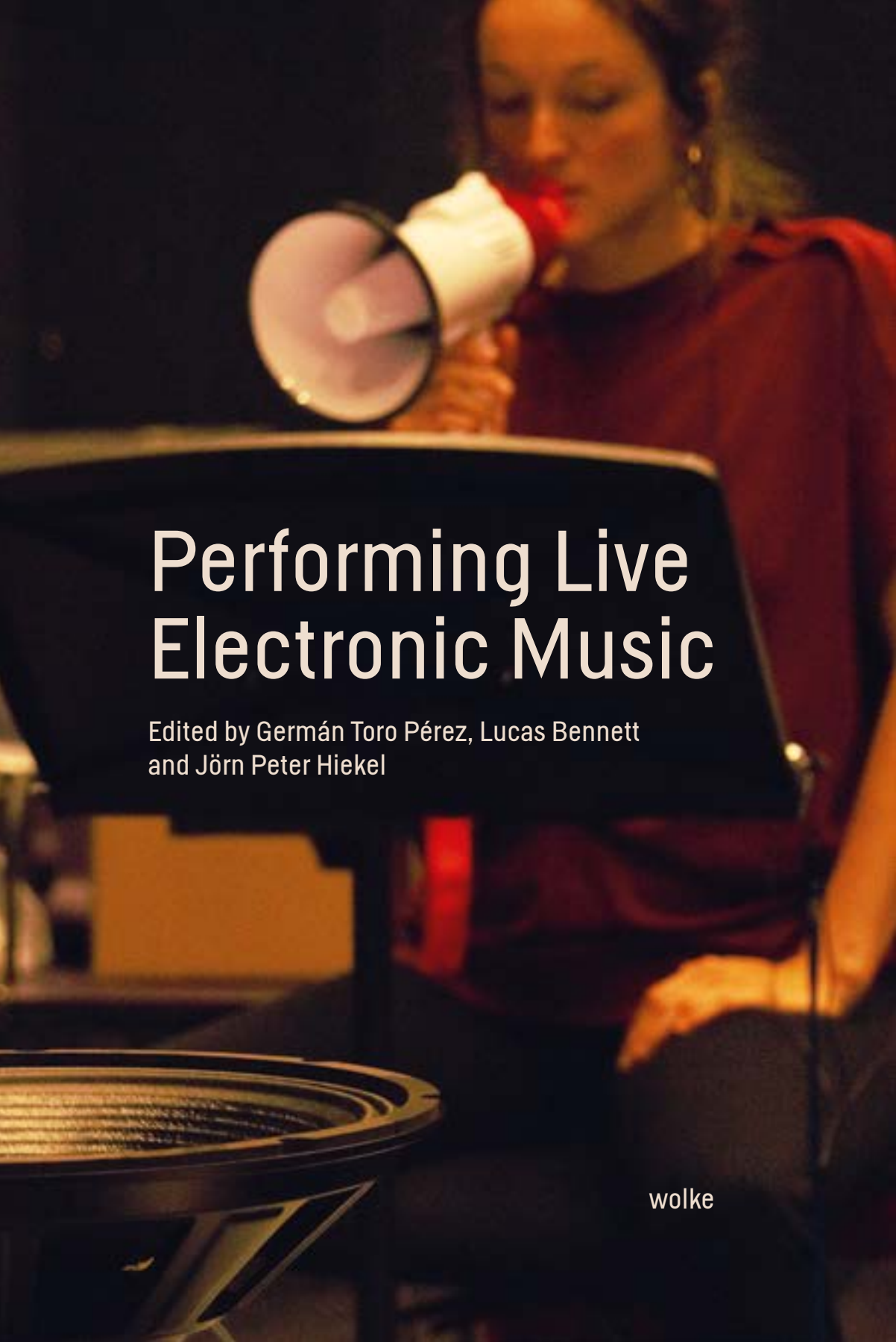


Performing Live Electronic Music

Edited by Germán Toro Pérez, Lucas Bennett and Jörn Peter Hiekel

wolke

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Institute for Computer Music and
Sound Technology | ICST
Zurich University of the Arts

Supported by

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Swiss National
Science Foundation

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Wolke Verlag, Hofheim
Cover design: Friedwalt Donner, Alonissos
Cover photo: Hannah Mehler, Kara Leva and Carlos Hidalgo rehearsing Ash Fure's *Shiver Lung* (Photo: Lucas Bennett)

ISBN 978-3-95593-159-9

www.wolke-verlag.de

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Preface

Germán Toro Pérez

Performing Live Electronic Music: Technical and Aesthetical Challenges in the Digital Age is the title of a research project realised at the Institute for Computer Music and Sound Technology between 2018 and 2023 and made possible by a generous grant from the Swiss National Science Foundation.[1] Intended as practice-based research, the project focused on the challenges met by performers today in view of increasing aesthetical diversity, rapidly evolving technology, and transforming reception cultures. Twenty-eight pieces were studied, performed and discussed in six workshops and a concluding symposium. The selection was based on a systematic view of the repertoire according to six compositional approaches to be understood as sets of interrelated and overlapping features:

1. Sound, space and interaction
2. Composing the instrument
3. Formalised and conceptual approaches
4. Collaboration, oral tradition, open form, improvisation
5. Sampling and pop aesthetics
6. Multimodality, visuality, body and gesture

The research was structured along modules entailing source study, exchange with composers and experts (scholars, performers, musicians involved in the creation and/or the performance of the pieces, publishers and archives), and our own performative work. Each module would end with a workshop giving composers, experts and the research team the opportunity to share insights, discuss the pieces in open rehearsals and experience them in concert. Thus far, the output consists of articles on individual pieces published in our database,[2] exemplary recordings,[3] lectures and performances.

