DiMMI

Dictionary for Multidisciplinary Music Integration: Interaction

Trento, November 25-26, 2022

PROCEEDINGS

UNIVERSITÀ DI TRENTO

Silvia Sacchetti, Nicola Conci (eds.)

INTERACTION

Proceedings of the 3rd DiMMI conference, held in Trento, 25-26 November 2022

Università degli Studi di Trento

DiMMI. Dictionary for Multidisciplinary Music Integration

Vol. 1 - Interaction

The Dictionary for Multidisciplinary Music Integration (DiMMI) is a proceedings series about the event organized by the University of Trento and the Conservatory "F. A. Bonporti" of Trento and Riva del Garda, in which musicians and representatives of the academic world are called to reflect together on a word of common interest, each from the perspective of their own discipline.

Published by
Università degli Studi di Trento
via Calepina, 14 - I-38122 Trento
casaeditrice@unitn.it
www.unitn.it

Dictionary for Multidisciplinary Music Integration (DiMMI)
Vol. 1 - Interaction

Cover Design: Grafica > UniTrento | IMG > stock.adobe.com

ISBN 978-88-5541-044-1
DOI 10.15168/11572_398471

Table of Content

S. Sacchetti, and N. Conci. Dictionary for Multidisciplinary Music Integration (DiMMI) 2022: Interaction **pg. 1**

E. Dissanayake. The First Interaction Foretells Musical Behavior in Our Species **pg. 3**

N. Crossley. Music as Social Interaction **pg. 8**

A. Farina. Ecology and Semiotics of Sounds in an Interacting World **pg. 12**

F. De Sanctis De Benedictis. Interaction between Past and Future: the Algorithmic Composition Library FDSDB_XXth_CT **pg. 20**

N. Kotsani, G. Dedousis, E. Angelakis, A. Andreopoulou, and A. Georgaki. The ASMA Tool-Suite: Augmenting Singing Instruction of Elementary School Students **pg. 25**

F. Caruso, T. Di Mascio, M. Pennese, and S. Peretti. CrazySquare: an Interactive Tool **pg. 30**

F. A. Dal Ri', and N. Conci. Towards an Integration of OMR Models in Pattern Improvisation **pg. 35**

O. Mich, N. Mana, and G. Schiavo. Can Multimodal Interaction Support Older Adults in Using Mobile Devices? The ECOMODE Study **pg. 39**

E. Dorigatti, and S. Pearse. Interacting with E-waste in the Name of Ecology and Sound Art **pg. 43**

G. M. Filindeu. Swingin' Architecture **pg. 47**

S. Beozzo, C. Chioni, and C. Venturini. Is Landscape Sound? A Multidisciplinary Approach to the Soundscape of Trento (Italy) **pg. 51**

S. Sacchetti, and A. Salustri. Musicians' Work Preferences: Teaching or Playing? **pg. 56**

C. Bassetti, and A. Bruni. Sounds, Rhythms and Artefacts in Social Interaction **pg. 60**

M. Diani, and S. Sacchetti. The Network Dimensions of Musical Production **pg. 65**

L. Danieli. From “Space” to “Spaces”: Enabling Interaction with Multiple Environments to Contribute to Politics of Reuse and Audience Development **pg. 71**

E. Piergiacomi. Teatrosofia. Interactions between Philosophy and Musical Performance **pg. 75**

F. Corrias, and E. Dorigatti. Acoustic Views of Dorgali **pg. 78**

G. Klauer. Spillover, A Risky Game **pg. 80**

G. Deppieri, and N. Mana. How ICT and non-ICT Solutions Can Facilitate the Interactions in Migration-related Work? **pg. 82**

G. Tamanini. Making Music Together. A Study in Correction and Synchrony **pg. 84**

P. Casari. Event After Event: Collectivity Formation Process in Music Worlds **pg. 87**

E. Dorigatti. Interacting with Audio in Unity **pg. 91**

M. Cagol. An Intra-actionist Approach to Musical Composition **pg. 93**

Dictionary for Multidisciplinary Music Integration (DiMMI) 2022: Interaction

Silvia Sacchetti[1] and Nicola Conci[2]

[1] *Dept. of Sociology and Social Research, University of Trento, Italy*
[2] *Dept. of Information Engineering and Computer Science, University of Trento, Italy*

Editorial

The Integrated Multidisciplinary Music Dictionary (DiMMI) is an annual conference in which scholars, researchers, musicians and practitioners are asked to interpret a single keyword within the perspective of their own discipline, seeking to promote the exchange of ideas at the crossroad with other research communities. After two editions, we have decided to launch a series of conference proceedings that collect the extended abstracts presented at the conference. Like the conference, this manuscript collection is multidisciplinary by its very nature.

This volume comprises the papers of all authors who contributed to the 2022 edition of the event, jointly organized by the University of Trento and the Conservatorio di Musica F.A. Bonporti of Trento.

After "dissonance" in 2020 and "rules" in 2021, the keyword chosen for the 2022 edition was "interaction". The term interaction takes on different connotations depending on the context and the discipline in which it is adopted, in relation to the processes, languages, and technologies used. Interaction implies coordination, action, reaction, reciprocal modifications between the entities involved to guarantee communication and exchange. Interaction is present in all processes in which codes, devices, organizations, and people influence each other.

A reflection on exchanges in symbolic, physical and socioeconomic systems, which is even more relevant following the the rise of novel ways of organizing and computing paradigms based on machine learning and artificial intelligence, can provide significant perspectives for interpreting the interactions that characterize our experience and our perception of music, making music and the world of sounds from unusual points of view.

Overview of the Volume

The conference has seen the participation of researchers and practitioners from different countries and academic contexts, and it has been a great opportunity for fruitful discussions that span across a variety of topics. The volume will be introduced by the contribution of three keynote speakers, Ellen Dissannayake (Univ. of Washington), Nick Crossley (Univ. of Manchester), and Almo Farina (Univ. degli Studi di Urbino). These three manuscripts set the stage for locating the conference contributions in context, ranging from the biological origin to musicality (Dissannayake), to social networks in music (Crossley), to ecology (Farina).

In particular, Dissannayake addresses how the first interaction between mothers and infants can build the foundation of a universal interactive behavior between them, commonly known as "baby talk," which, according to the author, can be seen as a forerunner of what eventually becomes music or musicality. Crossley's contribution addresses the issue of social interaction in music and discusses how music can be conceived as a social interaction based on rules and resources to be coordinated. He maintains that networks play a crucial role in combining resources and especially those required for making and enjoying music.

Farina's contribution is instead focused on the analysis of the interactions across natural and human domains, investigating the central role of sound in landscape ecology. The author explores the properties of sound and the possibility of using it as a tool to activate interactions between the natural and the hybrid (created by humanity) worlds.

The second part of the volume follows the conference program, consisting of presentation sessions, poster sessions and demonstration sessions. Presen-

tation sessions include the discussion of theoretical and practical frameworks to promote the idea of interaction in different domains, bringing to the attention of the audience an all round perspective on what "interaction" means, spanning across social sciences, music, philosophy, and technology. The contributions include algorithms, teaching frameworks, multimodal and multidisciplinary interaction paradigms. The poster and demonstration sessions are instead aimed at presenting practical implementations and in-progress works, such as software libraries, user studies, complementing the technical program with tangible experiences that stimulated a fruitful discussion among all the participants.

We hope the reader will enjoy the contributions included in this volume, which, in the perspective of DiMMI, aim at promoting cross-disciplinary debate, and a space where researchers, scholars, and musicians can benefit from the mutual exchange of knowledge.

The First Interaction Foretells Musical Behavior in Our Species

Ellen Dissanayake

School of Music, University of Washington, Seattle, WA, USA

Abstract

Could human musicality be a species-specific behavior like language, laughter, hand-use, cooperation, ethnocentrism, and so forth—something that evolved because it contributed to our ancestors' survival and reproductive success? I propose such a hypothesis based on a universal interactive behavior between human mothers and infants, commonly called "baby talk," which I propose is a forerunner of what eventually became music or musicality.

1 Background

My approach to the origin of musicality is based on information and ideas from many subjects:

- *Human prehistory/archaeology* (the deep human past)
- *Ethology* (the biology of the behavior of animals in their natural environment)
  Human ethology: the biology of human behavior—e.g., musical behavior or "musicality"
- *Anthropology*
  Physical: anatomy and physiology of music-making (singing, instrument playing)
  Cultural: musical behavior in various cultures—similarities and differences
- *Psychology*
  Developmental: how musicality develops in the individual from birth to maturity
  Cognitive: what mental capacities contribute to musicality? How does music express and generate emotions?
- *Neuroscience*
  Cognitive and affective: roughly, making and understanding music and responding to it
- *Aesthetics*
  Philosophy of art; knowledge and experience of individual arts

There are at least five reasons that suggest that musicality is a biological adaptation (or predisposition). Music-making is: (a) found in every known society, past and present; (b) "costly"— even (and especially) in subsistence societies, it takes time and effort that could be devoted to activities more obviously relevant to survival (such as hunting, gathering, or preparing food; making implements, clothing, and other necessities of daily life; courtship, and even resting); (c) like other evolutionarily important things (such as eating, socializing with others, having sex, caring for children, being warm and safe, and playing), music-making is a source of pleasure; (d) without being taught, very young children are predisposed to engage in musical behavior: they move to music, sing, and dance (as well as engage in other arts—playing with words, wearing costumes, making believe); (e) most culturally-important social activities are accompanied by music.

2 The Biological Origin of Musicality

2.1 The first relationship

People all over the world speak and act differently with infants than with older children or adults. Why should this be so? Though physically helpless, newborns are socially precocious. Immediately alert at birth, they respond to human voices and faces more than to any other sound or sight. Soon after birth they look into their mother's eyes in what is called mutual gaze. A mother talks to her baby in a soft, high-pitched, sing-song voice, repeating words and phrases. Although the infant does not understand the words, it pays rapt attention. If its attention strays, the mother will respond by altering her vocalizations in order to regain the baby's regard; if it starts to fuss or cry, the mother again adjusts her sounds to calm and soothe it.

Not only vocalizations are altered (repeated, exaggerated, and elaborated), but there are exaggerated facial expressions (open mouth, wide eyes, wide sustained smiles, raised eyebrows) and head movements (head bob backwards, nodding). Maternal body movements in the interaction include rhythmic pats and strokes, as well as hugs and kisses. These vocal, visual, and gestural signals are exaggerated forms of ordinary friendly sounds, expressions, and movements that adults use with each other when they express familiarity, agreement, agreeableness, or readiness for contact. Fathers and other fond relatives also find themselves behaving like this, which they would never dream of doing with anyone else. It is biological evolution that induces both mother and infant to engage in these unusual behaviors because they are important for the baby's survival and the mother's reproductive success, even if they don't have a clue why they are acting this way. And surprisingly, it is the infant who comes into the world ready to "teach" its caretaker to make special sounds and funny facial expressions by responding to these with smiles, wriggles, and coos. If an adult talks to a baby as it does to another adult, the baby will look away and fuss. Mothers quickly catch on to what a baby wants (and needs), which is certainly not adult conversation.

2.2 Resemblances between baby talk and music

Looking at a transcript of baby talk as one hears and watches a video of mother-infant engagement, one can note musical features (melody, rhythm, variations in volume and speed, and manipulation of expectation) and a similar temporal structure (phrases, repeated motifs or themes, framed episodes with a consistent expressive mood, theme and variations, and evidence of mutual coordination). Using frame-by-frame microanalysis one can see coordination in time: imitation, joint action (chorusing), and turn-taking. In both music and baby talk, movement is essential, and both behaviors may have similar results or effects: pleasure, "wordlessness" or "indescribability," social regulation and enculturation, attunement and entrainment, and emotional bonding ("self-transcendence").

2.3 But (evolutionarily speaking) how did we get from baby talk to music?

2.3.1 Anatomical adaptations from our ancestral past

In the millennia after 1.8 million years ago, in the early evolution of our genus, Homo, two momentous adaptations began to collide. The first was gradual upright walking on two legs (bipedality), which produced over time a deluge of anatomical changes, including reshaping and relocating the opening of the spinal cord, restructuring the rib cage and the bones of the inner ear, altering the anatomy of the hips, lower limbs and the ankles, toes, and soles of the feet, reconfiguring of joints and body musculature. Significantly, among these required anatomical adaptations was a reshaped pelvis and consequently a narrowed birth canal. The second anatomical change was in brain size (encephalization), increasing between the earliest hominid, Australopithecus (508 cc.) and Homo erectus (973cc), between four and three million years ago, and even more dramatically between H. erectus (perhaps H. habilis or H. ergaster, which has a longer vocal tract) and modern humans, who have a brain size of about 1400 cc.

2.3.2 The "obstetric dilemma" and its evolutionary solutions

The alterations to the female pelvis required by bipedality included gradual shortening from fore to rear so that the trunk became centered over the hip joints and thereby reduced fatigue during upright walking. And gradual adult brain enlargement entailed a larger and larger head of the unborn baby. Anatomical and behavioral adaptations further occurred to allow a successful birth and rearing of infants.

A. Anatomical adaptations: (a) the infant skull became compressible at birth: the fontanelle (or "soft spot"); (b) cartilage between the two halves of a mother's pelvis could stretch slightly during childbirth; (c) significant brain growth of the baby occurs outside the womb (i.e., the brain size of a newborn triples between birth and four years, and at maturity the brain is four times larger than at birth); (d) the gestation period is comparatively reduced (when compared with and adjusted to that of other primates): it is estimated that a human baby would require 21 months in utero and at birth would weigh 25 pounds.

B. Behavioral adaptations:the mother-infant interaction, as described earlier, results in emotional bonding that ensures that the mother wants to take care of a helpless and demanding (if adorable) infant for not just weeks and months but years. Special characteristics of the interaction reinforce her brain's neural networks and neurochemistry for affiliation by (a) the mother's use of special alterations to the vocal, visual, and gestural affinitive signals that she directs to her infant: formalization (composed, simplified), repetition, exaggeration, elaboration, and manipulation of expectation) as well as by prolonging and temporally coordinating them; (b) affiliative hormones such as oxytocin, present in the brains of all mammals, are released during patterned, dynamic, rhythmic activity with infants (as with adults); (c) feelings of trust and confidence are further effects of coordination and entrainment with other humans.

3 Why Should the Baby Talk Interaction Ever Have Evolved?

As mentioned earlier, babies are born wanting (and able to entice) their caretakers to engage in the peculiar altered vocal, visual, and gestural signals that comprise baby talk. In addition to establishing the just-described physiological and emotional attunement called "bonding" that promotes maternal care of helpless infants, there are numerous other benefits to babies as they develop.

- *Emotion recognition and regulation.* Through interaction with a caretaker, babies learn to discriminate different emotions as they are expressed vocally and visually; they gain acquaintance with their own shifting levels of excitation and positive or negative feelings, thereby developing some degree of self-regulation of these; they learn that through their own responses and signals they can regulate the other person's stimulation.
- *Cognitive practice.* By anticipating, babies "hypothesize" what will come next and learn how to evaluate discrepancies from the expected; they test and perfect their expectations or predictions.
- *Social practice*. The interaction first acquaints infants with back-and-forth, give-and-take socializing, the rudiments of their prospective lives as social beings where their behavior calls forth reciprocal responses in another; they learn that others presuppose, require, and react in turn to their (the baby's) responses.
- *Language learning*. Babytalk prepares the way for a baby's being able to produce and understand the prototypical and meaningful sounds of the language it will eventually speak.
- *Learning of culture.* In the interaction, different cultures instill their own norms of proper behavior, whether demonstrative, restrained, and so forth.

The developmental importance of these benefits of bonding is clearly illustrated by the well-known "unintended experiment" revealed by some overcrowded Eastern European orphanages after the break-up of the Soviet Union. The babies' physical needs were haphazardly addressed, but just as serious was that there was essentially no face-to-face interactive play with their attendants. After later adoption by Western European and North American parents, it was noted that the children had difficulties interacting socially with their adoptive families and in school with other students, as well as with their own emotional regulation and control.

4 Conclusion: A Hypothesis of the Origin of Human Musical Behavior

4.1 Exaptation and ritualization

My hypothesis of the origin of human musicality requires the incorporation of two more theoretical subjects that were too complex to describe in my conference presentation, although I will describe them briefly in this article. First, it is important to emphasize that mother-infant interaction *is not itself music, but it provides the ingredients that became musicality in an evolutionary process called* ***exaptation***. This term describes an evolved feature that has become adaptive in one context (as when feathers evolved for warmth) but later evolved further in a different adaptive context. In the case of feathers, they went on to enable flight as well as, in some cases, becoming colored and patterned for male courtship or territorial display. In the case of musicality, the ancestral adaptive feature is mother-infant interaction whose components evolved, as I have described, to instill and enable the emotional bond that facilitated better care by mothers of increasingly immature and helpless infants.

I propose that the origin of these bonding components of mother-infant interaction was earlier social signals of voice, face, and body that in human adults today (and presumably in the ancestral past) are universally used to communicate friendliness and a willingness to cooperate. These are so common that we may not even be consciously aware of them until they are described by psychologists of emotional expressions;: they subliminally convey positive, nonaggressive intentions such as smiling; a receptive face with open eyes and mouth; an agreeable voice; and unthreatening movements. These everyday communicative signals in our remote ancestors were available to be exapted by mothers with babies when altered by the five "operations" described above—again, formalization (organization or simplification), repetition, exaggeration, elaboration, and manipulation of expectation (or surprise). The operations gave the friendly adult signals an evolutionarily new emphatic effect when solicited by and directed to infants: attracting their attention, sustaining their interest, and creating and manipulating their emotions.

Such a transformation of communicative signals in animals—especially birds, but also many species of fish, reptiles, and even insects—was identified by twentieth-century ethologists and called ***ritualization***, the second theoretical subject. Although some researchers have claimed that humans have no ritualized behaviors, it can be argued that individuals in groups everywhere observe conventions of greeting and parting, displaying status, showing submission, and so forth, in culturally different ways. However, I claim that in mothers' interaction with their

infants, the five behavioral components or operations, and their effects, can be considered as an adaptive ritualized behavior, albeit with some cultural variants.

4.2 Ritual

The ethological term "ritualization" was derived from the widely observed human practice of rituals, which take place at times of existential uncertainty and transitions from one state to another. They reflect a universal desire for supernatural help or protection, with the hope of obtaining goods or deflecting evils. Rituals are important occasions in which groups spend a great amount of time, energy, and costly goods in order to demonstrate to their "spirits" or deities that they really care about the matter at hand. The costliness and effort of the ritual is commensurate with (and thus demonstrates) the group's need and worthiness.

In ritual ceremonies ordinary speech and sounds become singing, chanting, or playing instruments; ordinary movements become dancing. Activities such as decorating one's surroundings, wearing costumes and masks, performing stories, and making marks are similarly transformations of everyday behaviors. They attract attention, sustain interest, and create and shape emotion, using the same "operations" that in ancestral mothers and infants were adaptive solutions to the consequences of the obstetric dilemma. The same adaptive neural connections and hormones that promoted bonding between mother-infant pairs became, in ritual contexts, exaptations that, as music and the other arts, bonded members of a social group in confidence and unity. In other words, the multimodal behaviors of voice, face, and movement that we identify today as "music" (or "musicality") arose and were developed in ritual practices that bonded small human bands together in their dangerous and unpredictable world, thereby contributing to their survival and reproductive success.

It is important to recognize that rituals, fundamentally, are collections of arts and would not exist without them. The arts are essential to ritual ceremonies. They discharge the neurochemicals that bind members of a group together in confidence and unity.

This article, like my talk, has presented a whirlwind tour over many complex subjects that have to do with human-human "interaction," the theme of this conference. I leave my readers to wonder how many of the "operations" of musical behaviors foreshadowed in mother-infant interaction still obtain in human-computer interactions. If we examine these compositions. I daresay that we will generally find the exapted operations of (once again) formalization (organization or simplification), repetition, exaggeration, elaboration, and manipulation of expectation (surprise) and their emotional effects of attracting attention, sustaining interest, and creating and manipulating emotions.

References

[1] 2022 Lament and liminality: A musical prototype of early artmaking. In Jonathan L. Friedmann, ed., Music in Human Experience: Interdisciplinary Perspectives on a Musical Species Cambridge: Cambridge Scholars Press, pp. 161-186.

[2] 2021 Ancestral human mother-infant interaction was an adaptation that gave rise to music and dance. Commentary to P. E. Savage, et al., "Music as a coevolved system for social bonding." Behavioral and Brain Sciences 44, p. 68. DOI: https://doi.org/10.1017/S0140525X20001144

[3] 2018 Homo musicus: Are humans biologically predisposed to be musical? In Dusan Bogdanovich and Xavier Bouvier, eds., Tradition and Synthesis: Multiple Modernities for Composers and Performers. Lévis Québec: Doberman-Yppen, pp.17-28.

[4] 2014 Homo musicus: ¿Estamos biológicamente predispuestos para ser musicales? In Silvia Español (ed.), Psicología de la música y del desarrollo Una exploración interdisciplinaría sobre la musicalidad humana. Buenos Aires: Paidós.

[5] 2012 The earliest narratives were musical, Research Studies in Music Education 34(1) 3–14.

[6] 2010 Tracking musical chills, In Alice Andrews & Joseph Carroll, eds., The Evolutionary Review: Art, Science, Culture. 1(1). State University of New York Press, 64-68.

[7] 2009 Root, leaf, blossom, or bole: Concerning the origin and adaptive function of music. In Stephen Malloch & Colwyn Trevarthen, eds., Communicative Musicality. Oxford: Oxford University Press, 17-30.

[8] 2009 Bodies swayed to music: The temporal arts as integral to ceremonial ritual. In Stephen Malloch & Colwyn Trevarthen, eds., Communicative Musicality. Oxford: Oxford University Press, 533-544.

[9] 2008 If music is the food of love, what about survival and reproductive success? Musicae Scientiae Special Issue: 169-195. (2010) French translation: Si la musique est nourriture d'amour, qu'en est il de la survie et du success reproductif? In Irène Deliège, Oliver Vitouche, & Olivia Ladining, eds., Musique et Evolution, Wavre, Belgium: Mardaga, 65-80.

[10] 2010 French translation: Si la musique est nourriture d'amour, qu'en est il de la survie et du success reproductif? In Irène Deliège, Oliver Vitouche, Olivia Ladining, eds., Musique et Evolution, Wavre, Belgium: Mardaga, 65-80.

[11] 2006 Ritual and ritualization: Musical means of conveying and shaping emotion in humans and other animals. In Steven Brown & Ulrik Volgsten, eds., Music and Manipulation: On the Social Uses and Social Control of Music. Oxford: Berghahn, 31-57.

[12] 2000 Antecedents of the temporal arts in early mother-infant interaction. In Nils Wallin, Björn Merker & Steven Brown, eds., The Origins of Music. Cambridge, MA: MIT Press, pp. 389-410.

[13] 2007 Natalie Angier, The dance of evolution, or how art got its start, New York Times Science Section (29 November).

[14] 2010 Bruce Bower, Birth of the beat: Music's roots may lie in melodic exchanges between mothers and babies, (in Special Issue: A Mind for Music, Cover Title: "Infancy's Symphony: How Musical Instincts Help Mom and Baby Connect), Science News 178:4, 18-23.

[15] 2015 June Countryman, Martha Gabriel, and Katherine Thompson, "Children's spontaneous vocalisations during play: Aesthetic dimensions." Music Education Research (19 pages). /doi/full/10.1080/14613808.2015.1019440

Music as Social Interaction

Nick Crossley

University of Manchester, UK

Abstract

In this paper I present a sociological perspective upon interaction and music. Specifically, I argue that music is social interaction. I begin by making the basic case for this claim. I then embellish the claim by considering the role of conventions and resources in musical interaction. I conclude with a reflection on the broader networks of interaction involved in music worlds.

1 Music as Social Interaction

We sometimes refer to music as if it were an object but it isn't. Music is an activity or, better still, a form of social interaction [Becker, 1982], [Small, 1989]. This contention is nicely captured in Small's (1989) suggestion that 'music' be considered a verb ('to music'), taking the present participle, 'musicking' (see also [Crossley, 2022]). It can be elaborated by way of a more common definition of music, posited by Blacking [Blacking, 1973] amongst others, as 'humanly organised sound'. In contrast to the vibrations of air which become sound within the human auditory system, and which exist independently of human beings, sound itself is an intentional phenomenon which only exists in the experience of beings who hear it. Sound must be heard in order to exist (as sound). If music is sound, therefore, it only exists for and in virtue of audiences who hear it. Moreover, importantly, hearing is the product of interaction between a sentient, listening organism and generative events in the immediate environment of that organism which give rise to the aforementioned vibrations; namely, in the case of music, the activities of performers, either live or recorded. Music exists within the interaction between performers and listeners. Furthermore, whilst, in the case of music, sounds are organised by performers and, in many cases, by composers before them, listening too plays a role in the organisation of sonic materials. As [Merleau-Ponty, 1962] says of the gaze, listening, informed by demands arising from the activities of the organism, interrogates its environment, ordering and patterning the materials it encounters in an effort to make sense of that environment. It 'groups' discrete tones, for example, such that the listener hears melodies [Husserl, 1964] and, indeed, rhythms. There are no melodies or rhythms in the absence of listeners capable of arranging what they hear in these ways. If music is 'humanly organised sound', therefore, it is equally, necessarily, social interaction.

The performer and listener roles involved in these musical interactions are ordinarily played by different people, such that music is a straightforward case of social interaction. In some cases, however, including solitary practice, the same individual plays both roles – performer and listener. This may seem to contradict the argument that music is social interaction but I have suggested elsewhere that it is better considered a special case of it ([Crossley, 2020], see also [Small, 1989]). This is not the place to rehearse this argument in detail. Suffice it to say that, as G.H. Mead [Mead, 1967] argued for human reflexivity more generally, when players take up the listener role in relation to their own performances, reflecting upon and judging what they are doing, they draw upon the perspectives of others (both individuals and collectives to which they belong) with which they are familiar, effectively bringing those perspectives to bear in a simulated conversation. They anticipate what others might have to say about their tone or timing, for example, and act upon these 'responses'. In addition, in many cases they play and thereby interpret pieces written by others, using equipment designed, made, sold and sometimes maintained by yet others in an elaborate division of labour. They may be alone in the room but their activities depend upon and engage with those of multiple others.

As these latter comments suggest, the interaction between performer and listener is only one dyad in what is, in effect, a potentially complex network. In addition to the interaction between performers and a composer (typically mediated by way of a written score), for example, performers interact with one another, seeking to find and maintain a common groove, adjusting to one another's mistakes and stimulating and encouraging one another [Monson, 1996]. Likewise audiences interact. This is clear in the live situation, where they dance together, collectively form

mosh pits and support one another's crowd surfing. Together they enact rituals and generate what Durkheim [Durkheim, 1915] called 'collective effervescence', all of which shapes their listening and thus the music which they hear. In addition, the formation of audience subcultures, listening publics and fan clubs, alongside more mundane (though often animated) conversations between enthusiasts and critics all enter into musicking, framing and informing the listening process in ways which influence what is heard, the meaning it takes on and higher-order interpretations of it.

To these interactions we must add the input of what Becker [Becker, 1982] calls 'support personnel'; that is, producers, promoters, sound engineers, roadies etc. Whether it involves live performance, recording or playback of recordings, musicking is an event (sandwiched between openings and closings) whose possibility rests upon multiple roles. Some, such as sound engineers, contribute more directly to what is heard than others (e.g. box office staff and record store assistants) but, to take the example of live musicking, events must be publicised and tickets both sold and collected if they are to succeed both financially and as experiences. This makes promoters and ticket office staff, amongst others, indispensable.

2 Conventions and Resources

Considered thus, music is not only interaction but, as Becker suggests, collective action involving a vast network. I return to the idea of networks. Firstly, however, I want to explore musical interaction further by way of two of its key elements: conventions and resources.

Any attempt at social interaction must negotiate what Lewis [Lewis, 1969] calls 'coordination problems'. There are often many different ways in which participants could achieve their goals (individual and/or collective), none more obvious or better than the others. Participants could choose any of these ways but if they are to succeed in achieving their goals it is important that they agree in what they do. It does not matter, for example, whether we drive on the left or right-hand side of the road but it is important that road users agree on one or the other. Given the many variables involved in even quite simple interactions and the multiple parties who come and go in some cases it is clearly impossible for such agreements to be struck anew in each case. Rather, past agreements tend to become institutionalised in the form of conventions [Lewis, 1969], [Becker, 1982]. By orienting to conventions individuals know how they should act in particular situations, form expectations about the actions of others in those situations, and anticipate the expectations that others have of them.

This is important in relation to musicking, which, according to Susan McClary [McClary, 2001], is convention 'all the way down'. As we know from historical and cross-cultural comparisons, every aspect of musicking, from tonal intervals (e.g. the distance between Bb and B) and scales, through notation and forms (e.g. the sonata and twelve-bar blues), to audience behaviour and ticket sales is a matter of convention. This facilitates all of the above interactions and goes right to the very heart of musical meaning and the emotions it stirs. In a very influential argument, for example, Leonard Meyer [Meyer, 1956] argues that the emotional effect of musicking is achieved by way of the manipulation of conventions (which, in turn, drives the evolution of those conventions) (see also [Huron, 2007]). Audiences orient to the conventions employed by composers and performers when listening, he argues. This, in part, enables them to order their experience and make sense of what they hear. Pieces that are too conventional and therefore too predictable are often experienced as boring. To make a piece moving (in different ways) composers and performers must play with audience expectations by deviating from conventions, in particular by delaying resolutions or finding alternative routes to them. However, such deviation presupposes conventions which both performers and listeners orient to, even as the former deviate from them.

Some conventions are common across the multiple types of music found in a given national or even international society. Others, however, serve to mark out distinct musical styles and the different 'music worlds' in which they are enjoyed. The differences between reggae, heavy metal and soul, for example, can be specified in terms of the musical conventions they typically involve.

I return to music worlds but before I do I want to consider the importance of resources to musicking and the role which musical interactions play in the exchange, pooling and combination of those resources. Musicking involves a variety of resources including time, energy, skill, equipment and often dedicated spaces, as well as the money necessary to purchase some of these. Single individuals typically lack the resources necessary for even modest musical projects, on their own, and this is often amongst their incentives for entering into interactions and relations with others. Performers, skilled in and equipped with one instrument, seek out performers skilled in and equipped with other instruments, as well as individuals with managerial skills and relevant contacts, who may negotiate with promoters, venue owners and record labels on their behalf etc. Different musical projects require different resources and access to resources therefore shapes their opportunities.

In previous work I have developed this idea by reference to 'critical mass'; that is, the number of participants required to allow an event to be staged and to succeed [Crossley, 2015], [Crossley, 2020]. Critical mass is not necessarily entirely a matter of tangible re-

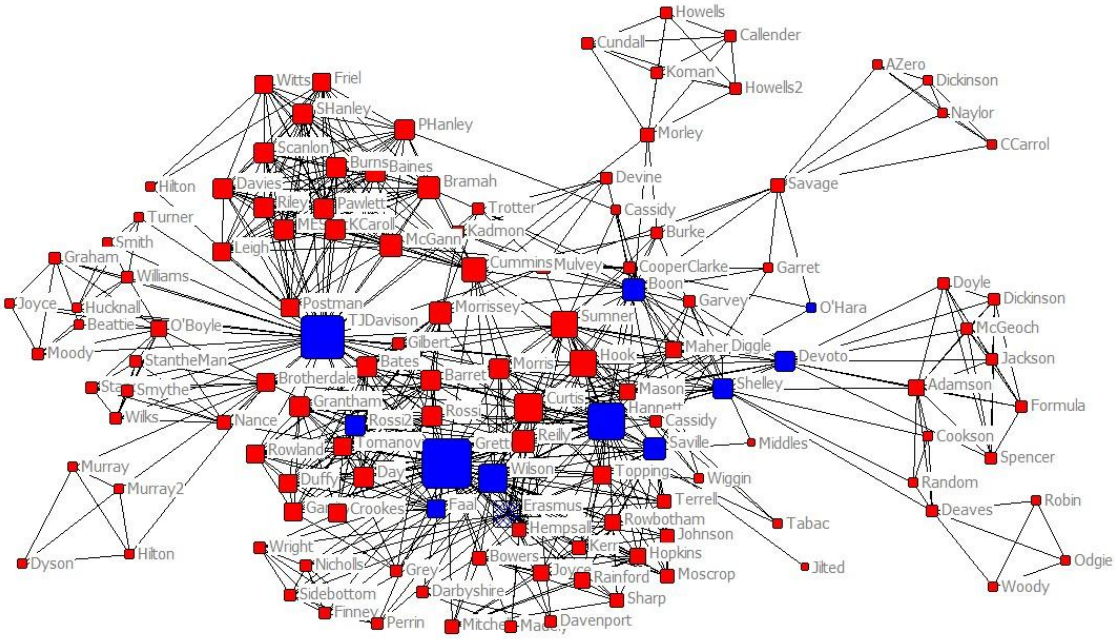


Figure 1: *The Manchester Punk/Post-Punk World, 1980*

sources. For example, the atmosphere and collective effervescence which contribute to the success of a gig – and of the course definitions of success may vary - depends in some part upon audience numbers. Beyond this, however, any musical event requires that a number of roles are performed, which, in turn, requires a sufficient number of suitably skilled people to fill those roles (one person may play several roles but the need for simultaneous contributions places limitations upon this). Furthermore, the financial incentives that may be required to fill some roles adds to costs (e.g. for venue hire, transporting and hiring equipment etc.) that must be recouped by charging audiences for admission, setting a further threshold for critical mass: audience members will generally have an upper limit to what they are prepared to pay for any given event, which determines the audience size required to break even.

3 Worlds as Networks

A critical mass of willing participants is a necessary prerequisite for a sustainable 'music world'. The classical concert world, the jazz, punk and folk worlds (and/or any of their local manifestations, e.g. the Milan jazz world, the Liverpool punk world, Italian opera) all require sufficient participants to do their particular forms of musicking, both live and recorded, and (in the absence of the wealthy patrons and/or government grants which more highbrow worlds might attract) a sufficient number of paying customers to meet the costs which those forms incur. However, a critical mass is more than an aggregate of individuals. It involves interaction and relations between participants, forming a network with identifiable (and variable) properties. These networks may be huge but smaller ones can be visualised as graphs. In Figure One I visualise the network of performers and support personnel involved in Manchester's punk and post-punk world, as of January 1980 (see [Crossley, 2015] for further elaboration). Individual participants are represented by small squares ('vertices') and relations between them, which in this case involve co-participation on a musical project, are visualised by lines which connect them ('edges').

To emphasise an earlier point I have coloured the vertices of participants who played a support/organisational role in this world (sometimes alongside a performer role) blue, and those who did not red. I also sized vertices according to the number of connections each has (its 'degree'). This very clearly shows that organisers are typically better connected in music worlds than performers (their average degrees are 24 and 9 respectively in this case), underlining their significance in musicking of this type.

Networks are crucial for the movement of resources through a world. However, they play a variety of other roles too. They are crucial for the coordination of activities (e.g. getting everybody involved in an event, including audiences in the case of gigs, to the right place at the right time). They cultivate trust, mutual support and cooperation, which, in turn, allows their participants to act in ways that may not otherwise be possible (e.g. borrowing equipment and learning new 'tricks') [Crossley, 2015]. They simultaneously cultivate competition, which encourages practice and in-

novation amongst artists, who seek to stand out from the rest. They facilitate recruitment, both of band members and audiences. And they create an environment in which styles (both musical and sartorial) which might be perceived as deviant and discouraged in wider society can be cultivated (ibid.).

4 Conclusions

In this paper I have a sketched a brief case for considering music to be a form of social interaction. I began by noting that the common definition of music as 'humanly organised sound' presupposes on-going interaction between performing and listening (even if both roles are played by the same person in some cases). I then considered the many wider roles often involved in musicking and the various interactions that occur both within and between sets of incumbents of these various roles. Embellishing this further, I first considered the 'coordination problems' posed by all attempts at interaction and the role of convention in helping participants to resolve these problems. I then considered the role of resources in musicking and the pooling, exchange and combination of resources in musical interactions. Finally, I considered the wider networks of interaction which comprise 'music worlds' and which in various ways enable musical interaction.

References

[Becker, 1982] Becker, H. (1982). *Art Worlds*. Berkeley, University of California Press.

[Blacking, 1973] Blacking, J. (1973). *How Musical is Man?* Seattle, University of Washington Press.

[Crossley, 2015] Crossley, N. (2015). *Networks of Sound, Style and Subversion: the Punk and Post-Punks Musical Worlds of Manchester*. London, Liverpool and Sheffield 1976-1980, Manchester University Press.

[Crossley, 2020] Crossley, N. (2020). *Connecting Sounds; the social life of music*. Manchester, Manchester University Press.

[Crossley, 2022] Crossley, N. (2022). *Musicking to Music Worlds*. Music Review Annual 3, 1-24, https://musicresearchannual.org/crossley-musicking-to-music-worlds-3/.

[Durkheim, 1915] Durkheim, E. (1915). *Elementary Forms of the Religious Life*. New York, Free Press.

[Huron, 2007] Huron, D. (2007). *Sweet Anticipation*. Cambridge, MIT Press.

[Husserl, 1964] Husserl, E. (1964). *The Phenomenology of Internal Time Consciousness*. The Hague, Kluwer.

[Lewis, 1969] Lewis, D. (1969). *Convention*. Cambridge, Harvard University Press.

[McClary, 2001] McClary, S. (2001). *Conventional Wisdom*. University of California Press.

[Mead, 1967] Mead, G. (1967). *Mind, Self and Society*. Chicago, Chicago University Press.

[Merleau-Ponty, 1962] Merleau-Ponty, M. (1962). *The Phenomenology of Perception*. London, Routledge.

[Meyer, 1956] Meyer, L. (1956). *Emotion and Meaning in Music*. Chicago, Chicago University Press.

[Monson, 1996] Monson, I. (1996). *Saying Something*. Chicago, Chicago University Press.

[Small, 1989] Small, C. (1989). *Musicking*. Middletown, Wesleyan University Press.

Ecology and Semiotics of Sounds in an Interacting World

Almo Farina

University of Urbino, Italy

Abstract

In this paper, we discuss the central role of sounds as semiotic vehicles to integrate and connect different compartments of natural and human domains.

We present the new discipline of ecoacoustics, which investigates in a non-invasive way the ecological role of sounds. This discipline is an example of epistemological integration with general ecology and, in particular, with landscape ecology.

Then, we will bring into question the ecosemiotic property of sounds and the possibility of using sounds as an efficient tool to activate interactions between the natural world and the hybrid world created by humanity.

Finally, we will explore new technological advancements that allow us to make virtual trips around the world, giving an extraordinary opportunity to people to explore remote areas thanks to a net of on-stream acoustic sensors, and to participate in the development of citizen science.

1 Introduction

The environment is an extraordinary collection of organisms and geophysical, biological, ecological and semiotic processes tuned by astronomical and climatic constraints. Most of our scientific knowledge is based on the functioning of the physical world driven by processes like climate dynamics, soil geochemistry and population and community dynamics [Odum, 1971]. However, despite the incredible acceleration of ecological knowledge that has occurred in the last decades, the semiotic domain that pertains communication, signification and environmental coding remains poorly investigated.

Visual, olfactory, acoustic and tactile senses are at the basis of this semiotic domain [Farina, 2022]. The information enclosed in this semiological "universe" is dominated by visual cues such as the colour patterns of bird feathers or the design of butterfly wings. These signals are utilized to maintain social cohesion in groups, populations, guilds and communities and in reproductive behaviour.

The semiology of sounds is part of this ecosemiotic universe that until now has provided only a minor amount of information. However, studies on natural and human sounds have recently experienced a promising spring opening, a grand vista on a new unexplored world of acoustic signs [Farina, 2014]; [Farina & Gage, 2017]. The advent of bioacoustics [Fletcher, 2014] and the recent development of ecoacoustics have shed new light on the complexity and diversity of bio-ecological processes.

A multitude of organisms produce sounds to activate and maintain intra- and inter-specific communication, navigate across the landscape and track resources. Passive/active sounds are extraordinary vehicles of information and meaning through natural and human-modified habitats. Although they have not received much attention, sounds are dominant phenomena in several environments. For instance, wind and rain are penetrative and persistent sounds that often mask or alter the majority of biological sounds. The spectacular falls of the Niagara River wouldn't be so majestic without the deafening sound of the river making a 99-meter leap. Bird choruses in the morning twilight in temperate and boreal forests or the insects' and frogs' daily choruses in tropical forests are examples of the degree of the dominant effects of this sonic phenomenon.

The roles of sounds and their application to the everyday life encouraged Stuart Gage, a pioneer in this field, to conceive that sounds are a powerful tool to listen the Earth's beat. Bernie Krause, composer and field recordist, considers sounds to be a celebration of the magnificence of the biodiversity offered by organisms as their choruses operate like "a natural orchestra" [Krause, 2012]. A decrease in the abundance of individuals in a population or a reduction in the number of species in a community reduces the quantity of sounds released. Several decades ago, the reduc-

tion of biological sounds was used by Rachel Carson to denounce the Earth's degradation [Brumm, 2009] as consequence of the abuse of pesticides were important causes of bird decline after the second world war. In particular, DDT and its relatives alter birds' calcium metabolism which results in thin eggshells.

