live coding performance – see file: Annastate-set-28
- Moving Downstairs live coding performance
  see file: Moving_Downstairs-24April21.scd

4. Flow States

- Flow States #1 – see file: Flow States #1