The majority of the texts gathered in this book were first presented and discussed at a concluding symposium realised in September of 2022.[4] These texts, reworked and expanded, in some cases refer to insights and materials collected during the project. Nevertheless, the aim of the symposium and subsequent pub-

1 *Performing Live Electronic Music: Technical and Aesthetical Challenges in the Digital Age*. https://data.snf.ch/grants/grant/182693.

2 *Performance Practice of Electroacoustic Music – The Database.* http://ppeam.zhdk.ch/

3 Les Espaces Électroacoustiques III, col legno WWE 40005 (SACD). https://www.col-legno.com/en/shop/40005-les-espaces-electroacoustiques-iii.

4 Zurich University of the Arts, 22–29 September 2022, https://www.zhdk.ch/en/event/48138.

lication was to discuss live electronic music in a broader, interdisciplinary context, adopting a perspective that, in contrast to the previous work-specific research, would allow to interweave single threads of inquiry from philosophy, musicology, music theory, composition and performance practice. Ultimately, the project in general, and this publication in particular intend to update our understanding of live electronic music as a practice able to highlight in an exemplary manner the transforming interrelations between arts, sciences, technology, and social practices. Two years later, in a time of growing global crisis—climate, democracy, migration—the reflection on live electronic music reveals the potential of artistic practice to perform the reconfiguration of relationships between us and our environment.

Accordingly, the texts presented in the first section of this book go beyond the specific forms of live electronic music represented by the selected pieces. Dieter Mersch highlights 'experimental electroacoustic live productions'—in opposition to a merely imitating 'AI-compositing'—from a philosophical-ethical standpoint as 'live electronic events', where composition and improvisation 'fold into each other', constituting the 'pragmatics of aesthetical research'. In the next chapter I discuss the 'epistemic potential' of live electronic music as a constitutive feature of sounding arts involving technology in the era of artistic research. Identifying 'epistemic markers' in instrumental devices and settings, the text discusses their impact on the 'way we understand, create and perceive musical form'. In a 'practitioner-focused discussion', Simon Emmerson advances his reflection on human-machine relationships in live electronic 'musicking'. Elaborating on models from musicology and philosophy, he shifts the discussion from liveness to meaning. Agostino Di Scipio greatly expands the concept of ecology and makes a strong case for a post-humanist understanding of live electronic performance as a practice that 'makes tangible—or better audible—what it means in our times to live as humans dwelling in utterly technologised ecologies'. 'Human-object relations' are also at the core of Rama Gottfried's essay, contemplating a composition and performance practice in which instrument design, inspired by human-computer interaction, theatre, puppetry and improvisation, constitutes a post-instrumental approach to live electronics.

The last chapter serves as a bridge to the next section, in which the authors approach topics of live electronic composition and performance practice mentioned above, such as instrument 'composition', notation, reconstruction and collaboration. All four chapters refer to pieces studied in the project. Based on reflections on the nature of instruments in live electronic practice, Miriam Akkermann refines models describing the relationships between all agents involved in performance systems in order to discuss the instrumental settings of *Flute Control* by Thomas Kessler and *Dead Wire* by Iris ter Shiphorst. The transformation of the status and role of notation, challenged by new musical practices such as live electronics, is the focus of Kilian Schwoon's contribution. The black box metaphor serves as starting

point for a discussion of the fragility of notation systems (and tools) in view of the reperformability of pieces. A critical take on limitations in reconstructing performance systems for the purpose of reperformances by Lucas Bennett and myself follows in the next chapter, discussing, among other pieces, *KOMA* by Gerhard. E. Winkler—a fascinating borderline case studied in the project. Finally, Laura Zattra's contribution offers a comprehensive study on creativity and collaboration based on interviews with composers and musicians involved in the creation of *Professor Bad Trip* by Fausto Romitelli, *Outer Space* by Clara Iannotta and *Regnum animale* by Andrea Valle and Mauro Lanza, advancing the fields and methods of philological research in electroacoustic music.