In the field of biodiversity conservation, sounds are extraordinary testimonials of thousands of undescribed species that are at risk of extinction before humanity can classify them for the first time. "Fragment of extinction" is a wonderful program carried out by David Monacchi, composer and music professor at the Giacomo Rossini Conservatory in Pesaro, Italy. This scholar has tested innovative recording technologies based on multichannel devices in primeval forests of Borneo, Ecuador and Central Africa. The acoustic files collected in this way return a multidimensional sound used for a more realistic reproduction in a dedicated exhibition theatre, "the sonosfera" [Monacchi, 2016].

Natural sounds and the sounds produced by machines have a contact in hybrid landscapes where human intrusion intercepts the natural processes, reducing the level of spontaneous functionality of the environment. The diffusion of hybrid landscapes, characterized by a blend of undisturbed and modified habitats, poses a great challenge to the conservation of natural habitats, their dynamic processes and biodiversity.

2 Ecoacoustics: a short presentation

The ecological study of sound has been carried out in recent years by a new branch of ecology: Ecoacoustics [Sueur & Farina, 2015]. After a world congress in 2014 in Paris, scientists attributed the name "Ecoacoustics" to the study of sounds under an ecological perspective. Ecoacoustics is the result of the integration of other disciplines like physical acoustics, bioacoustics, ecology, animal behaviour, biotremology, landscape ecology and ecosemiotics [Farina, 2022]. Figure 1 depicts a scheme of the sources, epistemological references, tools and applications offered by ecoacoustics.

Ecoacoustics has been recognized as an umbrella discipline that offers a scientific and cultural "niche" to several aspect of the sonic domain. Soundscape ecology, a term used before 2014 to indicate the study of sounds across a landscape, was recognized as a branch of ecoacoustics. Scholars were aware that the epistemological and semantic aspect of the study of environmental sounds was of primary importance to offer a clear vision of this subject.

Sounds in ecoacoustics are processed according to two major acoustic fundamentals: Frequency and Amplitude. The quantitative analysis of frequencies (represented by a spectrogram) is possible

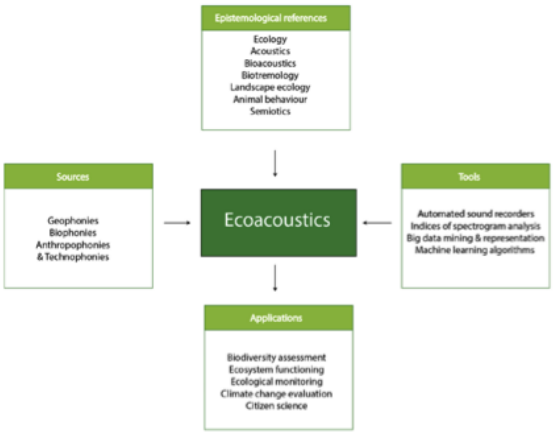


Figure 1: *The epistemological domain and its competences [Farina, 2022].*

thanks to indices like the Acoustic Complexity Index [Pieretti et al., 2011], the Normalized Difference Soundscape Index NDSI index [Gage & Axel, 2014]; [Kasten et al., 2012], [Harris et al., 2016]] and their implementation. There are more then 60 indices available to ecologists to dissect sound and to return quantities and qualities [Sueur et al., 2014]; [Gasc et al., 2015]].

3 The ecological and ecoacoustic paradigms

Before exploring the level of similarity between landscape ecology and soundscape ecology, we make a connection between ecoacoustics and some ecological paradigms like habitat, community and niche.

Ecological habitat and acoustic habitat

The habitat is a geographical area that guarantees most resources for a species [Farina, 2012]. In ecoacoustics, the acoustic habitat is a geographical area characterized by sounds that are perceived as favourable to a species. For instance, some species avoid the urban soundscape but others find this soundscape at least neutral [Mullet et al., 2017]. The acoustic habitat represents the acoustic resources necessary to a species to settle down and find other resources.

Ecological community and acoustic community

The ecological community consists of aggregates of groups of various species occupying the same geographical area at the same time. In ecoacoustics, the acoustic community is defined as an aggregation of species that produce sounds by using internal or extra-body sound-producing tools. An acoustic community is composed of only soniferous species and has an ephemeral life, regulated by solar dynamics [Farina et al. in prep.]. For instance, an acoustic community active during morning twilight is substituted by another after sunrise. The same may

happen at evening twilight when bird choruses are substituted by nocturnal insect choruses. Acoustic communities also change during a season and across different regions.

Ecological niche and ecoacoustic niche The ecological niche is a central paradigm in ecology because it conjugates evolutive and adaptive processes with environmental constraints. This concept has attracted generations of ecologists for more than a century, feeding a scientific debate headed by Joseph Grinnell, Charles Sutherland Elton and G. Evelyn Hutchinson. For Grinnell, a niche is the habitat in which a species lives [Grinnell, 1917]. For Charles Sutherland Elton the niche is the place where an animal is in relation to food and enemies [Elton, 2001]. For Hutchinson, niche is a "n-dimensional hypervolume" where the dimensions are realized by the environmental condition and resources [Hutchinson, 1957]. In ecoacoustics, the acoustic niche is the frequency repartition that distinguishes one species from another and may be considered one axis of the ecological niche. This hypothesis has been introduced by Bernie Krause [Krause, 1987]; [Krause, 1993] to explain the contemporary presence of singing species that use different frequencies to avoid an acoustic overlap. Today a growing mass of evidence confirms this hypothesis, especially in frogs, insects, birds and bats (e.g., [Sinsch et al., 2012]; [Schmidt & Balakrishnan, 2015]; [Gomes et al., 2021]).

4 Landscape ecology and soundscape ecology: an example of epistemological interaction

Landscape ecology is a branch of ecology and has a main goal of investigating the geographical dimension of ecosystems. It was developed in Central Europe at the beginning of the last century and achieved popularity in North America at the end of the nineteen-eighties thanks the great contribution of botanist Richard Forman [Forman & Godron, 1986] and agronomist Frank Golley, founder of the journal Landscape Ecology, just to cite two of the most influential figures. In Europe during the same period, thanks to the contribution of ecologists like Zev Naveh and Wolfgang Haber, landscape ecology developed a more cultural integrated approach linking the spatial pattern of the environment with cultural stratification, identity and human values attributed to landscapes [Naveh, 1990]; [Haber, 2004]. In synthesis, landscape ecology focuses on the spatial distribution of vegetation, the movement of animals across an environmental matrix and the influence of human transformation of the landscape [Wiens, 2002]. Because the spatial distribution of sounds across a region is influenced by the characteristics and dynamics of the landscape, landscape ecology has been a source of inspiration to develop new ecoacoustic theories and experiment on novel indicators to assess and monitor the environment [Pijanowski et al., 2011a]; [Fuller et al., 2015]. The relationship between landscape attributes and soundscapes is the object of interesting studies on behavioural ecology [Laiolo & Tella, 2005]; [Briefer et al., 2010].

Sounds are so important in the natural world that we have no hesitation to call the acoustic universe around us a "sound-scape", using a substantial modification of the more popular term "land-scape". According to the source, a soundscape is the result of the overlap of geophonies (e.g., running water, rain, wind, sea waves), biophonies (e.g., bird song, insects, fishes calls), anthropophonies (e.g., human voice) and technophonies (e.g., movement of cars, trains, airplanes, music) [Pijanowski et al., 2011a]; [Pijanowski et al., 2011b].

Sounds are present in every type of freshwater, marine and terrestrial environment. Every environment/habitat/landscape has a specific sonic ambience that concurs to create a strict relationship with different abiotic and biotic components of the ecosystems [Tonolla et al., 2010]; [Staaterman et al., 2013]; [Gottesman et al., 2020]. Soundscape ecology, as a branch of ecoacoustics, investigates the distribution of sounds across the landscape. Thus, the first point in common between landscape ecology and soundscape ecology is the geographic dimension in which sonic processes occur. Sounds spread across the spatial structure of a landscape and are influenced by such a configuration with a strong impact on the behaviour of species [Laiolo & Tella, 2005]; [Briefer et al., 2010]. Landscape ecology and soundscape ecology are examples of semantic and epistemological interactions. To better understand the epistemological link between landscape ecology and soundscape ecology, it is useful to examine separately the patterns and the processes that occur across a landscape. According to the American school [Forman, 1995], a landscape is composed of a mosaic of spatial units (patches) with homogeneous characters. Composition, size, shape and spatial distribution are the major attributes of these units that are the result of alternation between vegetation, bare soil, water and human settlements.

The spatial distribution of different sounds creates homogeneous units like landscape patches that we call "sonotopes" [Farina, 2014] composed of the combination of geophonies, biophonies and technophonies. When we consider only the distribution of biophonies, we call such aggregations "soundtopes" [Farina, 2014] (Figure 3). Soundtopes are the geographical representation of the acoustic communities. In landscape ecology ecotones are areas of connection between two or more different patches. In soundscape ecology the areas of contact between two or more sonotopes/soundtopes are called sonotones and

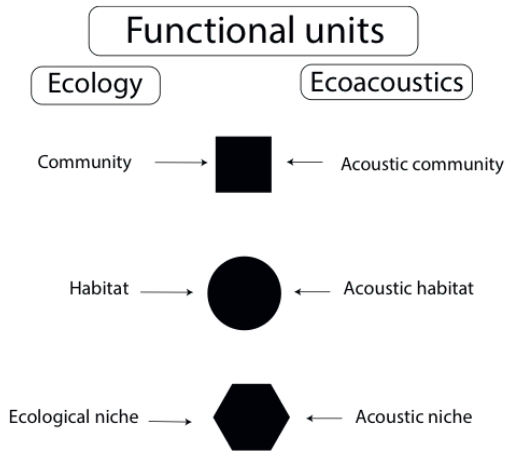


Figure 2: *Functional units in ecology and ecoacoustics.*

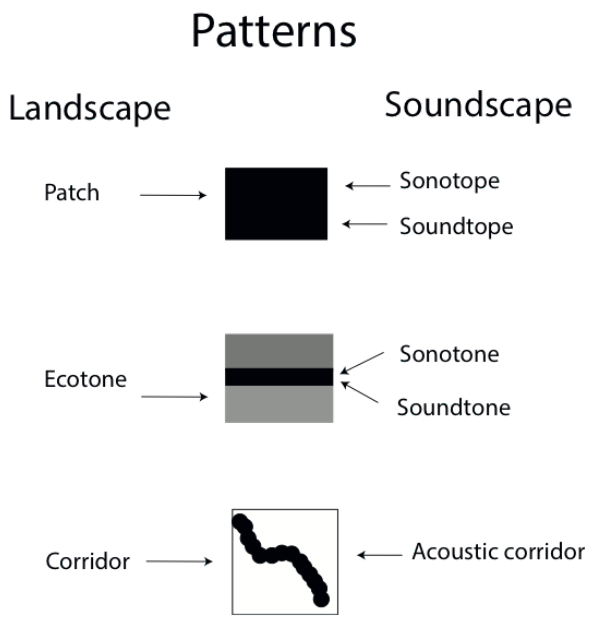


Figure 3: *Comparisons between landscape and soundscape structural entities.*

soundtones, respectively.

Disturbance, fragmentation, connectivity, connectedness and corridors are further elements in common between landscapes and soundscapes.

Disturbance

Disturbances such as a wildfire, a flood or the spray of pesticides are common processes in landscapes, originating new patterns and processes [Rykiel Jr, 1985]; [Rundel, 1998]. In ecoacoustics, disturbance is represented by the competition between sounds that have the same frequencies. For instance, technophonies with high amplitudes that commonly occur in urban areas have frequencies that overlap the same frequencies of biological origin. In this case the masking of a dominant sound (e.g., car traffic) at a higher amplitude over weaker sounds originated by biophonies is commonly known as noise and produces changes in the acoustic performance of soniferous species. Noise represents one of the most popular themes in ecoacoustic research [Erbe et al., 2018]; [Fletcher, 2012]; [Brumm, 2013].

Fragmentation

Fragmentation is a process by which homogenous areas are transformed into isolated fragments of different sizes and levels of separation according to the severity of the natural disturbances (e.g., wildfires, tornados, tree gaps) or the level of human intervention (deforestation and urbanization) [Lindenmayer & Fischer, 2013]. Fragmentation has consequences for several organisms that move across the landscape and that perceive the spatial configuration at different level of connectivity. In ecoacoustics this process has direct consequences with the separation between intraspecific acoustic sources. For instance, the isolation of a singing bird from another conspecific singer or from eavesdropping reduces or prevents intraspecific communication. Acoustic fragmentation may also be observed at the scale of an acoustic community. In this case, acoustic fragmentation is noticed as a high value of dissimilarity between two sampled positions [Farina et al. in prep.].

Connectivity and connectedness

The habitat is part of the environment that a species perceives as favourable/suitable for finding all the necessary resources to stay alive. Connectivity measures the way in which organisms maintain a functional contact with their habitats. When part of the necessary resources are located in another geographical area a species must travel to track those resources across a hostile environment. The amount of travel and the friction suffered while crossing such unfavourable environments to move from a part of a habitat to another is measured as the level of connectivity and remains species-specific. Connectedness, on the contrary, is the physical distance between two patches that have the same characters, and this variable is independent of the species [Baudry & Merriam, 1998]. These two concepts find some difficulties in being translated into the ecoacoustic domain. For instance, we can assume that the presence of a physical obstacle like a ridge, barriers like a row of dense, tall vegetation or a noisy stream may prevent the propagation of sound. When an area is favourable for several individuals of the same species, acoustic connectivity is potentially high. Landscape connectivity has been demonstrated as influencing acoustic communities and the diversity of the acoustic community [Desjonquères et al., 2018].

Corridors

In fragmented habitats, corridors represent a strategy to connect isolated patches of habitat offering an amount of favourable habitat sufficient to guarantee the transit of species from one portion of habitat to another (e.g., [Xu et al., 2019]). Ecoacoustic corridors are represented by a portion of an acoustic community represented only by one or a few species that are

sufficient to guide other conspecifics.

5 The anthropological importance of soundscapes

The study of the relationships between natural and anthropogenic sounds is gaining a growing interest worldwide [Schafer, 1994]; [Samuels et al., 2010]. Sound analysis is fundamental to investigate biodiversity and the human impact on terrestrial and aquatic systems. Sounds are sources of information on population and community dynamics. The phenological phases of sounds, called sonophases [Mullet et al. in prep.], may be used as a proxy of the long-term climate change or simply to document the effect of environmental manipulation by human action. Sounds are characterized by a high capacity to integrate different epistemological approaches and have been sources of inspiration by our ancestors, a way to reduce the philosophical distance between the real world and the spiritual world beyond. Sounds have been used in sacred ceremonies in all the religions and historic periods. The use of instruments like drums (universally used by all the ancient people) or the bullroarer (used by Australian aborigines) that mimics the sound of nature have encouraged this cultural approach. It is important to spend more words on this subject that is investigated by archeoacoustics, a branch of acoustics that tries to connect space, the position of ancient monuments and sacred sites as resonant boards [Díaz-Andreu et al., 2022]. For instance, the location of a sacred/dangerous place close waterfalls in the Virginia Blue Ridge Mountains is an example of utilization of the sound of a waterfall as a sensory experience. The location of visual motifs in Upper Paleolithic caves and acoustic responses seem correlated, confirming that sound could have influenced the behaviour of Paleolithic societies [Fazenda et al., 2017].

Modern anthropogenic sounds contribute to the identity of a place and the disappearance of characteristic sounds and may reduce the identification and recognition of a place. The sounds become an integral part of every landscape and may be considered true landmarks. Sounds are recognized in the same way as mountain peaks or other scenic environments. In particular, in rural landscapes the sounds of nature are mixed with the sounds of human activities, creating a unicum that becomes an important component of the local culture. The decennial land abandonment of rural areas in most of the world contributes to the loss of this intangible resources. For instance, on Gomera Island the whistle of residents represents a language based on sound modulation [Classe, 1957]; [Lindblad,]. This "language" developed in an environment with a steep morphology, rich in vertical walls separated by deep canyons. The great difficulty of crossing the territory has produced the whistles as a semiotic tool of human communication.

Education from sounds

Our ancestors utilized passive sounds to localize prey and prevent predator attacks in the savanna and forest in which they were wandering in search of prey, seeds and fruits. In modern societies this attitude has been forgotten but not erased in our genetic heritage and the rediscovery of sounds eliciting a great number of dormant sensations. According to the ecosemiotics narrative, natural sounds may be considered optional resources according the GTR [Farina, 2012] that become necessary to achieve some spiritual and psychological goals. The human well-being is also passing through the presence of natural sounds. The recent history of honeybee therapy that uses the sounds produced by thousands of wings flapping (buzzing) from the interior of a hive teaches us about the importance of this sound in alternative medicine and opens new modalities to recover from several diseases. If sound is important for the scientific advancement, in the same way it is a relevant subject for a permanent education of "common" people. Today, new technologies of digital communication based on the transmission of information from satellite internet allows deployment of microphones in remote regions of the Earth to hear live-streaming of the environmental sounds to obtain a useful and educational tool available to every category of people.

For instance, the "Locus Sonus Stream Project [1] offers a worldwide network of "open mikes" that permanently stream local soundscapes to a dedicated server. The resulting live audio is used in a large variety of artistic projects.

A recent project (December 2022) of the Fivizzano Commune of Northern Tuscany, EcoSoundscape[2] offers the soundscape from four mikes that stream all day from different rural landscapes. The website provides detailed information about the locations, the species and also offers a "scientific diary" in which relevant acoustic events are published (Figure 4). This project will receive a further implementation with the automatic identification of the species by applying techniques of machine learning that allow the automatic identification of species. The original files are stored in a temporary memory located in the device and can be downloaded on demand for scientific data processing and analysis. The creation of a net of such devices in a region will allow us to monitor changes in animal phenology, biodiversity composition and dynamics and assess the level of human intrusions, just to list some of the potential services offered by this technology.

Recently, thanks to the new algorithms of artificial intelligence (AI) are available platforms that identify bird species in real time and are grow-

[1] https://locusonus.org/wiki/index.php?page=Locustream.en
[2] https://Ecosoundscape.it

Figure 4: *A SET™ (Lunilettronik.it), a station used in the Eco-Soundscape project ® for the International Institute of Ecoacoustics.*

ing projects in so-called citizen science that may be defined as public participation in scientific projects [Eitzel et al., 2017]. For instance, BirdNET is a citizen science platform launched by the K. Lisa Yang Center for Conservation Bioacoustics at the Cornell Lab of Ornithology[3]. BirdNET is also a software that is used to analyse large collections of audio. This application can identify 3,000 of the world's most common species and the list will be enlarged in the future.

An active role from citizen science is realized by Merlin, a platform launched at the same laboratory, that can transmit a record from a smartphone to a server that will be associated with the GPS position of the smartphone in the locality in which the contact is established. In this way, a great amount of acoustic information can be harvested around the world, creating an open data bank that can be accessible to scientific processing and evaluation.

6 Concluding comments: Sound as an ecosemiotic barrier to Earth's degradation

Sounds, conceived as a tangible resource actively tracked by soniferous species to satisfy functions like reproduction, territorial patrolling, socialization, safety assessment, navigation and habitat selection, are also efficient vehicles of eco-semiotic interactions at the scale of individuals, populations and communities. Many of the vital traits of organisms are guided and shaped by emitted and received sounds. Sounds create a network of dynamic interactions that converge into the semiotic agency of the "acoustic community". Sound is probably the least expensive ecosemiotic vehicle to transfer information between organisms. Sound is a dynamic and independent vector according to who is hearing it and complete information is associated to it. Its ecosemiotic nature is confirmed and represents the best way to track biodiversity or to assess environmental quality without moving through a hostile environment or disturbing the source. In conclusion, while biodiversity is currently decreasing at an alarming rate and species change their habitats or suffer from phenological mismatches, natural sounds represent the most accessible tool to investigate environmental quality.

[3] https://birdnet.cornell.edu/

References

[Baudry & Merriam, 1998] Baudry, J. & Merriam, H. (1998). *Connectivity and connectedness: functional versus structural patterns in landscapes*. In: Schreiber, K.-F. (Ed.), Connectivity in Landscape Ecology. Proceedings of the Second International Seminar of the International association for Landscape Ecology, Munster, 1987, vol. 29. Munsterusche Geographische Arbeiten, pp. 23–28.

[Briefer et al., 2010] Briefer, E., Osiejuk, T., Rybak, F., & Aubin, T. (2010). *Are bird song complexity and song sharing shaped by habitat structure? An information theory and statistical approach*. Journal of Theoretical Biology, 262(1), 151–164.

[Brumm, 2009] Brumm, H. E. (2009). *Silent Spring*. 1962.

[Brumm, 2013] Brumm, H. E. (2013). *Animal Communication and Noise (Vol. 2)*. Springer Science Business Media.

[Classe, 1957] Classe, A. (1957). *The whistled language of La Gomera*. Scientific American, 196(4), 111–124.

[Desjonquères et al., 2018] Desjonquères, C., Rybak, F., Castella, E., Llusia, D., & Sueur, J. (2018). *Acoustic communities reflect lateral hydrological connectivity in a riverine floodplain similar to macroinvertebrate communities*. Scientific Reports, 8(1), 1–11.

[Díaz-Andreu et al., 2022] Díaz-Andreu, M., Jiménez Pasalodos, R., Rozwadowski, A., Álvarez Morales, L., Miklashevich, E., & Santos da Rosa, N. (2022). *The Soundscapes of the Lower*

Chuya River Area, Russian Altai: Ethnographic Sources, Indigenous Ontologies and the Archaeoacoustics of Rock Art Sites. Journal of Archaeological Method and Theory, 1–28.

[Eitzel et al., 2017] Eitzel, M., Cappadonna, J., Santos-Lang, C., Duerr, R., West, S., Virapongse, A., & Jiang, Q. (2017). *Citizen science terminology matters: Exploring key terms*. Citizen science: Theory and practice, 1–20.

[Elton, 2001] Elton, C. (2001). *Animal Ecology*. University of Chicago Press. p. 64. ISBN 978-0226206394.

[Erbe et al., 2018] Erbe, C., Dunlop, R., & Dolman, S. (2018). *Effects of noise on marine mammals*. Effects of anthropogenic noise on animals, 277–309.

[Farina, 2012] Farina, A. (2012). *A biosemiotic perspective of the resource criterion: Toward a general theory of resources*. Biosemiotics, 5, 17–32.

[Farina, 2014] Farina, A. (2014). *Soundscape ecology*. Springer, Dordrecht.

[Farina, 2022] Farina, A. (2022). *Principles and Methods in Landscape Ecology: An Agenda for the Second Millennium*. In Principles and Methods in Landscape Ecology: An Agenda for the Second Millennium (pp. 1–42). Cham: Springer International Publishing.

[Farina & Gage, 2017] Farina, A. & Gage, S. E. (2017). *Ecoacoustics: The ecological role of sounds*. John Wiley Sons.

[Fazenda et al., 2017] Fazenda, B., Scarre, C., Till, R., Pasalodos, R., Guerra, M., Tejedor, C., ..., & Foulds, F. (2017). *Cave acoustics in prehistory: Exploring the association of Palaeolithic visual motifs and acoustic response*. The Journal of the Acoustical Society of America, 142(3), 1332–1349.

[Fletcher, 2012] Fletcher, J. E. (2012). *Effects of Noise on Wildlife*. Elsevier.

[Fletcher, 2014] Fletcher, N. (2014). *Animal bioacoustics*. Springer handbook of acoustics, 821-841.

[Forman, 1995] Forman, R. (1995). *Land mosaics*. Cambridge University Press, Cambridge, US.

[Forman & Godron, 1986] Forman, R. & Godron, M. (1986). *Landscape Ecology*. Wiley Sons Canada.

[Fuller et al., 2015] Fuller, S., Axel, A. C., Tucker, D., & Gage, S. H. (2015). *Connecting soundscape to landscape: Which acoustic index best describes landscape configuration?* Ecological indicators, 58, 207–215.

[Gage & Axel, 2014] Gage, S. & Axel, A. (2014). *Visualization of temporal change in soundscape power of a Michigan lake habitat over a 4-year period*. Ecological Informatics, 21, 100–109.

[Gasc et al., 2015] Gasc, A., Pavoine, S., Lellouch, L., Grandcolas, P., & Sueur, J. (2015). *Acoustic indices for biodiversity assessments: Analyses of bias based on simulated bird assemblages and recommendations for field surveys*. Biological Conservation, 191, 306–312.

[Gomes et al., 2021] Gomes, D., Toth, C., Cole, H., Francis, C., & Barber, J. (2021). *Phantom rivers filter birds and bats by acoustic niche*. Nature Communications, 12(1), 3029.

[Gottesman et al., 2020] Gottesman, B., Francomano, D., Zhao, Z., Bellisario, K., Ghadiri, M., Broadhead, T., ..., & Pijanowski, B. (2020). *Acoustic monitoring reveals diversity and surprising dynamics in tropical freshwater soundscapes*. Freshwater Biology, 65(1), 117–132.

[Grinnell, 1917] Grinnell, J. (1917). *The niche-relationships of the California Thrasher*. The Auk, 34(4), 427–433.

[Haber, 2004] Haber, W. (2004). *Landscape ecology as a bridge from ecosystems to human ecology*. Ecological research, 19, 99–106.

[Harris et al., 2016] Harris, S., Shears, N., & Radford, C. (2016). *Ecoacoustic indices as proxies for biodiversity on temperate reefs*. Methods in Ecology and Evolution, 7(6), 713–724.

[Hutchinson, 1957] Hutchinson, G. (1957). *Concluding remarks*. Cold Spring Harbor Symp, 22, 415–427.

[Kasten et al., 2012] Kasten, E., Gage, S., Fox, J., & Joo, W. (2012). *The remote environmental assessment laboratory's acoustic library: An archive for studying soundscape ecology*. Ecological Informatics, 12, 50–67.

[Krause, 1987] Krause, B. (1987). *The niche hypothesis: How animals taught us to dance and sing*. Whole Earth Review, 57(57), 14–16.

[Krause, 1993] Krause, B. (1993). *The niche hypothesis: a virtual symphony of animal sounds, the origins of musical expression and the health of habitats*. The Soundscape Newsletter, 6, 6–10.

[Krause, 2012] Krause, B. (2012). *The great animal orchestra: finding the origins of music in the world's wild places*. Hachette UK.

[Laiolo & Tella, 2005] Laiolo, P. & Tella, J. (2005). *Habitat fragmentation affects culture transmission: patterns of song matching in Dupont's lark*. Journal of Applied Ecology, 42(6), 1183–1193.

[Lindblad,] Lindblad, P. *On the whistle language of Gomera*. Working papers/Lund University, Department of Linguistics and Phonetics, 9.

[Lindenmayer & Fischer, 2013] Lindenmayer, D. & Fischer, J. (2013). *Habitat fragmentation and landscape change: an ecological and conservation synthesis*. Island Press.

[Monacchi, 2016] Monacchi, D. (2016). *A philosophy of eco-acoustics in the interdisciplinary project fragments of extinction*. Environmental sound artists, 159–168.

[Mullet et al., 2017] Mullet, T., A, F., & SH, G. (2017). *The Acoustic Habitat Hypothesis: an ecoacoustics perspective on species habitat selection*. Biosemiotics, 10, 319–336.

[Naveh, 1990] Naveh, Z. (1990). *Landscape ecology as a bridge between bio-ecology and human ecology. Cultural aspects of landscape*. PUDOC, Wageningen, 45–58.

[Odum, 1971] Odum, E. (1971). *Fundamentals of Ecology*. Saunders, Philadelphia.

[Pieretti et al., 2011] Pieretti, N., Farina, A., & Morri, D. (2011). *A new methodology to infer the singing activity of an avian community: The Acoustic Complexity Index (ACI)*. Ecological indicators, 11(3), 868–873.

[Pijanowski et al., 2011a] Pijanowski, B., Farina, A., Gage, S., Dumyahn, S., & Krause, B. (2011a). *What is soundscape ecology? An introduction and overview of an emerging new science*. Landscape ecology, 26, 1213–1232.

[Pijanowski et al., 2011b] Pijanowski, B., Villanueva-Rivera, L., Dumyahn, S., Farina, A., Krause, B., Napoletano, B., ..., & Pieretti, N. (2011b). *Soundscape ecology: the science of sound in the landscape*. BioScience, 61(3), 203–216.

[Rundel, 1998] Rundel, P. (1998). *Landscape disturbance in Mediterranean-type ecosystems: an overview*. Landscape Disturbance and Biodiversity in Mediterranean-Type Ecosystems, 3–22.

[Rykiel Jr, 1985] Rykiel Jr, E. (1985). *Towards a definition of ecological disturbance*. Australian Journal of Ecology, 10(3), 361–365.

[Samuels et al., 2010] Samuels, D., Meintjes, L., Ochoa, A., & Porcello, T. (2010). *Soundscapes: Toward a sounded anthropology*. Annual Review of Anthropology, 39, 329–345.

[Schafer, 1994] Schafer, R. (1994). *The Soundscape: Our Sonic Environment and the Tuning of the World*. Rochester, VT, Destiny.

[Schmidt & Balakrishnan, 2015] Schmidt, A. & Balakrishnan, R. (2015). *Ecology of acoustic signalling and the problem of masking interference in insects*. Journal of Comparative Physiology A, 201, 133–142.

[Sinsch et al., 2012] Sinsch, U., Lümkemann, K., Rosar, K., Schwarz, C., & Dehling, M. (2012). *Acoustic niche partitioning in an anuran community inhabiting an Afromontane wetland (Butare, Rwanda)*. African Zoology, 47(1), 60–73.

[Staaterman et al., 2013] Staaterman, E., Rice, A., Mann, D., & Paris, C. (2013). *Soundscapes from a Tropical Eastern Pacific reef and a Caribbean Sea reef*. Coral Reefs, 32, 553¬–557.

[Sueur & Farina, 2015] Sueur, J. & Farina, A. (2015). *Ecoacoustics: the ecological investigation and interpretation of environmental sound*. Biosemiotics, 8, 493–502.

[Sueur et al., 2014] Sueur, J., Farina, A., Gasc, A., Pieretti, N., & Pavoine, S. (2014). *Acoustic indices for biodiversity assessment and landscape investigation*. Acta Acustica united with Acustica, 100(4), 772–781.

[Tonolla et al., 2010] Tonolla, D., Acuña, V., Lorang, M., Heutschi, K., & Tockner, K. (2010). *A field-based investigation to examine underwater soundscapes of five common river habitats*. Hydrological Processes, 24(22), 3146–3156.

[Wiens, 2002] Wiens, J. (2002). *Central concepts and issues of landscape ecology*. Applying Landscape Ecology in Biological Conservation, 3–21.

[Xu et al., 2019] Xu, H., Plieninger, T., & Primdahl, J. (2019). *A systematic comparison of cultural and ecological landscape corridors in Europe*. Land, 8(3), 41.

Interaction between Past and Future: the Algorithmic Composition Library FDSDB_XXth_CT

Fabio De Sanctis De Benedictis

Conservatory P. Mascagni, Livorno, Italy

Abstract

According to Meyer, the musical style gradually evolves through the normalization of deviations and the creation of new ones. This raises the question of continuity and interaction between the music of the past and the future, in particular for the music of the last century and the current one. The writer's algorithmic composition library, FDSDB_XXth_CT,[1] for OpenMusic, devoted to compositional techniques of the twentieth century and beyond, can fit into this panorama, contributing to the continuity between past, present and future. After a brief description of general concepts, we move on to describe the overall structure of the library menus, the functions introduced in the updating phases, and those planned for the next release, exemplifying some patches. The compositional techniques globally refer to composers such as Schönberg, Berg, Webern, Babbitt, Boulez, Carter, Donatoni, Ligeti, Maderna, Manzoni, Messiaen, Nono, Stockhausen, Xenakis, and soon also Harvey and Eimert. The possible dangers inherent in an unaware use of these tools are also highlighted during the paper, and the benefits and applications are described in the conclusions, both for composition and for teaching, as well as possible uses for electronic composition.

1 Introduction

Meyer defines style as a system of relations between sounds, characterized by exact probabilistic relationships.[2] The most frequent procedures establish the normative components, the less frequent ones represent the deviations. Precisely because they are rarer, deviations create the expectation of solving a problem posed by their very occurrence, and thus produce an affective reaction, and a series of interactions – anticipations and feedbacks – between what the listener expects and what will actually occur in the unfolding of the music. The stylistic evolution occurs when the most experimental composers, impelled by a more fervent expression, use a larger number of deviations than the average, deviations that, in the long run, stabilize and become the normative procedures of the next stylistic stage. In Meyer's perspective, mainly aimed at the tonal system, we find an evolution that is essentially continuous. How can we reconcile this position with twentieth century music and current compositional production? Or again: what place can the compositional techniques of the recent past occupy in today's composition? The writer's algorithmic composition library, FDSDB_XXth_CT, devoted to compositional techniques of the twentieth century and beyond, proceeds from the reversibility of musical analysis and compositional techniques,[3] formalizing in algorithms a series of compositional processes derived from one's own music analysis or those of others, finally arriving at the realization

[1] FDSDB stands for the initial letters of my first name and my two surnames, XXth refers to the last century, CT stands for "Composition Techniques". You can download it from the following page: https://sites.google.com/site/fdsdbmascagni/code/fdsdb_xxth_ct-per-open-music-1.

[2] [Meyer, 1992], p. 77.

[3] [Bent, 1990], p. 2.

of a library for OpenMusic.[4] Compositional techniques, musical analysis and aesthetics according to Bent are in fact elements distributed along an axis. In this sense, the path from the finished work to its constituent cores is substantially the reverse in musical analysis and composition. That is, just as the analyst can come to define the main cores of a work, so the composer, starting from a few basic elements, can arrive at the finished work.

The library object of this contribution can have different purposes and applications, which will be illustrated at the end, but at the same time it could also arouse a certain compositional automatism, reducing the compositional techniques of the past to passive instruments, without a real awareness of personal compositional and aesthetic processes. Moreover, this danger is always present when we place ourselves in front of assisted musical composition and information technology tools in general.[5] However, we would like to make Donatoni's statement our own: «I am almost certain I can share the opinion according to which composing cannot be taught if with this expression one wishes to consider the inventive act considered in its entirety. [...] It may happen, however, that the dormant inventiveness of a young person needs any discipline in order to wake up. [...] It is within the framework of this discipline that [...] the means [...] that make up any compositional process can be taken into consideration.»[6]

Computer-assisted musical composition can then be considered a tool of rapid and precise development of the musical material and of the composer's intentions, and also a mean of preserving and transmitting a heritage of compositional techniques of the past, as well as a source of stimulus for "l'inventiva assopita", towards new solutions and personal inventions. Trying, we hope, to create an interactive bridge between past and present, towards the future, in order to recover that continuity which we mentioned earlier in relation to Meyer.

In this paper, after brief notions of a general nature, the structure of the library object of this dissertation is presented, illustrating some of the updates made with respect to what has already been described elsewhere,[7] and previewing those of the next release, to end with some conclusive considerations.

2 The assisted composition

Computer-assisted composition, or algorithmic composition, is the musical composition that uses algorithms, that is a series of unambiguous, detailed and finite instructions, which can be interpreted and executed with speed and accuracy by a computer program or by an automaton. The approach to this discipline can be constructive or declarative, that is the computer program can be used for the production of musical material, or the actual creation of a composition that responds to constraints imposed by the user.[8] Almost all the functions of the library object of this paper follow a constructive approach. However, by combining some functions together it is possible to arrive at the determination of complete compositions or compositional fragments, with a very similar approach to the declarative one, although without the aid of constraint programming.

3 The library FDSDB_XXth_CT

A library is a piece of software that adds new functionalities to an existing computer program. FDSDB_XXth_CT presents numerous functions related to the composition techniques of composers of the last century and beyond. With a few exceptions, it appears that extensive work has never been done in this area,[9] at least as far as we know. Its main menu is divided into: Dodecaphony, Serial-postserial music, PCST (Pitch-Class Set Theory), Rhythm, Pitch, Utilities. Each item is divided into submenus which include the techniques of composers who have used that particular system: under Dodecaphony we have the items Schoenberg, Berg, Webern, Babbitt; about serial and post-serial music we find Babbitt, Boulez, Carter, Donatoni, Ligeti, Maderna, Manzoni, Messiaen, Nono, Stockhausen, Xenakis; PCST includes functions for composing with pitch-class sets, mainly referring to the theoretical work of Robert Morris;[10] the Rhythm menu includes generic development tools for the duration parameter; under Pitch we have other tools for the pitch parameter; finally Utilities menu contains utilities to facilitate the work with the functions of this library.

The addressed compositional techniques are many, and each function is accompanied by a specific inline documentation, as well as specific examples that can be showed by selecting the function and

---

4 OpenMusic is an algorithmic composition software developed and maintained at Ircam: http://repmus.ircam.fr/openmusic/home.

5 See also what is discussed finally in [De Sanctis De Benedictis, 2018].

6 [Donatoni, 1982], pp. 83-84. Translation by the author.

7 We again refer to [De Sanctis De Benedictis, 2018].

8 About constraint programming we refer to [Truchet – Assayag, 2011]. About the concepts of constructive and declarative approach to algorithmic composition we refer to [Agon – Assayag – Bresson 2006] e [Bresson – Agon – Assayag 2008].

9 We can remember an algorithmic formalization of the compositional process of *Achorripsis* by Xenakis, made by Michail Malt in Open Music, and libraries like OMTristan or Esquisse that contain functions relative to spectral composition techniques.

10 [Morris 1987, 1991, 2001].

pressing the "t" key on the computer keyboard. Tutorials are also available. The documentation and the examples show the bibliographic source from which the compositional technique was taken, subsequently formalized and verified in an OpenMusic patch, finally coded in LISP language to create the library function.
In a previous article we have already discussed version 1.0 of the library,[11] here, in order to avoid unnecessary repetitions, we would like to illustrate the steps taken to upgrade to version 1.1 and 1.2, as well as to mention some of the features that will soon be implemented in the next update. In Figure 1 the scheme of the main menu of the library and the sub-menu related to Messiaen's compositional techniques.

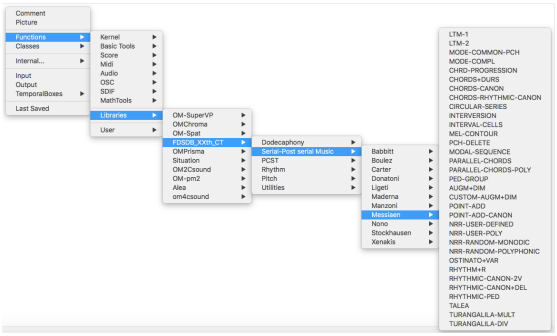


Figure 1: Library menu structure

4 Updates to version 1.1 and 1.2

In version 1.1, the work set up for a Masterclass held during the academic year 2020-2021 at the Sassari Conservatory – together with my friend and colleague Francesco Maria Paradiso, and focused on the figure of Messiaen – mainly merged. The writer's role concerned the implementation in OpenMusic of the compositional techniques described and the explanation of the mechanism of the involved functions. Some of those were already present in the first version of the library, this occasion gave the starting point and the possibility to expand them, to include almost all the compositional processes described in *Tecnica del mio linguaggio musicale*.[12] In Figure 2, for example, we find a patch relating to the automatic development of a rhythmic pattern similar to the 14th-century *Talea*.

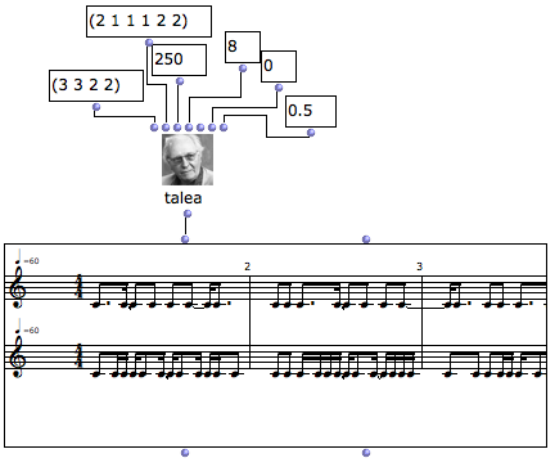


Figure 2: The talea function.

The function receives the following parameters as input:

- proportions of the duration of the first rhythmic module → (3 3 2 2)
- proportions of the duration of the second rhythmic module → (2 1 1 1 2 2)
- rhythmic unit of measure in milliseconds, here 250, equivalent to the sixteenth note with the quarter note set to 60
- last four parameters related to rhythmic quantization

In Figure 3 we can see the complete result in musical notation. The convenience of this function, and more generally of computer assisted composition, consists in the fact that to obtain other results we have just to change the initial parameters, without having to rewrite the whole algorithm from scratch.

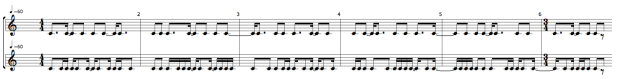


Figure 3: The result of the previous function.

In the next update is already foreseen a function that allows to use not only two modules, as reported in the examples in the Messiaen treatise, but also more than two. In Figure 4 the preparation and verification patch for the subsequent addition of this function to the library.

[11] [De Sanctis De Benedictis, 2018].
[12] [Messiaen, 1944-1999].

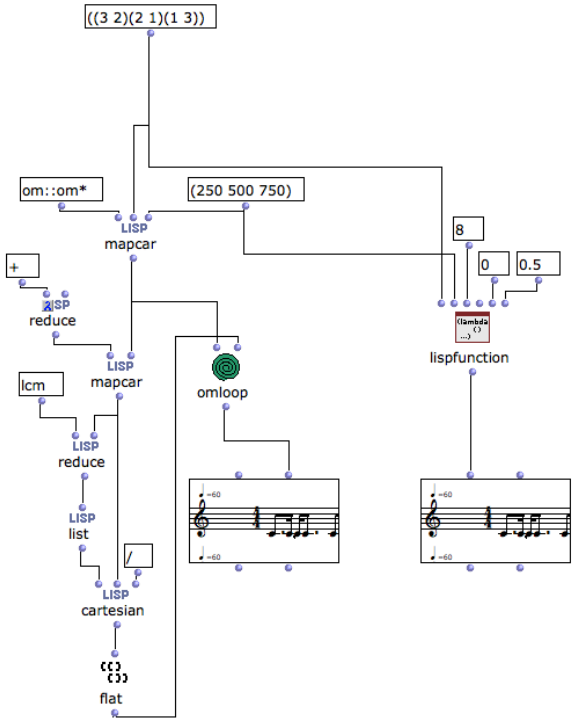


Figure 4: The patch relating to the next implementation of the talea-n function.

This is not the place to explain in detail all the functions used and the logic of the algorithm. We can simply say that in the left part of the figure we have the implementation of the algorithm through the native functions of OpenMusic or of the LISP language in general.[13] The function in the right part of the figure, denominated "*lispfunction*", contains the LISP code built on the model of the objects used in the previous algorithm. It is essentially the coded version of the "visual" algorithm, so to speak, of the left part of the figure. It will be this code, with a few necessary additions, to be used for the realization of the specific object of the library, *talea-n*. The resulting advantage consists in having a single object instead of ten or more functions of the starting algorithm, thus being able to develop more complex combinations with greater immediacy and in less visual space.
In Figure 5 we report the contents of *lispfunction*.

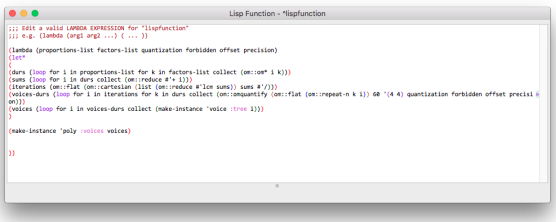


Figure 5: The LISP code contained in the lispfunction object.

Figure 6 instead shows the musical result of the previous algorithm, which will be identical both evaluated through the functions of OpenMusic and through the LISP code.

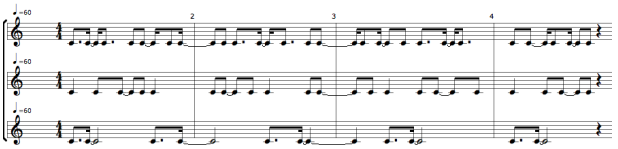


Figure 6: Result of Figures 4 and 5.

The input parameters are, in order:

- the list of proportions lists, one for each voice → ((3 2) (2 1) (1 3))
- the list of multiplying factors for each voice → (250 500 750), i.e. sixteenth note, eighth note, dotted eighth note
- the rhythmic quantization parameters in the last four inputs

In the update to version 1.1 Messiaen's compositional techniques have been enriched to the point of having a situation like the following:

- limited transposition mode theory, including functions for detecting common notes between two modes and complementary sets
- various types of chord sequences such as chord canons, rhythm canons, rhythm pedal, modal successions, etc.
- various ways of managing regular and irregular rhythmic augmentation and diminution, including the addition of the point
- rhythmic canons of different types, by augmentation, by adding a point, by retrogradation, etc.
- different techniques related to non-retrogradable rhythms, including the creation of random rhythmic polyphonies or determined by user parameters
- various forms of melodic permutation, use of interval cells, circular series, repetition of a sequence of notes with progressive elimination of pitches from the end

In version 1.2 they have been implemented: quarter tone series, series with specific interval relations, as in *Klang* by Stockhausen, Babitt's time points system, the twelve-tone matrix in music notation, techniques derived from *Lumen* by Donatoni, tendency masks, techniques taken from *Canto Sospeso* by Luigi Nono, inversion in space of absolute pitches (P-Space), random asynchronous

[13] LISP is the programming language on which OpenMusic is based.

rhythms. In the next version, probably the number 1.2.1, in addition to the cited *talea-n*, they will be introduced techniques taken from:

- Jonathan Harvey (*Quartetto n. 1*, *Ritual Melodies*)
- an additional version of Ligeti's *Lux Aeterna* polyphony
- various forms of development of a twelve-tone series, desumed from Eimert and Berg

Similar work is expected in the future for some analytical methodologies.

5 Conclusions

About the possible purposes of this library we have already mentioned the dissemination, preservation and enrichment of the compositional techniques of the past, with a view to continuity with the future, encouraging an effective interaction between past, present and future. An additional advantage in adopting a this library, if you choose to use the described techniques, consists in freeing the composer from the tiring work of development of the compositional material, allowing him to focus more on results and processes, on music. A non-negligible aspect is then the use in teaching, being able to immediately show examples of even complex processes, listening to the sound result by means of the MIDI implementation possibilities given by the software. A further particular, and often fruitful, use may consist in combining these tools with audio synthesis and spatialization, using other OpenMusic libraries such as OMChroma, om2csound, om4csound, Modalys, OM-Chant, OM-pm2, OM-Spat, OM-SuperVP, OMPrisma, obtaining potentially unprecedented results.

References

[Agon – Assayag – Bresson 2006] Agon C. – Assayag F. – Bresson J. (2006). *The OM Composer's Book. Volume One*. Delatour/Ircam.

[Bent, 1990] Bent I. (1990). *Analisi musicale*, EDT.

[Bresson – Agon – Assayag 2008] Bresson J. – Agon C. – Assayag F. (2008). *The OM Composer's Book. Volume Two*. Delatour/Ircam.

[De Sanctis De Benedictis, 2018] De Sanctis De Benedictis F. (2018). FDSDB_XXth_CT: una libreria di composizione algoritmica per Open Music e PWGL dedicata alle tecniche compositive del Novecento. In *XXII Colloquio di Informatica Musicale, Atti della Conferenza* (pp. 122-127). Udine, Italia.

[Donatoni, 1982] Donatoni F. (1982). Processo e figura. In Donatoni F. *Il sigaro di Armando* (pp. 83-86). Spirali edizioni.

[Meyer, 1992] Meyer, B.L. (1992), *Emozione e significato nella musica*. Il Mulino.

[Messiaen, 1944-1999] Messiaen O. (1944-1999). *Tecnica del mio linguaggio musicale*. Durand. (Italian translation by Lucia Ronchetti).

[Morris, 1987] Morris R.D. (1987). *Composition with Pitch-Classes: A Theory of Compositional Design*. Yale University Press.

[Morris, 1991] Morris R.D. (1991). *Class Notes for Atonal Music Theory*. Frog Peak Music.

[Morris, 2001] Morris R.D. (2001). *Class Notes for Advanced Atonal Music Theory*. Frog Peak Music.

[Truchet – Assayag, 2011] Truchet, C. – Assayag, G. (2011), *Constraint programming in music*, Wiley.

The ASMA Tool-Suite: Augmenting Singing Instruction of Elementary School Students

Natalia Kotsani[1], Giorgos Dedousis[1], Evangelos Angelakis[1], Areti Andreopoulou[1] and Anastasia Georgaki[1]

[1] *Laboratory of Music Acoustics and Technology (LabMAT), National and Kapodistrian University of Athens, Greece*

Abstract

The ASMA project (Assistance for Singing and Music Aesthetics) studies the social and aesthetic importance of vocal training in elementary schools, under the prism of contemporary teaching methods and the informed use of assistive educational tools. The aim of this project is the development of an interactive educational tool-suite supporting vocal instruction and correct singing practices in the Greek elementary school music courses. This work presents the revised ASMA Tool-Suite in its entity, after the necessary revisions that followed its original testing. The ASMA tool-suite consists of (a) Vowel Maps and Phonetograms, (b) Vocal Quality Tools, (c) Rhythmic and Melodic Tools, and (d) Polyphonic Tools, offering a wide range of vocal analysis and tuning tools, as well as vocal warm-up and training exercises. The Tool-Suite is accompanied by a "Guidebook of Proper Vocal Practice and Instruction for Elementary School Teachers", providing teachers with a fundamental scientific, aesthetic, empirical, and technological background, necessary to better incorporate singing in the elementary school classroom.

1 Introduction

The act of singing is a very powerful tool in the hands of music teachers as it is a natural way of introducing students to, otherwise rather complex, music concepts, such as melody, rhythm, dynamics, form etc, while also promoting the children's well-being [Welch et al., 2014]. Nevertheless, vocal instruction in Greek elementary schools is challenging for several reasons, including but not limited to i) the reduced time music instruction occupies in the weekly curriculum (once a week), ii) the lack of specialized classrooms, acoustically treated and properly equipped for music lessons, and iii) the fact that the majority of music teachers does not have the proper expertise to approach children vocal instruction effectively [Sotiropoulou Zormpala et al., 2015]. Based on the above observations, it becomes evident that music instruction in Greek elementary schools needs to be reformed through the use of a modern educational model, employing contemporary teaching practices and educational tools which will tailor music instruction to needs of the students [Stavropoulou et al., 2014].

Over the past two decades there has been an increase in the number of academic or commercial software tools enriching music instruction and providing opportunities for personalized learning experiences to students. There exists evidence showing that such tools can widen the students' vocal range and help them become conscious of their voices [Fuchs et al., 2009]. These tools monitor a wide variety of parameters, such as pitch / tonal accuracy, rhythm precision, formant analysis, spectral qualities, or even electroglottograph (EGG) indications, in an attempt to affect the students' singing voice development and musicianship, in general [Tu, 2020]. Examples of such tools include but are not limited to Voce Vista[1] and AIRS (Advancing Interdisciplinary Research in Singing) Test Battery of Singing Skills [Gudmundsdottir & Cohen, 2015]. For a comprehensive overview of such software, including both scientific prototypes and commercial products, see [Andreopoulou et al., 2021].

ASMA (Assistance for Singing and Music Aesthetics)[2], is a 2-year research project, funded by the H.F.R.I. (Hellenic Foundation for Research and Inno-

[1] https://www.vocevista.com/
[2] https://asma.music.uoa.gr

vation), which studies the social and aesthetic importance of vocal training in elementary schools, under the prism of contemporary teaching methods and the informed use of assistive educational tools. Within this scope, ASMA has focused on the development of an interactive educational tool-suite supporting vocal instruction and correct singing practices in elementary school music courses. Prototype versions of selected tools from the project have been published in [Andreopoulou et al., 2021, Angelakis et al., 2021, Kotsani et al., 2021]. This work will present the ASMA Tool-Suite in its entity, after the necessary revisions that followed the Alpha testing period, during which, constructive feedback was collected from members of the extended project team, the external project advisors, and selected user groups.

2 The ASMA Datasets

Three distinct periods of audio sample collection from students and adults speech and singing voices, choir, or solo recordings, resulted in the creation of a rich dataset with annotated audio samples. More specifically, the first two periods consisted of solo student voices, recorded and used for the design and implementation of the analysis and assessment tools of solo voices, and the third included recordings of selected children choirs, which was used for the design and implementation of tools assessing accuracy and coordination in polyphonic settings. An additional dataset of warm-up vocal exercises, melodic and rhythmic exercises, and scales in various tuning systems was compiled for the implementation and enrichment of the Melodic and Rhythmic Tools.

3 The ASMA Tools

The initial stage of the ASMA project included the creation of a "Guidebook of Proper Vocal Practice and Instruction for Elementary School Teachers", which accompanies the proposed manual and digital tools listed within the next subsections. This guidebook is intended to assist teachers, by providing them with the fundamental scientific, aesthetic, empirical, and technological background, necessary to better incorporate singing in the elementary school classroom. The guidebook objective is two-fold: i) to help teachers acquire a more concise knowledge and use of their own voice, and ii) to equip them with information, knowledge, educational strategies, and music tools, enhancing and enriching the singing instruction of their young pupils. This edification of the Elementary School Music teachers is intended to make the music lesson at school more efficient, enjoyable, motivating, and engaging, as well as safer both for the children's and the teachers' voices. To this end, the guidebook provides i) a thorough overview of the vocal instrument (anatomy, physiology, acoustics) through a practical approach, ii) edification on pertinent learning theories, psychology matters, methodological approaches, and advice on vocal health, and also contains iii) an overview of vocal training basics (exercises, repertory suggestions, etc.). The Guidebook is supplemented by a database of appropriate music material for use in the classroom.

3.1 Phonetic Maps and Phonetograms

This set of tools targets basic characteristics and qualities in speaking and singing, the assessment of which is fundamental in any attempt to characterize an individual's voice. The *Phonetic Map tool* and the *Formant Range Profile (FRP) tool*, take as input a student's voice pronouncing the Greek vowels, and outputs a visualization of the user's vowel pronunciation. When the spoken vowels are used as input, the tool extracts the first two formants (F_1 by F_2) from the audio files and outputs an F_1 by F_2 static plot (Phonetic Map). When the sung vowels are used as input, the user can choose to see how the first two formants change over time. The Phonetic Map and the FRP tools, help music teachers identify the way children articulate each vowel when speaking and how it is positioned in the articulatory space. In addition, the FRP tool can be used for studying the homogeneity in a student's singing voice timbre among the various voice registers or among other students' voices in a choir (see Section 3.4. The output of FRP tool can be seen in Figure 1.

The Vocal Range Profile (VRP) tool, otherwise known as a *Phonetogram*, takes as input a variety of students' vocal recordings gradually reaching their vocal range extremes. The more information is given as input, the denser a student's Phonetogram is. The Phonetogram tool helps music teachers determine the vocal range of their students, as it visualises the calculated pitch (fundamental frequency) by its dynamic level (sound intensity).

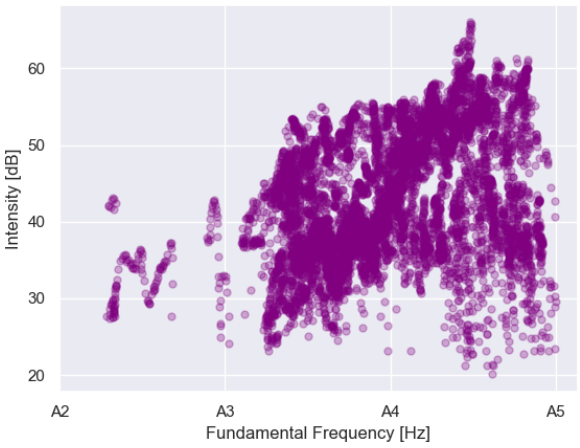


Figure 1: *The Output of the Phonetogram Tool*

3.2 Vocal Quality Tools

For the analysis of the students' vocal quality, two novel tools for quantifying breathiness and nasalitation in singing were implemented [Angelakis et al., 2021, Kotsani et al., 2021]. The *Breathiness tool* quantifies the breathiness characteristic of the students' singing voice using as a parameter the Smoothed Cepstral Peak Prominence (CPPS). In addition, using multiple linear regression, a new index (CDH) for the quantification of the breathiness characteristic is being introduced, which is based on audio samples and EGG signal results from the CPPS, DOQ, and HOQ parameters.

The *Nasality tool* quantifies the nasality characteristic of the students' voice based on the formant central frequencies and bandwidths. Both tools take as input an audio sample of a student's voice pronouncing the 'A' vowel, and output a rating of the nasality and breathiness quality of their voice.

3.3 Rhythmic and Melodic Accuracy Tools

This set of tools, which is developed in Max/MSP, targets the improvement of the students' tonal and rhythmic accuracy, through practice exercises, tuning tasks, and real-time qualitative and quantitative feedback.

The *Digital Warm Up Tool* (Figure 2) loads midi files of melodic and rhythmic exercises in a variety of scales, tempos, and levels of difficulty to be used by the students for properly and effectively warming up their voices prior to singing. A database of such exercises (Section 2) is already pre-loaded in the tools, but the collection can be further expanded by new, user-defined entries. All exercises have recommended presets for the tempo and the optimal range of transpositions. Nevertheless, users can also choose to change those to their preferred settings. The tool operates in two modes: "student-view", which displays only the score of the exercise to be sang, and "teacher's view", which includes the melodic line accompaniment of each exercise with a pre-count bar, as well as real-time visual feedback of the student's voice spectral characteristics and their tonal accuracy. Both modes offer the same parametrization option to the users. The students can either just read the score and sing or can choose to listen to the exercises in real-time via head-phones.

The *Beat Tracking Tool* operates in two modes: as a regular metronome and as a rhythmic trainer. In its first functionality, the tool operates as a regular metronome, which the students can use to maintain a steady paste as they sing or train. Users can parametrize the frequency of the metronome tone, as well as its speed. In its second functionality, the tool allows users to load rhythmic exercises, either from a wide variety of presets (Section 2) or user defined, and helps them train their rhythmic accuracy by providing them visual feedback of their deviation from the target onset times. In the "teacher's mode" the tool also displays statistics of the overall accuracy of the students as they practice a certain rhythmic pattern.

The *Tuner Tool*, operates in two modes too: as a regular tuner and as a musical interval trainer. As a regular tuner, it lets users set a reference tone in Hz, and monitor their tonal accuracy and deviation from the target tone, as they attempt to sing that reference. Users have control over the frequency, timbre, and duration of the reference tone. Deviations from the target are displayed on the tools graphically (color coded) as well as numerically in cents. As a musical interval trainer the tool is designed to respond to various tuning systems, including but not limited to "European-equal tempered", "European-modal", "Byzantine-modal", "Ancient Greek", as well as custom tunings defined by the users. Users are supposed to select a tuning system, as well as a certain interval or melodic phrase from a collection of presets, and attempt to sing it, while maintaining the interval characteristics of that system. Onve again, deviations from the proper tuning are displayed on the tool graphically as well as numerically.

Both the *Beat-Tracking* as well as the *Tuner* tools, can function either as stand-alone applications or in conjunction with the the *Digital Warm-up Tool* providing additional real-time feedback to the users singing melodic or rhythmic practice exercises.

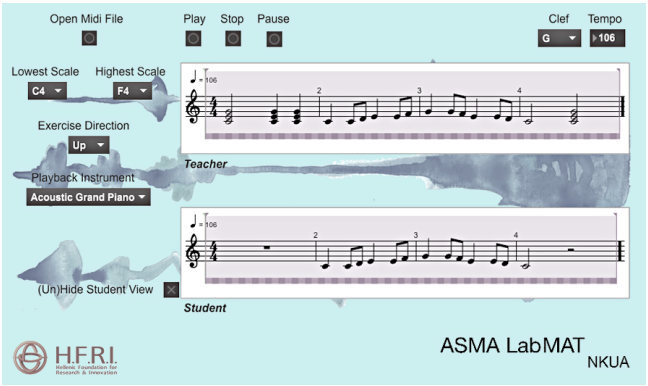


Figure 2: *The ASMA Tool-Suite Digital Warm-up Tool*

3.4 Coordination and accuracy in polyphony

This set of tools is designed to assist teachers monitor the singing accuracy and enhance the coordination of students singing in large ensembles. More specifically, the *Vocal Homogeneity Tool* is programmed to help teachers quantify the vocal homogenity of a small ensemble or choir, based on the students phonetic map and vocal data. With the help of simple vocal measurements as described in Sections 3.1 and 3.2 teachers can identify where the vocal properties of each

student lie in comparison to the rest of the ensemble and help them solve individual issues in a targeted manner.

The *Tonal Accuracy in Polyphony Tool* uses auditory spatialization in order to surround users with virtual choir-related auditory information, to help them train in more realistic situations. It assists vocal tuning when singing in a choir, a setting which is normally polyphonic. In such a setting, the position of a choir member within a large ensemble is directly related to what they hear around them, and as a result to what cues they may use in order to be in tune and coordination with the others. With this tool, the aim is to virtually place the users, who will wear headphones, in various spots within a choir, helping them realize the changes in auditory cues they may perceive, and, in a way, training them for a smoother integration with the choir.

4 Future Work

The ASMA Tool-Suite opens up new possibilities in singing education in Greek public schools, offering teachers the additional tools to assess student voices, and, more importantly, to engage students in exploring the foundations of artistic expression using their voice. For the purpose of developing ASMA digital tools, the human voice has been regarded as a system consisting of separate, albeit interconnected, physiological mechanisms. However, the practical-empirical scope, under which the accompanying Guidebook presents the necessary background for a healthier and more efficient vocal production, attempts an approach involving the whole individual through kinesthetic learning and cognitive functions that promote voice perception and awareness [Leman, 2007]. This is also the direction toward which the ASMA tools will evolve in the future. In its current state the ASMA Tool-Suite has been re-designed after having completed its Alpha testing by the extended team of the project, external project advisors, and selected users. Currently, we are in the final stage of the project, during which the tools are being extensively tested by music teachers. A publication of the evaluation results will follow along with a public release of the tools. Future extensions of the ASMA Tool-Suite will include (i) the transfer of all tools to a web-based platform, (ii) gamification possibilities, to assist teachers engage students in using the tools in the classroom, and (iii) more options for parametrization.

5 Acknowledgments

The research work was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "First Call for H.F.R.I. Research Projects to support Faculty members and Researchers and the procurement of high-cost research equipment grant" (Project Number: HFRI_FM17_TΔ E_3832).

The authors would like to thank Prof. Iakovos Steinhaouer, Dr. Sofia Stavropoulou and Kostas Katsantonis, for their valuable contribution to this work.

References

[Andreopoulou et al., 2021] Andreopoulou, A., Kotsani, N., Dedousis, G., & Georgaki, A. (2021). Evaluating the vocal characteristics of elementary school students: Basic assessment tools and methodology. In *Interaction Design and Children* (pp. 216–223).

[Angelakis et al., 2021] Angelakis, E., Kotsani, N., & Georgaki, A. (2021). Towards a singing voice multi-sensor analysis tool: System design, and assessment based on vocal breathiness. *Sensors*, 21(23), 8006.

[Fuchs et al., 2009] Fuchs, M., Meuret, S., Thiel, S., Täschner, R., Dietz, A., & Gelbrich, G. (2009). Influence of Singing Activity, Age, and Sex on Voice Performance Parameters, on Subjects' Perception and Use of Their Voice in Childhood and Adolescence. *Journal of Voice*, 23(2), 182–189.

[Gudmundsdottir & Cohen, 2015] Gudmundsdottir, H. R. & Cohen, A. J. (2015). Advancing interdisciplinary research in singing through the AIRS Test Battery of Singing Skills. *Musicae Scientiae*, 19(3), 234–237. Publisher: SAGE Publications Ltd.

[Kotsani et al., 2021] Kotsani, N., Angelakis, E., & Georgaki, A. (2021). Evaluating the nasalisation of the singing voice. *Models and Analysis of Vocal Emissions for Biomedical Applications: 12th International Workshop*, (pp. 119).

[Leman, 2007] Leman, M. (2007). *Embodied music cognition and mediation technology*. MIT press.

[Sotiropoulou Zormpala et al., 2015] Sotiropoulou Zormpala, M., Trouli, K., & Linardakis, M. (2015). Arts education offered by Greek Universities to future pre-school and primary school teachers. *Preschool and Primary Education*, 3(1), 34–52. Publisher: Laboratory of Pedagogical Research & Applications.

[Stavropoulou et al., 2014] Stavropoulou, S., Georgaki, A., & Moschos, F. (2014). The effectiveness of visual feedback singing vocal technology in greek elementary school. *ICMC-SMC 2014*, (pp. 1786–1792).

[Tu, 2020] Tu, C. M. (2020). Correlations among Music Aptitude, Singing Voice Development, and Singing Accuracy Achievement in Young Children. In F. A. Russo, B. Ilari, & A. J. Cohen (Eds.), *The*

Routledge Companion to Interdisciplinary Studies in Singing, Volume I: Development, volume 1 (pp. 520). Routledge, 1st edition.

[Welch et al., 2014] Welch, G. F., Himonides, E., Saunders, J., Papageorgi, I., & Sarazin, M. (2014). Singing and social inclusion. *Frontiers in psychology*, 5, 803.

CrazySquare: an Interactive Tool

Federica Caruso[1], Tania Di Mascio[1], Marco Pennese[2] and Sara Peretti[3]

[1] *DISIM, University of L'Aquila, Italy*
[2] *Scuola Media G. Pascoli, Rieti, Italy*
[3] *Centre of Excellence DEWS, University of L'Aquila, Italy*

Abstract

In a world in which a large amount of learning interactive tools deal with the musical abilities, without really supporting a high level of music education, CrazySquare, inspired by the Gordon's theory, guarantees the acquisition of the learning guitar objectives that students should learn at the end of Italian Middle Schools. Initially implemented as a paper-and-pencil game, supporting the study of rhythm and its representation, currently, CrazySquare is an interactive tool for learning guitar. It is designed according to a multidisciplinary Technology-Enhanced Learning User-Centered Design methodology, which allows to adequately integrate the technology into teaching activities.

This paper, after presenting the current prototype of the interactive tool, briefly reports the conducted expert-based evaluation and presents the ongoing user-based evaluation protocol.

1 Introduction

Millions of people listen to music every single day. As a consequence, learning to play musical instruments is something that many people have interest in. Moreover, it is recognized by the literature that musical learning (music education and learning to play musical instruments) enhances a wide range of cognitive and affecting functions, such as language and social cognition [Miendlarzewska & Trost, 2014]. Nevertheless, learning to play musical instruments is not an intuitive and automatic task; in fact, many people consider this a challenging task that requires a lot of time and adequate guidance [Miendlarzewska & Trost, 2014]. This is especially true for the guitar that it is one of the most popular musical instrument in Italian Middle Schools [Caruso et al., 2020].

Existing tools for learning guitar (pure commercial products, scientific literature outcomes, and research prototypes become commercial products) adopt either one of or both the two approaches: (1) a more experience-oriented approach supporting the instrumental practice and (2) a more lesson-oriented approach including music theory (e.g., ear-training) and "how to play" modules. Most popular solutions follow the approach (1). Commercially based solutions are generally Software (SW) applications assisting the users during the execution of exercises with the guitar, providing real-time feedback of their performance, thus improving the self-evaluation procedures. Research-based prototype solutions are mainly based on augmented reality technology. All the solutions following the approach (2) are SW applications implementing lessons trough video-tutorials made by some teachers or musicians who explain in detail how the learners have to properly perform practical exercises. Solutions mixing the two approaches are commercial SW applications that not only provide lessons through video-tutorials but also interactively implement them, proposing "question and answers" modules. For a detailed discussion see Table 1.

Unfortunately, as discussed in [Beck, 2017], existing tools are often not adequately evaluated (especially in the case of commercial ones) and do not offer the high level of music education that is guaranteed, at school, by the expertise of teachers following consolidated music-oriented pedagogical approaches (e.g., [Gordon, 2007, Jaques-Dalcroze, 1921]). In particular, Gordon proposed a music learning theory based on the concept of *audiation* [Gordon, 1989].

Furthermore, [Konecki, 2014] observed that although research shows the positive impact of interactive tools in music education, most of the existing ones have limited effect due to the lack of individualization of the learning process. Indeed, these issues are also highlighted by the [Decree law no. 201, 1999] that organized the music education in Italian Middle Schools. This decree explicitly describes the musical education skills that students should achieve at the end of Middle School (melody, harmony, rhythm, timbre, dynamic, agogic, and instrumental skills). Furthermore, the adequately controlled adoption of tools made available by modern technologies is defined to

be methodologically effective. Although the Decree Law points out that one of the main objectives of music education is to guarantee musical literacy, (1) no specific guidelines are provided in terms of which pedagogical approaches and interactive learning tools should be applied to achieve the cognitive and instrumental skills and (2) no specific guidelines on the interactive learning tools could be used to achieve these skills.

According to new technologies that incorporates concepts coming from games to boost students' motivations and interests [Denis & Jouvelot, 2005], CrazySquare aims at filling these lacks, by designing a game-based interactive tool for music education, inspired by one of the most well-consolidated pedagogical theories to music education (i.e., the Gordon's Music Learning Theory (MLT) [Gordon, 2007]).

The tool is described in Section 2 both from the the learning model and the interaction tool viewpoints. Section 3 reports the conducted expert-based evaluation and presents the ongoing user-based evaluation protocol. Finally, in Section 4, conclusion and future works are described.

2 CrazySquare

CrazySquare was conceived as a teachers' ally in music teaching activities in Italian Middle school, hence utilized by students in the 10-14 age range. Currently, CrazySquare is dedicated to the guitar since it is one of the most popular musical instrument in Middle Schools. To provide a "way" to effectively integrate this technology into teaching activities, CrazySquare is underpinned by the Technology-Enhanced Learning oriented User-Centered Design (TEL-UCD) approach [Di Mascio et al., 2016] that guarantees the compliance of CrazySquare as an interactive learning tool with Gordon's MLT. The TEL-UCD methodology expands the traditional iterative UCD approach to emphasise the necessity of designing in parallel both a learning intervention and the interactive tool, realising it in a context of mutual dependency, along with the choice of a learning theory.

After the identification of learner needs, the specification of the context of use and the identification and specification of psycho-pedagogical assessment strategy is necessary, followed by the specification of requirements, the definition of the learning model, and the creation of the learning material. Additionally, the evaluation of the prototyping solutions is mandatory, both from the learning model and the usability viewpoints. At the end, the realisation of the tool solution, consists of the realization of both interactive tool and the learning intervention.

2.1 The CrazySquare learning Model

According with the TEL-UCD, we regarded the specific teaching method adopted, within the Italian Middle School, as a possible instantiation of a more general model capturing its specifics, as well as its principles, from consolidated music-oriented pedagogical approaches, starting with Gordon's MLT. In [Gordon, 1989], the author underlines the distinction between *music aptitude* and *music achievement*, where the former mainly represents one's potential to learn to *audiate* whereas the latter mainly represents what one has learnt to *audiate*. An adequate interactive tool supports students with low music aptitude as well as those have high music aptitude, the former should not become frustrated by the difficulty of proposed exercises, whereas the latter should not become bored by the simplicity of proposed exercises. The CrazySquare Musical Skill Learning Model, namely MuS-LM, hence embed the two concepts of achievement and aptitude, introducing gamification elements to ameliorate the learning intervention and to making it more motivating and engaging [Margoudi et al., 2016].

In particular, students have to achieve a set up of (interdependent) *musical skills*:

- **R - Rhythm skill**: Perceive and maintain the pulsation for predefined Beats Per Minute (BPM) value;
- **RS - Rhythm Symbols skill**: Recognize and execute by reading a sequence of rhythmic symbols;
- **MN - Musical Notes skill**: Play with the instrument musical notes, articulating them through a reading of rhythmic symbols;
- **CC - Chord Change Speed skill**: Execute change chords at different speeds.

These skills are in turn achieved by acquiring competencies of two levels of difficulty: base and advanced (from now denoted as 1 and 2). The learning intervention is then represented by the competencies' list to be acquired in a certain order, that is: (R^1, R^2, RS^1, MN^1, CC^1, RS^2, MN^2, CC^2). Thus, such competencies will be acquired by doing sets of homogeneous learning exercises; the number of these to do is not fix: students with low music aptitude have to perform the set of mandatory one, while students with high music aptitude can perform also the set of optional ones. After a specific number of learning exercises, all students relax themselves by playing relaxing mini-games (a type for each musical skill), which serve precisely as rewarding mechanism, with the dual aim of lowering the cognitive load, preventing its overload, while entertaining and engaging students with riddles and quizzes. Mini-games are not the only gamification elements; other elements (e.g., levels, stars, rewards, unlockable content) are introduced in the CrazySquare tool to improve the interactivity of the tool itself.

Specifically, taking advantage of the game-based approach, each learning exercise is itself a game level and, consequently, a specific set of learning exercises address a specific musical skill. As better a students perform learning exercises (i.e., game levels), as

Table 1: *Analysis of existing interactive tools for learning guitar (C - Commercial product, R - Research outcome) against the main requirements of CrazySquare: (U1) Mastery of playing guitar; (U2) Adaptive and motivating learning intervention.*

Approach	Type	Name	Application	Learning Intervention	U1	U2
(1)	C	SmartMusic [SmartMusic, 2022]	Web application	The system provides different exercises (i.e., music sheets) to be executed with the guitar by the student. The system assists the students during the execution of exercises, providing also real-time feedback on their performance.	Yes	-
		RockSmith [Rocksmith, 2022]	Music videogame for computer, PlayStation, and Xbox	The player plugs in virtually any electric guitar to the device and plays the songs included in the game. The system assists the player during the execution of songs, providing also real-time feedback on their performance	Yes	Yes
	R	GuitarSolo [Seol et al., 2016]	AR-based system including an Arduino Mega2560 as the main controller board, a LED guitar fretboard for fingering display, and a smartphone application to select the songs to play.	The system allows students to practice guitar, without a music sheet, by lightening the LEDs on the corresponding positions at the guitar fretboard. The augmented guitar is able to identify that the user is playing correctly by using the sensing information and then providing real-time feedback.	Yes	-
		GuitAR [Löchtefeld et al., 2011]	AR-based system including a light-projector system to be mounted on the guitar fretboard (or in front of the player) and a mobile application.	The system allows students to practice guitar, without a music sheet, by projecting lights on the corresponding positions at the guitar fretboard. The system is able to identify that the user is playing correctly by using the audio heard from the mobile device running the application and then providing real-time feedback.	Yes	-
	Both	Novaxe [Novaxe.com, 2022]	Web application	The system provides different exercises (i.e., guitar tablature) to be executed with the guitar by the student. The system assists the students during the execution of exercises, providing also real-time feedback on their performance.	Yes	-
(2)	C	GuitarTricks [GuitarTricks, 2022]	Web application providing video lessons for learning guitar	The system offers different video lessons.	Yes	
		FenderPlay [FenderPlay, 2022]	Mobile application	The system offers different video lessons.	Yes	-
	Both	Rockway [Rockway, 2022]	Web application	The system offers different video lessons.	Yes	-
(1)+(2)	C	MelodiQ [MelodiQ, 2022]	Android mobile application	The system provides a series of video lessons including also an interactive practice activity. The system is able to provide real-time feedback on the player performance.	Yes	Yes
		Yousician [Yousician, 2022]	Cross-platform application	The system provides video lessons including also an interactive practice activity. The system is able to provide real-time feedback on the player performance.	Yes	Yes

higher the rewards student obtains in terms of gained stars.

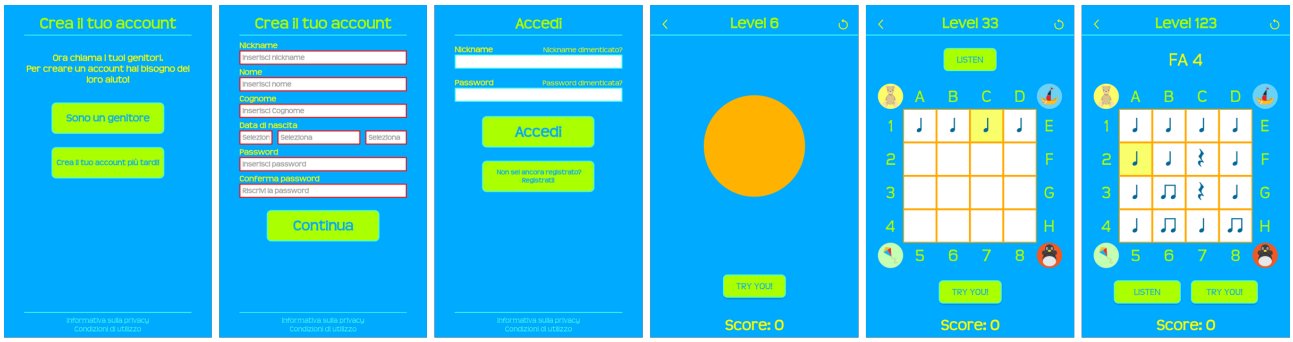
2.2 The CrazySquare interactive tool

CrazySquare was implemented based on the so described MUS-LM founding model as an Android mobile application using Android Studio 3.2 and exploiting several libraries (e.g., Tarsos-DSP and MIDI library). Its Grafical User Interface (GUI) is compliant with the main guidelines and suggestions concerning preadolescents' GUI design [Nielsen, 2019]; for example the used language is clear, simple, and close to teen slang (see Fig. 1).

Each student need a personal account to play. Then, the system provides both sign-up (see Fig. 1a and Fig. 1b) or sign-in (see Fig. 1c) options. For the sign-up, the system provides a two-step procedure, also involving the student's parents (as indicated by [EU-GDPR – Art. 8, 2016]).

With its personal account, the student can start a learning intervention according to the MuS-LM, which is articulated into incremental difficulty game levels (i.e, learning exercises). For example, game levels addressing R deal with the learning of predefined rhythms, that are easier in R^1 (i.e., 70, 75, and 65 BPM) and more advanced in R^2. The student has to perceive and keep the rhythm by executing a number of musical beats clapping their hands, vocalizing, or pitching a guitar string. As a hint, the rhythm is visualized by a bouncing circle placed at the center of the GUI provided by this kind learning exercise (see Fig. 1d); in addition, there is also an acoustic metronome to help student keeping the rhythm. The game levels addressing RS, MN, and CC are similar to each other; the student has to recognize and execute by reading a sequence of rhythmic symbols following a specific BPM that is displayed through a visual metronome. These symbols are presented within a four-by-four square grid (that inspired the crazy square name). The visual metronome is shown as a yellow highlighter of the rhythmic symbol to play (see Fig. 1e and Fig. 1f). In particular, within the game levels dealing with RS, the student performs the execution of rhythmic symbols (basic in RS^1, advanced in RS^2) by clapping hands, with the voice, or by pitching a guitar's string. Instead, within the game levels addressing MN, the student has to articulate the execution by playing, with the guitar, predefined musical notes (basic in MN^1, advanced in MN^2). The game levels relating to CC differ from those provided by MN only on the number of rhythmic symbols to be played with the same musical note. In fact, within MN's game levels, the change of chord happens every four symbols; instead, within CC^1's game levels the change happens every two symbols, and in CC^1's game levels the musical note changes at every symbol.

During the execution of the task provided by each game level, the system assists the student via different visual/acoustic hints as well as evaluates



(a) (b) (c) (d) (e) (f)

Figure 1: *Some screenshots of the current CrazySquare mobile application. (a-b) Sign-up, (c) Sign-in, (d) GUI of R's game levels, (e) GUI of RS's game levels, (f) GUI of MN's game levels*

if he/her is performing well or not. Coherently, at the end of each game level, CrazySquare shows the student the number of stars gained according to his/her performance. Once all the mandatory game levels related to a specific competence were passed, the system allows the student to continue along the learning intervention accordingly to the MuS-LM, i.e., the student can decide if play optional game levels provided by this competence or continue along the learning intervention, as indicated in the MuS-LM, by playing the game levels related to the following competence. As indicated by the MuS-LM, CrazySquare regularly intersperses the learning intervention with four types of relaxing mini-games, according to the musical skills being learned. For example, whether the student is playing with R's game levels, the system proposed a relaxing mini-games consisting of watching two different videos of people playing music (without sound) and the student has to choose which one of the two plays with the fastest or the slowest rhythm by tapping the corresponding button on the screen. As another example, during the learning intervention related to RS, CrazySquare proposes a riddle, i.e., the system plays a sequence of four rhythmic symbols and the student has to find the corresponding sequence on a row, a column, or a diagonal of the crazy square and select his/her answer by tapping it on the display. A video demo and the android Application Package (APK) of the current prototype of CrazySquare are available at https://drive.google.com/drive/folders/1sSw-QTZZrdnUDBHwMOssD4YOY39JKhHT?usp=sharing.

3 The CrazySquare Evaluation

The evaluation of the CrazySquare interactive tool is currently articulated in one expert-based evaluation (already conducted, see for details [Caruso et al., 2020]) and several user-based evaluations, to be conducted. The expert-based evaluation aim was assessing the adequacy of learning model and the usability of preliminary prototypes. Experts (i.e., music teachers, guitar teachers, musical pedagogues, involved within the project) evaluated the MuS-LM and the correlated learning material consisting of 574 learning exercises (350 mandatory and 224 optional) and about 100 relaxing mini-games, while experts of visual design evaluated the GUIs prototypes using heuristic evaluation and expert review. A number of issues came up and successively fixed (e.g., the choice of how to display the visual metronome in the GUI).