The third and last section is dedicated to the performers' view of their own practice. Alvise Vidolin, one of the main contemporary witnesses in the field, recounts the transformation that occurred in the practice of electroacoustic performers ('sound directors') from its beginnings to our days. This retrospective view is complemented by Lydia Jeschke's reflections on the practice as it developed at the SWR Expermentalstudio, a prominent study object with respect to the role of institutions in the development of performance traditions. In contrast—albeit also addressing collaborative creative approaches—Thomas Moore describes and reflects on post-instrumental, performative and curatorial practices of new ensembles of 'digital natives' specialised in a highly technical, multi-modal repertoire as exemplified by the Belgian Nadar Ensemble. Additionally, Joan Oliver, one of the performers involved in the project, presents a comparative analysis of the performer's attitudes required in Horacio Vaggione's *Shifting Mirrors* and Marco Stroppa's *… of Silence*. The section concludes with the transcription of a panel discussion with Martina Schucan, Matthias Ziegler, Joan Oliver and myself, extending the topic to other case studies.

I would like to take the opportunity to express my deep gratitude to all persons involved in realising the present publication: first of all the co-editors, Lucas Bennett, who has been my main collaborator and support in our research on performance practice of electroacoustic music at ICST since 2012, and Jörn Peter Hiekel, who's advice and commitment have been fundamental for the conception of the symposium and the present publication, and who accompanied the four-year research as our main project partner; Alvise Vidolin and Kilian Schwoon, who have supported our research as advisers for more than a decade, adding to it great performances, lectures and contributions to our SACD releases. Finally, I would like to express my gratitude to the project team at ICST, among them former students that are now colleagues as well as long-time companions at ZHdK, for their professionalism and artistic commitment: Leandro Gianini, Carlos Hidalgo, Peter Färber, Dominikas Girčius, Mario Bruderhofer, Milena Winter and Florian Bogner.

Zurich, 23 June 2024

I. Live Electronic Music and Performance

Instantaneity. On Presence, Live-Performance and Improvisation

Dieter Mersch

1. Electronic Music: Early Issues

Electroacoustic music can look back on at least 80 years of history with changing protagonists, technologies and problems.[1] From the very beginning, it has also been embedded in a complex field of discourse: from scientific research into perception, with special consideration of the mathematics and physics of acoustics, to the four basic paradigms of an interdisciplinary unified science, such as cybernetics, systems theory, computer science and semiotics.[2] In addition, the humanities saw extensive debates about 'art in the technical age', which shaped the theoretical context, particularly in Darmstadt and Cologne, and helped to determine the development of electronic music—particularly worthy of mention in the devastated post-war Germany of the 1950s are the rather alarmed discussions involving philosophers and art historians such as Ortega y Gasset, Martin Heidegger, Kurt Bausch and Max Bense on the one hand and on the other artists such as the so-called 3-N pioneers of computer art Michael Noll, Georg Nees and Frieder Nake or music theorists and composers such as Abraham Moles and Karlheinz Stockhausen, who interpreted processes of musical composition in terms of information, system theory and mathematics. Meanwhile, research institutes or projects dedicated to the investigation of different facets of electronic music emerged in the USA, such as the New York Project of Music for Magnetic Tape, conceived by John Cage together with Earle Brown, Morton Feldman and David Tudor, which led to such diverse compositions as *Imaginary Landscape* or *Williams Mix* (both from 1952), or the Columbia-Princeton Electronic Music Center run by Vladimir Ussachevsky, Otto Luening and Milton Babbitt. In Europe, the new radio stations concurrently set up special studios, such as the RAI in Milan with Luciano Berio and Lucio Fontana or the NWDR studio in Cologne, where Stockhausen and Herbert Eimert worked together. Furthermore, in the 1960s, Manfred Eigen, together with personalities from philosophy, art and science such as Georg Picht, Pierre Boulez, Carl Friedrich von Weizsäcker and others, endeavoured to found a Max Planck Institute for the study of the foundations of music within the Hinterzarten study group, a project which ultimately failed and much later led to the Max

1 For the history, see (Ruschkowski 2010: 184 ff).
2 Cf. (Mersch 2013).

Planck Institute for Empirical Aesthetics. Following these developments, Boulez pursued plans for his own research institute in Paris in the 1970s, which was finally integrated as IRCAM into the *Centre Pompidou* in 1977, with the aim, as Boulez wrote, to pursue research 'not only for electroacoustics and electronics, but for […] all areas relating to music and acoustics' (Boulez 1977: 125).

These early beginnings should be mentioned because they reveal remarkable overlaps of interest between the arts and natural sciences, so that from the mid-20th century onwards we can speak of a dynamic situation with respect to research *for music* and *with music*, i.e. of a scientific as well as philosophical and artistic research *avant la lettre* with a remarkably convergent epistemic orientation. Regarding its productivity and creativity, it is to a certain extent comparable to early film history, which was also not only concerned with this new medium's technical advances, with optimisations of its machinery, but above all with the exploration of the medial and artistic possibilities of this aesthetic means of production itself—one would think in particular of the early experimental phase of silent film with exponents such as Ernst Lubitsch, Fritz Lang, Georges Méliès or Yasujirō Ozu and Sergei M. Eisenstein, to name but a few.[3] It was by no means a matter of course to transform the 'moving images', as they were called, into a cinematic narrative; this first had to be painstakingly and tentatively achieved through the practices of film editing—just as electroacoustic music had to make its way from its primitive beginnings to today's elaborate processes via numerous research steps: Examples can be heard in Herbert Eimert's *Klangstudie I* for sine tones from 1952 or in Vladimir Ussachevsky's more conventional use of tape recorder and controller as musical instruments in connection with traditional orchestral sounds and in his compositions *Sonic Contours* or *Fantasy in Space*, both also from 1952, which were created using additive processes.