The user-based evaluation aim is evaluating if the CrazySquare interactive tool is better/worse/equal than its paper-and-pencil version, in terms of students' performance. A between-group (true) experimental design is to be arranged and conducted. Its protocol will be administrated during regular school activities:

1. Students are randomly divided into two groups, (G_a and G_b), matched for age and sex.
2. At the beginning of the school year, before starting the learning intervention, all students (of both groups) perform two tests that provide the psycho-pedagogical assessment strategy: (1) an entrance test to assess the students' starting musical skills; and (2) the Intermediate Measures of Music Audiation (IMMA) [Gordon, 2007].
3. During the school year, G_a adopts the paper-and-pencil version of CrazySquare while G_b the CrazySquare interactive tool.
4. At the end of the school year, both groups perform again both tests.
5. The statistical analysis to evaluate the differences between G_a and G_b in terms of students' performance, musical aptitude, and musical achievement levels, has to be carried out.

4 Conclusion and Future works

In this paper, we introduced and discussed the current status of CrazySquare that aims to provide a game-based interactive tool to support the teaching/learning of guitar musical skills by preadoles-

cences attending Italian Middle Schools, inspired by Gordon's MLT. A multidisciplinary research team was involved within each step of the CrazySquare project.

The strength of the CrazySquare, unlike the available interactive tools for music education, is that it aims to guarantee the acquisition of the learning objectives that students should learn at the end of Italian Middle Schools. In addition, being designed following multidisciplinary TEL-UCD methodology, it could be easily integrated into classroom practices as a support during the musical teaching activities and at home, as a support of homework activities.

During the last school year, we conducted a (pilot) controlled experiment involving a small group of first-year students (i.e., 6 students, 4 males and 2 females) attending the "*Giovanni Pascoli*" Middle School in Rieti (Italy). However, due to the small sample size and the limited continuity of the experimental activities due to COVID-19 related issues, the so far data collected is not enough to draw accurate conclusions. In the next future, another user-based evaluation with a large sample of students attending Italian Middle Schools will be conducted.

References

[Beck, 2017] Beck, D. (2017). Literature review: Music technology. *Education Kierstin Bible University of Arkansas ETEC 5203-Foundations of Educational Technology*.

[Caruso et al., 2020] Caruso, F., Peretti, S., Corbacchini, L., Centofanti, C., & D'Errico, A. (2020). The crazysquare project: A technological pedagogical content knowledge solution. In *CSEDU (1)* (pp. 655–662).

[Decree law no. 201, 1999] Decree law no. 201 (1999). Ministerial decree august 6, 1999, n. 201, on the subject of *Reconditioning and arrangement of experimental courses in music in middle school*.

[Denis & Jouvelot, 2005] Denis, G. & Jouvelot, P. (2005). Motivation-driven educational game design: applying best practices to music education. In *Int. Conf. on Advances in computer entertainment technology* (pp. 462–465).

[Di Mascio et al., 2016] Di Mascio, T., Gennari, R., Melonio, A., & Tarantino, L. (2016). Supporting children in mastering temporal relations of stories: The terence learning approach. *Int. J. Distance Educ. Technol.*, 14(1), 44–63.

[EU-GDPR – Art. 8, 2016] EU-GDPR – Art. 8 (2016). Eu general data protection regulation 2016/679 (GDPR), art. 8 *Condition applicable to child's consent in relation to Information Society Services*.

[FenderPlay, 2022] FenderPlay (2022). https://www.fender.com/play. Accessed: 2022-03-01.

[Gordon, 1989] Gordon, E. (1989). Audiation, music learning theory, music aptitude, and creativity. In *Suncoast music education forum on creativity*, volume 75.

[Gordon, 2007] Gordon, E. (2007). *Learning sequences in music: A contemporary music learning theory*. Gia Publications.

[GuitarTricks, 2022] GuitarTricks (2022). https://www.guitartricks.com/.

[Jaques-Dalcroze, 1921] Jaques-Dalcroze, E. (1921). *Rhythm, music and education*. GP Putnam's Sons.

[Konecki, 2014] Konecki, M. (2014). Learning to play musical instruments through dynamically generated lessons in real-time based on adaptive learning system. In *25th Central European Conf. on Information and Intelligent Systems* (pp. 124–129).

[Löchtefeld et al., 2011] Löchtefeld, M., Gehring, S., Jung, R., & Krüger, A. (2011). guitar: supporting guitar learning through mobile projection. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems* (pp. 1447–1452).: ACM.

[Margoudi et al., 2016] Margoudi, M., Oliveira, M., & Waddell, G. (2016). Game-based learning of musical instruments: A review and recommendations. In *European Conf. on Games Based Learning* (pp. 426).

[MelodiQ, 2022] MelodiQ (2022). https://play.google.com/store/apps/details?id=com.ultimateguitar.assessment&-%20hl=en.

[Miendlarzewska & Trost, 2014] Miendlarzewska, E. A. & Trost, W. J. (2014). How musical training affects cognitive development: rhythm, reward and other modulating variables. *Front. Neurosci.*, 7, 279.

[Nielsen, 2019] Nielsen, J. (2019). UX Design for Teenagers, 3rd edition.

[Novaxe.com, 2022] Novaxe.com (2022). Novaxe: Your platform for learning music. https://www.novaxe.com/. Accessed: 2022-03-01.

[Rocksmith, 2022] Rocksmith (2022). https://www.ubisoft.com/en-gb/game/rocksmith/plus.

[Rockway, 2022] Rockway (2022). https://www.rockway.fi.

[Seol et al., 2016] Seol, S., Shin, Y., & Lee, K. (2016). Learning guitar with an embedded system. *Contemporary Engineering Sciences*, 9(12), 553–560.

[SmartMusic, 2022] SmartMusic (2022). https://www.smartmusic.com/.

[Yousician, 2022] Yousician (2022). https://yousician.com/.

Towards an Integration of OMR Models in Pattern Improvisation

Francesco Ardan Dal Rì[1, 2] and Nicola Conci[1]

[1] *Department of Information Engineering and Computer Science - DISI, University of Trento, Italy*
[2] *Conservatory F.A. Bonporti, Trento, Italy*

Abstract

In this paper, we present a prototype for an interactive musical system, which allows the user to manage musical patterns in real-time using images of printed music in traditional Western notation. Monophonic scores are interpreted by a pre-trained Optical Music Recognition model, converted into numeric sequences, and sent to a pattern generator/synthesizer. This prototype constitutes a novel proposal, integrating deep learning and computer vision techniques into music making and promoting interactivity across disciplines.

1 Introduction

Musical composition through pattern manipulation has a long tradition, ranging from the earliest experiments in algorithmic music to the latest computer music practices [Magnusson & McLean, 2018]. In the last two decades, the emergence of live coding as a performative practice has positioned the use of musical patterns at a prominent role in musical creation. In this context, a great variety of libraries and dedicated environments have been presented, each characterized by a specific form of notation capable of controlling the evolution over time of these patterns (e.g [Kirkbride, 2016, Roberts & Kuchera-Morin, 2012, McLean & Wiggins, 2010]). Regarding the notation of melodic-rhythmic structures, however, the traditional notation - here referred to as Common Western Music Notation (CWMN) - is still particularly effective.

On the other hand, the recent advances in deep learning have allowed for the development of models able to automatically interpret the content of printed music, which have proven to be particularly effective in the case of monophonic scores (e.g [Liu et al., 2021, Castellanos et al., 2020]).

Our proposed prototype combines these two trends into a single system that uses an Optical Music Recognition (OMR) model to convert score images into patterns that can be played by a digital synthesizer. This paper is structured as follows: in Section 2 we present the relevant related work in the fields of pattern music, notations, and OMR; in Section 3 we briefly describe the implementations of the prototype; we then discuss the usage and limitations, and eventually conclude outlining possible future developments.

2 Background

In this section, we briefly introduce several relevant works and concepts from which we started to design our system.

2.1 Pattern music

In the musical context, the term *pattern* generally refers to a well-recognizable melodic-rhythmic cell, which repeats itself over time. In the last century, examples of compositions through the creation, superimposition, and permutation of patterns can be found both in the field of instrumental music (significant examples are *In C* by Terry Riley or *Clapping Music* by Steve Reich), and in that of computer music (for example in the works of Grossi [Mori, 2015] or Spiegel [Spiegel, 1981]). Although the use of musical patterns has been explored since the first experiences of algorithmic music, in the last two decades their use has become particularly prominent in the context of live coding, a performative practice in which the performer improvises music on the computer by compiling instructions in real-time in the form of code [Magnusson & McLean, 2018]. Most of the dedicated libraries and environments (e.g. TidalCycles [McLean & Wiggins, 2010], Gibber [Roberts & Kuchera-Morin, 2012], FoxDot

[Kirkbride, 2016], ect) allow the user to generate patterns that are synchronized and repeated cyclically. While these improvisations are generally performed from scratch, another popular approach involves specifying a series of patterns in advance and simply playing them in a given order during the performance. Magnusson defines this approach as "weak coding" [Magnusson, 2014a].

At this stage, our system allows for a similar compositional approach, in which the user can pre-define a palette of patterns and play them to his or her liking.

2.2 Notations

In Section 2.1, we have seen that there are several environments that allow users to manage musical patterns in real time. Each of them requires the use of a specific form of notation. Various ways of encoding music have been proposed: some systems allow the user to specify a melodic-rhythmic pattern through pairs of numerical values, respectively pitch (note or frequency) and duration (absolute or relative), as in SuperCollider [McCartney, 2002]; others implement specific *mini-notations* (e.g. TidalCycles [McLean & Wiggins, 2010] or ixi lang [Magnusson, 2011]), or make use of graphical objects or visual feedback (e.g. Betablocker or Scheme Bricks [McLean et al., 2010]). These notations are often designed to be also applicable to control parameters, effects, functions, etc. However, they can result quite difficult to interpret, especially in the case of sequences of a certain length or density [Blackwell & Collins, 2005]. Indeed, writing instructions requires a certain abstraction, that is, to formalize musical thought into a symbolic-syntactic notation capable of being understood by the software interpreter. As for the notation of twelve-tone equal tempered pitch and metrical rhythm and duration musical cells, CWMN can prove to be more effective [Magnusson, 2014b], but its use is currently overlooked.

Therefore, we have decided to integrate it into our work.

2.3 Optical Music Recognition

OMR has been defined as "a field of research that investigates how to computationally read music notation in documents" [Calvo-Zaragoza et al., 2020]. Although it has been explored for over 50 years, research in this field has advanced considerably in the last decade thanks to the adoption of deep learning techniques (e.g. [Liu et al., 2021, Baró et al., 2019, Castellanos et al., 2020]). Nowadays, various commercial softwares exist that integrate OMR for score scanning (e.g. SharpEye [1], PhotoScore [2], SmartScore [3]). Nevertheless, OMR still involves a variety of non-trivial tasks to be addressed. In the first place, the set of semantic relationships between the various musical symbols - as in the case of polyphonic music, articulation marks, or irregular rhythms - can be particularly complex. Furthermore, the general lack of large labeled datasets with balanced classes makes it difficult to deal with the great variety of symbols in CWMN [Novotnỳ & Pokornỳ, 2015]. As shown by Shatri and Fazekas, most works in the OMR field are focused on the encoding of monophonic scores, in which neural networks are able to achieve excellent performance [Shatri & Fazekas, 2020].

Since pattern music is generally composed of a series of monophonic and quite simple musical structures, we have decided to include one of these neural networks in our system.

3 Implementation

The system proposed consists of three main modules: an OMR model, which converts the images into semantic notation, a translator/OSC parser module, which converts the semantic notation into messages suitable for the pattern generator, eventually sending them to the server via OSC, and a synthesizer module, which plays the notes as they are sequenced (Figure 1).

In this section, we briefly describe each module.

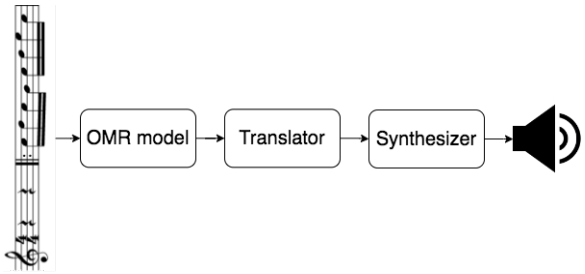


Figure 1: *Overall system pipeline*

3.1 OMR model

For this prototype, we decided to use a pre-trained, end-to-end, and open-source solution [Calvo-Zaragoza et al., 2017]. The model is trained on a series of monophonic musical incipits, namely the PrIMuS dataset [Calvo-Zaragoza & Rizo, 2018], and therefore proves to be sufficiently accurate for our needs. The model consists of a feed-forward Convolutional Recurrent Neural Network (CRNN), which extracts the individual features and converts them into discrete sequences of musical symbols. Further implementation details can be found in the original paper [Calvo-Zaragoza et al., 2017].

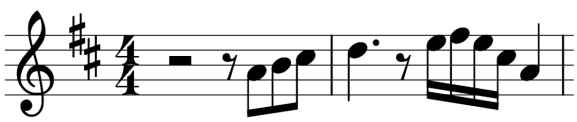
[1] http://www.visiv.co.uk/

[2] https://www.neuratron.com/photoscore.htm

[3] https://www.musitek.com/smartscore-pro.html

The model receives as input an image of a monophonic score on a single staff, and is sensitive to both clef and key signature. Consistently with the dataset used in the training phase by the authors of the original work, we consider inputs of a maximum of 4 bars in length. As output, we obtain a semantic encoding, which contains a list of all the musical symbols detected by the network in an extended format (Figure 2).

(a)



(b)

```
clef-G2, keySignature-DM, timeSignature-4/4,
rest-half, rest-eighth, note-A4_eighth,
note-B4_eighth, note-C#5_eighth, barline,
note-D5_quarter., rest-eighth, note-E5_sixteenth,
note-F#5_sixteenth, note-E5_sixteenth,
note-C#5_sixteenth, note-A4_quarter, barline
```

Figure 2: *An example of an input image (a) and the respective output in semantic notation (b)*

3.2 Translator

The translation module is responsible for converting the OMR model output into a format that the pattern generator for the synthesizer can understand, and for sending it through the Open Sound Control (OSC) protocol. The translation is performed by directly mapping a fixed vocabulary of durations and notes. The durations are considered to be relative to the quarter (e.g. quarter = 1, eighth = 0.5, etc.), while the notes are mapped to MIDI notes (e.g. C4 = 60, Db4 = 61, etc.). Rests are represented by the symbol "\" (Figure 3). We preferred to insert this translation module rather than retrain the model end-to-end for two main reasons: first, the retraining would have required the entire dataset to be completely reprocessed. Even if end-to-end retraining would be necessary for a possible definitive system, as specified in 5, at this stage we found semantic notation flexible enough to be easily translated into different types of notation.

3.3 Synthesizers

The synthesis engine, implemented in the popular open-source software SuperCollider (SC)[4], is composed of seven instruments: two additive synthesizers (characterized by a different type of envelope), two pitched single-oscillator (one octave up and one octave down, respectively), one subtractive, one FM and one producing pink noise (ideally simulating a simple drum). These instruments are recalled by the OSC messages sent by the translation module, while the related melodic-rhythmic patterns are recorded and sequenced on a quantized rhythmic grid. By default, a maximum of eight patterns can be played at the same time. In addition, the patterns are indexed: in this way, the user can activate/deactivate/overwrite specific patterns. In this first version, we have decided to keep the timbre characteristics of each instrument fixed: the user can therefore decide which instrument to play the input pattern.

[4]https://supercollider.github.io/

(b)

```
clef-G2, keySignature-DM, timeSignature-4/4,
rest-half, rest-eighth, note-A4_eighth,
note-B4_eighth, note-C#5_eighth, barline,
note-D5_quarter., rest-eighth, note-E5_sixteenth,
note-F#5_sixteenth, note-E5_sixteenth,
note-C#5_sixteenth, note-A4_quarter, barline
```

(c)

```
['\', '\', 57, 59, 61, 62, '\', 64, 66, 64, 61, 57]
[2, 0.5, 0.5, 0.5, 0.5, 1.5, 0.5, 0.25, 0.25, 0.25, 0.25, 1]
```

Figure 3: *An example of a semantic notation (b) translated into value arrays suitable for SuperCollider (c)*

4 Usage and limitations

As for the practical use of the system, it is first necessary to load a series of N images containing short musical sequences, which will be recalled with their index. These images constitute the palette of different musical sequences that can be converted into patterns. The user can input instructions consisting of four numbers, specifically representing: 1) image [1 - N]; 2) pattern index [0 - 7]; 3) instrument number [0 - 7]; 4) amplitude [0. - 1.]. The script is constantly waiting for instructions from the user, who at any time can decide to allocate a new pattern or overwrite an existing one. Note that the interpretation/translation system, on an 8GB commercial CPU, takes ∼200ms to send the message to the SC server. Since the pattern generator is by default quantized to the quarter note and set to a tempo of 60 b.p.m., this latency has to be taken into account.

As for the limitations, the model used is currently not very robust in the presence of numerous ledger lines and particularly high musical densities. However, being sensitive to the keys, it is already possible to obtain a sufficient pitch range: in case the user needs more extended sounds, we have inserted two transposing instruments (see 3.3). As for the rhythmic density, we have decided not to consider durations lower than thirty-second. While we recognize this as a limitation, shorter durations are rarely used in pattern music. Finally, the available prototype does

not allow direct manipulation of musical patterns or control over the parameters of the instruments.

5 Conclusions and future work

In this paper, we have presented a working prototype of a pattern music improvisation system starting from musical fragments in CWMN. We believe that the system proposed in this paper represents a contribution to developing further systems that can integrate Western musical notation in the context of interactive music production, constituting a possible creative stimulus, especially for more traditionally trained musicians, or a possible tool for music education. In addition, the prototype lends itself to various expansion possibilities, such as integration into existing systems/environments, both software and hardware, and the addition of additional interfaces/control possibilities. As a future work, the main objective will be to work on a new OMR model trained on fragments of handwritten scores in an end-to-end fashion, which also allows taking into account more complex musical symbols and relationships, in order to create an interactive system with more expressive possibilities with which the user can interact directly by writing music in real-time.

References

[Baró et al., 2019] Baró, A., Riba, P., Calvo-Zaragoza, J., & Fornés, A. (2019). From optical music recognition to handwritten music recognition: A baseline. *Pattern Recognition Letters*, 123, 1–8.

[Blackwell & Collins, 2005] Blackwell, A. F. & Collins, N. (2005). The programming language as a musical instrument. In *PPIG* (pp.1̃1).

[Calvo-Zaragoza & Rizo, 2018] Calvo-Zaragoza & Rizo, D. (2018). Camera-primus: Neural end-to-end optical music recognition on realistic monophonic scores. In *Ismir2018* (pp. 248–255).

[Calvo-Zaragoza et al., 2020] Calvo-Zaragoza, J., Jr, J. H., & Pacha, A. (2020). Understanding optical music recognition. *ACM Computing Surveys (CSUR)*, 53(4), 1–35.

[Calvo-Zaragoza et al., 2017] Calvo-Zaragoza, J., Valero-Mas, J. J., & Pertusa, A. (2017). End-to-end optical music recognition using neural networks. In *Proceedings of the 18th International Society for Music Information Retrieval Conference, ISMIR* (pp. 23–27).

[Castellanos et al., 2020] Castellanos, F. J., Calvo-Zaragoza, J., & Inesta, J. M. (2020). A neural approach for full-page optical music recognition of mensural documents. In *ISMIR* (pp. 558–565).

[Kirkbride, 2016] Kirkbride, R. (2016). Foxdot: Live coding with python and supercollider. In *Proceedings of the International Conference on Live Interfaces* (pp. 194–198).

[Liu et al., 2021] Liu, A., Zhang, L., Mei, Y., Han, B., Cai, Z., Zhu, Z., & Xiao, J. (2021). Residual recurrent crnn for end-to-end optical music recognition on monophonic scores. In *Proceedings of the 2021 Workshop on Multi-Modal Pre-Training for Multimedia Understanding* (pp. 23–27).

[Magnusson, 2011] Magnusson, T. (2011). The ixi lang: A supercollider parasite for live coding. In *ICMC*.

[Magnusson, 2014a] Magnusson, T. (2014a). Herding cats: Observing live coding in the wild. *Computer Music Journal*, 38(1), 8–16.

[Magnusson, 2014b] Magnusson, T. (2014b). Scoring with code: Composing with algorithmic notation. *Organised Sound*, 19(3), 268–275.

[Magnusson & McLean, 2018] Magnusson, T. & McLean, A. (2018). Performing with patterns of time. In R. T. Dean (Ed.), *The Oxford Handbook of Algorithmic Music* chapter 14, (pp. 245–266). Oxford University Press.

[McCartney, 2002] McCartney, J. (2002). Rethinking the computer music language: Supercollider. *Computer Music Journal*, 26(4), 61–68.

[McLean et al., 2010] McLean, A., Griffiths, D., Collins, N., & Wiggins, G. (2010). Visualisation of live code. *Electronic Visualisation and the Arts (EVA 2010)*, (pp. 26–30).

[McLean & Wiggins, 2010] McLean, A. & Wiggins, G. (2010). Tidal–pattern language for the live coding of music. In *Proceedings of the 7th sound and music computing conference* (pp. 331–334).

[Mori, 2015] Mori, G. (2015). Pietro grossi's live coding. an early case of computer music performance. *ICLC2015 Proceedings*, (pp. 125–132).

[Novotnỳ & Pokornỳ, 2015] Novotnỳ, J. & Pokornỳ, J. (2015). Introduction to optical music recognition: Overview and practical challenges. In *DATESO* (pp. 65–76).

[Roberts & Kuchera-Morin, 2012] Roberts, C. & Kuchera-Morin, J. (2012). Gibber: Live coding audio in the browser. In *ICMC*, volume 11 (pp.6̃).

[Shatri & Fazekas, 2020] Shatri, E. & Fazekas, G. (2020). Optical music recognition: State of the art and major challenges. *arXiv preprint arXiv:2006.07885*.

[Spiegel, 1981] Spiegel, L. (1981). Manipulations of musical patterns. *Proceedings of the Symposium on Small Computers and the Arts*, (pp. 19–22).

Can Multimodal Interaction Support Older Adults in Using Mobile Devices? The ECOMODE Study

Ornella Mich, Nadia Mana, Gianluca Schiavo

Fondazione Bruno Kessler (FBK), Trento, Italy

Abstract

Several studies investigated the potentialities of multimodal interfaces for improving accessibility for older people. This paper presents a study that evaluated the user experience of sixty people who worked with a tablet PC running the ECOMODE technology. This technology consists of an event-driven compressive vision algorithm, that allows the realization of a new generation of low-power cameras, able to elaborate real-time vocal- and video-inputs. The users interact with the applications on the tablet PC using mid-air hand gestures and vocal commands. Even if the ECOMODE technology suffers from some technical limitations, older people appreciated the proposed multimodal interaction mode. The results pointed out that the ECOMODE technology was considered to be particularly promising for daily tasks involving communication, such as placing calls, sending and listening to audio and messages, and taking and sharing pictures. It also seems effective in navigating archives, such as pictures, audio, or music databases.

1 Introduction

Interfaces that allow multiple perceptual processes through parallel sensory channels enhance user interaction with computers [Brewster S.A., 1994]. Several studies investigated the potentialities of these interfaces for improving accessibility for diverse users, including older people (eg. [Naumann A.B., 2010]; [Ferron, 2015]). However, multimodal interfaces that specifically combine speech and mid-air gesture interaction are rarely explored in the literature.

In this paper, we present a study that evaluated the experience of a group of older adults who had to operate a tablet PC using both mid-air gestures and vocal commands.

More specifically, they used the ECOMODE technology. The main aim of this evaluation was about the User eXperience (UX).

2 The ECOMODE project

ECOMODE (Event-Driven Compressive Vision for Multimodal Interaction with Mobile Devices) is a four-year project funded by the EU H2020 ICT22 call. The main goal of the project was to develop multimodal human-computer interfaces for mobile devices where the interaction is based on a combination of vocal commands and mid-air hand gestures, specifically addressing the needs of older adults and visually impaired people.

The project exploited the EDC (Event Driven Compressive) algorithm to realize a new generation of low-power cameras (Figure 1), able to elaborate real-time vocal- and video inputs.

Figure 1: *The ECOMODE prototype running on tablet PC (left) and a user during the evaluation (right).*

A user-centered design based on a participatory approach [Sanders, 2002] was followed by involving groups of end-users along the entire design process, from the collection of the initial requirements to the final summative evaluation. In this paper, we report on the latter one phase.

3 Study with elderly people

This study aimed to evaluate the UX of older adults with the ECOMODE system: a software application - the facilitator - that allowed the navigation of photo archives and audio podcasts using mid-air gestures and vocal commands.

3.1 Participants

The summative evaluation study of the ECOMODE facilitator involved a total of 60 older adults (gender composition: 35 females and 25 males). The age range varied from a minimum of 61 years old to a maximum of 87 years old, with an overall average age of 73.09 years old (SD= 6.87). Participants with an age in the range of 60-70 made up 45% of the sample, 27% of the sample had an age-range between 70 and 75 years, and a considerable part (28%) included also older-old participants (age 75+). Participants were generally right-handed (92%), but the sample included also some left-handed and ambidextrous participants.

On average, the sample reported a mild positive attitude toward technology (M= 3.5, SD= 0.9 - considering a scale between 1 “Very negative attitude” and 5 “Very positive attitude”), with a minimum value of 1.4 and a maximum value of 5. The score is in line with the value observed in other studies with a similar population [Zambianchi, 2018].

Most of the participants (75%) owned and used frequently a smartphone. People who did not own a smartphone used a traditional mobile phone with a physical keyboard. About a third of the sample (35%) owned a computer and used it almost every day, while 28% owned and used tablet devices. More than half of the participants (60%) used Internet every day, and 68% used email. Concerning WhatsApp, 72% of the total sample reported using it frequently, while 41% used Facebook. Fifteen people (25% of participants) reported to know about and have used a vocal assistant.

3.2 Procedure

This evaluation study was based on a between-subject design. Participants were randomly assigned to one of two command sets: simple and full set (Figure 2), different for the number and type of commands included to interact with the mobile device [Ferron, 2019]. We involved a pool of target users to reveal the best scenario for testing the ECOMODE technology.

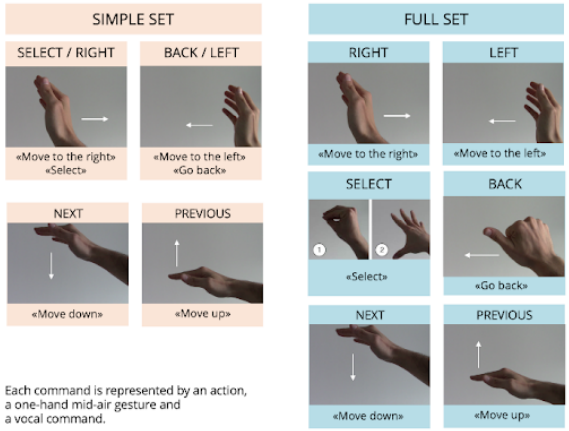


Figure 2: *Simple and full set of multimodal interaction commands.*

Using questionnaires and interviews, we found that the older adults appreciate the tablet device to take pictures when travelling or attending specific social events (e.g., birthday parties, anniversaries, art exhibitions, concerts). They also love using the tablet to read newspapers, navigate the Internet to search information, listen to music, podcast, etc.

Starting from the users’ preferences and needs, two use cases were elaborated: 1) taking and sharing a picture and 2) listening to a podcast. Both are suited to test the ECOMODE technology in indoor and outdoor scenario with standing or sitting users. Due to time constraints, we decided to evaluate the ECOMODE facilitator only through the scenario “Listening a podcast”. We considered two different contexts: the indoor context, participants listened to a cooking recipe, whereas in the outdoor context they listened to an audiobook. The order of the two scenarios was randomly assigned to each participant and counterbalanced. Each podcast had a maximum duration of about 2 minutes. In both cases, the participant was asked to listen to the audio for a while, then pause, and then listen again.

In the indoor scenario, the participant was standing and the ECOMODE tablet device was placed on a support on a kitchen shelf, close to the stove. In the outdoor scenario, the participant was sitting on a bench in the garden, holding the tablet with one hand while performing the interaction gesture with the other one.

The experimental session itself included the following steps:

- Welcome
- Task explanation
- Signing of consent form
- Gathering of personal information, such as age, handedness, attitudes to and use of technology
- Training session: Participants were introduced to the ECOMODE prototype by receiving a de-

scription of the application and of the interaction commands. Such commands were firstly showed through the tutorial video, secondly performed by the experimenter, and finally tried by the participants themselves that could navigate through the interface guided step by step by the experimenter. The latter also informed the participants about how to do the gestures (e.g., not too low, so that the hand was within the view of the ECOMODE camera) and what to avoid (e.g., to pass in front of the camera to position the hand on the top for performing the down gesture)

- Task1: Completion of a specified task in an Indoor condition (standing)
- Task2: Completion of a specified task in an Outdoor condition (sitting on a bench) with the order of tasks 1 and 2 counter-balanced
- Post-task questionnaires: after each task, the experimenter read aloud some questions about exertion, difficulty in carrying out the task, time spent on accomplishing the task and the satisfaction about the support (feedback) received by the system
- Post-session Questionnaire Interview: at the end of the experimental session, the experimenter read aloud the questions about the user experience and the participants provided their answers, giving a score for each of the 40 items. Comments regarding their interaction experience with the ECOMODE technology were gathered too.

The participants were offered a gift voucher to thank them for their participation.

3.3 Results and discussion

In this section, we present the main findings related to the reported evaluation. We focus here mainly on usability issues. Furthermore, few technical issues are also reported.

Command learning and execution: the simple set of command was generally better than the full set with respect to UX dimensions and overall system accuracy. The simple set was also considered easier to remember.

Holding the device: We observed a high variability on how users held the tablet PC (Figure 3). Even though the ECOMODE case includes a side support, users show different types of grasps. Form factor and physical affordances are crucial elements to be considered.

User experience and usability of the Facilitator: it is globally perceived as offering good usability and user experience. The highest scores are reached for certain UX dimensions such as Ease of Learning, Ease of Use, Likeability and Satisfaction. Physical and cognitive demands derived by the interaction with the Facilitator are generally scored as low, and the Annoyance dimension as well. The participants recognised the importance of such technology for several activities (making calls, listening audio material, taking and sharing pictures, navigating on Internet or archives of pictures, music, etc.).

Figure 3: *User grasping the tablet with the whole hand (left), holding the corner (center) or placing a part of the device on the palm of the hand (right).*

Feedback and Feedforward mechanisms: the tested version of the Facilitator includes some interaction mechanism of feedback and feedforward. Feedback was provided by visual and audio messages. The summative evaluation showed that elderly users were aware of such feedback information and used them to evaluate their interaction (e.g., repeating a command if it was incorrectly recognised). However, users expressed the need for more informative feedback, for example suggesting which action to take, or having more specific indications on how to adjust the mid-air / vocal command.

Training and first-time use: Using the Facilitator does not require any technical skill (it can be used by novice users too). However, training sessions are needed to get the user to correctly perform the commands.

Role of user attitudes toward technology: The summative evaluation showed that a positive attitude toward technology is related to more positive opinions on the interaction with the system and perceived accuracy. This is in line with previous studies on the relationship between attitudes and acceptance of novel technologies [Porter, 2006], [Al-Gahtani, 1999].

Technical issues: We observed that certain environmental conditions influenced the interaction experience. For example, the presence of artificial light sources (such as fluorescent lamps or tubes), low-light environments, and moving backgrounds negatively influence the accuracy rate of the system. When the user interacts with the system while moving (e.g., walking), or even if they move their head when seated, the facilitator tends to detect events and commands even when they are not present. This causes a significant lack of control over the interaction. We also observed that users with hand tremors and shaking hands had more difficulties in holding the device firmly, in controlling the interaction, and in correctly performing the mid-air gestures.

4 Conclusions

In this paper we reported on a study with older people, aiming to analyze their interaction with a tablet PC using both mid-air gestures and vocal commands. A group of 60 older people was invited to navigate a photo and audio archive using the ECOMODE facilitator, an application whose core is an algorithm able to recognize real-time gestures and vocal commands using very little energy.

The ECOMODE technology suffers from some technical limitations, that were afterward reported to the developers who resolved them. Even if the facilitator was not perfectly working in recognizing gestures and commands in any environmental conditions, older people affirmed that they like using multimodal interaction based on hand mid-air gestures and simple vocal commands.

ECOMODE technology was considered to be particularly promising for tasks involving communication, such as placing calls, send and listen audio and messages, and taking and sharing pictures. Other usage scenarios were applications for domotic control, rehabilitation and physical therapy, and activities involving reading (e.g., multimodal e-book reader).

In conclusion, although with some technical limitations, from the study conducted during the ECOMODE project, the proposed multimodal interaction was overall perceived as positive by the older adults and facilitating the use of mobile devices, therefore supporting their communication, social inclusion and well-being.

5 Acknowledgements

This work is supported by the EU HORIZON project ECOMODE - Event-Driven Compressive Vision for Multimodal Interaction with Mobile Devices (http://www.ecomode-project.eu/), under Grant Agreement 644096. The authors would like to thank the participants who contributed to this study.

References

[Al-Gahtani, 1999] Al-Gahtani, S. S., . K. M. (1999). *Attitudes, satisfaction and usage: factors contributing to each in the acceptance of information technology*. Behaviour Information Technology, 18(4), 277–297.

[Brewster S.A., 1994] Brewster S.A., Wright PC, E. A. (1994). *The Design and Evaluation of an Auditory-enhanced Scrollbar*. In: Proc. SIGCHI Conf. Hum. Factors Comput. Syst. ACM, New York, NY, USA, pp 173–179.

[Ferron, 2015] Ferron, M., M. N. . M. O. (2015). *Mobile for older adults: towards designing multimodal interaction*. In Proceedings of the 14th International Conference on Mobile and Ubiquitous Multimedia (pp. 373–378).

[Ferron, 2019] Ferron, M., M. N. . M. O. (2019). *Designing mid-air gesture interaction with mobile devices for older adults*. In Perspectives on human-computer interaction research with older people (pp. 81–100). Springer, Cham.

[Naumann A.B., 2010] Naumann A.B., Wechsung I., H. J. (2010). *Multimodal Interaction: A Suitable Strategy for Including Older Users?* Interact Comput 22:465–474. doi: 10.1016/j.intcom.2010.08.005.

[Porter, 2006] Porter, C. E., . D. N. (2006). *Using the technology acceptance model to explain how attitudes determine Internet usage: The role of perceived access barriers and demographics*. Journal of business research, 59(9), 999–1007.

[Sanders, 2002] Sanders, E. B. N. (2002). *From user-centered to participatory design approaches*. In Design and the social sciences (pp. 18-25). CRC Press.

[Zambianchi, 2018] Zambianchi, M., . C. M. (2018). *Positive Attitudes towards Technologies and facets of Well-being in Older Adults*. J. of Applied Gerontology, 37(3), 371–388.

Interacting with E-waste in the Name of Ecology and Sound Art

Enrico Dorigatti and Stephen Pearse

University of Portsmouth, UK

Abstract

This presentation introduces Sound Art from Scrap, a project based on the interaction occurring between sound art and discarded electric and electronic devices (EED) through the practice of circuit bending. The hypothesis at the ground of this project is that circuit bending has strong ecological meaning and, used in the context of ecological sound art, can boost the message conveyed by the artwork. After an introduction to the background relevant to this research, the project to date is reviewed.

Keywords: e-waste; ecology; interaction

1 Background

The production of waste is an increasing global problem which does not seem to invert the trend but, instead, appears doomed to a rapid increase [Chen et al., 2020]. The increasing global population and the emergence of new economies are perhaps the two most significant factors influencing this rise. These are often bonded to one another, populations typically grow fast in developing countries [Cleland, 2013] but they are usually not strong enough at an infrastructural, economic, political, and organisational level to manage correctly and efficiently the stream of waste [Guerrero et al., 2013, Muniafu & Otiato, 2010]; it comes clear, therefore, how dramatic and critical the situation is. Additionally, increasing living standards should be carefully considered. While this means that people can generally have easier access to, for example, services and goods, this also inevitably implies a massive boost in waste production [Song et al., 2015].

For many, the solution to this problem, or at least the best date option, seems to be to increase the usage of biodegradable or compostable materials and to increase the rate of waste recycling. However, these proposals, often loudly advertised and highlighted, not rarely end in being mere market strategies leveraging popular belief and wisdom. For example, in the case of bio and organic materials, if simply landfilled and not treated properly, end up generating methane (CH_4) and carbon dioxide (CO_2), which are well-known greenhouse gases greatly contributing to global warming [Ayodele et al., 2020]. Thus, this takes the shape of enlarging a problem while trying to solve another. Concerning recycling in general, instead, the crude truth is that our technologies and waste management systems are not advanced enough to support and perform efficient recycling of the waste [Liehu et al., 2022], not to mention that benefits of recycling are not significant if this practice fails in offsetting the amount of raw material required for producing new goods [Geyer et al., 2016], and that the materials themselves degrade after every recycling cycle [Mistry et al., 2018]. However, no intention to deprecate recycling and new materials here, as these can surely help to address and mitigate the problem. The core concept is that, ultimately, the best way to avoid waste is to implement best practices to avoid their production in the first place [Goodship, 2007].

1.1 E-waste

So far, we have only talked about solid and municipal waste. However, while this more general introduction can be applied generally to any waste category, in this paper we are dealing specifically with e-waste. As for the other types, e-waste represents a challenging and increasing global problem, with the main difference being that the latter are both sources of valuable materials and hazardous chemicals [Perkins et al., 2014, Robinson, 2009]. E-waste comprises all the EED that are discarded daily and, more often than not, replaced with brand-new ones. Two main issues arise from this cycle: on the one hand, the over-production of tonnes of e-waste, complex to recycle; on the other, the over-exploitation of rare and precious natural resources for building

the devices [Robinson, 2009], amongst which iron, copper, gold, and platinum [Premalatha et al., 2014]. Thus, so far, except for the toxicity of this type of waste and the type of materials they are composed of, usually more precious and rare, there is not much difference between them and the common solid waste.

However, at a closer look, the two issues mentioned before—over-consumption of resources and over-production of e-waste—are closely bonded since one does not exist without the other. Old products would not be discarded if new products were not available and ready to take their place, and vice-versa. Digging and inspecting the matter further closer, however, it can be evidenced that everything leads to a single phenomenon, rooted in the culture of wealthy western countries and named consumerism. To simplify, companies, in need of a constant, and possibly increasing, income, have to have consumers constantly buying their products. As different companies are competing for the same market segment, this opens the way to fierce marketing and advertising campaigns, as well as the usage of the most different selling techniques. These latter include artificially creating the need, for the customers, to own a new product, and thus inducing them to buy it even when there is no real need [Flipo, 1986]. Parallel to this comes the encouragement, or at least the invite, to substitute over reuse, as well as discard over repair, and, to foster this, the longevity of the devices, given by a combination of their functionalities and design, gets purposely shortened[1]. This also affects consumers' right to repair [Hernandez et al., 2020]. All this is part of obsolescence, aimed at letting companies make money by selling new products. «Did you know that you don't need a new product until companies decide to instill the need for them?» [Mancini, 2019].

Consumers, on their own, rarely engage in self-reflection upon their behaviours, partially due to the manipulation operated by advertisement campaigns, asking whether a device is truly needed, and this mechanism keeps going. Discarding an EED is easy, as is buying a new one from the vast assortment offered in the shop windows of shopping malls. But do we ever think about the processes which, in the background, often forgotten or completely ignored, have to run to deliver these shining goods whose availability we take for granted? Do we know what they mean from an ecological, social, and environmental perspective [Argabrite et al., 2022]?

1.2 What is Unseen

Consumers, indeed, should carefully reflect upon these processes which, unfolding through space and time, allow us to own a brand new piece of technology [Argabrite et al., 2022]. All of these processes are integral and essential to the tech supply chain, and while some of them continue to over-exploit rare natural resources, often devastating the environment [Dudka & Adriano, 1997, Von der Goltz & Barnwal, 2019], others make use of child work as low-cost labour [Faber et al., 2017]. While this happens before the actual assemblage of the EED, symmetrically the same happens, although in other ways, once the EED is disposed of, with the central phase, the one with the EED employed by the owner, being like a brief and suspended moment in which the device really seems to shine. This means that the EED dismantling chain is no better, with large streams of e-waste reaching developing countries from the wealthy ones, in a trafficking system often blurring the border with legality, with criminal organisations regularly interfering with the process. Once at their destination, with China and Africa as the most eager importers, illegal and uncontrolled dismantling takes place in the majority of the cases [Premalatha et al., 2014]. This activity, known as informal recycling, sees unprotected and untrained workers opening the discarded EED to extract and separate the different components and materials. While these processes are usually carried out by bare hands, common are other rudimental techniques such as acid melting and burning, which release into the air, soil, and water extremely toxic compounds, poisoning the food chain and, eventually, the people [Premalatha et al., 2014]. To give a sense of how spread e-waste trafficking and informal recycling are, according to the UN E-waste Monitor in 2019 53.6 million metric tons (Mt) of e-waste were generated worldwide, of which only 17.4% (9.3 Mt) were formally recycled, while the rest (82.6%, 44.3 Mt) met an uncertain fate [Forti et al., 2020].

A solution to all this seems more complicated than it may appear, as over-production, over-consumerism and (e-)waste over-production are mutually bonded. But also assuming the possibility to change the consumerism model and change people's minds, thus removing one of the engines of this chain, companies have the final word. Since obsolescence and rapid turnover of EED contribute to their profits, it is unlikely, or rare, that they trim their earnings in the name of environmental justice. However, despite the (apparently) hopeless situation, there is to start from somewhere (to try) to change things.

2 Engaging with the Problem

Fortunately, external actors are stepping in and proposing alternative and creative ways and suggestions to increase awareness and, through small and daily actions, mitigate the problem. It is the case with various non-governmental organisations and movements with initiatives such as Repaircafè[2], promot-

[1] https://www.bbc.co.uk/news/technology-63132831

[2] https://www.repaircafe.org/en/

ing knowledge sharing and collaborative repair. What stands out thanks to these initiatives is that the effort of everyone from the most diverse contexts is needed to tackle the e-waste phenomenon and its causes, and the contribution from the artistic field makes no exception. Sound artists and musicians, through the artistic medium, can shed light on the problem also by taking advantage of the longstanding and multifaceted interest music and sound art have in nature and the environment. From the music of Vivaldi, Beethoven and Debussy, to the studies on the soundscape of Raymond Murray Schafer and Barry Truax and the development of the field of acoustic ecology, and to the formalisation of the branch of sound art called ecological sound art, many different experiences are demonstrating this linkage [Gilmurray, 2016, Wrightson, 2000].

2.1 (Circuit) Bending E-waste

Dealing with technology, art, and environmentalism, as a general definition, «Circuit bending primarily focuses on exploring unexpected behaviours of circuits by applying modifications to their electronics.» [Dorigatti & Masu, 2022]. In the artistic domain, circuit bending is used to turn EED into unexpected and unique musical instruments. Discovered by chance by Reed Ghazala [Ghazala, 2004], circuit bending is today an established artistic practice [Hodgson, 2017].

While it is clear how circuit bending connects to technology and art, it might not be how it deals with environmentalism. Firstly, this connection lies in that bent devices do not have to be new but can be recovered amongst the often still functioning and daily discarded ones [Dorigatti & Masu, 2022, Ghazala, 2004, Hertz & Parikka, 2012]. However, the practical side is just a facet of the whole [Goddard, 2015], as it is argued that the real linkage resides in the possibility, through artistically-employed bent devices, to promote awareness and reflection of the audience on the problem of e-waste [Dorigatti & Masu, 2022].

2.2 Interaction as Reaction

Despite this potential, usually, circuit bending is neglected from this perspective. Therefore, it is from this background that this project, Sound Art from Scrap, takes its shape and objectives. On the one hand, it aims to turn discarded EED into repurposed artistic devices to further employ their media output in ecological sound and media art aimed to shed light and awareness on the e-waste problem and its causes. On the other hand, it aims to investigate circuit bending as a practice, exploring, understanding, and testing its overlooked ecological and environmental potential.

To summarise, this project aims to interact with e-waste, circuit bending, and sound art at once to investigate circuit bending at the intersection of its core set of disciplines by fostering the interaction between the ecological-theoretical and practical-artistic sides.

3 Progress and Discussion

This project is mostly stepping into unknown territory as available research on circuit bending does not usually focus on the ecological and theoretical sides and barely explores it beyond the techno-practical and material surface. For this reason, the first step has been to frame and contextualise circuit bending drawing from subjects such as philosophy, ethics, aesthetics, and sustainability. The results showed how broad and complex is the network of relationships linking circuit bending to different disciplines which, beyond its core set of more technical-oriented subjects, «[...] contribute to its contextualization in the contemporary world and society from a different, humanistic perspective.» [Dorigatti & Masu, 2022].

Successively, mainly by drawing from existing literature on sustainable HCI, a set of suggestions have been developed to bring environmental and sustainability instances within the circuit bending practice, thus making it as sustainable as possible. These suggestions, additionally, propose ways to make the audience conscious of such environmental issues when embedded, thus fostering the aforementioned critical reflection and awareness, should bent instruments or their output get employed within the artistic context.

Further planned steps are the perfection and expansion of these suggestions through engaging with the community of benders through workshops and focus groups and their actual implementation in sound art and consequent evaluation. This last step will involve engaging with other artists and with the audience.

Acknowledgements

The first author acknowledges the University of Portsmouth - Faculty of Creative and Cultural Industries for the PhD Studentship supporting this research.

References

[Argabrite et al., 2022] Argabrite, Z., Murphy, J., Norman, S. J., & Carnegie, D. (2022). Technology is Land: Strategies towards decolonisation of technology in artmaking. In *NIME 2022*. https://nime.pubpub.org/pub/uv5rj19j.

[Ayodele et al., 2020] Ayodele, T., Alao, M., & Ogunjuyigbe, A. (2020). Effect of collection efficiency and oxidation factor on greenhouse gas emission and life cycle cost of landfill distributed energy generation. *Sustainable Cities and Society*, 52, 101821.

[Chen et al., 2020] Chen, D. M.-C., Bodirsky, B. L., Krueger, T., Mishra, A., & Popp, A. (2020). The world's growing municipal solid waste: trends and impacts. *Environmental Research Letters*, 15(7), 074021.

[Cleland, 2013] Cleland, J. (2013). World population growth; past, present and future. *Environmental and Resource Economics*, 55(4), 543–554.

[Dorigatti & Masu, 2022] Dorigatti, E. & Masu, R. (2022). Circuit Bending and Environmental Sustainability: Current Situation and Steps Forward. In *NIME 2022*. https://nime.pubpub.org/pub/025d4cv1.

[Dudka & Adriano, 1997] Dudka, S. & Adriano, D. C. (1997). Environmental impacts of metal ore mining and processing: a review. *Journal of environmental quality*, 26(3), 590–602.

[Faber et al., 2017] Faber, B., Krause, B., & Sánchez de la Sierra, R. (2017). *Artisanal Mining, Livelihoods, and Child Labor in the Cobalt Supply Chain of the Democratic Republic of Congo*. Technical report, Department of Economics, Institute for Business and Economic Research, UC Berkeley.

[Flipo, 1986] Flipo, J.-P. (1986). Service firms: interdependence of external and internal marketing strategies. *European journal of Marketing*.

[Forti et al., 2020] Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). *The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential*. Technical report, UNU/UNITAR and ITU, Bonn/Geneva/Rotterdam.

[Geyer et al., 2016] Geyer, R., Kuczenski, B., Zink, T., & Henderson, A. (2016). Common misconceptions about recycling. *Journal of Industrial Ecology*, 20(5), 1010–1017.

[Ghazala, 2004] Ghazala, Q. R. (2004). The folk music of chance electronics: Circuit-bending the modern coconut. *Leonardo Music Journal*, 14, 97–104.

[Gilmurray, 2016] Gilmurray, J. (2016). Sounding the alarm: An introduction to ecological sound art. *Musicological Annual*, 52(2), 71–84.

[Goddard, 2015] Goddard, M. (2015). Opening up the black boxes: Media archaeology,'anarchaeology'and media materiality. *New Media & Society*, 17(11), 1761–1776.

[Goodship, 2007] Goodship, V. (2007). Plastic recycling. *Science progress*, 90(4), 245–268.

[Guerrero et al., 2013] Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste management*, 33(1), 220–232.

[Hernandez et al., 2020] Hernandez, R. J., Miranda, C., & Goñi, J. (2020). Empowering sustainable consumption by giving back to consumers the 'right to repair'. *Sustainability*, 12(3), 850.

[Hertz & Parikka, 2012] Hertz, G. & Parikka, J. (2012). Zombie media: Circuit bending media archaeology into an art method. *Leonardo*, 45(5), 424–430.

[Hodgson, 2017] Hodgson, J. (2017). Circuit-bending: A micro history.

[Liehu et al., 2022] Liehu, I., Pekonen, I., Hynninen, R., & Lähteinen, J. (2022). Utilizing digital technologies for waste management.

[Mancini, 2019] Mancini, M. (2019). Design-driven obsolescence. *The Design Journal*, 22(sup1), 2243–2246.

[Mistry et al., 2018] Mistry, M., Allaway, D., Canepa, P., & Rivin, J. (2018). *Material Attribute: RECYCLABLE – How well does it predict the life cycle environmental impacts of packaging and food service ware?* Technical report, State of Oregon Department of Environmental Quality, Portland, Oregon.

[Muniafu & Otiato, 2010] Muniafu, M. & Otiato, E. (2010). Solid waste management in nairobi, kenya. a case for emerging economies. *Journal of Language, Technology & Entrepreneurship in Africa*, 2(1), 342–350.

[Perkins et al., 2014] Perkins, D. N., Drisse, M.-N. B., Nxele, T., & Sly, P. D. (2014). E-waste: a global hazard. *Annals of global health*, 80(4), 286–295.

[Premalatha et al., 2014] Premalatha, M., Tabassum-Abbasi, Abbasi, T., & Abbasi, S. (2014). The generation, impact, and management of e-waste: State of the art. *Critical Reviews in Environmental Science and Technology*, 44(14), 1577–1678.

[Robinson, 2009] Robinson, B. H. (2009). E-waste: an assessment of global production and environmental impacts. *Science of the total environment*, 408(2), 183–191.

[Song et al., 2015] Song, Q., Li, J., & Zeng, X. (2015). Minimizing the increasing solid waste through zero waste strategy. *Journal of Cleaner Production*, 104, 199–210.

[Von der Goltz & Barnwal, 2019] Von der Goltz, J. & Barnwal, P. (2019). Mines: The local wealth and health effects of mineral mining in developing countries. *Journal of Development Economics*, 139, 1–16.

[Wrightson, 2000] Wrightson, K. (2000). An introduction to acoustic ecology. *Soundscape: The journal of acoustic ecology*, 1(1), 10–13.

Swingin' Architecture

Giovanni Maria Filindeu

I.S.I.A., Urbino, Italy

Abstract

The assumption that it is possible to associate the idea of a controlled spatial organization with musical composition, combining rhythm, harmonic rules and proportions is still alive both in the field of musical research and in architecture. Even today, Goethe's evocative definition of architecture, considered as frozen music, intercepts the sensitivity of many.

However, the complexity of the new scenarios in architecture hardly seems to coexist with the need to control the outcomes of individual projects. The architectural project is no longer comparable to a simple device that allows to relate perceptible reality with the formal system that organizes it, but is increasingly affected by the unexpected, compulsive invasion of data and increasingly complex and heterodirected needs as regards this specific discipline.

For the contemporary architect, absorbing the evolution of the actors and the context in the project means cultivating the ability to react and adapt one's own strategies and professional tools, in a word improvising.

Music in the past has certainly been a good model for defining effective analogies with architecture. However, the great changes in contemporary architecture are making this confrontation suffer now. Is this comparison still effective? If so, how or what type of model is the most appropriate? Among the different musical forms, jazz defines a method that places improvisation at the center of its constituent elements.

The organizational form of the creative process, whether based on the code of notation or on the system of communication and transmission of contents between jazz musicians, is very close to the diagrammatic form used by some contemporary architects.

1 Anticipation versus reaction

Properly considered as a process of searching and individuation of problems rather than the definition of solutions, the architectural project, urban project in particular, today appears increasingly influenced by the unexpected and compulsive incursion of needs and data not strictly referred to architecture discipline.

No longer comparable to a simple device through which a perceptible reality can be related to the formal system that organizes it, the architectural project has shifted its conceptual axis from the noun to the verb, abandoning, almost definitively, the primary purpose of create spatial forms by referring more to the processes that produce them. The city is no longer intended as a fixed scene of our lives [Rossi, 1995] and is more properly linked to the progressive importance that the temporal dimension has acquired both in the project and their spatial expressions.

To accept change and unstable spatial and social contexts as part of the project, giving up the primary goal of a final and complete form, brought the architectural project closer to the real problems of communities and territories. However, in this way, architecture has consolidated its current crisis, recognizable both in the processes of defining the project's objectives and in the professional tools that measure its effectiveness.

The Cartesian division between res cogitans and res extensa still seems to strongly pervade the rational idea of the project. While admitting the importance of instability, uncertain data and transformations, it is often preferred to proceed by considering an objective reality "interpreted" by a subjective reality.

However we know that such an objective reality, a set of tangible elements opposed to the subject, does not exist. There is, more likely, a reality described by the incessant flow of relations, defined and linked between the subject and the object. Such relationships are capable of configurations that are different each time and sensitive to every slightest variation of every objective and subjective element.

If on the one hand the current interpretation of the transformation processes of the urban ethos consolidates the uselessness of producing design efforts that order, according to a hypothetical file, pieces of contemporary society, on the other it has allowed the identification of aggregates of behaviors that finally allow us to see the construction of unprecedented areas in continuous transformation and new forms

of social cohesion nurtured in disaffection with the city. "The nature of the urban environment is contact, change, heterogeneity, becoming" [Sobrero, 2009].

Design means, in a certain sense, preparing to face the future with all its load of uncertainties. Triggering a process of conscious and reasoned transformation in its genesis and controlled and assisted in its realization, on the other hand, cannot be protected from unforeseen events. Waiting for the unexpected, being ready to manage change is one of the most pursued, and perhaps least achieved, objectives within the theories on the construction of the transformation processes of space. The construction of the methods of reaction to unexpected data through processes of adaptability, comparison, spontaneous reconfiguration cannot ignore the investigation within disciplines that, although distant from architecture, absorb the culture of the project. Knowing how to deal with and interpret a changing and unstable scenario means accepting and absorbing elements such as improvisation and indeterminacy within the project.

2 Improvisation and decisions

Quickly stimulating or absorbing a change, within the project, means relying on one's reactive skills, cultivating a sense of the "possible", having, in a word, the ability to improvise. The study and reflections on improvisation seem to contribute effectively not only to the interpretation of contemporary phenomena but also to provide significant elements for the construction of the project.

What more than any other consideration pushes different disciplines towards the study of improvisational models is the fact that there is a difficult coexistence, within the same model, of elements that are effective in managing complexity (understood both as a quantity of variable information and as quantity of possible combinations) and effective elements with respect to the forecasting capacity (understood as the ability to direct the project towards the expected results).

Among the different models that are studied and used as a reference in relation to the contribution that improvisation is able to provide in the construction of the project, jazz is certainly one of the most investigated. Jazz is, in fact, a discipline that absorbs and develops phenomena that place these elements at the center of its constitutive laws. The attention referred to Jazz as a valid model for the interpretation of knowledge processes has often crossed numerous scientific fields. Jazz has recently caught up with architectural research. 1. "To account for improvisation it is therefore necessary to refer to a theory of tradition and a theory of practical knowledge, which clarify both the constraints to which generative action is subjected, and the particular competence necessary to create something new by making music together [Sparti, 2005].

Improvisation therefore does not grow in the fading of historical knowledge and It is not aimed at reaching a hypothetical "zero degree" in which everything is yet to be defined, but takes shape from a complex and full-bodied scenario of elements that opens up to new expressive possibilities with every improvisational act. Tradition coincides with this scenario: a world of fundamental acquisitions and resources lying in a state of narcosis until the musician intervenes to regenerate him in improvisation. In jazz improvisation, freedom is a central factor that does not coincide with the absolute autonomy of the musician but with the self-proliferative ability to produce creative material which, starting from consolidated elements, the improvisation itself helps to build.

Tradition is actually something inexhaustible that is produced continuously and cyclically through the performance. Regardless of the historical era, the tradition in jazz is strongly linked to the construction of new meanings and creative directions. The difficulty of associating historical material with new elements is not true in jazz. Actually, what happens in jazz is that the tradition is "updated" every time during improvisation.

3 Jazz as Diagrammusic

Actually, what happens in jazz is that the tradition is "updated" every time during improvisation The new tools for architectural projects today are no longer confined to the usual technical arsenal of the professional. These tools highlight sequential processes in which information is an integral part of the project. The possibility of processing an enormous amount of data in a design project leads us to the definition of a diagram, a device that, albeit with significant differences, unites the positions of numerous contemporary architects (Figure 1). In this sense Stan Allen wrote: "A diagrammatic architecture is not necessarily an architecture produced through diagrams" and again "a diagrammatical architecture is an architecture that behaves like a diagram".

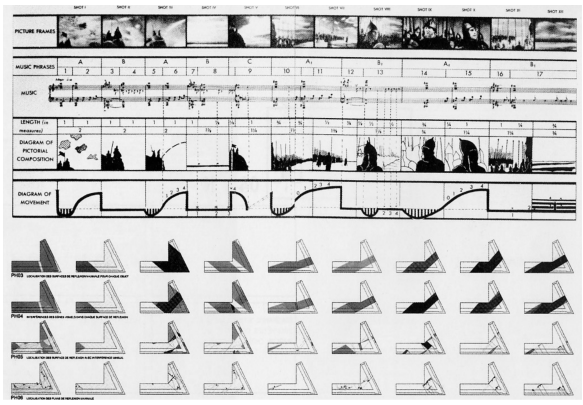


Figure 1: *Diagram score taken from F. Soriano "Fisuras" [Soriano, 2002].*

On the other hand, it is precisely the peculiar characteristic of Jazz to manage a huge number of information contained in not particularly elaborate devices that operate through synthesis. Even the sheets that musicians generally use on stage could be defined as extremely poor compared to the creative and expressive material that emerge from them during the performance. The written notation that accompanies a performance is almost a draft intended as a guide, as a fundamental reference which cannot be used successfully without a significant interpretation. The graphic of the score generally is the same used for classical music: the pentagram sheet. However, jazz condenses all the information necessary for performance into as few sheets as possible. On jazz scores, the graphics provide the greatest amount of information and indications occupying the least possible space. The use of short notations allows musicians to leave space on the page in order to leave each musician free to insert other useful information and notations on his score, perhaps within his own Real Book. It can be said that the score tends to disappear as the musician's skill increases (Figure 2).

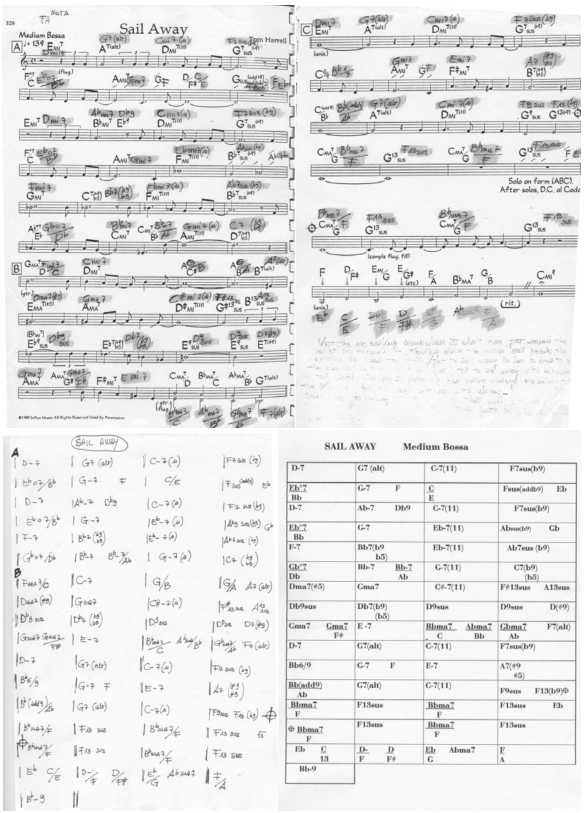


Figure 2: *Semplification process of a jazz score.*

How does the analogy between Jazz and architecture resist, given that the organization of the musician's creative material fixed on paper (the Jazz score) and the proliferative diagram of the architect are considered in an almost opposite way, tending in the first case to evaporate and in the latter to be considered central elements? What would the alleged analogy be supported on?

Jazz creates a process that tends to impoverish the diagram - music sheet of the greatest number of graphic elements when the interpretative skills of the musicians increase. Jazz musicians use scores not only as diagrams but they play within a diagrammatic creative process. The organizational form of the creative process in jazz, whether it refers to the code of written notation or to the system of communication and transmission of contents between musicians, is properly diagrammatic. The jazz score (the music sheet) can be intended as a diagram because it contains the greatest number of information included in the least number of graphic elements. The formal structure (compositive and performative) is considered as a diagram because in jazz it operates as a "machine for instructions" aimed at the possibility of their simultaneous management rather than at the progressive elimination of elements. In this aspect, perhaps more than others, the relationship between jazz and architecture appears particularly promising in the redefinition and reconsideration of the constituent terms of the project.

4 Conclusion

How the contemporary project in architecture can be lead with diagrams, intended not as formal representations but as generative structures of spatial contents, is given by Kazuyo Sejima's work. Talking about Sejima's manner to work, Toyo Ito states: "She arranges the functional conditions that the building should contain, in a final diagram of the space, then immediately converts that diagram into reality" [Ito, 1996] that is the same speed that we can recognize in the creative process of jazz. It is not a matter of manage tested procedures but is related with the capability to translate, into concrete facts, a large number of data coming from different fields in continuous reconfiguration. The goal is to manage a creative process that considers multiple options, without eliminating significant elements absorbing their errors. A creative process which does not translate into a graphic formalization of the project synthesis but which, on the contrary, remains open to new configurations. The architect, like the jazz musician, should be capable of planning and improvising, assuming different roles, seizing unexpected opportunities and bringing them back to the advantage of achieving the final goal. According to David Brown, the architect should consider himself as a jazz drummer who holds together both the potential directions of the creative flow and the internal coherence of the general structure, always placing himself in an intermediate position within the project by managing foreseen and unexpected phenomena [Brown, 2006].

References

[Brown, 2006] Brown, D. (2006). *Noise Orders. Jazz, improvisation and architecture*. University of Minnesota Press.

[Ito, 1996] Ito, T. (1996). *Diagram architecture*. El Croquis, 77.

[Rossi, 1995] Rossi, A. (1995). *L'architettura della Città*. Città Studi Edizioni. Torino.

[Sobrero, 2009] Sobrero, A. (2009). *Antropologia della città*. Carocci Editore, Roma.

[Soriano, 2002] Soriano, F. (2002). *Diagramas@*. Fisuras, 07/2002.

[Sparti, 2005] Sparti, D. (2005). *Suoni inauditi. L'improvvisazione nel Jazz e nella vita quotidiana*. Il Mulino. Bologna.

Is Landscape Sound? A Multidisciplinary Approach to the Soundscape of Trento (Italy)

Sebastiano Beozzo[1], Chiara Chioni[2] and Camilla Venturini[3]

[1]*Conservatory F.A. Bonporti, Trento / Riva del Garda, Italy*
[2]*Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy*
[3]*Department of Engineering and Architecture, University of Trieste, Italy*

Abstract

This multidisciplinary—landscape architecture, urban planning, electronic music, composition, and field recording—research project investigates the relationships and interferences between landscape and sound (i.e., soundscape) in Trento (Italy) through environmental sound sampling and mapping. Interaction between disciplines—and between sight and hearing, in the landscape perception—has a key role throughout the research. This contribution aims to report the stages of the activities carried out in the summer 2021 by the research team and to illustrate the first results, the most substantial of which is the sound map, a catalog of urban sounds; a conceptual sound section has also been drawn, to illustrate additional information and reflections that the map does not highlight.

1 Introduction

In the framework of the research project "Oi Dialogoi" (2021-ongoing), promoted by the Conservatory F.A. Bonporti, Trento / Riva del Garda (Italy), the multidisciplinary—landscape architecture, urban planning, electronic music, composition and field recording—research team started an investigation about the soundscape concept (the acoustic analogy to landscape), its digital registration and fruition, and its subsequent potential application in the urban and landscape planning policies of the historic center of Trento.

1.1 Theoretical framework: the soundscape

The title of the research, intentionally provocative, paraphrases the title of the essay "Is landscape...?" [Doherty and Waldheim, 2016], which highlighted the multiple identities of landscape, exploring the relationships between landscape and other disciplines, but among them the relationship between landscape and sound is not explored.
Nevertheless, the use of the term "soundscape" is spread among various disciplines, ranging from urban design to wildlife ecology to computer science. The term firstly appeared in "The Sonic Environment of Cities" [Southworth, 1969], originally coined by Michael Southworth, a city planner, former student of Kevin Lynch; only later it was popularized by the composer Raymond Murray Schafer, thanks to his "The Tuning of the World" [Schafer, 1977].
An important distinction has to be made between "soundscape" and acoustic environment: this latter is the combination of all the acoustic resources, natural and artificial, within a given area as modified by the environment; a "soundscape" is the acoustic environment as perceived by humans, in context. This recalls the definition of "landscape" according to the European Landscape Convention [Council of Europe, 2000]: "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors".
The International Organization for Standardization (ISO) standardized the definition of "soundscape" [International Organization for Standardization, 2014]—the "acoustic environment as perceived or

experienced and/or understood by a person or people, in context"—contributing to the 3rd (Good Health and Well-being) and 11th (Sustainable Cities and Communities) Sustainable Development Goals (SDGs) adopted by the United Nations.

1.2 Operative framework: the urban landscape of Trento (Italy)

Nowadays soundscape approaches—embedding "sound" into the framework of urban and landscape planning and design—focus on human-centered and context-based solutions that consider people's perceptions, needs, socio-cultural background, and expectations in relation to their acoustic environment. Since this latter is one of the critical environmental factors in judging the quality of life, soundscape analysis and mapping (i.e., "soundmaps") can be considered emerging tools to describe urban acoustic states and trends.
Publicly-shared recordings can be used for specific objectives, such as the study of noise pollution [Anderson, 2016] or the preservation of sound heritage (e.g., historical Venice lagoon's sound traces in Venice Soundmap[1]; Portobeseno's environmental sounds, voices and stories in AlpSound[2]), but also for practical applications (e.g., in the Hush City Map app[3] [Radicchi, 2021] anyone can map, evaluate and discover both quantitative and qualitative data about public quiet areas).
In the context of the Municipality of Trento, the main landscape planning tool is the Landscape Chart (lit. *Carta del Paesaggio*), which identifies the so-called landscape units, the territorial structure of identities and invariants. Here, visual perception is the only one taken into consideration, with no mention of the acoustic perception (and of the soundscape). The Municipality is only provided with an acoustic classification (or zoning) of its territory, differentiating it into six acoustically homogeneous classes, based on the main urban uses allowed and each responsible for specific acoustic limits.

2 Methodology

During three days between June and July 2021, the research team recorded, cataloged, and mapped the urban sounds of the city of Trento, inspired by the practice of "soundwalk", a "method that implies a walk in an area with a focus on listening to the acoustic environment" [International Organization for Standardization, 2018].
The spatial conformation of the historic center of Trento suggested the choice of some sample locations, paradigmatic for their geomorphological characteristics, in which to make the first sound recordings. By reducing the city to its essential geometric forms, generators of space—points, lines, and surfaces [Kandinskij, 2017]—the following were identified:

- The three bumps (lit. *Doss*) Trento, Sant'Agata and San Rocco, as points (in elevation).
- The current and former courses of the Adige River, as lines.
- Open public spaces (i.e., squares, parks) as surfaces.

The methodological steps of the work are described in the following paragraphs.

2.1 Data collection and elaboration

Since people experience space and sound in 360°, the translation at the recording level (made with the recorder Zoom F8n, 48000 Hz of sampling rate at 24-bit) and subsequent reproduction of these essential geometric shapes from spatial to sound was solved as follows, using relatively expeditious and inexpensive means:

- For points, the so-called "XY" technique was adopted by crossing two microphones (Neumann KM184) with "cardioid" polar pattern and making a stereo recording (left and right channel).
- For lines, movement of points in one direction, a microphone called "shotgun" (Sennheiser MKH 416, "super-cardioid" polar pattern) was used, which records in the direction in which it is oriented so that the movement can be rendered. This technique differs from the others because it is performed in motion.
- For surfaces (the most complex), sets of points/line movements, were used four microphones (Neumann KM184) with "cardioids" polar pattern, to define a circumscribed area of about 5x5 m, and a microphone with "omnidirectional" polar pattern (AKG C414), placed in the center of that area.

[1] Available at: www.venicesoundmap.eu/home/.
[2] Available at: www.portobeseno.it/alpsound/?page_id=2133.
[3] Available at: map.opensourcesoundscapes.org/view-area.

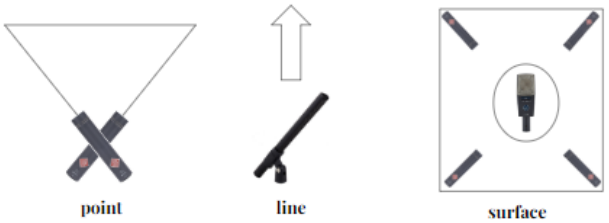


Figure 1: *Points, lines, and surfaces in audio domain*

After a first test of these procedures in Piazza Dante (the train station square), the main change made was in the size of the surface to record (from 12x12 feet to about 5x5 m).
For the data elaboration, the surface recordings were adapted to stereo listening because of the difficulty in reproducing the "surface effect" without a quadraphonic audio setup. Subsequently the audio files were cleaned with a Digital Audio Workstation (Pro Tools) using an equalizer to remove unwanted low frequencies picked up by microphones (caused in most cases by the wind). Rare adjustments were also made on the other portions of the audio spectrum, but only in case of annoying frequencies. After that, they were normalized at -3,0 dB for a correct listening, to resolve the differences of dynamic range in the various recorded soundscapes. Finally, all the audio files were collected, cutted to exactly one minute, and uploaded to a digital platform for listening.

2.2 Data visualization

To visualize these data and make them shareable and usable, a digital sound map has been developed. Specifically, the collected recordings have been cataloged in a geo-referenced sound map using Google My Maps, a platform to publish data, making them shareable and accessible.
The geometry of the various elements—points, lines, and surfaces—had already been approximately drawn directly in the map while recording, using the app on the mobile phone and thanks to the GPS. These traces have been used as landmarks when later the map has been improved and equipped with data. The geometries are clustered according to date and place of recording and accompanied by a brief description of the context.
To complete the map, also representing the sound depth [Feld, 2021], a conceptual section was developed, perpendicularly to the Adige River (from Doss Trento to Doss Sant'Agata): thus, places and their relations (e.g., the relative height) are shown in a different way.

3 Results

The main result of this work is the geo-referenced sound map[4]: points, lines and surfaces are described with soundtracks, photos taken during the recordings and, in some cases, videos. These elements are easily accessible to users clicking on the associated element in the map. In addition, each typology of geometrical elements is characterized by a different color: points in purple, lines in orange, and surfaces in blue; some points are in orange (lines' starting and ending points) and in blue (surfaces' vertices and center).
The framework of the research project "Oi Dialogoi" gave the possibility to present the research project and its first results in different phases, having feedback that enriched the entire process. An interesting experience was the use of the Kahoot app, during a meeting on 24th September 2021, with the audience involved. After listening to a track registered along the Adige River, people were asked to imagine some physical elements of that place, relying only on the sound perception. The results highlighted the little attention usually people pay on soundscape: having sound as the only information tends to confuse our perception of space (for example, someone did not recognize that the recording was in movement or along a river). The results of this experience are even more interesting if related to the history of the Adige River in Trento: in the proximity of the city center, nowadays this no longer follows its original watercourse; in the XIX century, it was deviated to build the railway [Consoli, 2012] and now on its original riverbed there is a street.

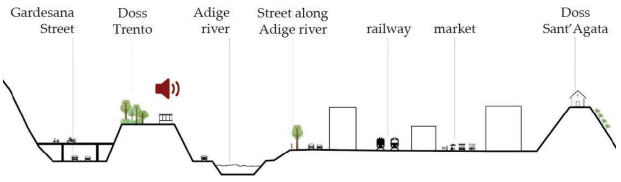


Figure 2: *"Soundscape section"*

Similar considerations emerged during the recording: the soundscape was sometimes very different from the landscape as "visually" perceived; and the "depth" of sound was not

[4] Available at: www.google.com/maps/d/viewer?mid=1cxqHKCpbTI5zDtjZK6iF50Vlvq1i1Tl2&ll=46.072360725662364%2C11.11010809384096&z=14.

always realistically captured (i.e., sometimes the sound source seems closer or more distant than it really is). This latter can be better understood referring to the "soundscape section"[5]: a track registered in Doss Trento (corresponding to the red symbol in Figure 2) is listenable. Some sounds (e.g., motorcycles and trains) do not match with the landscape—the Doss surrounded by trees that prevent the spectator from seeing the city.

4 Conclusions and outlook

Although the literature and multidisciplinary research on soundscape have been growing, especially in the last two decades, there is still a strong need to provide a holistic perspective for designing sustainable urban soundscapes.
This research could move towards the integration between urban planning and policy to noise pollution control and mitigation in the city of Trento. Indeed, considering that maps and sections are different ways to represent relations between spatial elements, and that in this case they are enriched with multimedia files, this research could be the starting point for a qualitative and quantitative data catalog towards a Trento's soundscape description to be used in urban planning. In particular, the in-progress "soundscape section", as conceptual representation, shows potentialities to be explored, beyond its current limits (e.g., it is not geometrically accurate; it is linked to only one soundtrack; it has to be accompanied with other parallel and perpendicular sections).
The considerations about perception during the recordings, as well as following the collective experience with the Kahoot app, suggested open questions: what changes did the modification of the course of the Adige River cause in the soundscape of the city of Trento? Is it possible to find some traces of the ancient Adige course's soundscape into its modern one, and vice versa?
From the point of view of sound sampling, this work can contribute to a better organization of procedures and audio recording equipment, specifically associated with geometrical entities of space (as points, lines, and surfaces). New forms of representation for a better interaction between senses could also be studied and experimented.
Even if the quality of tracks uploaded would not be guaranteed, further development could include citizen participation in constructing the map and the section(s); additionally, this could increase the number of recordings, enriching the data and making them more objective.

[5] Available at: soundcloud.com/sebastiano-beozzo/punto2-dosstrento-cut/s-EgfxJfp5600?si=29d6ef264fe74e8fabdcaba60fd22b0d&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Acknowledgements

This work is the result of a research collaboration born in the context of "Oi Dialogoi"[6], a research project born from students of the Conservatory F.A. Bonporti, Trento / Riva del Garda. The authors acknowledge the Conservatory F.A. Bonporti, Trento / Riva del Garda for the free loan of the instrumentation needed to sample the environmental sounds.
The authors also acknowledge Arch. Ph.D. Silvia Mannocci and Dr. Samuele Zilio as members of the research team: they have contributed to the conceptualization, methodology, investigation, data curation and visualization of this project as much as the authors.

References

Anderson, I. [2016]. Soundmapping Beyond The Grid: alternative cartographies of sound. *Journal of Sonic Studies*, *11*.

Consoli, M. [2012, January 6]. Quando l'Adige seguiva il corso dell'Adigetto. *L'Adigetto*. Retrieved from www.ladigetto.it/permalink/16339.html.

Council of Europe. [2000]. *European Landscape Convention*.

Doherty, G., and Waldheim, C. (Eds.). [2016]. *Is landscape...? essays on the identity of landscape*. London New York: Routledge, Taylor & Francis Group.

Feld, S. [2021]. L'estetica come iconicità dello stile. In *Il mondo sonoro dei Bosavi. Espressioni musicali, legami sociali e natura nella foresta pluviale della Papua Nuova Guinea*. Palermo: Edizioni Museo Pasqualino.

International Organization for Standardization. [2014]. *ISO 12913-1:2014 Acoustics — Soundscape — Part 1: Definition and conceptual framework*.

International Organization for Standardization. [2018]. *ISO/TS 12913-2:2018 Acoustics — Soundscape — Part 2: Data collection and reporting requirements*.

Kandinskij, V. [2017]. *Punto, linea, superficie: contributo all'analisi degli elementi pittorici* (34. ed). Milano: Adelphi.

[6] For more information: www.conservatorio.tn.it/oi-dialogoi.

Radicchi, A. [2021]. Chapter 6. Citizen science mobile apps for soundscape research and public spaces studies: lessons from the Hush City project. In A. Skarlatidou and M. Haklay (Eds.), *Geographic Citizen Science Design. No one left behind* (pp. 130–148).

Schafer, R. M. [1977]. *The tuning of the world: a pioneering exploration into the past history and present state of the most neglected aspect of our environment: the soundscape*. Toronto: McClelland and Stewart.

Southworth, M. [1969]. The Sonic Environment of Cities. *Environment and Behavior*, *1*(1), 49–70. doi: 10.1177/001391656900100104.

Musicians' Work Preferences: Teaching or Playing?

Silvia Sacchetti[1] and Andrea Salustri[2]

[1]*University of Trento, Italy;* [2]*Sapienza University, Rome, Italy*

Abstract

The aim of this work is to analyze the welfare of music teachers. The conceptual background comes from cultural economics literature (Throsby (1994). Building on the observation that music teachers act also in the role of performing artists, our aim is to appreciate to what extent the interaction between teaching and playing supports musicians' welfare. The analysis builds on an original survey that allowed to collect 141 questionnaires filled in by the teachers at the Trentino Music Schools over the first half of 2022, and 50 interviews with musicians and administrators. It encompasses the specific institutional context developed by the Trentino Province, in North-East Italy, and the market-mediated relations with the organizers of music events. We focus on several outcome indicators, including musicians' contractual conditions and pay, professional performances, motivations, and the resulting level of vitality and satisfaction. Our analysis is used as a starting point to suggest the "conducts" that may have determined the observed results as well as some preliminary policy implications for the sector.

1 Introduction and approach

In the economic disciplines, the word 'interaction' recalls the concept of strategic relationships among self-interested rational agents. However, most interactions are based on a wider spectrum of motivations (such as empathy, curiosity, habit, reciprocity, fairness, care), which economists have tried to incorporate into so-called 'behavioural' analyses (Stanca et al. 2009; Thaler, 2017). Also, there are relationships of a coercive nature, such as those established between the state and the community to avoid free riding in the provision of public goods or the financing of public expenditure (Sweeney, 1973). Finally, participating in social networks may require the acceptance of tacit rules among group members, which may radically alter the freedoms that individuals enjoy within and outside the group (Aoki, 2007).

Cultural economics has looked at interaction from the point of view of artists' labour market, and Throsby (1994) in particular focused on musicians' labour market, where the key interaction is between artwork and non-artwork labour choices. In his model, he postulates musicians' utility as a function of the intrinsic value of playing music, and the subsistence level of consumption, which requires minimum earned income. Consequently, after the achievement of a minimum standard of living, utility depends on the time allocated to artistic activity, so that the supply of artistic work follows an intrinsic driver, and the time allocated to it increases as unit earnings increase. In our revised model, the key assumption is that musicians prefer performing music rather than other occupations, and that however, given the level of wages in artwork, for many of them the earned income from music is not sufficient to meet subsistence consumption levels. Consequently, low-income musicians must supply labour to non-art work, where it is assumed that wages allow to meet the subsistence consumption levels. Given the alternative use of disposable working time, musicians will choose the amount of time to allocate to artistic work and to non-art work, while keeping, *coeteris paribus* the level of wage, their preference for artistic work, as it is associated to a positive use value (i.e., musicians are intrinsically motivated). Consequently, if the wage in the non-art labour market increases, the artist will devote more time to music performance, since the subsistence income will be reached with less hours of non-artistic work. Hence, the higher the level of non-artwork wage and the higher the artwork wage, the more the time allocated to music performance, and the higher the musicians' utility.

We use this model and expand it to discuss a specific collaborative solution between the public actor and private nonprofit schools in the Trentino province of Italy, as presented in the abstract.

2 Problematizing the context

In 1987, the Autonomous Province of Trento (PAT) implemented the policy of coordinating production resources for cultural production through a combination of public and private nonprofit partnerships with private nonprofit schools. The aim was twofold. On the one hand, PAT wanted to improve job stability for the many music teachers working in local associations, often without an employment contract, and on the other hand recognize the public value of music culture and fully support its development in both urban and rural areas. Under these conditions, PAT committed to funding schools' costs, largely for staff. Currently this totals about 6 million euros per year transferred to 13 schools and for 301 musicians - of which 60% are males - and 37 admin staff. In order to be co-funded by PAT, teaching activities need to be arranged according to agreed standards and guidelines (for instance defining the duration of a lesson, its frequency, the number of students participating in taught music groups). By lowering entry barriers for users (e.g., in terms of age, pre-requisites, localization, music preferences, fees) this system has improved access to music culture with respect to traditional music education.
Given policy aims, the system of incentives for schools, and their teachers, is centered on the number of students and hours taught. An obvious limitation is that it misses out the artistic component of doing music and music culture creation, which can surface by means of teachers' artistic commitment and relations outside their organizations, feeding teachers' intrinsic motives and as well as students' passion and motivation, beyond the original PAT's aims and standards. From these considerations we derive our research focus on teachers' welfare and assume that desired welfare level by musicians include a combination of teaching and artistic activity that enables them to achieve professional and personal fulfillment, as well as levels of income that are consistent with their needs and the overall cost of living.