Piece by piece, the new medium's compositional possibilities are revealed, each of them the result of complex tests and studies bearing witness to the gradual birth of electroacoustics through research and experimentation: By means of tape editing and later, derived from it, digital editing techniques, through sound modulation and sound control using devices borrowed and adapted from physical acoustics such as transducers and sine wave generators, as well as by working with magnetically recorded sound fragments or the implementation of random numbers and other probabilistic functions and the like. Besides the parallels with cinematography, there are also numerous parallels with the early days of computer graphics—consider, for example, the systematically arranged vectors on pictures by Georg Nees or Frieder Nake's rhythmic studies—the difference being that music as a temporal art required compositional processes different from those of visual spatial art.

3 On early film history, see (Kreimeier 2011).

By analogy, we can therefore speak of *two* dominant directions of experimental research in early electroacoustic music, which are also characteristic of the development of the other arts: *Firstly*, research-based *improvement of technologies* and simultaneous *advances in knowledge about perceptual and apparatus-related processes*, which Christopher Frayling in his classification of practice-based research methods in the arts and design apostrophised as 'Research for Arts' (Frayling 1993).[4] *Secondly*, we are dealing with *an ongoing practical learning process* through the experimental testing and working through of compositional procedures, which the arts, and especially compositional practice, used as a medium for self-exploration, thus generating not only knowledge about the mathematical and physical behaviour of sounds, but also knowledge *about themselves*.[5] The latter—as learning by research and research by learning ('Research through Arts')—appears particularly relevant with regard to the status of genuinely experimental artistic research work in New Music and above all in electroacoustic composition. It led to the invention of the 'aesthetic laboratory' in musical practice, provided in the early phase by radio stations, and from the 1980s embodied by the home studio made possible by portable computers, permanently changing the character and orientation of composition, even if the equipment initially was still too complex and static to simultaneously allow its instantaneous and improvisational use. Rather, the beginnings were characterised by an ongoing search for other forms of sound production, the focus being on the expansion of classical instrumentation as well as new media of sound production such as the synthesiser and the 'technical' sounds characteristic of film.[6] These led towards a new sound aesthetic, characterised above all by experimental 'tinkering', the apparatus-based 'do-it-yourself' and its bricolages.[7]

2. Caesura of Computer Music

The early, still cumbersome situation changed fundamentally with the availability of the computer for musical processes since the 1970s and especially in the 1980s and 1990s with the advent of the laptop and broadly accessible sound generation and editing programs. The transformation was like a quantum leap not only in technical, but also in aesthetic development—a caesura that was reflected in composition as well as in performance practice, especially since compositional production was no longer limited to studios with complex equipment, but could be realised with portable PCs, synthesisers, and later with mobile phones, tablets

4 Since then, a rich literature has emerged on what is now internationally established and institutionalised as a genuinely aesthetic practice under the heading of 'artistic research'.

5 Cf. esp. (Mersch 2015: 115ff).

6 See also (Jackson 2010).

7 Cf. (Boulez 1977: 126 ff); see also (Landwehr 2006).

and digital sound modulators etc., which were also used live. However, because of the technical explosions associated with this, the genealogical threads become entangled, whereby two, in my opinion decisive, points should be at the centre of considerations: *Firstly*, an *operative revolution*, as computers work on the one hand with discrete units that must first be inscribed into the continuum of analogue sound worlds and which are at odds with traditional notation and sound production, and on the other hand develop on the basis of decision-logic structures in time, whose non-analogue syntax penetrates the compositional process itself and leaves specific structural traces in it. The changes affect both the production of music and forms of sound control and performance. *The second caesura* has mainly arisen since the 1990s through the shaping of an *interactivity* and *participative quality* conditioned by the emergence of digital networking and the mastery of its interfaces, which in turn touches on what could be called the *social aspect* of the musical. This includes instantaneous composing and joint improvisation in real time, even in different spaces and with the active participation of the audience.

Let us first consider the *operative revolution*. It is primarily based on sound synthesis processes as well as manipulation and control of sounds down to their finest units, and at the same time on the reversed control of the actors by the machine- and pre-generated sounds, as working with technical units requires the actors to adapt to the internal possibilities of technology. In the following, however, I will focus primarily on the second point, limiting myself to a few pointers: the field is too broad to be satisfactorily discussed in a short essay. A direct line can be drawn here from Eimert's and Stockhausen's sound experiments with pure sine tones in the 1950s and 60s to Cage's *The Future of Music* and his *History of Experimental Music in the United States* (Cage 1971: 3–17, 67–75) and the artistic research of Alvin Lucier and others[8] to the development of systems capable of connecting through networks using MIDI interfaces or sampling processes.[9] For Eimert and Stockhausen, electronics and in particular the synthetic sound production of pure sine waves offered themselves to solve a systematic problem of serialism, which dominated the compositional process in Europe in the 1950s in the context of New Music. In serialism the compositional units were broken down in the sense of musical structuralism into a four-dimensional matrix consisting of pitch, time or rhythm, dynamics and timbre. While the first two parameters could be discretised according to the classical tonal scheme, timbre could not, and therefore was not suitable for serial development.[10] However, according to the Fourier