3 The size of artistic activity

Even if the focus of the TMS system is teaching, independent artistic activity has continued to be present among musicians. Artistic activities include production, performance, and composition. From an analysis of 241 music teachers' school and personal web pages (not all the 301 musicians are named in MS websites) and major online music platform (e.g. Youtube Music, Spotify, Apple Music, Discogs, Amazon), we found that nearly half of the teachers (45%) are or have been active in record production, while over half of them (56%) are active in performing with bands, orchestras, or ensembles. Composers are 3%. This result is consistent with what emerges from survey data, indicating that 'doing music' belong prevalently to the musician's professional activity outside their music school (54% of musicians), while the others either do not engage (12%) or engage with artistic activities within the context of school-related performances or productions (34%). The demand for artistic activity, looking at the places where performances mostly take place, comes from festival organizers and municipalities, which in most cases co-fund schools together with PAT, and demand musicians some degree of engagement with the town as part of the TMS mission of disseminating music culture. Demand comes less often from clubs, pubs, hotels, and recreational places in general (this may be related with classical music being the prevailing music genre taught and played by teachers, 79%).

4 Job conditions

The survey indicators on contractual conditions and income, as well as those on professional and personal fulfillment, enquire on musicians' perceived levels of welfare.
First, we consider material welfare with respect to contractual conditions, pay and whether musicians regard job-related pay adequate to their needs and living costs. Consistent with the public aim of improving job stability for musicians, 85% of contracts are permanent, and regulated largely by an *ad hoc* collective contract. 45% of respondents are full-time workers, 33% of musicians work part-time but not by choice, as they would prefer increasing their teaching hours, while 22% are part-time and happy with their current arrangement.
Second, we consider monetary rewards: 1194 Euros average salary for a full-time (19 hours teaching per week). Those who undertake extra-school activities earn on average 100 Euros less than those who do not. On a 1 to 7 scale, satisfaction with net salary is below 4, although it is considered on average fair with respect to the school's financial sustainability and inter-personal comparison. Also, it is considered severely insufficient to satisfy personal and family needs, as well as inadequate with respect to living costs.
Third, if we look at salary with respect to changes in musicians' motivation to teach (whether motivation has decreased, increased or been stable), we observe that a higher monthly pay (those who spend more time in teaching) is associated with

lowering motivations. A possible explanation (which is also consistent with qualitative data from interviews parallel to the survey) is that musicians who go away to play, besides teaching, renew their motivation more effectively than those who refer strictly to the school's environment.

Fourth, we observe the motivational drive underlying teaching, and designed items with reference to behavioral theory (Cassar & Maier, 2018). The initial choice to work as a music teacher, an average of musicians' self-rating on a scale 1 to 7, is given by other-regarding motives ('Having the opportunity to teach and pass on my passion for music' 6.32, 'Contributing to creating musical culture' 5.69), as well as by immaterial self-regarding motives ('Professional fulfillment' 5.45) and with living cost constraints ('Need for income and employment' 5.22), while salary (4.12), consistent with low average levels, scores below average (4.77).

Last, we consider on-the-job satisfaction. The items used to study this dimension are adapted from self-actualization theory in organizational psychology (Deci & Ryan, 1985, Pellegrino et al., 2021) and aim at exploring musicians' non-monetary welfare aspects, in particular: relational quality, personal fulfillment, creativity (average score 4.94). Satisfaction is mainly driven by the relationship with students (6.36), on-the-job autonomy (5.38), by the nature of activities, and by the creativity that teachers are able to express through them (5.13). It is held back by the scarcity of opportunities for professional growth and training (4.08), and the low artistic visibility offered by the school (4.15). Satisfaction with collaborations with colleagues is also below average (4.80).

5 The scope of interactions

Musicians see the value of combining teaching and artistic activity (5.79). Consistently, they express their creativity through both ordinary teaching (5.21) and public performances (5.18) (while artistic activities related to composition and arrangement score low, 3.64).

Those who were expanding their artistic engagement (in pre-pandemic years) identify the reason for this growth in their personal attitudes and objectives (6.29), and to some extent to the cultural context and to the choices of the intermediaries demanding music performance (4.53). Very little credit is given to the synergies with the school's activities (3.35) and even less to the contribution of fellow teachers (2.50). Those who reduced artistic engagement associate the contraction with the cultural context and the choices made by intermediaries (6.25), and with production choices in the music industry (5.00). Results indicate that musicians who have a strong personal drive and the capability to meet the industry's requests can surface the waters, while others struggle.

We hence attempt an explanation of personal drivers and focus on what supports musicians' effort in performance and production, enquiring on extrinsic drivers (expected economic reward 2.85; public recognition 4.88), intrinsic drivers (6.05), and creation of opportunities (5.09). The string of effort is pulled by the intrinsic pleasure that one experiences and by the potential for new opportunities, which positively correlate with the criteria that musicians apply to select their partners: their artistic quality, capacity to understand the artistic project and improve it. Oppositely, monetary rewards do not drive the artistic effort. This may indicate that either monetary payoffs are not important to musicians or they are not adequate to their performance level. We opt for the second explanation. And this reinforces the need to problematize the freedom that musicians have when choosing the time they allocate between being teachers and being artists. It is indicative that the subjective vitality of musicians, that is the energy they have when undertaking their school work, scores higher for those who focus on school activities only and have eliminated the trade-off between teaching and their own private artistic activity *tout-court*.

6 Discussion

The artist's labor supply model proposed by Throsby (1994) seems appropriate to represent the musicians' allocative choice of working time between teaching and artistic activities. In fact, being difficult to afford the cost of living with a fluctuating and often low income such as that one coming from playing gigs and concerts, Trentino's musicians devote part of their working time to teaching activities at TMSs, obtaining an additional and regular monetary income in return.

Should musicians receive *de facto* a fixed remuneration for their work, both in the case of teaching and concert activity, without anchoring their wages to their performances (number of students and participants at concerts) a self-interested musician would have no interest in accomplishing his or her job professionally. On the other hand, performance evaluation transfers on the musician the risk of the activity, both on the teaching and on the artistic side, without the latter receiving any compensation in return, as in the case of a mixed wage that is at least pegged to the number of students/spectators. In Trentino, payments are mostly attached to student numbers, while artistic activity is mostly dependent on event organizers and on the personality traits, social

capital and reputation of musicians. An unfair distribution of business risk may indirectly incentivize the musicians to participate in extracurricular activities in schools and in the organizational aspects of gigs/concerts to 'embed' themselves in both systems of relationships and thus stabilize their working activities. As the time devoted to complementary networking activities (useful for both teaching and playing) must be subtracted from the overall working time, when they become more time-consuming, musicians are forced to specialize in teaching or playing activity, losing one of the two sources of income and 'diluting' the remaining one over a higher number of hours.

Also, it is worth noting how such an eventuality may be either an involuntary institutional outcome (context matters) or a voluntarily outcome of self-selection processes. Assume, for example, that TMS teachers tend to self-select by participating in the organization of school activities and that, similarly, concert performers tend to self-select by means of social networking activities. By increasing the duration of organizing activities beyond a certain threshold of engagement, or by increasing social networking activities to a certain threshold, the 'insiders' of the two groups might deliberately marginalize musicians who are interested in adopting a mixed earning strategy. In this case, in fact, the participation in one system would make it impossible to participate in the other, and consequently to contemporarily achieve the composite performance (partly declared, partly tacit) required by the two labour systems. The result is that, even if theoretically feasible, the integration of the two types of activities (teaching and playing) would in fact be unsustainable at least in the long term. This in turn would generate a polarization of musicians, as they would have to 'choose' to become either teachers, or performers. In Pellegrino et al. (2021) the former is considered as a case of 'assimilation without freedom' (p.164).

Finally, the polarization of musicians' work activities could give rise to forms of extractivism, as horizontal relationships are replaced by vertical and hierarchical relationships between teachers and performers (insider-outsider dynamic). In the case of teachers, extractivism lies in having to distribute their hourly wages over a greater number of hours (teaching activities plus organizational activities), while in the case of concert performers, extractivism lies in the imbalance due to the artificial creation of an excess of supply and in the increase of opportunity costs, as both factors may lead to the compression of performers' remuneration. In both cases, the (dis)equilibrium achieved is sub-optimal and further penalized by conducts that, far from being cooperative, may instead be hierarchical and designed to transfer risk from the incumbents to the potential entrants. Finally, to improve musicians' welfare economic policy may allocate resources to: 1) introduce earned income tax credits (EITC) for schools; 2) integrate the artists' income provided that they earn some money in the field; 3) support (also financially) mixed career paths.

Acknowledgements

This work is part of the research funded by Caritro Foundation coordinated by Silvia Sacchetti on *The music education system in the Trentino Province. Developing a creative space for schools, communities and musicians through collaboration and networking*. Thanks to Miriam Fiorenza for constant discussion and Matteo Gaudiello for his work on preliminary descriptives.

References

[Aoki, 2007] Aoki, M. (2007) Endogenizing institutions and institutional changes. *J. Instit. Econ., 3*(1), 1-31.

[Cassar, Meier, 2018] Cassar, L. and Meier, S. (2018). Nonmonetary Incentives and the implications of work as a source of meaning. *J. Econ. Persp.*, 32,(3), 215-238.

[Deci, Ryan, 1985] Deci, E. L., and Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

[Pellegrino et al., 2021] Pellegrino, K., Johnson, E., Wagoner, C.L. and Powell, S.R., 2021. Music Teacher Resilience. In Jenlink P. M. (eds.), *Understanding Teacher Identity*, p.163.

[Stanca et al. 2009] Stanca, L., Bruni, L., Corazzini, L. (2009) Testing theories of reciprocity: Do motivations matter?, *J. Econ. Behav. & Organ.*, 71 (2), 233-245.

[Sweeney, 1973] Sweeney, J.W. (1973) An experimental investigation of the free-rider problem, *Soc. Sc. Res*. 2(3), 277-292.

[Thaler, 2017] Thaler, R. H. (2017). Behavioral economics. *J. of Pol. Econ.*, 125(6), 1799-1805.

[Throsby, 1994] Throsby, D. (1994). A work-preference model of artist behaviour. In Peacock A., Rizzo, I., *Cultural economics and cultural policies*, London, Kluwert Academy Press, pp. 69-80.

Sounds, Rhythms and Artefacts in Social Interaction

Chiara Bassetti[1] and Attila Bruni[1]

[1]*University of Trento, Italy*

Abstract

In this essay, drawing upon microsociological approaches to interaction we consider the way acoustics and rhythm feature in, and qualify, social interaction. Then, taking inspiration from social studies of science and technology, we focus on the role artefacts and technologies play in social interaction. By way of both theory and empirical examples, we propose a view of interaction whereby verbal communication is just one of the semiotic systems contributing to meaning, and artefacts do not feature just as mediators of social interaction but as interactants. As if they were propositional contents, sounds, rhythms, objects, and technologies shape (and are shaped by) interaction and relationships.

1. Introduction

In this short paper, we drawn upon interactionism, ethnomethodology and conversation analysis, and social studies of science and technology to show how social interaction does not merely amount to interpersonal communication but involves a varied range of entities including sounds, rhythms, and artefacts. We first illustrate how microsociology developed a distinguished approach to interaction, making it a phenomenon and a unit of analysis *per se* (Sect. 2). We then consider recent developments in such field, with particular respect to the role of acoustics and rhythms (Sect. 3). Further, we show how sociology reframed the idea of interaction as an exclusive human attribute to a more composite construct which entails the active role played by objects and technologies: far from being simply "tools" or "mediators" of social interaction, they participate to everyday life in various ways, thereby enabling changing forms of relationality (Sect. 4). We conclude considering the artefactual dimension of sounds and rhythms in interaction (Sect. 5), largely dependent on the ways technologies and humans relate to each other.

2. Microsociological approaches to interaction

In contrast with structuralist social theories seeing interaction as guided by a preexisting structure of social relations, a varied body of literature which could be labeled as microsociology —ranging from symbolic interactionism [Mead, 1934; Blumer, 1969] to ethnomethodology [Garfinkel, 1967, 2002] and conversation analysis [Sacks, 1972/1992], passing through Goffman's [e.g., 1959, 1967, 1983] interactionist approach — takes a processual and situated perspective on social action in interaction, which is considered as where social order and culture emerge and undergo both stabilization and change processes.

Symbolic interactionism is chiefly concerned with the question of meaning and interpretation. As stated since the opening of the seminal book by Blumer who systematized Mead's theory, this approach rests on three premises: that we act towards things in the world based on the meaning we attach to such things; that such meaning emerges out everyday interaction with our fellow social members; and that is also where meanings can be challenged, possibly leading to socio-cultural change. "Things in the world" are not just material objects, but also institutions, activities, categories of people and social roles, as much as others' actions. Symbolic interactionism maintains that individuals *interpret* others' actions rather than merely reacting to them. Whereas "[m]ost sociological schemes rest on the belief that a human society exists in the form of an established order of living, with that order resolvable into adherence to sets of rules, norms, values, and sanctions that specify to people how they are to act" [Blumer, 1969: 18), symbolic interactionism sees "the essence of society lie[ying] in an ongoing process of action -

not in a posited structure of relations. Without action, any structure of relations between people is meaningless" [*ivi*: 71].

According to Goffman, social interaction is an ordered activity — he talks indeed of the "interaction order" [1983]. Such an order is sustained by social members thanks to their "capacity to indicate their own courses of physical action and to rapidly convey reactions to such indications from others" [1983: 3]. Coordination is based on such a capacity of ours, on the fact that, whenever we "come into one another's immediate presence, [...] the line of our visual regard, the intensity of our involvement, and the shape of our initial actions, allow others to glean our immediate intent and purpose" [ibidem], hence to design their own actions accordingly. This also includes the expressive dimension of social interaction [Goffman, e.g., 1959, 1967], which has to do with social roles, participants' "faces", impression management, and the performance of deference and demeanour. This is has also been called "interaction ritual" [Collins, 2004].

Garfinkel, who was working in the same period on very similar issues [cf. also Rawls, 2022], makes a step further. Ethnomethodology considers social interaction as the ordered basis of the broader social order. Garfinkel [1967] maintains that social action, or "action in interaction", holds three properties: it is designed to result immediately intelligible and reportable to any other member of a given society (*accountability*); it is designed to be self-evident to our fellow social members without accompanying explanations (*reflexivity*); and that is possible based on the context at hand (*indexicality*). The orderliness of social action in interaction, building up to the broader social order, is thus a collaborative, situated and processual accomplishment by social actors.

Such an accomplishment has been then studied in great detail, and in a variety of contexts of both mundane and professional interaction, by scholars in conversation analysis. Whereas at the beginning "talk in interaction" was the only focus and the main aim was identifying systematic aspects of speech, in time many other modalities, or systems of signs [Goodwin, 2000], have been considered and "multimodal interaction" [Mondada, 2013] has been analysed to understand selected contexts of action, and even to orient the design of artefacts and technologies [e.g., Crabtree et al., 2000].

3. Acoustics and rhythm in interaction

Further developments in the detailed study of interaction also brought to greater attention towards the role of aesthetics and form —over content and symbols— in everyday interaction and the sensemaking it entails. Meaning, one could say, is a fleeting, not just conceptual phenomenon.

Scholars in ethnomethodology and conversation analysis studied the acoustic and rhythmical aspects of talk —and more recently, of multimodal interaction at large—, focusing on phonetics, prosody, the timing of turn-taking [e.g., Auer et al., 1999; Local, 2007; Local & Walker, 2004; Levinson & Torreira, 2015] as much as choral coproduction [e.g., Lerner, 2002]. Many of these analyses highlight the role sounds and rhythm play in managing social relationships in and through interaction (thereby showing once more that the structure of relationships does not univocally determine human actions in interaction; the latter, on the contrary, is where structuring takes place). Goodwin [2015], for instance, noticed how given phonation modalities are employed to build and display intimacy (e.g., a creaky voice bringing towards hugging). Cowley [e.g., 1998] analysed pitch matching and concluded that the chief contribution of such acoustic features of talk is to the enactment of relationships. He also found "that the phenomenon is particularly marked in languages where utterances finish with vowels and, as is the case for Italian, where it has been stylized by musical traditions" [1998: 561].

Rhythm is particularly central in simultaneous speech, or choral coproduction. Examples range from brief occurrences such as greetings [Duranti, 1997; Pillet-Shore, 2012] or laughing [Sacks, 1972/1992: 571], to ritualized instances of "joint speech" [Cummins, 2013] such as cheering, chanting and praying during both religious and secular rituals. Recently, Bassetti and Liberman [2021a, 2021b] investigated prologued occasions of improvised simultaneous talk in Italian conversations, where a rhythm is co-created to allow for choral contribution and to enhance and display the sociability of the occasion and the sociable nature of involved relationships. They identified several tools participants use to found and sustain a common rhythm, including lexical repetition (of self and others) as well as "matching each other in volume, pitch, style of vowel-elongation" [2021b: 102]. They found "[s]election of lexical items *for sound* rather than meaning can serve to animate a group of simultaneous speakers", and "vocal gestures that are elongated or that replicate a prosodic contour enhance the energy of the collaborative speaking" [2021a: 8]. "These conversationalists cultivate flourishes of sound, and this allows the number of people who participate simultaneously to increase" [*ivi*: 12]. In such an endeavour, "[s]peakers not only monitor the talk for its sense, but also for its rhythm

and its aesthetic form" [*ibid.*]. Indeed, Bassetti and Liberman also found music-like features of voicing [e.g., onset and velocity, cf. 2021b: 106-107].

4. Not just humans

Although different in the way of framing reality and conceiving interaction, the structuralist and symbolic approaches have one point in common: namely, the assumption that action is an exclusively human attribute and that, therefore, interactions are by definition those between humans.
Given the increasing relevance information and communication technologies have since the Eighties (first in the forms of the personal computer and the Internet, and today as digital technologies such as smartphones and social media), however, the social sciences have grown increasingly interested in the role performed by technologies, objects, and digital infrastructures. Building precisely on interactionist and ethnomethodological insights and borrowing the idea of reality as a social construction [Berger & Luckmann, 1966] since the Eighties social studies of science and technology (STS) question the role of technologies in society, underlining both the social processes that contribute to their stabilization, and the influence technologies can have on social interaction and social practices. In particular, a number of theorists call for an object-centered sociality [Knorr-Cetina, 1997] and the idea that humans and non-humans are actively involved in the making of social worlds. Thus, more and more studies go beyond the analysis of "purely" human interactions to examine how subjects and technologies "go along" together and support each other (as, for example, in online communities, where human interaction is made possible by technologies).
To paraphrase what Lucy Suchman [2002] has written about the demarcation line between human and technological interaction, it can be said that one of the major issues in contemporary social science debate is no longer where to insert a demarcation line between humans and non-humans but how to insert it. The sociality of machines is by now taken for granted: thanks to machine learning and artificial intelligence properties of relationality and competent interaction are increasingly attributed to software and machines, so that what used to be classified as an *object* is now an *emerging subject*. "Objects interpellate us", writes John Law [1999: 24] to underline the mutual relationship that ties people and technologies together and the active stance which characterizes contemporary technological devices. In the view of this author, persons, texts and objects are bound together in a process of *heterogeneous engineering*, in that: "What we call the social is materially heterogeneous: talk, bodies, architectures, all of these are implicated in and perform the social" [Law, 1994: 2].
Law [1994] therefore suggests the notion of relational materialism to pay closer attention to the roles of the materials involved in interaction: as for "structure", "interaction" is an abstract concept which translates in a multitude of material forms, and these are not simply given in nature but are the more or less stable effects of social practices and collective routines. Whether as machines, information technologies, artworks, commodities or architectures, the different materials of which the world is made have become issues of complexity and controversy when considered not simply as tools or mediators but as active components of social interactions [Pels et al., 2002].

5. Artefacts and rhythms in interaction

A striking example of how interaction entails different materialities can be easily found in music, where instruments are essential to make the interaction possible between musicians and between musicians and the audience. Not only, as musicians know well, the specific instrument one uses will influence his/her performance, so that the relationship one constructs with the instrument is an intimate one. Instruments also become prothesis of the body and at the same time they offer to the subject new possibilities of interacting with other subjects and with the world itself.
Trevor Pinch, for example, has reconstructed the history of the Minimoog (the first cheaper portable keyboard synthesizer sold in retail music store from the beginning of the Seventies) in order to show the relevance of users, marketers and salespeople (and of the interaction between these different social groups) in the development and stabilization of a new technology.
On the basis of this study a new vibrant "interdisciplinary area that studies the material production and consumption of music, sound, noise, and silence and how these have changed throughout history and within different societies" [Pinch & Bijsterveld 2004: 636] has emerged. Beside sociology, the areas involved in the so called "sound studies" range from acoustic ecology, to anthropology of the senses; from history of everyday life, to art studies and ethnomusicology. New fields of study are by definition ambiguous and in-process, but what is peculiar of sound studies is that they focus on the musical experience as a socially constructed activity largely depending

on the interactions between technologies and humans. Technology designers actively "configure" users [Woolgar, 1991], and "script" [Akrich, 1992] the appropriate human-machine interaction into the shape and the material functioning of objects and technologies. Users, in turn, by interacting with artefacts can reconfigure technologies [Latour, 1987], becoming agents of technological change. An example of such a recon- figuration is the use of record turntables for "scratching", a use which was not envisioned by the engineers who first developed turntables and which still nowadays represents a contested musical expression [Pinch, 2003].

But to understand how technologies enable and constrain social interaction, it is important not to take either their constraining or enabling features for granted and to envision instead both how technologies, and social interaction built around technologies, could be different [Pinch, 2008].

In conclusion, through this short essay we have highlighted how sounds, rhythms, objects, and technologies shape, and are shaped by, social interaction. Of course, sounds and objects have always been present in interaction, but todays' novelty relies in their becoming forms of relationality in themselves.

References

[Akrich, 1992] Akrich, M. (1992). The de-scription of technical objects. In W. Bijker & J. Law (eds.), *Shaping Technology/Building Society: Studies in Sociotechnical Change* (pp. 205–224). Cambridge, MA: MIT Press.

[Auer et al., 1999] Auer, P., Couper-Kuhlen, E. & Müller, F. (1999). *Language in time: The rhythm and tempo of spoken interaction*. Oxford University Press.

[Bassetti & Liberman, 2021a] Bassetti, C. & Liberman, K. (2021a). The orderliness and sociability of "talking together". *Social Interaction. Video-Based Studies of Human Sociality*, *4*(1).

[Bassetti & Liberman, 2021b] Bassetti, C. & Liberman, K. (2021b). Making talk together: Simultaneity and rhythm in mundane Italian conversation. *Language & Communication*, 80, 95-113.

[Berger & Luckmann, 1966] Berger, P.L. & Luckmann, T. (1966). *The Social Construction of Reality*, Penguin Book, London.

[Blumer, 1969] Blumer, H. (1969). *Symbolic interactionism*. University of California Press.

[Collins, 2004] Collins, R. (2004). *Interaction ritual chains*. Princeton University Press.

[Cowley, 1998] Cowley, S.J. (1998). Of Timing, Turn-Taking, and Conversations. *Journal of Psycholinguistic Research,* 27(5), 541-571.

[Crabtree et al., 2000] Crabtree, A., Nichols, D., O'Brien, J., Rouncefield, M. & Twidale, M.B. (2000). Ethnomethodological informed ethnography and information system design. *Journal of the American Society for Information Science*, *51*(7), 666–682.

[Cummins, 2013] Cummins, F. (2013). Joint speech: The missing link between speech and music?. *Percepta: Journal of Musical Cognition,* 1(1), 17-32.

[Duranti, 1997] Duranti, A. (1997). Polyphonic discourse: Overlapping in Samoan ceremonial greetings. *Text*, 17, 349–381.

[Garfinkel, 1967] Garfinkel H. (1967) *Studies in ethnomethodology*. Prentice–Hall.

[Garfinkel, 2002] Garfinkel H. (2002). *Ethnomethodology's program: working out Durkheim's aphorism*. Rowman & Littlefield.

[Goffman, 1959] Goffman E. (1959). *The presentation of self in everyday life*. Anchor Books.

[Goffman, 1967] Goffman E. (1967). *Interaction ritual: essays on face-to-face behavior*. Aldine Publishing.

[Goffman, 1983] Goffman E. (1983). The interaction order. *American Sociological Review,* 48(1), 1-17.

[Goodwin, 2000] Goodwin, C. (2000). Action and embodiment within situated human interaction. *Journal of Pragmatics*, 32, 1489-1522.

[Goodwin, 2015] Goodwin, M.H. (2015). Haptic Sociality: The Embodied Interactive Constitution of Intimacy through Touch. Keynote lecture, *Revisiting Participation*, Basel, Switzerland.

[Knorr-Cetina, 1997] Knorr-Cetina, K. (1997). Sociality with Objects, *Theory, Culture and Society*, 14(4): 1–30.

[Latour, 1987] Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard university press.

[Law, 1994] Law, J. (1994). *Organizing Modernity*. Blackwell.

[Law, 1999] Law, J. (1999). 'Machinic Pleasures and

Interpellations', Centre for Science Studies and the Department of Sociology, Lancaster University, http://www.comp.lancs.ac.uk/sociology/soc067jl.html.

[Lerner, 2002] Lerner, G.H. (2002). Turn-sharing: the choral co-production of talk in interaction. In C. Ford, B. Fox & S. Thompson (Eds.), *The Language of Turn and Sequence* (pp. 225-256). Oxford University Press.

[Levinson & Torreira, 2015] Levinson, S.C. & Torreira, F. (2015). Timing in turn-taking and its implications for processing models of language. *Frontiers in Psychology*.

[Local, 2007] Local, J. (2007). Phonetic detail and the organisation of talk-in-interaction. In *Proceedings of 16th international congress of phonetic sciences*, Saarbrucken, Germany, pp. 1-10.

[Local & Walker, 2004] Local, J. & Walker, G. (2004). Abrupt-joins as a resource for the production of multi-unit, multi-action turns. *Pragmatics*, 36(8), 1375–1403.

[Mead, 1934] Mead, G.H. (1934). *Mind, self and society*. University of Chicago Press.

[Mondada, 2013] Mondada, L. (2013). 37. Multimodal interaction. In C. Müller et al. (Ed.), *Body - Language - Communication. Volume 1* (pp. 577-589). De Gruyter Mouton.

[Pels et al., 2002] Pels, D., Hetherington, K. & Vandenberghe, F. (2002). 'The Status of the Object', *Theory, Culture and Society* 19(5/6): 1–21.

[Pillet-Shor, 2012] Pillet-Shore, D. (2012). Greeting: Displaying Stance Through Prosodic Recipient Design. *Research on Language & Social Interaction*, 45(4), 375-398.

[Pinch, 2003] Pinch, T. (2003). Giving Birth to New Users: How the Minimoog Was Sold to Rock and Roll. In N. Oudshoorn & T. Pinch (eds.) *How users matter. The co-construction of users and technology*. MIT Press.

[Pinch, 2008] Pinch, T. (2008). Technology and Institutions: Living in a Material World. *Theory and Society*, 37, 5: 461-483.

[Pinch & Bijsterveld, 2012] Pinch, T. & Bijsterveld, K. (eds.) (2012). *The Oxford Handbook of Sound Studies*, Oxford University Press.

[Rawls, 2022] Rawls, A. (2022). Situating Goffman's "Interaction Orders" in Durkheim's social fact lineage. *Etnografia e ricerca qualitativa*, 15(1), 27-6.

[Sacks, 1972/1992] Sacks, H. (1972/1992). *Lectures in Conversation*, edited by G. Jefferson. Blackwell.

[Suchman, 2002] Suchman, L. (2002). Human/Machine Reconsidered, Department of Sociology, Lancaster University, http://www.comp.lancs.ac.uk/sociology/ soc040ls.html.

[Woolgar, 1991] Woolgar, S. (1991). Configuring the user. The case of usability trials. In J. Law (ed.) *A sociology of monsters. Essays on power, technology and domination* (pp. 58-99). London, Routledge.

The Network Dimensions of Musical Production

Mario Diani and Silvia Sacchetti

Dipartimento di Sociologia e Ricerca Sociale, Università di Trento, Italy

Abstract

In this paper we look at the relational determinants of record production. Drawing upon data from 253 professional music teachers in Trentino, in the Italian North East, we show how record production is affected by the traits of musicians' collaboration networks.

1 Introduction and main hypotheses

Music making has long been recognized as a social process consisting of innumerable interactions between a multiplicity of actors (e.g. Becker 1982). Researchers interested in its relational and structural dimensions have increasingly relied on network analytic tools to systematically explore those mechanisms and their implications (e.g. Crossley 2020). We contribute to this line of research through the analysis of the impact of relational and structural properties over the artistic production of 253 professional music teachers active in the music schools of Trentino. We ask whether their propensity to engage in record production is related to the characteristics of the relational systems in which they are embedded, such as volume of collaborative ties, balance between ties internal and external to the local music schools' system, and organizational features (in particular, the prevailing relational patterns) of the school to which musicians are contracted. In exploring these issues we rely primarily on approaches to the embeddedness of social action in sociology and organization theory (e.g. Granovetter 1973; Burt 2005), and on our own theorizing on the mechanisms that secure the vitality of individuals and/or collectivities (Sacchetti, 2022).

In the first place, we may expect record production to be correlated with the volume of collaborative ties in which each musician is involved. One should note that collaborations are not necessarily linked to record production. People may collaborate in the context of gigs and concerts; they may jointly contribute to theater shows and other instances of performative arts, or cooperate in music education, or jointly conduct bands and ensembles. The ties forged in all these settings may provide the incentives to engage in record production, but may also work positively against them, as some may prioritize live performance over music composing or recording (Finnegan, 1998, chap. 3). Still, we may plausibly expect musicians with a high volume of collaborative ties to be more likely to find the motivations and the opportunities to also engage in record production:

H1. Musical production will be positively correlated to the overall volume of collaborative ties in which music teachers are involved.

At the same time, not only the volume of collaborators may matter, but also their location. Following Granovetter (1973), the more music teachers collaborate with musicians external to their local environment, the more one could expect them to receive new ideas, technical and emotional support, which might lead to a more active involvement in record production. The relative weight of external ties may be assessed using the E-I index (Krackhardt and Stern 1988), that measures the amount of heterophily or homophily in one's network. In our case, the reference will be

collaborative ties to musicians that are internal or external to the TMS system:

H2. *Musical production will be positively correlated to the proportion of collaborative ties that musicians have outside their local context/regular working environment.*

The structural configuration of the ties in which people are involved might also matter, as the most conducive networks to musical productivity might be those with a balanced presence of local and translocal ties. Being connected to musicians operating in the same environment through daily, face-to-face interactions provides people with a sense of belongingness in an artistic community; it may also encourage them to engage in musical production by mechanisms of mutual control and competition as well as positive influence and emulation. All this may be missing if people are only connected to people located in different, distant environments. At the same time, an exclusive reliance on local, densely-knitted ties may also facilitate complacency and self-referentiality, corresponding to a situation of lock-in (Sacchetti 2022), in which musicians lack the innovative ideas and the exposure to broader sets of experiences that might ultimately encourage production. To measure the balance of one's network we use the square of the E-I index. By squaring we are able to contrast networks with high heterophily or homophily, treated as a joint category (the index will tend to 1 in both cases) with networks with a balanced presence of heterophilic and homophilic connections (the index will tend to 0). Accordingly:

H3. *Musical production will be higher for musicians that may rely on a balanced combination of local and external ties in relation to their working environment*

We can also capture the combination of local embeddedness and external outreach by looking at musicians' position within a larger core-periphery structure. In particular, actors in a semi-peripheral position in their network of collaborations should be best located to bring innovation and engage in productive activity, as suggested by studies devoted to music (Uzzi and Spiro 2005) as well as other fields (Cattani and Ferriani 2008):

H4. *Musical production will be higher for musicians that occupy an intermediate position between core and periphery in their professional environment*

Finally, we also need to look at how the combination of relational patterns within and across specific organizational may affect organizational culture. Burt (2005) notes how organizations need to balance closure and brokerage mechanisms to be effective. Working units need a balance between their capacity to act in a cohesive, integrated manner (reflected in a sizeable number of internal ties), and brokerage, i.e., the capacity of some of their member to fill structural holes and to have access to a broader environment. Performance is higher in groups that achieve that balance, than in groups which are imbalanced in one or the other direction; it is minimal among units that display neither brokerage nor cohesion mechanisms (Burt 2005, 139). Accordingly, we may suggest that

H5a. Musical production will be highest for musicians who are located in schools where on the aggregate teachers hold a balanced combination of internal and external ties

H5b. Musical production will be lowest for musicians who are located in schools where on the aggregate teachers are poorly connected both internally, and to other musical milieus.

2 Analysis

Given that the population is evenly split between music teachers who have and have not at least one record production to their credit, it seems appropriate to conduct two separate analyses looking for the determinants first, of presence or lack of involvement in that particular activity, and then of the amount of that involvement. Results are reported in tables 1 and 2 below.

The most consistent finding is the significance of the gender dimension across all the models we have fitted. Unfortunately, our data do not allow us to established whether women's lower involvement in record production depend primarily on glass-ceiling type of mechanisms, imbalanced division of labor within the family, persistent lack of self-confidence, or else. They point, however, at female musicians' persistent assumption of what are primarily teaching roles.

Moving to our substantive hypotheses, H1 was a purely relational one, proposing that "Musical production will be positively correlated to the overall volume of collaborative ties in which music teachers are involved." This has been constantly supported in all models barring one (model 4 in Table 1): musicians who are involved in several musical collaborations are also more likely to have

some record production to their credit, and a higher number too than more isolated ones. Taking into account that there is no strong correlation between the overall amount of collaborations, and the amount of ties people have built around record production, this is a non trivial finding. It adds one more piece of evidence to the long established view of musicking as a relational process (as summarized e.g. by Crossley 2020).

We also suggested that productivity might be related to involvement in ties that reached out of the setting in which musicians were primarily embedded, namely, the Trento music school system (H2). However, we found no support to the expectation that musical production be positively correlated to the proportion of musicians' collaborative ties outside their local context. As such, strong orientation to external ties, measured by the E-I index, did not correlate with higher productivity. The square E-I index, however, was found to matter for variations in productivity. Rather than reliance on ties outside of one's local relational context, what mattered was a balanced combination of external and local/internal (to the system rather than to specific schools) connections.

Our data support H3 that "Musical production will be higher for musicians that may rely on a balanced combination of local and external ties in relation to their working environment". Rather than on the volume of ties, this finding points at the importance of coupling embeddedness in specific settings with relations that give access to ideas and stimuli from other milieus. Musicians holding many but highly dispersed connections risk isolation from any specific context; in contrast, musicians strongly integrated in their local community but with little contact with the outer world are exposed to mechanism of self-referentiality and lock-in.

We also found the importance of a balance between internal and external ties to matter at the organizational level. In particular, musical production turned out to be highest for musicians located in schools with a balanced combination of internal and external ties (H5a). However, the opposite does not hold for schools that are weak on both grounds. Schools with that profile perform in a similar way to schools with an intermediate profile.

Finally, our data do not support H4: "Musical production will be higher for musicians that occupy an intermediate position between core and periphery in their professional environment". Whether individuals occupied a peripheral, central, or intermediate position in the web of ties that make up the local musicians' field did not seem to affect their productivity.

3 Conclusions

Summing up, our findings suggest that balance between local and external ties plays an independent, non-negligible role in accounting for individual record production. This applies not only in reference to the distribution of ties for each individual, but also at their balance within each school. This suggests that further research is needed on the organizational properties that can play an autonomous role in encouraging artistic production.

This conclusion, however, needs to be qualified. First, it applies only to organizations where teachers are involved in a high number of connections both within and outside the local scene – this is different from what we found at the individual level with the square E-I index. Second, and most important, the overall distribution of internal and external ties is a partial measure of organizational traits, inasmuch as it largely stems from the aggregation of individual properties. It needs to be supplemented with evidence on other aspects of organizational processes that might affect productivity, such as the relative weight assigned by managers to teaching v. performance, lack or presence of interest in their integration, organizational arrangements that encourage participation in the life of the school.

Acknowledgements

This work is part of the research funded by Caritro Foundation coordinated by Silvia Sacchetti on *The music education system in the Trentino Province. Developing a creative space for schools, communities and musicians through collaboration and networking*. Thanks to Miriam Fiorenza for her work on data set construction.

References

Becker, H. (1982). *Art Worlds*. Berkeley, CA: University of California Press.

Burt, R.S. (2005). *Brokerage & Closure*. Oxford: Oxford University Press.

Cattani, G., and S. Ferriani (2008). "A Core/Periphery Perspective on Individual Creative Performance." *Organization Science* 19: 824–44.

Crossley, N. (2020). *Connecting Sounds.* Manchester: Manchester University Press.

Finnegan, R. 1998. *The Hidden Musicians*. Cambridge: Cambridge University Press.

Granovetter, M. (1973). The Strength of Weak Ties. *American Journal of Sociology*, 78, 1360–80.

Krackhardt, D., and R.N. Stern (1988). "Informal Networks and Organizational Crises." *Social Psychology Quarterly* 51: 123–40.

Sacchetti, S. (2022). The vitality of people. Paper for *IIPPE-International Initiative for the Promotion of Political Economy*. Bologna.

Uzzi, B. and J. Spiro. (2005). "Collaboration and Creativity: The Small World Problem." *American Journal of Sociology* 111: 447–504.

		Model 1	Model 2	Model 3	Model 4	Model 5
Total collaborations	(H1)	1.11**	1.10**	1.11**	1.00	0.98
		(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Gender (0/1; 1=male)		3.01**	3.02**	2.98**	2.78**	2.81**
		(0.85)	(0.86)	(0.85)	(1.04)	(1.09)
Semi-peripheral position (0/1)	(H4)		0.89	0.89	1.45	1.54
			(0.26)	(0.25)	(0.57)	(0.62)
Low performance expected (Burt: 0/1)	(H5b)			0.67	1.41	1.36
				(0.23)	(0.70)	(0.67)
High performance expected (Burt: 0/1)	(H5a)			0.76	1.16	1.03
				(0.25)	(0.47)	(0.43)
E-I index	(H2)				1.01	1.10
					(0.25)	(0.29)
E-I index square	(H3)				0.41)	0.45
					(0.25)	(0.28)
constant		0.37**	0.38**	0.48*	1.51	1.47
		(0.09)	(0.09)	(0.15)	(0.96)	(0.95)
N		253	253	253	156	143
Prob>chi2		0.00	0.00	0.00	NS	NS
Pseudo R2		0.11	0.11	0.11	0.06	0.06

Table 1. *Logistic regressions on musicians with at least one production* (NB: odds ratios; s.d. in brackets; model 5 excludes musicians from CDM school; ** $p < 0.01$; * $p < 0.05$)

		Model 1	Model 2	Model 3	Model 4	Model 5
Total collaborations	(H1)	0.04**	0.04**	0.03**	0.03**	0.03**
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gender (0/1; 1=male)		0.41**	0.40**	0.38**	0.49**	0.48**
		(0.14)	(0.13)	(0.13)	(0.16)	(0.18)
Semi-peripheral position (0/1)	(H4)		-0.06	0.03	0.09	0.10
			(0.11)	(0.17)	(0.12)	(0.14)
Low performance expected (Burt: 0/1)	(H5b)			0.03	-0.00	0.02
				(0.17)	(0.19)	(0.19)
High performance expected (Burt: 0/1)	(H5a)			0.61**	0.59**	0.50**
				(0.13)	(0.14)	(0.15)
E-I index	(H2)				-0.02	-0.07
					(0.10)	(0.11)
E-I index square	(H3)				-0.34*	-0.46*
					(0.17)	(0.19)
constant		0.52**	0.54**	0.28	0.44*	0.56*
		(0.13)	(0.14)	(0.16)	(0.22)	(0.24)
N		126	126	126	105	94
Prob>chi2		0.00	0.00	0.00	0.00	0.00
Pseudo R2		0.11	0.11	0.15	0.18	0.11

Table 2. *Poisson regressions on number of record productions* (NB: s.d. in brackets; model 5 excludes musicians from CDM school; ** $p < 0.01$; * $p < 0.05$)

From “Space” to “Spaces”: Enabling Interaction with Multiple Environments to Contribute to Politics of Reuse and Audience Development

Luca Danieli[1]

[1]*University of Music and Performing Arts Graz, Austria*

Abstract

Reasoning around the topics of sustainability and the European Green Deal is promoting novel approaches to rethink cultural networking and technological innovation in sight of a more resilient economy. Two important themes involve the design of new models to include citizens in the management of culture and the adaptive reuse of available infrastructure to expand audience participation in rural areas and suburbs. Promoting the reuse of available infrastructure means to conceptualize technological interaction in relation to different types of architectures and sociological contexts, boosting new creative practices that account for opportunities to be replicated and scaled up by capitalizing on spaces that were not originally designed to host cultural exhibitions. This scenario can be an opportunity to reconsider how digital technologies and physical environments interact in the perspective of sustainable development, enabling new technological designs that adapt more easily to different contexts. Better and more flexible curatorial practices to empower the community in presenting innovative exhibitions through bottom-up strategies can become a key factor in supporting new inclusive models of cultural management. Such an approach could be informed by a shift from conceiving technological interaction in relation with the abstract space to one in relation to multiple abstracted spaces, in which creative initiatives are accompanied by innovative experimental methodologies and technologies for cultural dissemination that can eventually enter the market and promote new forms of cultural development on a macro-systemic level.