8 Cf. in particular (Mersch 2018).

9 On the latter, see (Rutschkowski 2010: 384 ff).

10 It is significant that the central compositional principle of serialism was based on serial development, which required certain finite units. Serialism continued to adhere to the traditional 12-tone scale of European musical traditions and excluded microtonality. Because the constructions were predominantly such that could be notated, it was equally impossible to depict continuous transitions; here tradition only provided for glissandi. In addition, the mathematical-physical analysis of sound suggests a continuous transition from rhythm to tone in percep-

transformation of acoustic events every sound consists of a composite of pure sine waves that can be produced individually and theoretically converted back into any sound by addition, so that it had to be possible to synthetically construct sounds. With appropriate filtering, synthetic sounds can then be obtained, such as they were later realised digitally with synthesisers and through their computerised versions implemented and used in live performances. We are therefore dealing with 'com-positions' in the literal sense of an analytical 'composition' of technical or artificially generated soundscapes, which appear to be freely modulable and controllable and thus also capable of producing previously 'unheard' and 'unheard of' sounds. Electroacoustic composition is interwoven with this goal: not the perfection of an imitation of analogue sounds, but the generation of completely different sound forms and corresponding listening experiences. It thus implies—in the true sense of 'art in the technical age'—a technicist break in music; not so much in relation to the compositional processes themselves, such as serialism, whose time had already passed by the early 1960s, but rather in the sense of a dissolution of all traditional genre concepts and musical principles in order to present a 'new', previously unthinkable music in the truest sense of the word. It ranges from a proliferation of mathematically precise syntaxes of the compositional process to new, instantaneous forms of improvisation, such as those used early on in pop music—think of Pink Floyd, Kraftwerk or Led Zeppelin in terms of electroacoustic sound expansions.[11]

One of the consequences for musical composition is that since then the focus has been less on the design and arrangement of completed *works* and more on *performative sound studies*, which are more resemblant of experimental research objects than of traditional pieces and whose essential feature since the 1970s has been the creation of multi-layered space-time sculptures or stochastic dynamics as well as new interface settings. The electroacoustic sound experiments operate between analogue-material physics and mathematical structurality, in particular digitality and the possibility of freely linking and nesting all possible sound elements regardless of their respective origin, tonal quality and meaning, solely on the level of arbitrarily assemblable units that do not even have to be of a musical nature. This means that digital cuts allow more flexible combinatorics and more precise modulation of sounds; their simulative power is almost unlimited. In particular, infinitesimal samples allow the combination of completely unpredictable polyrhythmic as well as polyphonic types of sound, and their control and regulation no longer depend on acoustic-physical conditions in the strict sense, which appeal solely to hearing, but on the constructiveness of numbers or visual or graphic representations, which make possible completely different ways of working. To a

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tion. On the connection between serialism and 'electronic music' as understood by Eimert and Stockhausen, see also (Ruschkowski 2010: 232ff).

11 Cf. e.g. (Ross 2007).

much greater extent than was previously possible in classical electronic music with its clumsy mechanical arrangements, the modes of montage are then intertwined with a creative spontaneity that connects the individual musical parameters like collective actors. The result, as Umberto Eco wrote in the 1960s in his *Open Work of Art*, pointing far ahead to future practices, are creations that transform multiple apparatuses into an ensemble of direct live performances in such a way that not even instrumentalists are required to give the sounds their physical 'grounding' (Eco 1977: 27 ff).

However, a number of other consequences and limitations must be taken into account. *On the one hand*, digitisation indeed dissolves the previously close link between body, instrument and playing.[12] It leads to a disembodiment, so that the caesura of computerisation tends to imply a detachment from the performer's almost 'bodily attachment' to his or her instrument, achieved through long training—a tendency that must be readjusted, as it were, with increasing interaction between man and machine. Furthermore, the moment of democratisation is repeatedly emphasised in the debates on digitisation, as the 'dilettantism', as it were, of autodidacts without any conservatory training is sufficient to operate computers. This, too, has been demonstrated in Jazz and popular music of the 1960s and 70s, up to an almost unbelievable improvisational virtuosity, which is now in a similar way being transferred to compositional and improvisational skills in using the computer and playing with electroacoustic devices—at the price, however, that at the same time the sounds no longer obey the laws of resonance and resonating bodies, but are given a synthetic-abstract architecture that is literally deprived of their classical grounding. We are thus not so much dealing with a direct *physical* relationship between computer and user, which spills over into the sound production and remains audible; rather, digital productions are characterised by a manifest independence from such a bond and the resulting vibrational character of the sounds. *Synthetic sounds are structural sounds*, which is why they can be freely transferred to any location.

This, secondly, has to do with the fact that the Fourier theorems are decisive only with respect to the *structure of sounds*, and not their *phenomenality*, so that synthetic sounds are perceived differently than acoustical or mechanically generated sounds. Mathematical synthesis involves a break with the empirical, so that no acoustic ontology can be derived from Fourier analysis that would form the basis of musical aesthetics—something which is often claimed by technophile theorists—rather, aesthetic phenomena are always singular and eventful in their appearance, while the computer relies on the principle of repeatability and calculability of schemes. This means that additive sound syntheses merely come close to our listening experience; they lead to similarities, even in complex sounds, but not to sameness. At this point, one can even speak of 'similarity without dissimi-

12 On the topos of embodiment, see (Corness 2008: 21–24) and (Leman & Maes 2014: 236–246).

larity',[13] since classical aesthetics are based on a fundamental difference that only makes the similar recognisable *as* similar against the background of something dissimilar, while synthetic sounds sometimes seem to sound as if they were produced by classical instruments, but only in the mode of *as if*, which does not appear to be resolvable to something different, not illusory. This also means that, strictly speaking, synthesisers do not *simulate* classical instrumentation, but at best their surfaces; instead, they generate their own sound worlds, even if they sometimes fall below the human hearing threshold.[14] *Thirdly*, working under digital conditions with their emphasis on the discrete and visual, differs both from intuitive composition by ear and from notational construction on the drawing board. The decisive factor here is rather the calculation of each individual musical event beyond its continuity made possible by discretisation into which an experimental moment is implemented from the outset: from the micro-assembly of individual signal components to compositions based on statistics and relying on artificial intelligence on the basis of large quantities of data and their underlying decision-logic algorithms to the implementation of mathematical, i.e. deterministic pseudo coincidences.[15]

3. Computer-Generated Compositions

The entire musical landscape, including the contemporary discourse about it, is changing accordingly, as digitisation and computerisation not only intervene in the compositional processes themselves, but also reject their previous theorisation. At the same time, computers are becoming autonomous agents that take over compositions or parts of them in such a way that educated listeners can hardly identify them as 'machine works'.[16] This is done, for example, by using logical decision-making procedures to gradually impose a measure of order on the initially chaotic sounds generated according to random patterns, so that order is literally created from chaos (*ordo ab chao*) in accordance with second-order cybernetics. The first computer-controlled compositions such as the *ILLIAC* suite by Lejaren A. Hiller and Leonard M. Isaacson from 1955 were of this type.[17] An initially unordered set of tones was successively structured in such a way that they were assigned the four serial parameters of pitch, dynamics, time sequence and timbre, into which were implemented either characteristic sets and production rules defined by programmers or statistical extracts taken from music history such as counterpoint, harmony, circle of fifths or sentence structure and the like, and

13 Cf. (Mersch 2024).
14 Cf. in particular (Hansen 2014).
15 Cf. (Mersch 2023).
16 On programmed composition, see in particular (Miller 2019: 133 ff).
17 See (Hiller & Isaacson 1959); cf. also (Ruschkowski 2010).

finally, as in David Cope's composition program *Emmy* (EMI),[18] stylistic characteristics of Bach, Beethoven or jazz music were added, from which in turn certain patterns were derived that would generate the compositions. However, they were inscribed into the tone rows until they themselves again sounded like Bach, Beethoven or jazz.

Early computer music, which in no way resembled today's AI-controlled processes, was therefore consistently oriented towards traditional music theories and thus unable to produce anything other than their musical reproduction; the advent of the statistical processing of the entire history of classical music, on the other hand, opened up more far-reaching possibilities, however, the products still seemed like extracts or images from the long history and were therefore disappointing: They systematically fell short of the bold designs of avant-garde futurity. The processing of entire musical epochs into new material dilutes them rather than transcending or enriching them; it evens out the historical canon by proceeding according to the principle of genetic recombination and, as it were, mixing the compositional genes into 'bastards'. In her epochal work *The Creative Mind, Myths and Mechanisms*, Margaret Boden (1990) listed various necessary and sufficient criteria for creativity using artificial intelligence, but one notices that the term is generally only used to describe the value of originality, novelty or surprise, i.e. creativity is confused with innovativeness—even though Boden recognises the concept of radical creativity, which is associated with normative breaks and historical paradigm shifts in thinking.[19] The confusion between creativity and innovativeness is therefore typically prevalent in theories on creativity in artificial intelligence; this applies particularly to the latest art experiments using machine learning, image generators or improvisation machines, whose mode of operation not only remains opaque in the true sense, but whose source lies much more in the art of humanity, atomised and compiled so that machines might *'learningly' continue into the future what has already been in the past*. This is why writer Daniel Kehlmann aptly referred to AI as a 'secondary recycler' in his Stuttgart speech on the future *Mein Algorithmus und ich* (2021), and Noam Chomsky has outright accused it of plagiarism. Because they *project* into the *future what was in the past*, they are devoid of any volatile creativity; their *inventio's* potential remains bound to past history, true to Nelson Goodman's dictum that 'to create [...] is to re-create.' (Goodman 1991: 19) The number of existing aesthetic works is thus multiplied many times over, automatically and arbitrarily.