1 Introduction

With the definition of the 2030 Agenda for Sustainable Development, the European Union has undergone profound changes in its objectives and operating framework. The Horizon Europe program has introduced new research priorities focused on culture to enable new paradigms for social inclusion and empower local communities through innovative management models aimed at expanding the sharing of cultural activities among citizens. The New European Bauhaus program takes a relevant focus, promoting initiatives at the intersection of arts and architecture to contribute to the design of more sustainable models to interact with the environment towards a resilient economy. One topic that is at the centre of attention of current politics supported by the European Union consists in the opportunity for arts to revitalize rural and suburban areas, since art and culture are considered as valuable means to accelerate environmental progress [Helicon Collaborative, 2018]. Music is considered to play an important role in such a shift, for its power in promoting

participatory engagement with the community [Wolcott, 2016; Horwitz et al., 2022].

The reuse of spaces to generate innovative cultural services is an important objective within the aforementioned European framework. On one hand, it allows us to capitalize on available infrastructure and generate new dynamics supporting audience development on a macro-systemic level [Viola, 2022]. On the other hand, the approach raises opportunities to reach rural areas more effectively – since the distance from an event is considered as a major factor obstructing cultural participation [Getzner, 2020]. Empowering smaller audiences by reaching dispersed destinations may become a powerful asset to contribute to fighting popular trends in the entertainment industry that favor the creation of festivals, which are considered unsustainable from an environmental perspective as they tend to concentrate large groups of paying participants in uncontaminated fields [Creative Europe, 2019], with negative impacts related to carbon dioxide pollution and waste dispersion.

2 Audience development and new spaces

From a sociological perspective, trends in consumption have undergone substantial changes in dynamics to experience cultural products. The sharing economy highlighted patterns of appreciation by consumers towards new forms of alternative and sustainable tourism aimed at rediscovering natural or folkloristic destinations [Robinson et al., 2011]. Such trends invested the consumption of culture in similar ways, with rising patterns characterized by novel interests in experiencing artistic content in unusual settings through new forms of adaptive reuse of available cultural heritage [Richards, 2011]. The shift poses new challenges for museums and other cultural institutions, since old paradigms aimed at centralizing cultural production and dissemination in dedicated centers located in urban areas have decreased in attractiveness. These challenges have been further expanded by the COVID-19 crisis, which accelerated the need for cultural centers to capitalize on more inclusive management models as a way to promote audience participation in non-traditional ways [Choi & Kim, 2021].
The interest toward new management models for social inclusion triggers novel paradigms in the technological sector to empower communities so as to promote new approaches for cultural dissemination. This topic presents simultaneously an opportunity and a challenge for the field of electroacoustic music or other artistic formats that include digital technologies. New research in digital creativity include the creation of cross-sectoral performances bridging music, dance, theater, and moving images with innovative undertakings mediated by digital media either independently or in combination, with the effect to increase the landscape of digital-led artistic outputs conceived for live exhibition. One research that has moved in this direction consists in the Creative Europe-funded project "Interfaces" [Landy, 2019], coordinated by the organization Onassis Stegi (Greece) and including partners like IRCAM (France) and the ZKM | Centre for Art and Media (Germany). The project aimed to open a discussion on the possibility to rethink and develop new approaches to artistic technology for audience development, including new performance formats in new innovative spaces and across disciplines.

3 Adaptive digital curatorship

The rising paradigm to reuse available infrastructure to promote new forms of cultural development and networking poses problems for scaling up the presentation of outputs produced within the creative and technological sectors on a macro-systemic level. Initiatives such as the mentioned "Interfaces" project [Landy, 2019] tend to imply site-specific approaches to content creation, which may find difficulties for replication in diverse contexts. Whenever conceived for site-specific exhibition, an artwork may perform well in the original environment and poorly in alternative spaces, since the reuse of cultural heritage often presumes environments characterized by different spatial architectures not intended to host musical performances or digital exhibitions.
On one hand, the problem affects research initiatives developed within international projects and artistic residencies, since these innovative management principles may turn useful to maximizing the potential replication of produced artworks and bring benefits on the side of public expenditure. On the other hand, the developing framework on reuse affects the creative process of artistic creators, who are asked more and more to generate flexible cultural products that can perform well in impromptu environments, since irregular spaces force curators and designers to constantly rethink art display tactics [Lindsay, 2013]. Such types of spaces may include historic buildings in urban centres to be re-functionalized, old factories in suburb areas, railways, platforms and stations to be redeveloped, religious buildings, as well as

abandoned military bases, strongholds, or forts. Although the long-lasting reactivation of such types of environments should involve steady policies and investments by municipalities or donors, the depicted sociological context may turn music and arts into vehicles to better attract the interest of the community and local governments towards regenerative opportunities for cultural development, by experimenting new forms of cultural products in the territory and retrieving information on their potential impact.

Such types of inactive and adaptive spaces may eventually present potential to become novel outposts for the dissemination of culture and artistic performances in rural areas and suburbs, by capitalizing on voluntary actions and local policies through new forms of distribution models. An example can be represented by the case of the *Anfiteatro del Venda* [Euganamente, n.d.], an old landslide-mitigation structure that was privately converted into a space for cultural events organized through self-run voluntary initiatives by groups of young citizens to host performances ranging from movies to classic music. The term "adaptive space" not only refers to unused spaces in search for regenerative actions. It includes other types of spaces with potential for exhibition such as public schools, which could be conceptualized as living museums with educational purposes for the whole community if enabled with new affordable technologies to promote such transition over time. An example in this direction may consist in the residency initiative by researcher Rosa Llop as part of the European Interstice project [Universitat Autònoma de Barcelona, 2022], in which the artist developed an audiovisual experience with educational purpose to be presented in both schools and art centers.

Figure 1: *Example of adaptive reuse, the Anfiteatro del Venda, Gazigliano Terme (PD), Italy*

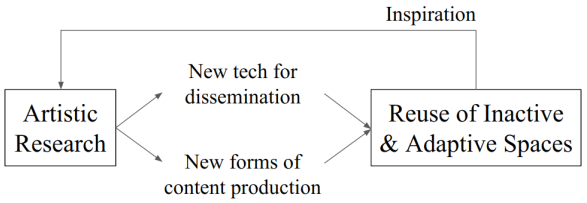


Figure 2: *Circular model for technological innovation inspired by reuse practices*

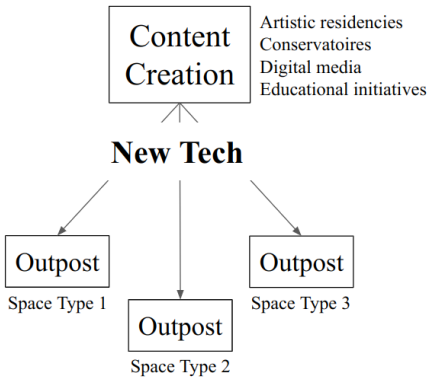


Figure 3: *Distributed model for cultural development enabling replication of content and new technologies*

4 From "space" to "spaces"

The present article suggests a shift in thinking about the interrelation between music (or digital art technologies) and space to account for innovative curatorial models that may be replicated in multiple scenarios, moving from considering technological interaction and artistic creativity in relation to the abstract space to considering them in relation to multiple abstracted spaces, through new research aimed at generalizing different architectural and sociological properties to inform innovative creative approaches with solid opportunities for replication in different contexts.
Acting on and accounting for opportunities to better promote well-curated exhibitions in different environments, as well as opportunities to facilitate the implementation of technology in different contexts may spark creativity in generating new forms of digital innovation together with innovative models or formats for cultural sharing. Such an approach implies a raise in awareness in relating artistic research with innovative methodologies to improve the exhibition and scalability of produced outputs through new forms of curatorial strategies. Previous research on audience participation led the way to introduce anthropological thinking and contextual factors in

art-making practices [Ardenne, 2002], towards the generation of new flexible models of co-creativity and interactivity mediated by innovation in computer science [Hödl et al., 2012; Shilton 2022]. To day, such approaches have mostly focused on the interrelation between performers and digital technologies from the perspective of content creation, and emphasis on investigating emerging characteristics in relation to different physical environments may lead to the generation of new technologies that integrate spaces more efficiently for exhibition purposes.

As highlighted in the introduction, local communities are apt to play a crucial role in the development of new models for cultural management through current Horizon Europe policies. The opening context which foresees a role for adaptive spaces to transform into cultural outposts in sight of audience engagement practices should be supported by new technological paradigms to facilitate citizens in the organization and implementation of innovative culture, and the opportunity to regenerate available cultural heritage may accelerate new forms of distributed management models, connecting museums and larger organizations with local communities through new forms of digital innovation.

References

Ardenne. P. (2002). *Un Art contextuel*. Paris: Editions Flammarion.

Choi, B., & Kim, J. (2021). Changes and Challenges in Museum Management after the COVID-19 Pandemic. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(2): 148.

Creative Europe. (2019). *Co-operation of small music venues. Call for proposals EAC/S17/19*. Luxembourg: Publications Office of the European Union.

Euganamente. (n.d). Anfiteatro del Venda. *www.euganamente.it*.

European Commission. (n.d.). *Digital Transition*. Reform-support.ec.europa.eu.

Getzner, M. (2020). Spatially Disaggregated Cultural Consumption: Empirical Evidence of Cultural Sustainability from Austria. *Sustainability*, *12*(23): 10023.

Helicon Collaborative. (2018). *Farther, Faster, Together: How Arts and Culture Can Accelerate Environmental Progress* (ArtPlace Field Scan, Vol. 4). ArtPlace America.

Horwitz, E. B., Korošec, K., & Theorell, T. (2022). Can Dance and Music Make the Transition to a Sustainable Society More Feasible? *Behavioral Sciences*, *12*(1): 12.

Hödl, O., Kayali, F., and Fitzpatrick, G. (2012). Designing Interactive Audience Participation Using Smart Phones in a Musical Performance. In *Proceedings of the 38th International Computer Music Conference, ICMC 2012, September 9-14, 2012*. Ljubiana, Slovenia.

Landy, L. (2019). Bringing New Music to New Audiences. *Organised Sound*, *24*(3), 1-3.

Lindsay, G. (2013). *The Denver Art Museum and the Bilbao Effect* (PhD diss.). The University of California Berkeley.

Richards, G. (2011). Creativity and Tourism: The State of the Art. *Annals of Tourism Research*, *38*(4), 1225-1253.

Robinson, P., Heitmann, S., & Dieke, P. (Eds.). (2011). *Research Themes for Tourism*. Wallingford, UK: CAB International.

Shilton, D. (2022). Sweet Participation: The Evolution of Music as an Interactive Technology. *Music & Science*.

Universitat Autònoma de Barcelona. (2022, Jan 25). Artist Rosa Llop to conduct artistic and educational actions as part of the Interstice project. *www.uab.cat*.

Viola, S. (2022). Built Heritage Repurposing and Communities Engagement: Symbiosis, Enabling Processes, Key Challenges. *Sustainability*, *14*(4): 2320.

Wolcott, S. J. (2016). The Role of Music in the Transition Towards a Culture of Sustainability. *Empowering Sustainability International Journal*, *3*(1).

Teatrosofia.
Interactions between Philosophy and Musical Performance

Enrico Piergiacomi

Technion University, Israel Institute of Technology | Bruno Kessler Foundation, Center for the Religious Studies (FBK-ISR)

Abstract

Teatrosofia is a scientific dissemination project launched in November 2014 that investigates the ways in which ancient philosophers interpreted theatrical and musical performance. Until June 2021, every three weeks the journal *Teatro e Critica* published an essay on an aspect of this topic, followed by an appendix with an Italian translation of the main sources discussed in the text. The number of articles published so far is 118. In this article, I outline the goals/methods of the project and offer a very concise case study.

1 Introduction

Teatrosofia starts from the so-called "Pre-Socratics" and is expected to finish with Damascius, or with the closure of the school of Athens (529 AD). This event is conventionally interpreted as the end of ancient philosophy and the beginning of the medieval philosophical tradition [Napoli 2004]. Although this distinction is debatable, for numerous medieval philosophers have continued to think with methods, notions, and languages of the ancients (cf. *e.g.* [Westra, 1992]), the closure of the school of Athens is an important and very symbolic historical event. It can therefore constitute a useful yet arbitrary point of arrival of the investigation of *Teatrosofia*.
The target audience of the column is a cultured audience interested in music and performative arts without being experts in classics and philosophy. Consequently, *Teatrosofia* limits the use of technical language, while maintaining the rigor of the scientific method and refusing to simplify the issues or theories analyzed.
In concrete terms, the long-term end would be to publish five volumes that would contain rewritten versions of the articles that have been (and will be) published in *Teatro e Critica*. At present, the first volume (*From the Presocratics to the first Platonists Plato*) is close to completion.

2 Historical and theoretical goals

Teatrosofia has two *raisons d'être*. The first is that there is no systematic study dedicated to the interpretation of musical and theatrical performances by ancient thinkers. The studies carried out so far are almost exclusively focused on "major" authors, for instance Plato, Aristotle, and the Stoics (cf. recently [Halliwell, 2011].
Yet there are many other interesting figures who spoke of music and the performative arts. The studies dedicated to the authors mentioned above have neglected promising research paths. Thus, Plato is mainly studied for his attack on poetry in the *Ion*, the *Republic*, and the *Laws*, where it is presented as a discipline that leads astray and gives rise to emotional disorder. Far less explored is the "dramatic" structure of Platonic dialogues, which could be read as theatrical dramaturgies, where what emerges from the relationships between the characters is more important than the arguments themselves [de Luise 2017]. In the case of Aristotle, scholars have explored the musical catharsis of book VIII of the *Politics* and of the *Poetics*, neglecting other interesting texts that shed light on Aristotle's view of the performing artist. Suffice it to mention chapter 5 of book VII of the *Nicomachean Ethics*, which refers to the art of acting to explain incontinence, or the tendency to pursue evil against one's will [Crisp 2004, 124]. Finally, there exist numerous studies on the metaphor of the Stoic

sage-actor who knows how to interpret the role assigned to him by fate or by divine providence (*i.a.* [Vegetti 1983]). However, this theme also needs to be studied in greater depth in order to trace how it evolves over time. In fact, the metaphor of the sage-actor undergoes a radical metamorphosis, in the thought of Stoics such as Aristo of Chios, Seneca, Epictetus, and Marcus Aurelius.

A comprehensive study of the discourse of ancient philosophers on music/performative arts will shed light on some aspects of the thought of these thinkers. Many references to music and other performing arts have a strategic nature, for they are used by philosophers to support their ontological, epistemological, and ethical arguments.

The second main reasons for cultivating *Teatrosofia* is of theoretical nature. The historical comparison with ancient philosophers allows us to identify and define some recurring concepts associated with theatrical and musical performance, such as "rhythm"/"catharsis". By examining what ancient philosophy has to say about these key terms, two different lines of inquiry can be opened. On the one hand, it is possible to collect these fundamental concepts in a "syllabary" and try to illustrate the main definitions that were ascribed to them in antiquity. In turn, these proposals could encourage us to reconsider some of the prejudices that we have towards music/theatre and, by extension, to investigate and interrogate them with greater awareness. On the other hand, this investigation would lead us to consider ancient philosophical reflections on more general issues, many of which are still the subject of debate.

3 Methodology and dissemination

From a methodological point of view, these theoretical objectives show how music/theatre and philosophy could positively interact. Indeed, both could learn something from each other. With the help of theoretical reflection, people involved in musical and theatrical productions could better understand the concepts and problems that these arts face on a daily basis. On the other hand, philosophy can elaborate, with the study of performance, a rational method / discourse that can account for the specificity of theatrical language and stage practice. Thus, a sort of "sacred alliance" is established between the two disciplines, which leads to a kind of hybrid field: a "theatrical philosophy", or a "philosophical theatre".

Such a theoretical move could appear questionable to specialists, who might see it as a collision of two incompatible fields: history of ancient thought and performing arts. However, we can interpret it as a positive attempt to create an interdisciplinary dialogue with the hope of fostering collaboration between philosophers and musicians/actors.

In this respect, an interesting form of collaboration could be a "lecture-performance", by which I mean a scholarly presentation accompanied by performative elements. An example is my lecture-performance *From Sound to Mystery*, which focused on Augustine's use of music as a means to understand the providential order of the world. It took place in February 2022 in cooperation with the Conservatorio Bonporti, the Muse, the University of Trento. A lecture-performance could address a complex notion related to music (*e.g.* catharsis or rhythm), using ancient thinkers as interlocutors in order to gain a better understanding of it.

4 Case study: Heraclitus' harmony

I conclude with a brief example on how ancient philosophers can help us reconsider our common conceptions of music and performing arts: Heraclitus' criticism of musical catharsis (for textual references, cf.[Piergiacomi 2018]).

This Presocratic philosopher (535-475 BC) defends the unity or «harmony» of opposites, including that of beauty and ugliness. Heraclitus dialectically recovers this notion from musicians. On the positive side, the latter show that beautiful and ugly sounds are opposites that form a single whole (= the melody). But since musicians of Heraclitus' time were credited with the power to soothe excessive passions with their songs, *e.g.* to generate a mean between anger and tranquility, Heraclitus may have also argued that, on the negative side, music risks to destroy the unity between these two emotional opposites.

Now, if we consider the Heraclitean theory, we can problematize the ordinary view that music must aim at a sort of catharsis. Indeed, Heraclitus could lead us to think that the musical art may harm us, insofar as it "conceals" the "dark" side of reality as it is blended with the good/positive side. In a constructive sense, he can point out to a very different view of the goal of music: to cause spiritual anguish, *i.e.* to create melodies that would allow us to grasp the complexity of the world and the unreality of oppositions. Due to its power to unify beautiful-ugly sounds, the musical art could be conceived as a means for understanding that everything is mixed with everything.

References

[Crisp, 2004] Crisp, R. (ed.) (2004). *Aristotle: Nicomachean Ethics*. Cambridge University Press.

[de Luise 2017] de Luise, F. (ed.). *Il teatro platonico*

della virtù, Università degli Studi di Trento.

[Halliwell, 2011] Halliwell, S. (2011). *Between Ecstasy and Truth. Interpretations of Greek Poetics from Homer to Longinus*, Oxford University Press.

[Napoli, 2004] Napoli, V. (2004). Note sulla chiusura della Scuola neoplatonica di Atene. *Schede Medievali*, 42, 53-95.

[Piergiacomi, 2018] Piergiacomi, E. (2018). I rimedi di Eraclito. Empietà della catarsi?. *Teatro e Critica*, 14/10/2018. Accessed: 31/10/2022.

[Vegetti 1983] Vegetti, M. (1983). La saggezza dell'attore. Problemi di etica stoica. *Aut Aut*, 195-196, 19-41.

[Westra, 1992] Westra, H.J. (ed.) (1992). *From Athens to Chartres. Neoplatonism and Medieval Thought*. Brill.

Acoustic Views of Dorgali

Francesco Corrias[1] and Enrico Dorigatti[2]

[1] *Conservatory L. Canepa, Sassari, Italy*
[2] *University of Portsmouth, UK*

Abstract

We present Acoustic Views of Dorgali, an ecological sound sculpture designed to immerse the audience within a reconstructed natural soundscape, allowing them to interact with it through physical movements. After a brief overview of the relevant context, rooted in sound art and acoustic ecology, the sound sculpture is presented. The last section proposes some observations derived from the premiere.

1 Sound Art and Sound Sculpture

The late Seventies registered the birth of a new form of artistic expression employing sound in peculiar ways, through creative processes more familiar to the context of plastic art rather than to the traditional music composition. Blending amongst the other disciplines, music, plastic arts, and architecture, it took the name of sound art. In this context, of primary importance is sound, fitting an augmented compositional process that bonds it with images, space, and time [Licht, 2009]. Sound sculptures, the outcome of this new artistic paradigm, free themselves from the sole material dimension characterising the traditional plastic art context, acquire a multidimensional one and allow sound to reach an expressive potential never experienced before.

1.1 Eco Sound Art

The interest of the artistic field, and the musical one in particular, for ecology, intended as the broader interaction with the natural environment, was not new, as composers like Vivaldi or Beethoven demonstrate. However, eco sound art gained momentum thanks to the development of the field of acoustic ecology. This discipline, which founders and most prominent figures are Raymond Murray Schafer, also the founder of the World Soundscape Project (WSP[1]), and Barry Truax, is interested in studying, preserving, documenting, and raising awareness on the soundscape [Wrightson, 2000]. In light of this renewed interest in the natural environment, eco sound art started as an artistic practice making use of the natural environment, either as a site or material. Eco sound art can be described as the artistic output of acoustic ecology, with the only difference being that it is not bonded to address ecological issues [Gilmurray, 2016]. Nowadays, despite the importance that this artistic movement gained, and although it fits the more general context of eco art, eco sound art still lacks wide recognition and clear definition [Gilmurray, 2017].

[1] https://www.sfu.ca/sonic-studio-webdav/WSP/index.html

2 Acoustic Views of Dorgali

Acoustic Views of Dorgali is an eco sound sculpture allowing the audience to explore and interact with the natural environment through sound. It diffuses 12 natural soundscape recordings, whose locations are shown in Figure 1, through a system composed of 17 hi-fi loudspeakers and three subwoofers. The placement of these sources within the 3D environment took advantage of some architectural characteristics of the building hosting the premiere, such as the two floors, to enhance the illusion of being immersed within the Sardinian soundscape, making it possible for the audience to wander it. The mockup in Figure 2 shows the placement of the sound diffusion system used within the theatre of the 'L. Canepa' conservatory in Sassari, where the premiere was held.

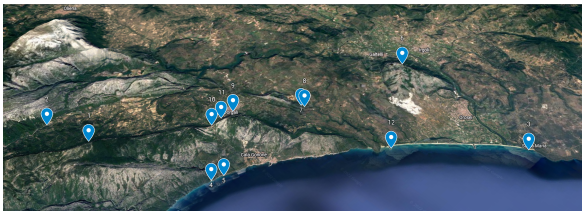


Figure 1: *Locations of the 12 recording sites*

The recording sites chosen are of particular interest due to their characteristics, most importantly the

morphology and the fauna present. Additionally, they are characterised by a low human presence, which results in perceptually minimal disruption of the natural soundscape. There is to notice, however, that 'minimal' is way different from 'absent', and the recordings, further analysed, made it possible to trace the sonic pollution present, which, generated by distant human activities, still affects the recording sites.

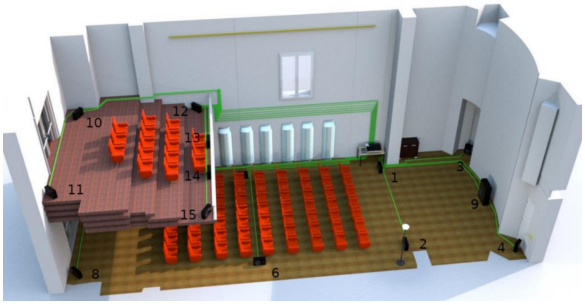


Figure 2: *Mockup of the placement of the sound sources*

2.1 Realisation

Acoustic Views of Dorgali consists of two sound environments distinctly characterised soundwise and space-wise, in which the audience can interact with the sculpture by moving freely. The two-floor theatre was chosen to create a metaphor in which the soundscapes recorded in a mountainous environment were placed on the higher floor, while the ones belonging to the maritime environment were on the ground, linking the actual height to the represented one.

The two sound environments interact with each other through spatialisation and sound trajectories. Additionally, they are ideally and artistically connected one to the other through a loudspeaker placed on the second floor and projecting the sound of a waterfall. By walking under it, the audience can experience the physicality of water, which is rendered through the sound interacting with their bodies.

Through these artefacts and spatial arrangements, the audience was able to experience a reduced recreation of some of the less anthropomorphised, and thus unknown, locations within the Dorgalese outskirts, which translates into a metaphorical, virtual exploration of the actual physical places home of the recordings. As mentioned, the interactive experience when visiting Acoustic Views of Dorgali relies on the movement of the persons. The interaction takes place as the visitor moves to explore the environment, and the recreated soundscape unfolds accordingly, giving them the possibility to hear the sound of a specific physical space. There is also to consider that, in nature, the environment interacts with sound, determining its constituent matter. However, in the case of recreated soundscapes, this paradigm is overturned: sound shapes the environment by delimiting or extending the physical boundaries of the space thanks to its aural power [Leitner, 1971], and this should be considered when designing sound sculptures.

3 Discussion

The practical realisation of Acoustic Views of Dorgali highlighted some points for further discussion, which could also lead to improvements for future showcases.

Firstly, the sculpture proved valuable in promoting ecological awareness in the audience, as it allows one to experience, through interacting with the recreated soundscape, places either difficulty accessible or unknown. Discovered through informally questioning the ones attending the premiere, this also demonstrates that deep knowledge and understanding of the natural environment are not trivial and only achievable through constant and careful human-environment interaction. However, for future showcases, formal and structured questionnaires should be designed to collect data and evaluations on themes such as engagement, immersiveness, and fidelity.

Additionally, it highlighted two main points concerning acoustic ecology. On the one hand, the pervasiveness of anthropomorphisation, which affects even the most isolated places, while, on the other, by offering a peculiar shared experience to the audience, it allowed them to understand the impact of human activity on the environment, the sonic one in this case.

Lastly, this sound sculpture is the first of a planned series of works exploring different natural places. As it happened for Acoustic Views of Dorgali, suitable buildings will be chosen from time to time to highlight the characteristics of the chosen environments.

The premiere of Acoustic Views of Dorgali was held in October 2021. Documentation realised through a collage of audience-made videos is available here[2].

References

[Gilmurray, 2016] Gilmurray, J. (2016). Sounding the alarm: An introduction to ecological sound art. *Musicological Annual*, 52(2), 71–84.

[Gilmurray, 2017] Gilmurray, J. (2017). Ecological sound art: Steps towards a new field. *Organised Sound*, 22(1), 32–41.

[Leitner, 1971] Leitner, B. (1971). Sound architecture—space created through traveling sound. *ARTFORUM, New York March*.

[Licht, 2009] Licht, A. (2009). Sound art: Origins, development and ambiguities. *Organised Sound*, 14(1), 3–10.

[Wrightson, 2000] Wrightson, K. (2000). An introduction to acoustic ecology. *Soundscape: The journal of acoustic ecology*, 1(1), 10–13.

[2] https://www.youtube.com/watch?v=sojOLCExAEo

Spillover, A Risky Game

Giorgio Klauer

Conservatory G. Tartini, Trieste, Italy

Abstract

Noisy sounds with often surprising morphological features can be obtained by means of trivial binary manipulations applied to bitmap image files. Score sketches that may be performed on the fly can be get by analysing these same sounds through common information retrieval processes. In the project *Spillover* a computer system lets data to be transposed between the visual, auditory, and symbolic scopes to generate musical information thanks to the collaboration of interacting musicians. The project has two outputs, the first of which consists of a real-time composition for two pianos, sound synthesis, live electronics, video projection and laser printers premiered in February 2022 - the subject of this paper. The second output consists of the *Spillover* installation, where images are handed over to the system by the user, and sound files and scores are returned to be played, respectively, on a loop station and on toy instruments.

1 The composition

In the *Spillover* composition, the electronic performer displays on the screen the graphic interface of the system and proceeds to scrutinize bitmap images of his choice, which he audificates on the fly by means of bit sequence manipulations. The sounds thus get are played on a self-programmed loop station building up MIDI files by means of, mainly, pitch and onset detection algorithms. At the same time, the sounds are diffused through the loudspeaker system. When the electronic performer stops writing a MIDI track and starts a new exploratory session, the file is recoded in traditional notation and a score is immediately printed by printers placed next to each pianist. The instrumental players take the sheets, and after a short look at their part, silently projecting their own interpretative schemes, on which a strategy has been agreed previously, they play it trying to fit into the overall sound. The printers are also amplified; the sound of the pianos is processed through further bit manipulation algorithms and fed to the loudspeakers. The steps of the procedure here described are repeated circularly at least three times, resulting in a performance lasting about 10-15 minutes.

2 Trivial audification

With the term we intend to differentiate the practices here described from sonification, the topic of sound and music computing studies. Audification, presented there as an elementary technique of sonification, responds to needs of an eminently functional nature, that is to say the auditory display of properties and information contained in sequences of data, offered to the user through the immediacy of perceptual-cognitive mechanisms [Hermann et al., 2011].

In the performance the image formats are left untouched. Their often poor quality gives rise to a remarkable sonic variety. The only constant is that the chosen repertoire consists of JPEG files with various compression amount. After an initial evaluation of uncompressed images, in particular TIF, it was found that compression allowed to access differently the chromatic information of the rasterized image and the bit sequence of the file itself. From the practical point of view, the lossy format obviously produces unpredictable results, while in an uncompressed file the image pattern and data sequence are consistent.

2.1 Technique

For the image audification, GNU octave[1] scripts are used, called on the fly from the system's main interface. The audification techniques are essentially the following.

The image file is read as a three-dimensional matrix (8 bits for each RGB channel). Optionally, the size of the matrix is reduced by 8 or 16 times[2], to avoid the generation of excessively long audio files with sonic content distributed in the lower spectrum mainly or even in the inaudible region.

- The bit sequence is read as an array of 32 bit signed integers (script "rgb bit compose").

[1] https://octave.org

[2] Operators *imread*, *imresize*.

- The three chromatic channels are interleaved reading the matrix by column; each 8 bit unsigned integer is decreased by 128, divided by 128, and converted into a double precision floating point (script "rgb interleave cols").
- As above, but the matrix is read by row (script "rgb interleave rows").

The arrays thus obtained are filtered as a digital signal though a second order Butterworth high pass - a functional filter aimed at electroacoustic reproducibility - and saved as a mono audio file with 48 kHz sampling rate and 32 bit resolution (a single array element becomes a single audio sample).

3 Symbolic transposition

Musical scores can be generated from the previously described audio files using well-known information retrieval algorithms implemented in audio to MIDI conversion programs. Software having been evaluated included Melodyne[3], intelliScore[4], AudioScore[5], AnthemScore[6] and online services[7].

To better adapt to the interactivity of the project, it was preferred to program an *ad hoc* SuperCollider algorithm[8].

3.1 Technique

When the previously generated audio files are played during the performance, the sound stream is analysed by an algorithm using the Onsets [Stowell & Plumbley, 2007], Loudness[9], and Pitch[10] operators. Basically, the detection of an attack causes pitch and intensity data to be stored as *Note on* events. *Note off* events are returned according to composition-oriented conditional logics and arbitrary mappings.

When a MIDI file is closed, a score representation can be obtained. MuseScore[11] is called here in the background using the *velocity* plugin[12] to obtain, as an exploratory step, the basic dynamics for an effective musical interpretation[13].

[3] https://www.celemony.com
[4] http://www.intelliscore.net
[5] http://www.sibelius.com/products/audioscore/ultimate.html
[6] https://www.lunaverus.com
[7] https://www.ofoct.com/audio-converter/convert-wav-or-mp3-ogg-aac-wma-to-midi.html
[8] https://supercollider.github.io
[9] From the software reference: "A perceptual loudness function which outputs loudness in sones; this is a variant of an MP3 perceptual model, summing excitation in ERB bands. It models simple spectral and temporal masking, with equal loudness contour correction in ERB bands to obtain phons (relative dB), then a phon to sone transform. The final output is typically in the range of 0 to 64 sones, though higher values can occur with specific synthesised stimuli. [...] This UGen is an informal juxtaposition of perceptual coding, and a Zwicker and Glasberg/Moore/Stone loudness model."
[10] From the software reference: "Autocorrelation pitch follower".
[11] https://musescore.org
[12] Coded by Joachim Schmitz, 2018.
[13] Commands "musescore -M ms/midi_import_options.xml -o msscore FILENAME.mscz FILENAME.mid" and then "musescore -j ms/job.json", with import options such as 1/16 quantization, 4 voices, tuplets, staccato, dots and others, to facilitate the symbolic interpretation by the piano players.

4 Interface and live electronics

The performance is managed on a graphic interface programmed in SuperCollider.

Among the various windows, one in particular is used to control the processing of the piano with some algorithm implementing following techniques:

- signal degradation by reducing the number of bits;
- left and right bit shift (with dynamic compensation);
- logical (AND) and inclusive (OR) conjunction of the bits of the signals of the two pianos;
- bit shift left and right depending on the (degraded) signal of the other piano.

5 Recordings

A video recording of the performance is available at https://www.youtube.com/watch?v=YFjum3ktZm4. Also refer to the recording of a rehearsal where the ensemble seems to the author a little more balanced at https://klauer.it/giorgio/public/pieces/2022_-spillover/take/mix2.wav (or /mix2.mp3).

References

[Hermann et al., 2011] Hermann, T., Hunt, A., & Neuhoff, J. G., Eds. (2011). *The Sonification Handbook*. logos.

[Stowell & Plumbley, 2007] Stowell, D. & Plumbley, M. D. (2007). Adaptive whitening for improved real-time audio onset detection. In *Proceedings of the International Computer Music Conference (ICMC2007)* Copenhagen, Denmark.

How ICT and non-ICT Solutions Can Facilitate the Interactions in Migration-related Work?

Giulia Deppieri and Nadia Mana

Fondazione Bruno Kessler - FBK, Trento, Italy

Abstract

In this paper, we present a preliminary study carried out within the Horizon 2020 PERCEPTIONS project (2019-2023), in which we investigated through quantitative and qualitative methods how ICT and non-ICT solutions can facilitate the interactions among users (practitioners, stakeholders, migrants) in migration-related work.

1 Introduction

In the last few decades, attention at the European level on the topic of migration has increased greatly, and with it the search of solutions to support the management of processes aiming at the social and economic inclusion of migrants and refugees. In this context ICT solutions may play an important role. There are many solutions (ICT and non-ICT) for migrants and practitioners, but with some limitations that impact on the interaction among the users. While many recent studies have investigated the use of technology by migrants (e.g. [Gioppo et al., 2022], there are fewer studies investigating the use of technology as a daily work tool for practitioners or stakeholders working for or directly with migrants (e.g. [Leligou et al., 2021]).
This paper is a preliminary contribution to the research in this area. To this end, we present the main findings emerged during the study carried out within the Horizon 2020 PERCEPTIONS project by involving practitioners working with or for migrants.

2 The PERCEPTIONS project

PERCEPTIONS project (2019-2023) investigates what perceptions of Europe exist among migrants, refugees, and asylum seekers, i.e. how they are informed, whether the information corresponds to reality and how such information influence migration decisions [Bayerl et al., 2020].
Within the project, we investigated how best practices in migration-related work can facilitate the interactions among practitioners and multi-stakeholders who work with and for migrants (e.g., policymakers or members of NGOs, civil society organizations, charities, etc.), and between practitioners and migrants. In particular, we evaluated gathered third-party solutions that successfully address challenges related to migration (e.g., discrimination, misinformation, human trafficking, etc.) through a survey and online focus groups with the practitioners. We figured out positive and negative User eXperience (UX) aspects [Hartson & Pyla, 2012] of the gathered best practices in order to take inspiration for the final output of the project, the PERCEPTIONS platform, and to improve its design and implementation.

3 Study with practitioners

Among the activities conducted during the project, we contributed to the elaboration of an online project survey to collect quantitative data regarding the human computer interaction (HCI) and specifically the UX with ICT solutions of stakeholders and practitioners who work in migration-related work. We investigated through the questionnaire mainly if the organizations where the respondents work use ICT solutions and for which purpose. We also asked how effective, user-friendly, and easy to understand they found the existing solutions. Moreover, we organized five online workshops with a total of fifteen multinational (from nine different countries) and multi-stakeholder participants. During the online workshops we investigated, through the use of a Miroboard, the interaction of the users with the ICT solutions (e.g., *for education and training, for sharing guidelines and practices, for enabling connections, etc.*)

and non-ICT solutions (e.g., *awareness campaigns, music performances, art-based exhibitions*).

4 Findings

According to the 381 answers to the survey questions specifically concerning ICT solutions, the use of ICT tools is mainly devoted to support practitioner/stakeholders' education and training (24.1%) and accessing data on migration (17.6%). Such solutions are considered quite effective, user-friendly and understandable, whereas solutions for migrant education and training (17.6%) are considered effective but less user-friendly and still less understandable.

The participants of the online workshops underlined that the ICT solutions should be user-friendly. They should also be user-centered. Indeed, it is fundamental to always take into consideration the intended users of the solution (be they migrants, practitioners, or stakeholders) and tailor it to their characteristics and needs. For the PERCEPTIONS web platform, which addresses different stakeholders – particularly policymakers, researchers, and first-line practitioners – this means finding a common language that allows to address these groups. When the intended users are mainly migrants and refugees, it is fundamental that the ICT solutions are mobile friendly, since they often have smartphones than laptops, and easily accessible, multilingual, interactive, and adapted to specific needs. For example, use of visual representations, images, and infographics can help the user to navigate through the site bypassing the problem of not understanding the host country's language.

According to the participants of the study, the ICT-related solutions (e.g., online interactive platforms, mobile applications, digital portfolios) can play a crucial role in empowering the migrants to access services, interact and engage with others in a digital way, since they help manage data and information. At the same time, a "face-to-face" interaction among the participants is considered the best tool to understand and fight prejudice since in-person interaction grants an efficient and successful delivery of information and communications through a better engagement on behalf of the participants.

Also, arts and culture (through photo galleries, festivals, theater, exhibitions, concerts, etc.) can support the creation of awareness and engagement of communities, trust, and shared values.

Finally, about the specific needs of the practitioners and stakeholders in migration-related work, it emerged that they usually get in contact with other national or international organizations for their work. For this reason, it might be helpful for them a platform that facilitates networking organizations through (a) "Sharing practices and experiences", (b) "Co-developing activities" with other practitioners, and (c) creating/improving a "professional networking".

5 Conclusions

According to this preliminary study, we can confirm that ICT and non-ICT solutions can be a great support for interactions among users (both migrants and practitioners/stakeholders) in migration-related work. If these solutions are user friendly and user centered, and if they are able to create both digital and "face-to-face" interactions, they can play a crucial role in empowering the migrants and support the creation of awareness and engagement of communities, trust, and shared values. More details will be presented in the poster.

Acknowledgments

This work is supported by the EU H2020 project PERCEPTIONS (https://project.perceptions.eu//), under Grant Agreement 833870. The authors would like to thank all the participants who contributed to this study.

References

[Bayerl et al., 2020] Bayerl, P. S., Hough, K. L., Pannocchia, D.,.. (2020). Migration to the EU. A Review of Narratives and Approaches. Available on the project web site https://projec.perceptions.eu

[Gioppo et al., 2022] Gioppo, L., Cserpes, B., & Gortázar, F. (2022). Lowering Barriers to Migrants' Integration Through Smart ICT Interaction. In *Information and Communications Technology in Support of Migration* (pp. 157-175). Springer, Cham.

[Hartson & Pyla, 2012] Hartson, R., & Pyla, P. S. (2012). The UX Book: Process and guidelines for ensuring a quality user experience. *Elsevier.*

[Leligou et al., 2021] Leligou, H. C., Anastasopoulos, Vretos, N., Solachidis, V.,...(2021). Experiences and Lessons Learnt from the Evaluation of ICT Tools for and with Migrants. Social Sciences, 10(9), 344.

Making Music Together. A Study in Correction and Synchrony

Gianni Tamanini

Independent, gtamanini@posteo.eu

Abstract

The research focuses on rehearsals by an amateur group in which many errors occur. In response to these, the musical flow in some cases continues thanks to specific practices that allow synchrony to be restored, and in others is interrupted by the conductor who begins a sequence of correction.

It is important to emphasize that synchrony during the performance continuously occur through practices that are carried out by the players and the conductor, using a set of patterns which has been isolated and described using the ethno- methodological approach. The influences of wider social structures have been taken into consideration along with the role of the score on synchrony and error correction.

1 Introduction

How do musicians manage to be in time while playing together? The process is often taken for granted and the mechanisms are rarely analysed. In fact, several social practices are required to successfully play together.

In large groups, performance is often managed by the conductor. He not only provides the desired *prescriptive* musical version, but incessantly communicates where the musical flow should go, and where it is at that exact moment. He also corrects errors made by the players, either during the performance, or by interrupting it.

The musicians themselves must play in a coordinated manner not only by taking the conductor or the score as a point of reference but also by constantly adapting their musical flow with the others.

The error itself is thus the fundamental element that brings out anything taken for granted.

2 Analytical Framework

The starting point of my research is an essay by Alfred Schutz entitled Making Music Together (1964). In it he analyses music from a phenomenological point of view as a social construction. His focus is on the social roles of the composer and listener, as well as on the relationship between inner/external times (Bergson) within the *polythetic* time (Husserl) of the musical flow [Schutz, 1964].