The 'creative leap' is simulated by arranging the models in such a way that their essential core consists of random parameters: be it as random numbers entering into them according to the stochastic minimax optimisation method or as randomly selected data sets. This means that machines and their programs are

18 See (Cope 2001).

19 On various concepts of creativity, see (Mersch 2006 & 2017a, also forthcoming).

not creative in themselves—this would be a misleading exaggeration—but their so-called 'creative' output is largely based on mathematical random operators, so that AI 'creativity' *mimics* creativity and thus also imitates art and composition; to confuse it with human art-making misses the point. What it produces instead can never be more than what Kendall Walton calls 'make-believe' (Walton 1993)—despite Turing's 'imitation game' being cited as proof of validity[20] and now also being applied to artificial and artistic aesthetics by presenting various human and machine-produced compositions to an audience of apparent experts in order to decide *whether* they are of human or synthetic origin.[21] It is not the quality itself and its meaning that forms the measure of their difference, but the 'that' of their binary decidability or undecidability. The nonsensical nature of this undertaking is apparent in the AI-supported 'completion' of Beethoven's fragmentary 10th Symphony: The 'work' is devoid of any 'wit',[22] of emotional dramaturgy and structure; it processes fragments from all of Beethoven's symphonies and therefore remains a meaningless collection of sterile fragments without an overarching central idea, albeit some commentators have declared to be 'moved'.[23] The audience is left out; it judges something according to its subjective taste and not according to its always open and responsive 'participation' (*koinōnia*).[24]

Obviously, just as with early attempts to compose by means of computational processes, AI-generated practices also come up against both mathematical and aesthetic limits, not only because complex compositions rely on large databases and have to cope with vast numbers, which can be compensated for by compressing or standardising them, but above all because the principle of sound generation is based on the manipulation, control and regulation of musical elements solely related to prevailing patterns. Such practices not only produce a hyper-mimetically enhanced arsenal of historical imitations, but also seek to create a semblance of elaborate compositional concepts that arouse our aesthetic interest. They essentially follow rules and arrangements that nevertheless produce different results with each repetition of the experimental arrangement. In other words: Their ontology is the game into which, as Marcus du Sautoy has also pointed out, a number of preliminary decisions such as symmetry of numbers, geometric properties or rules of probability enter, without which the pieces would appear chaotic or

20 Cf. (Turing 1950) and also (Davidson 2010), making it clear that even where we as humans fail against the computer, this says nothing about whether a machine 'thinks'. On the preliminary state of research see (*Moor 1987).* A critical view on this is also presented in (Mersch 2013: 9–28). Cf. also S. Emmerson's text in this book, pp. 56.

21 Time and again, such tests are carried out with grand gestures and staging, without being in the least meaningful.

22 See (Fliescher 2019).

23 The world premiere of 'Beethoven's 10th', completed by a Ki, took place on 10 October 2021. Cf. https://www.zeit.de/news/2021-10/09/von-ki-vollendete-10-sinfonie-von-beethoven-uraufgefuehrt (viewed 16 January 2024). The first sequences of the 1st movement are the most coherent, but the sketches for them were written by Beethoven himself.

24 Cf. (Mersch 2014: 325–375).

unstructured (du Sautoy 2021: 189 ff). The predominant idea is the characteristic 'musical signature' which can be permutated through recombination patterns in order to create what *sounds like music but is not necessary*, as in artificial genetics.

This is the crux of computer-generated composition, to which yet another crux is added. For the genuinely algorithmic genesis of compositions fundamentally violates the principle of 'com-positio', always driven by reflexivity, the constellation of what Adorno called the musical 'material', denoting everything composers have to do with (Adorno 1973: 18–19, 58–63 et al). Decisive here is the type of constellation, not the fact that it occurs at all. In this regard, Adorno, particularly in his fragmentary Beethoven monograph, speaks of a specific 'non-judgmental synthesis' (Adorno 1993: 31 ff), which fulfils an epistemic function qua synthesis. AI-controlled compositions fulfil this synthesis exclusively through the generation of patterns, syntactic structures or ordering procedures and not with a view to what Arnold Schönberg aptly apostrophised as the actual 'musical thought' (Schönberg 2018).[25] Synthetisations are therefore teleological; they work towards a *symbolon*, a meaning, which at the same time retains its own asyntheses, its *diabolon*, because 'Sinn' (meaning) is always unfulfilled, open. This is why the 'joints' of synthesis always contain their unresolvable 'un-joints', a non-fitting or unwieldy quality like the unclosable passages or skippable passages in the montages. The actual productive 'resonance' of the compositional process is therefore based on its never opening up, on its telos, in other words, refusing to close. For this reason, composers do not work in linear fashion, but in different blocks, as it were, arising at different times and developing discontinuously, while algorithmic processes are based on production rules that continuously go on in time, producing nothing but rule-generated positivities, no gaps, differences or cracks, even if these positivities include coincidences.