Another key point of reference is *Ethnomethodology* by Harold Garfinkel. It is the phenomenological study of *social facts* through which people produce and manage everyday relationship situations, such as the processes used to make them *accountable* in the social world through specific practices [Garfinkel, 1967].

Additional fundamentals are studies by Sacks, Schegloff and Jefferson on the organization of turn-taking and on the preference for self-correction in conversation, which have been applied in the domain of performance [Sacks, 1974, Sacks, 1977].

Also important are works by Peter A. D. Weeks on the synchrony and error-correction within the performance, from which the concepts of verbal (VES) and illustrative expressions (IES) have been taken [Weeks, 2002b, Weeks, 2002a]. The transcription methodology used for the dialogues is the same of Weeks, i.e., *Conversation Analysis* [Psathas, 1967], to which I have added the transcripts of illustrative gestures with images sequences, and of music using scores.

3 Results

During the empirical analysis (a/v recordings of three rehearsals of the amateur wind orchestra *Corpo Musicale S. Giorgio di Vigolo Vattaro*, Italy, in which I was a member of the group), I looked for the forms/expressions and patterns where social practices to maintain synchrony and correct errors, were carried out. A few of the examples will now be discussed.

The guidance of the conductor (*Self* – cf. Sacks, et al., 1974) to maintain synchrony during the performance typically occurs through embedded correction, or *Other* (players) *adjustment*, with a dialectical relationship between external/inner time (i.e., every gesture brings a new context into the *polythetic* time). The forms of the corrections are IES (quasi-singing, gestures) and/or VES (counting). In the first rehearsal the sound expressions are more frequent than VES (e.g., verbal cues), because the performers need to stay focused on the score, and the corrections (only IES) of the conductor are focused on rhythm. Although the study by Sacks et al. states that the *Self/Other* in the conversation is not fixed [Sacks, 1974], the conductor has instead a predetermined role (*Self*). It is usually him who interrupts the musical flow and initiates the sequence of correction. The pattern of interruption is an IE (gesture of interruption or stopping movements to indicate the beat) sometimes with a VE with evaluations. After that, the correction sequence begins with the pattern VESIES or IESVES. Sometimes, the IES include a pair of contrasting IE to emphasize the error, one IE is the correct version and the other the wrong one. Unlike the ongoing performance guidance, there is never a single form of expression, but always patterns. We thus have the demonstration that IES/VES are *reflexive* and *indexical* [Garfinkel, 1967]. In other words, to understand the meaning of any expression, one must incorporate it within the context in which it was produced. In this way the embodied practices employed, produce recognizably ordered, 'natural' courses of action for the members of the group.

It is therefore clear that there is a quite different use between the patterns for correction during performance (IES perceived through mutual listening) and the sequences of corrections during interruptions (always IES/VES pairs).

Another role of the conductor is to locate the 'now' in the music flow (i.e., linking the external time with the *polythetic* inner time). During the performance he can use the counting (VE) to emphasize the metre before a cue or to guide a player out of time. Sometimes it can be paired with IES (e.g., the gestures of conductor). The pattern of localisation can begin after the interruption, as well. It is usually composed of a VE (e.g., the bar number) and/or an IE (e.g., singing the passage, reproducing the rhythm clapping the hands, etc.). The VES and IES in this situation are often independent and one may be understandable without the other.

4 Discussion and Conclusion

In the episodes examined, it became clear that attempts to correct and maintain synchrony within the performance are fundamental to its success. The forms/expressions and patterns identified by Weeks were thus confirmed and integrated with the conductor's gestures. It was shown that there is a relationship between the context and the use of forms/scores/IES. Despite the prescriptive nature of musical notation, it was approached differently according to each situation. For instance, during the last rehearsal, the players attributed greater importance to listening to each other and to the IES of the conductor than to the score. It is my opinion that the results achieved from this research can contribute to making the interactions within the performance more intelligible. Once the *black box* has been opened and the mechanisms within it identified, they can be used to improve the processes required to maintain synchrony. The next step will be to test the models in situations involving complex algorithms or AI in real time (see post-internet art, or Internet of Musical Things). It is possible, for example, to think of Alexander Schubert's intermedial opera Asterism of 2021. Through a creative use of AR, AI and environment, the relationships between them and the performers are taken to the limit. What forms are put in place by the performers *in situ* to maintain synchrony? How would the influence of the external social structure be reflected? Furthermore, it is my opinion that the identification and description of such patterns may open the way for their development in algorithmic terms. They could then be integrated into new software, and be used in performance without affecting the synchrony, but also to help manage it in a more successful way.

Acknowledgements

My study began with my dissertation in Sociology at the University of Trento under the tutelage of Prof. Giolo Fele, and of the unforgettable Prof. Luigi Del Grosso Destreri. I would like to offer both of them my sincerest thanks.

References

[Garfinkel, 1967] Garfinkel, H. (1967). *Studies in ethnomethodology. Englewood Cliffs*. Prentice Hall.

[Psathas, 1967] Psathas, G. (1967). *Conversation analysis. The study of Talk-in-Interaction*. Thousand Oaks (USA), Sage Pubblications.

[Sacks, 1974] Sacks, H., S. E. . J. G. (1974). *L'organizzazione della presa del turno nella conversazione*. Trad. it. parziale a cura di G. Fele. In: Giglioli, P.P., Fele, G., (a cura di), (2000), Linguaggio e contesto sociale, Bologna, il Mulino, pp. 97-135.

[Sacks, 1977] Sacks, H., S. E. . J. G. (1977). *The preference for self correction in the organization of repair in conversation*. In: G. Psathas ed., Interac-

tion Competence, Irvington Publishers, New York, 1990, pp. 31-62.

[Schutz, 1964] Schutz, A. (1964). *Making Music Together, a study in social relationship*. In: Social Research, Vol. 18, No. 1 (March 1951), Baltimore, The Johns Hopkins University Press, pp. 76-97.

[Weeks, 2002a] Weeks, P. (2002a). *Performative error-correction in music: a problem in ethnomethodological description*. In: Human Studies, n.25, Dordrecht (Netherlands), Kluwer Academic Publishers, pp. 359-385.

[Weeks, 2002b] Weeks, P. (2002b). *Synchrony lost, synchrony regained: The achievement of musical coordination*. In: Human Studies, n.19, Dordrecht (Netherlands), Kluwer Academic Publishers, pp. 199-228.

Event After Event: Collectivity Formation Process in Music Worlds

Pietro Casari

Scuola Normale Superiore, Pisa-Firenze, Italy

Abstract

The general aim of this study in progress is to investigate the relational dimension of musicking collectivities formation and development processes, placing emphasis on the events, to be intended as key elements to understand how the participants act collectively. The case study for this research is Algorave. Strictly tied to the live coding practice, this collective phenomenon emerged and developed worldwide in the last ten years, articulating in a network of (trans)local communities and normed musicking events. My suggestion is that the collectivity formed around the Algorave phenomenon has generated from a pre-existing musicking network – the 'live coding world' – thanks to the sustained involvement and the repeated sharing of the same experience during the events by the actors involved. To empirically explore this statement, I adopt a network-based approach for the study of collective action and related methodology, namely formal Social Network Analysis.

1 Events, Music Worlds, and Networks of Collective Action

Among the different elements argued to characterize 'music worlds' [Crossley, 2015; 2020], the 'structuring factor' of *focal time-space* [Crossley, 2020] is to be understood as crucial for the purposes of this study.
Events represent opportunities for the people involved to "converge in particular places at particular times", thus facilitating both interaction and, in Durkheimian terms, the collective effervescence necessary to a world to be formed [Crossley, 2020: 7; see also Crossley, 2015: 87-9].

More broadly, events represent an important element to understand collective action as a process. From this perspective, the consistent course of action pursued by the constructing individuals can be intended as also articulating in series of interconnected events, in which the interaction among participants becomes sustained, thus providing the occasion not only to 'combine' orientations [Melucci, 1996], but also to reinforce or forge, whether these are already present or not, social relationships, possibly resulting in the formation of a wider collectivity [Diani, 2009].

2 Research Purposes

This study aims to investigate the process of collective creation of an 'action system' [Melucci, 1996], *event after event*, by the individuals involved in the same practice, eventually assessing if, despite possible barriers – e.g., physical distance or belonging to a wide variety of diverse social contexts, they can be considered to have formed a collective entity.
In sum, my point is that the involvement and sharing of experience has been possible through mechanisms underlying, among others, the active participation to a system of social events, that eventually constitutes the phenomenon investigated. I propose to understand these events as social situations – meaningful contexts in which interaction between the actors involved takes place – which have to be intended as interconnected, not because of sharing certain characteristics, but because manifestation of a singular collective action.

3 Algorave: the Case Study

Since its appearance in the United Kingdom back in 2012, the term 'Algorave' has been used in several acceptations. Starting from a basic etymological dissection, the term derives from the crasis of the English words' 'algorithm' and 'rave'.
This portmanteau essentially suggests a connection with the so-called 'Rave Culture' [Anderson, 2009], while placing the emphasis on the distinctive involvement of algorithms in the musical performance.
Relying on both the self-definition provided by the main actors involved and the existing literature on the topic, four distinct dimensions – *practical*, *situational*, *normative*, and *collective* – of Algorave as a concept emerge from the investigation of the particular meanings associated with the term over the years.
Algorave is strictly tied to the 'live coding' practice, to the extent that it has also been considered as "an important subset" of it [Haworth, 2018: 573]. In general, live coding can thus be considered "what ties together" [McLean, 2019: 175] a multi-faceted phenomenon like Algorave.
In the ten years since its emergence, the Algorave phenomenon "has taken hold as a distributed network of thriving scenes, with events organized by experienced promoters finding large audiences in club and festival venues, or adopted by local musicians putting on parties in small rooms with big sound systems" [Ibid.].
Adopting a socio-phenomenological perspective, Algorave presents itself as constituted by a series of events "[focused] on humans making and dancing to music" (algorave.com/about), and may thus be intended as a 'collective phenomenon', insofar it represents a "[set] of social events [comprising] a number of individuals or groups exhibiting, at the same time and in the same place, behaviours with relatively similar morphological characteristics" [Melucci, 1996: 20]. In this sense, Algorave as a collective phenomenon is argued to involve a body of social actors, whose joint work has been able to sustain the organization of particular events, reproduced over the years among a wide variety of socio-cultural environments. Moreover, my suggestion is to understand Algorave community as a 'cell' [Gerlach, 1971] originating from a pre-existing network built around the live coding practice, which I refer to as the '*live coding world*''.

4 Methodological Note

This study is framed within the research program based on a relational approach to the study of collective action, applying the tools of formal social network analysis (SNA) method [Diani and McAdam, 2003; Diani and Mische, 2015; Crossley and Diani, 2019]. The intent is to consider not only the ties connecting the individual actors involved, but rather to focus the analysis also on their connections to the Algorave events to which they actively participate (*multi-modality*), considering two different perspectives: the individuals' one and the one of the events (*multi-levelness*). I confine my attention on a particular tie linking individual musicking actors to the events, namely the performance of the firsts at the latter, signifying their active participation to the construction of the Algorave action.
In order to assemble the network datasets, I mainly rely on digital archival data as primary data, retrieved from the reference website for the community (algorave.com), focusing first on the reconstruction of the Algorave events set. For the present study, only the events organized during the first five years of the phenomenon (from March 17th, 2012, to March 17th, 2017) have been considered, focusing on its initial expansion. Data have been elaborated in order to make them usable for network-based analytical purposes.
A matrix including the connections among single actors and the event(s) at which they performed has been created, resulting in a 2-mode relational dataset – the Algorave Event-Performer Network (AEP). In order to particularly focus the attention on the process of collectivity formation through active participation to events, a *single-mode projection* analytical strategy is adopted [Everett and Borgatti, 2013], presenting the results from the performers' perspective (Figure 1, next page).

5 First Results

5.1 One single component, a unique collectivity (A)

The suggestion of Algorave as constituted by a set of interconnected events – an 'event system' – has been substantiated by empirical evidence, showing the cohesiveness of this system, and favouring its interpretation as a whole. This was reflected in the fact, as clearly emerging from the network visualization presented (Figure 1), that a community composed by the performers actively participating to these events has emerged as a unity – or, in network terms, as a single component.

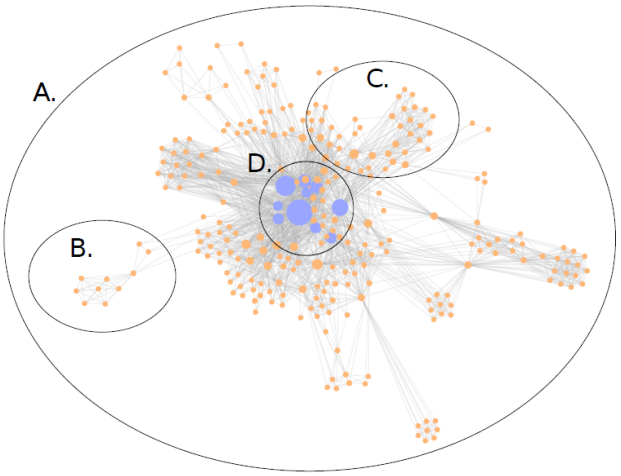


Figure 1: *The Algorave Performers Network [N=276, tie: performance to at least one common event, Core (Light Blue) Periphery (Orange) distinction, size of the node proportional to total number of events performed at, single-mode projection of the Algorave Event-Performer bipartite Network]*

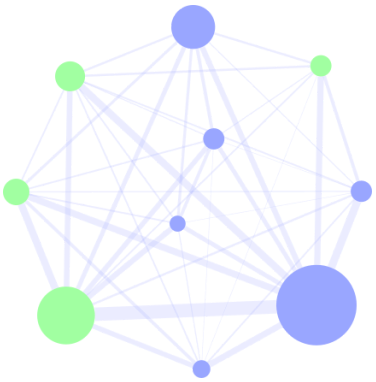


Figure 2: *Core of the Algorave Performers Network [N=10, Females (Light Green) Males (Light Blue), size of the node proportional to total number of events performed at, size of the tie proportional to number of events in common]*

5.2 Local Communities (B)

Local communities emerged in the more peripheral areas, as densely connected sub-structures of Algorave-based interactivity. It has to be considered, though, that these communities may be existing *a priori* with regard to the collective action inquired, thus representing communities belonging to the wider 'live coding world' rather than specific Algorave local communities. Significantly, several actors central within these communities do not belong to the group positioned at the core of the network, hence characterizing Algorave collective as not dependent on the presence of few central individuals, but rather to be also supported by a wide share of locally more active individuals assuming key roles in the action. In this sense, the initial intuition of framing Algorave collective as characterized by a 'polycephalous' structure [Gerlach, 1971] seems to be supported by evidence emerging from the analysis.

5.3 Translocal Communities (C)

Addressing the issue of Algorave events 'orderability' [Abbott, 2001] has been proven crucial to reconstruct the Algorave system formation process. Focusing on the emerging chains of consequent events framed as 'tours', made come forth distinct patterns of musicking interactivity across different localized social places over time. In literature, the act of touring has been argued to forge and reinforce relationships by mean of which individuals belonging to different local communities connect, favouring the constitution of 'translocal' communities [Verbuč, 2022]. From the analysis performed, Algorave tours seems in line with this statement. Nevertheless, one particular aspect characterizing Algorave tours emerged: namely, its collective dimension, from which the suggested definition of *collective touring*. Indeed, differently from other known forms of touring – such as the most common related to music industry – the events saw the joint participation of temporary collectives, instead of single performers or bands. Thanks to this shared experience the participants not only forge – or reinforce – relationships with those belonging to the contexts in which the tours stopped, but also establish durable ties among each other, that eventually contribute to the formation of a wider collectivity.

5.4 The Algorave 'Carrier Group' (D)

A 'carrier group' [Weber, 1968] of performers positioned at the core of the network emerged (Figure 2), who not only participated to the largest number of events, but did this together, resulting crucial in the spreading of their view on the live coding practice and the consequent development of the collective formation process. This group appears as fairly balanced in the distribution of male and female individuals composing it – respectively 6 and 4 over the total of 10, thus not being characterized by male-exclusivity.
Some of the events connecting these performers seems to be meaningful and may be even considered as *turning points* in the construction of the collective, being the occasions in which part of these actors shared their first Algorave experience, or the ones of collectively sharing an experience in

another country.

6 Further Research

The preliminary results here reported could open new lines of research, which I suggest should be based on the following points:

- regarding the case study, as my research has covered only the first five years of the phenomenon so far, a natural extension is to also consider the second ones (2017-2022), insofar as a preliminary descriptive analysis based on the number of events organized per year highlighted the distinct presence of a wave, which peak is reached in 2019, before a significant decrease in the following two years.
- the relationship occurring between the Algorave phenomenon and related collectivity with the wider 'live coding world' is a key element to be investigated, as in my research I only focus on the Algorave collectivity, only theoretically referring to the presence of a pre-existing network upon which it originated.
- more data regarding the performers have to be collected, both in terms of their characterization with more socio-demographic information, meanings, and motivations, as well as regarding the relations among them outside Algorave and the live coding world.

References

Abbott, A. (2001). *Time matters: On Theory and Method*. University of Chicago Press.

Anderson, T. (2009). *Rave Culture*. Temple University Press.

Crossley, N. (2015). *Networks of Sound, Style and Subversion: the Punk and Post-punk Worlds of Manchester, London, Liverpool and Sheffield, 1975–80*. Manchester University Press.

Crossley, N. (2020). *Connecting Sounds*. Manchester University Press.

Crossley, N., and Diani, M. (2019). Networks and fields. In D. A. Snow, S. A. Soule, H. Kriesi, and H. J. McCammon (Eds), The Wiley Blackwell Companion to Social Movements (pp. 149-166). John Wiley & Sons.

Diani, M. (2009). The Structural Bases of Protest Events: Multiple Memberships and Civil Society Networks in the 15 February 2003 Anti-war Demonstrations. *Acta Sociologica*, 52(1), 63-83.

Diani, M., and McAdam, D. (2003). *Social movements and networks: Relational approaches to collective action*. Oxford University Press.

Diani, M., and Mische, A. (2015). Network Approaches and Social Movements. In D. della Porta and M. Diani (Eds.), The Oxford Handbook of Social Movements (pp. 306-325). Oxford University Press.

Everett, M. G., and Borgatti, S. P. (2013). The Dual-projection Approach for Two-mode Networks. *Social Networks*, 35(2), 204-210.

Gerlach, L. P. (1971). Movements of Revolutionary Change: Some Structural Characteristics. *American Behavioral Scientist*, 14(6), 812-836.

Haworth, C. (2018). Technology, Creativity and the Social in Algorithmic Music. In A. McLean and R.T. Dean (Eds), The Oxford Handbook of Algorithmic Music (pp. 557-582). Oxford University Press.

McLean, A. (2019). Algorave: Dancing to Algorithms. In The Cambridge Companion to Music in Digital Culture, edited by Nicholas Cook, Monique M. Ingalls, and David Trippett, 175–177. Cambridge University Press.

Melucci, A. (1996). *Challenging Codes: Collective Action in the Information Age*. Cambridge University Press.

Verbuč, D. (2022). DIY Touring Practices: Assembling the Translocal DIY Community. In his DIY House Shows and Music Venues in the US: Ethnographic Explorations of Place and Community (pp. 203-228). Routledge.

Weber, M. (1968 [1921]). Economy and Society. University of California Press.

Interacting with Audio in Unity

Enrico Dorigatti

University of Portsmouth, UK

Abstract

Unity is a well-known game engine used within academia and industry, as well as by makers and artists. While it comes equipped with a powerful graphics engine and plenty of possibilities concerning interaction, interfacing with external systems through different protocols, and generative graphics, it lacks tools for procedural audio, as it relies heavily on pre-made clips. The URALi project, here presented, proposes a possible solution to fill this gap.

Keywords: Unity; sonification; generative art; interactive audio

1 Introduction to Unity

Unity is a game engine used by a wide and diverse audience in different scenarios. On the one hand, Within academia, it is often used for prototypes and demos, especially for applied VR and XR research, given the potential the software has this way. On the other, it is employed for high-fidelity rendering (e.g. in architecture and automotive) thanks to its capabilities concerning 3D models and lights. Furthermore, as a game engine, it is used mainly by independent or small to medium-sized game development studios. Lastly, Unity is also employed within the artistic context thanks to its multimedia features, which include a high-level graphic engine and the possibility to communicate with the outer world through different protocols, amongst which the Open Sound Controller (OSC) [Wright, 2005].

Unity is programmed through C# scripts, with programs usually organised within scenes with a camera and one audio listener, the eyes and ears of the player.

1.1 Overview of Audio in Unity

There are different ways to deal with audio in Unity. The most popular is to rely on pre-made clips attached to a source and played back when needed. This way offers basic clip controls and a mixer similar to the one found in modern Digital Audio Workstations (DAW). The audio flow can also be manipulated through different filters provided (e.g. delay, echo, equalisers) and also affected by 3D spatialisation.

Another way to deal with audio is to connect third-parties plugins and external software, which provide specific environments and abstractions for sound and music. This category comprises the possibility to connect software such as SuperCollider, Pure Data, ChucK, and Max/MSP, which, however, lack native support and need additional libraries or software to be at least partially supported. This argument is currently quite debated in specialised forums.

Using audio middleware such as FMOD and Wwise grants flexibility and freedom. However, these tools are employed commonly within the context of game development, not only because they are designed specifically for this professional sector but also due to their specificity and knowledge required.

The last way to deal with audio in Unity is to implement a custom OnAudioFilterRead function, which allows the access and manipulation of the audio stream before the output. The stage in which this happens depends on the position of the script in which the function is implemented. Implicitly this means that the programmer can procedurally populate the audio stream rather than manipulate it.

2 URALi

URALi is the acronym for Unity Real-Time Audio Library. As the name suggests, it is a project developed to provide programmers with functions for real-time audio synthesis and manipulation through chains of high-level audio objects designed to be the building blocks of complex audio algorithms. The logic recalls the workflow of well-known software such as Max/MSP and Pure data, although, here, their visual interfaces are substituted by lines of code.

The development of URALi started as an attempt to bridge the gap related to the absence of tools for generative audio in Unity. The purpose was to cover the scenarios in which pre-made audio clips result insufficient due to the necessity to drive sounds by data

or algorithms, which may offer unpredictable evolutions and thus interactions with such samples. As notable use cases, this includes projects dealing with data sonification and generative multimedia artworks [Dorigatti, 2022]. At the same time, however, URALi was designed to seamlessly integrate within Unity scripting system, giving access to C# functions to the users by simply loading the .dll file in the project, thus allowing them to work within the same environment while avoiding the necessity to rely on external software and learn another specific language.

2.1 Functioning of the Library

OnAudioFilterRead is a function automatically called at a fixed rate to provide the number of samples necessary for a smooth audio stream. This means that relying too much on it for calculation, especially in the case of complex audio chains, could lead to slowdowns, data starvation, and, perceptually, glitches.

The system designed to avoid this occurrence and free OnAudioFilterRead from the heavy load, schematised in Figure 1, consists of a separate thread and two circular buffers, one for data and the other for flags. Additionally, it requires the user to create a specific synthesis function, a 'sandbox' in which to work with the previously instantiated audio objects. This function is then passed to the thread, which runs it and calculates each sample. Through busy waiting, the thread checks the flag corresponding to the cell of the buffer it is going to write: should it report a free cell, the sample is stored in that position; otherwise, writing pauses until data are read and erased and the corresponding flags reset.

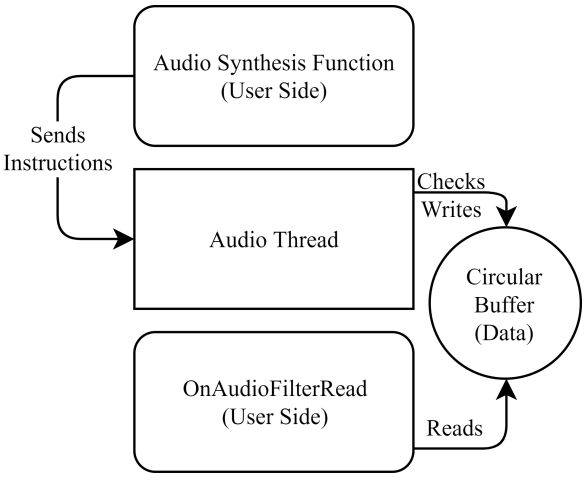


Figure 1: *Schema of the system*

While the calculation of the audio data occurs in a thread which is not timed and therefore has no speed constraints, it is at the reading time that OnAudioFilterRead starts handling the samples. Within this function, the user only needs to access and retrieve a number of samples corresponding to the size of the buffer times the number of channels.

3 Discussion and Conclusions

The system implemented proved to be robust and reliable, providing a smooth and glitch-free output stream even in the case of complex audio chains and operations. Yet, more in-depth testing is certainly needed and might lead to improvements. Related to glitches and artefacts, the problem of aliasing [Schimmel, 2012], particularly affecting some waveforms, has been addressed by implementing the technique described in [Välimäki et al., 2012].

Overall, URALi is already a fully-functioning software, yet its building is still in progress. While many audio objects have already been implemented, there is a list of features yet to be added, including new objects and some usability improvements, such as the possibility to draw the envelopes graphically in place of defining them numerically. The implementation of these features is also planned in light of a future public release of the library, which date, however, is uncertain due to time constraints slowing its development. Currently, a short demonstration of some of the features available can be found here[1]. The demo, employing a short delay effect and shelf filters, also shows how URALi integrates with Unity built-in audio features. In the scenes showed, different audio parameters are linked to the mouse axes, which also control the direction of the particle system. However, visuals here cover a purely artistic role, unlike the work covered in [Dorigatti, 2022], realised alike in Unity.

Given the current status of the project and its aim, discussing it with programmers, musicians, and multimedia artists, to whom it is designed, would benefit the development in terms of gaining feedback and suggestions on new and future features.

References

[Dorigatti, 2022] Dorigatti, E. (2022). Automating art: A case-study of cellular automata in generative multimedia art. In *Proceedings of the International Computer Music Conference* (pp. 175–181). Limerick, Ireland.

[Schimmel, 2012] Schimmel, J. (2012). Audible aliasing distortion in digital audio synthesis. *Radioengineering*, 21(1).

[Välimäki et al., 2012] Välimäki, V., Pekonen, J., & Nam, J. (2012). Perceptually informed synthesis of bandlimited classical waveforms using integrated polynomial interpolation. *The Journal of the Acoustical Society of America*, 131(1), 974–986.

[Wright, 2005] Wright, M. (2005). Open sound control: an enabling technology for musical networking. *Organised Sound*, 10(3), 193–200.

[1] https://www.enricodorigatti.com/wp-content/uploads/2021/12/URALi.mp4

An Intra-actionist Approach to Musical Composition

Michele Cagol

Free University of Bozen-Bolzano, Faculty of Education (Brixen-Bressanone), Italy

Abstract

The present contribution concerns a compositional (or pre-compositional) process for the elaboration of the pitch material of a composition within which two sound fragments/worlds are placed in a particular relationship. The starting theoretical perspective is that of relationality.

1 Theoretical framework

There are many different relational ontologies: Nagarjuna's Buddhist thought, Bateson's theory, Rovelli's relational interpretation of quantum mechanics, Ladyman's ontic structural realism, Barad's agential realism, etc. I will not be going into the merits of the different interpretations and characteristics of relationality – some more radical, others less so (see, for instance, Marmodoro, Yates, 2017; Candiotto, Pezzano, 2019). The physicist Carlo Rovelli, in his recent book entitled *Helgoland*, writes: "We must abandon something that seemed most natural to us: the simple idea of a world made of things. We recognize it as an old prejudice, an old vehicle that we no longer have any use for" (Rovelli, 2021, p. 164). Going a little further back in time, in his 1979 *"Last Lecture"*, Gregory Bateson wrote: "I have offered you the idea that the viewing of the world in terms of *things* is a distortion supported by language, and that the correct view of the world is in terms of the dynamic relations which are the governors of growth" (Bateson, 1991, p. 311) and, just above that statement, he specified: "You should be counting not the things which are related, but the relationships; not the relata, but the relationships" (ivi, p. 310). Again Rovelli, discussing his relational interpretation of quantum mechanics – which, among other things, draws on the philosophical thought of Nāgārjuna, an Indian Buddhist monk born in the second century AD –, writes: "The best description of reality that we have found is in terms of events that weave a web of interactions. 'Entities' are nothing other than ephemeral nodes in this web. Their properties are not determined until the moment of these interactions; they exist only in relation to something else. Everything is what it is only with respect to something else" (Rovelli, 2021, p. 166). The physicist and feminist philosopher Karen Barad, an exponent of the new materialism, even proposes to speak of 'intra-action' instead of 'interaction' because the latter notion assumes the prior existence of independent entities, the *relata*. Barad states that "relations are not secondarily derived from independently existing 'relata', but rather the mutual ontological dependence of 'relata'—the relation—is the ontological primitive. […] relata only exist *within* phenomena as a result of specific intra-actions" (Barad, 2003, p. 815).

2 Proposed method

These reflections led me to wonder what could be a musical/compositional procedure that could be considered as 'relational' as possible and the least 'object-based' as possible, thus going into Barad's intra-action relation and having a focus on relations rather than *relata*.

The starting point was, in a certain sense, metaphorical: I wondered what kind of a process (if any) would result in an 'absence', an emptiness of things, objects, *relata*. And I thought of the coring process in geology, or rather its inverse. In the coring process, a core sample – a cylindrical section of a natural substance – is obtained by drilling the natural substance. I referred to the inverse, because I was not interested in the core sample, but rather in the hole that the process leaves behind: the 'core hole'. At this point, trying to reason in terms of relationship (i.e. between at least two elements), I identified an analogy between the *core hole* and the

exclusive or or *exclusive disjunction* (XOR), a logical operation that is true if and only if its arguments differ. Simply speaking, what is in common is eliminated.
Thus, the general idea is to try to realise a sort of 'sonic coring' (*carotaggio sonoro*, in Italian), to throw away the 'core sample' (*carota*, in Italian) and keep what remains. To put this general idea into practice I make use of the logical operator XOR, which in set theory corresponds to the symmetrical difference: given two sets, A and B, the symmetrical difference between A and B is the set C to which all the elements of A and B belong, with the exception of the elements that A and B have in common, that is, with the exception of their intersection (the intersection, therefore, is the 'core sample'). See Figure 1: the brown part is set C.

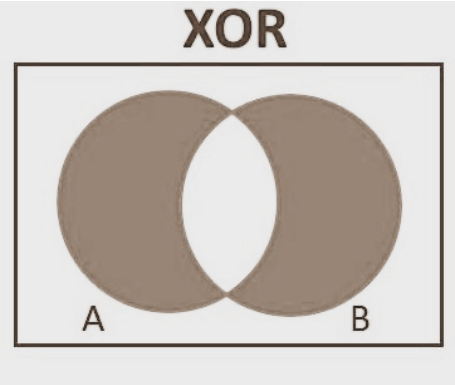


Figure 1: *XOR in set theory*

3 Results

I have used this procedure in two recent compositions: *greens' xor* for clarinet, vibraphone, piano, violin, and cello, and *radical beauty* for flute, tenor sax, percussions, guitar, baritone, violin, and double bass. *Greens' xor* was performed by Ensemble21 and directed by Marc Collet at the Trento Conservatory (24.03.2022). *Radical beauty* was performed in the context of the Gustav Mahler Music Weeks 2022 in Dobbiaco/Toblach by El Cimarrón Ensemble (with baritone Robert Koller) and directed by Clemens Heil (17.07.2022).
In *greens' xor*, A is the sound spectrum of a bell; more precisely, the set of its *nominal* note (one octave above the *prime* and two octaves above the *hum*) and lower and upper partial tones with their respective intensities. There are eleven Bs: these are the chords derived from the theoretical (even partials only) spectra of a clarinet transposed on the pitches of a melodic fragment taken from the *Lacrymosa* of Verdi's *Requiem*.

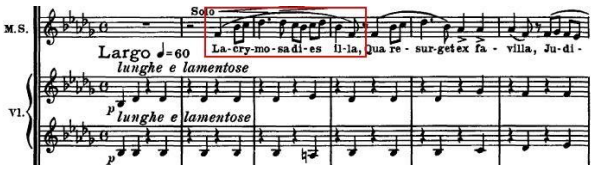


Figure 2: *Lacrymosa melodic fragment (11 notes)*

The symmetrical difference between the *bell chord* and the *Lacrymosa chords* was calculated (using Max/MSP software) and gave origin to the pitch material (eleven pitch sets).

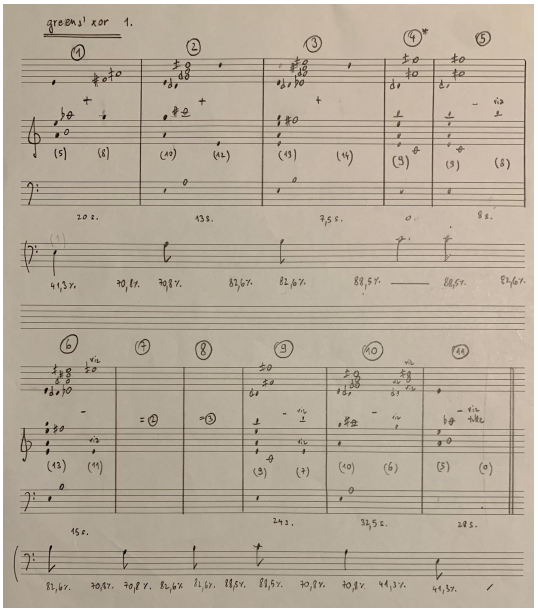


Figure 3: *Sketch (the 11 pitch sets)*

Radical beauty is a composition inspired by the fourth movement (*Von der Schönheit*) of Mahler's *Das Lied von der Erde*. At the basis of Mahler's *Von der Schönheit* there is a strong dualism: that between the feminine and the masculine (Mitchell, 1985; Hefling, 2000). I decided to start from a very general dualism in the development of the material. My two starting points are the song of a whale and the sound of an ice shelf melting. The whale song fragment is related to the male element through a reference to a paper by Gregory Bateson (1972), who argues that cetaceans have developed a discrete (rather than analogue) form of communication for discourse about relationships. On the other hand, the sound of the glacier melting is ideally connected to the feminine element: both in its strength and power and in its ecosystemic fragility.

I undertook some analyses of these two fragments and derived two spectra or groups of notes (in this case, there are two As). In short, this was the workflow. I cleaned up and normalized the two sound files, the whale song of about 10 seconds in length, and the melting glacier recording of about 30 seconds. With the Ircam AudioSculpt software I did spectral analysis and Chord Sequence Analysis. Basically, I finally merged the spectra of the whale song into a single chord and did the same with the melting glacier recording (frequencies have been approximated to quarter tones).

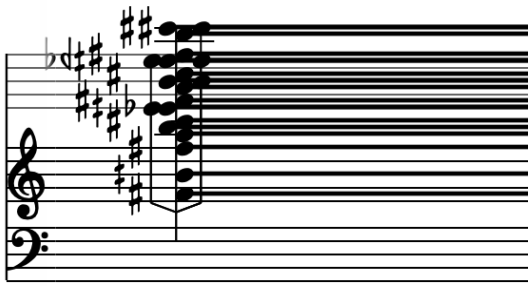


Figure 4: A[1]: *Whale song (frozen)*

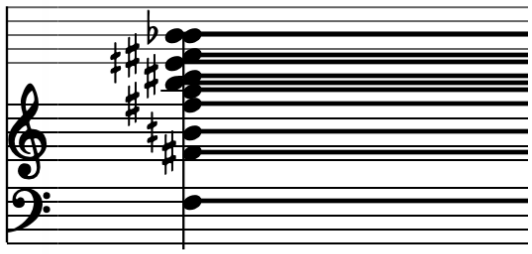


Figure 5: A[2]: *Melting glacier (frozen)*

The common element of comparison (the B) is the *Von der Schönheit*'s line (10 notes) of the first clarinet from 130 to 132. Adorno (1960) speaks of that clarinet motif as a sublime musical passage, condensing joy, beauty, and melancholy.

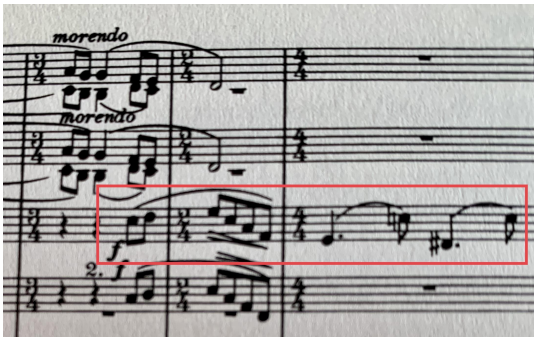


Figure 6: B: *Mahler's fragment (10 notes)*

Thus, there are ten Bs: ten chords derived from the theoretical (even partials only) spectra of the clarinet.
At this point I compared (i) the *whale song chord* to the *Mahler fragment chords*; (ii) the *melting glacier chord* to the *Mahler fragment chords*. I operated the symmetric difference (XOR) obtaining two sets of chord charts (10+10 pitch sets) with note priority indications (given by the relative amplitude of partials).

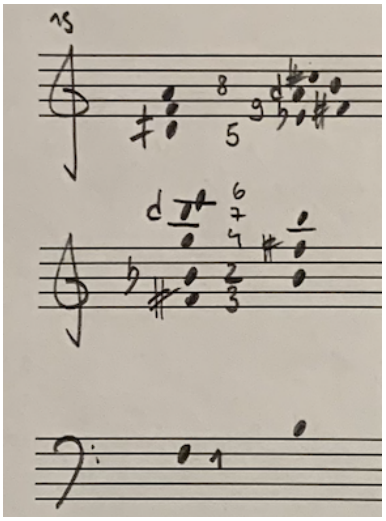


Figure 7: *Sketch (one of the 20 pitch sets)*

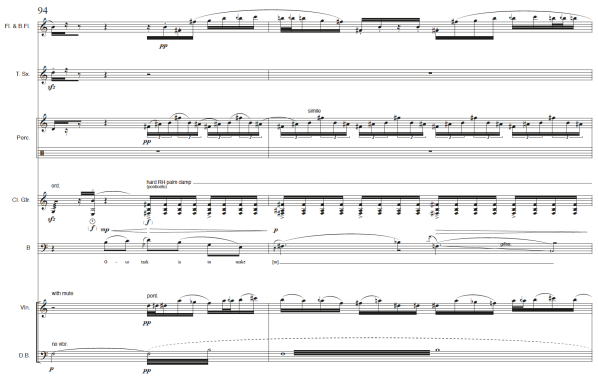


Figure 8: *Radical Beauty excerpt (section in which the pitch set in Figure 7 is used)*

4 Conclusions

In discussing this compositional process (also using audio examples), I will try to show its adherence to a relational perspective, its potential for interweaving relations between (even quite distant) sonic worlds, and its ('harmonic') consequences.

From the perceptual point of view of listening, the two sound worlds put into relation with the proposed XOR procedure are not discernible, they interconnect and lose their individuality: this fact actually goes in the direction of an intra-action, where the relation is more relevant than the individual *relata*. This theoretical 'conquest' has an interesting consequence, again from the point of view of listening, because this procedure – especially in the case where the XOR operation is applied to a single A (a fixed or frozen sound spectrum) and several Bs constructed on a melodic fragment – can generate a pitch set with its own 'harmonic' consistency and uniformity.

References

Adorno, T. W. (1960). *Mahler*. Suhrkamp.

Barad, K. (2003). Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. *Sings. Journal of Women in Culture and Society*, *28*(3): 801–831.

Bateson, G. (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. Chandler Publishing Company.

Bateson, G. (1991). *A Sacred Unity. Further Steps to an Ecology of Mind*. HarperCollins.

Candiotto, L., & Pezzano, G. (2019). *Filosofia delle relazioni. Il mondo* sub specie transformationis. il melangolo.

Hefling, S. E. (2000). *Mahler. Das Lied von der Erde*. Cambridge University Press.

Marmodoro, A., & Yates, D. (Eds.). (2017). *The Metaphysics of Relations*. Oxford University Press.

Mitchell, D. (1985). *Songs and Symphonies of Life and Death*. Faber & Faber.

Nāgārjuna, *Il cammino di mezzo (Madhyamakakārikā)*, ed. E. Magno, trans. M. Meli. Unipress, 2004.

Rovelli, C. (2021). *Helgoland* (trans. E. Segre & S. Carnell). Allen Lane.

Chairs

Fabio Cifariello Ciardi
Conservatorio “F.A. Bonporti” di Trento e Riva del Garda
Nicola Conci
Department of Information Engineering and Computer Science, University of Trento
Lara Corbacchini
Conservatorio “F.A. Bonporti” di Trento e Riva del Garda
Sara Favargiotti
Department of Civil, Environmental and Mechanical Engineering, University of Trento
Silvia Sacchetti
Department of Sociology and Social Research, University of Trento

Co-organizers

CONSERVATORIO DI MUSICA F.A. BONPORTI
Trento - Riva del Garda | Italia

UC UNICITTÀ

Patronage

iprase

FONDAZIONE BRUNO KESSLER

AIMI