What Cage already criticised with respect to Schönberg's row technique thus also applies here: 'There is not enough of nothing in it' (Cage 1971e: 79). The nothing means that which cannot be derived, but from which the series originates, as it were. Accordingly, Stockhausen remarked in his 1973 essay 'Four Criteria of Electronic Music': 'It is not the sounds that are good or bad music, what matters is what is done with them. Whether they are conveyed, whether they are really composed, or whether they are only displayed in an exhibition.' (Stockhausen 1978: 393 f) In tune with this are Adorno's polemic remarks in his Kranichstein lecture 'Vers une musique informelle': Starting out from a discussion of free atonality he roundly rejects mathematical-constructive procedures, declaring 'audibility' the decisive criterion of composition (Adorno 2003: 506 ff).

25 See also (Reinecke 2007).

4. The Computer as Instrument and Medium: Improvisation, Live Coding, Experimentation

All these attempts and criticisms remain to a certain extent bound to the conventional, because they hardly change the classical concept of composition, but only the means with which to imitate traditional compositional processes in a no longer distinguishable way. This raises the suspicion that this approach to computerised music is inadequate and misses its real opportunity. To me, the experimental nature of electroacoustic live productions therefore seems much more adequate and in keeping with digitisation and its immanent ludic character, insofar as it exploits the possibilities of a different and new form of musical performance. It is not about programming *compositional principles* that are subjected to rules or the statistical creative power of machine learning and thus transferred to technology, but about an *interplay* of different creative moments and their relationship with each other, which as a game develops its special performative power in processes such as live coding or various degrees of interaction between different human and non-human actors. Then, *firstly*, technology and its potentials enter into a 'real-time' dialogue with a network of diverse performers or audiences to investigate the multiple variations of human-machine relationships, including their mutual collaboration; and *secondly*, they lend this interaction a character that is as improvisational as lively, which, as we would posit, corresponds better to the computer's creative conditions than what artificial intelligences are capable of.

Electroacoustic live performance presupposes a computerisation and programming that have become flexible, allowing for reactions between disparate actors. We are then indeed dealing with a 'leap' making possible something entirely new: not only other, machine-generated sound universes, but also their simultaneous and instantaneous production, operating in a twofold dialogic manner; between machines and humans, who do not so much control as *handle* them or—literally—manipulate them, and between distributed human-machine ensembles and the presence of an audience that is equally capable of influencing these ensembles and intervening spontaneously.

This circumstance first requires that we return to what was previously said and cast it in a different light. Neither the discretisation of the musical material itself nor its subjugation to program codes, nor the moment of disembodiment between apparatus and operation or the supposed democratisation of control agents are decisive characteristics of a productive use of the computer in the musical field, but rather its deployment as a 'co-player' within the framework of performative settings. The transformation of the musical situation is thus based, *on the one hand*, on a free play with discrete units and their equally fluid and combinatorial dynamics, which can take place directly 'on the device', so to speak, and is related to the improvisational gesture, and *on the other hand* on the exploitation of the possibilities that the miniaturisation of the computer since the 1970s and

its manifold uses as an independent *instrument* with its own interactive stage, or rather, media presence. The fact that anyone who can programme is able to exploit these interactive possibilities in his or her own way, without having acquired and tested their mastery of a musical instrument over many years, points less to the aspect of democratisation than to a change in cultural education, which is shifting from classical training to the elaborate use of media technologies. The transition requires an 'experimental sense', because performative testing, the exploration of manoeuvring space and limits are a genuine part of live electronic processes, the peculiar charm of which lies in an experimental, technical and ludic virtuosity that unfolds. Experimentation and improvisation then prove to be the central characteristics of a *technical ludic situated in the musical realm*. It becomes a specific pragmatics of aesthetic research.

The digitisation of music and the use of the computer as a musical medium, as well as the exploitation of its potential for complex networking, no longer requiring a physical presence but interacting with its audience regardless of time and place, has transformed the entire new music scene especially since the 1990s. It overlaps in particular with the 'other' scenes of popular music, the two spheres seeming to indifferently mix with one another. Drawing on the distinction between *mode 1* and *mode 2* in the philosophy of science, the transition from a dominance of basic research to the pragmatisation of science,[26] which focuses on the laboratory and experiment, the change in the artistic practices of the era can also be understood as a shift from a theory-led foundation of composition with its complex calculations borrowed from mathematical algebra to performative 'design' practices[27] which are rooted in the always provisional draft and satisfy the spontaneity of a permanent exchange between arrangements of devices, the dialogue between different actors and the situational production of intensities. This caesura corresponds to the primacy of pragmatic applications which, as Jean-François Lyotard predicted in his 1979 report *La Condition postmoderne*, tend to lead art and science to a convergence. As a result, we are dealing with completely different musical practices that are not comparable to and indeed incompatible with classical structures and their organisation and for which the difference between analogue and digital is less decisive than its ludic-experimental dynamic, which is constantly realigning itself. Furthermore, each performance must not only sound out and explore its own tonal variance, but also the various possibilities of control and decontrol, as well as the link between improvisation and composition, especially in connection with live coding, which is an uninterrupted celebration of the moment, as it were, as the piece and its execution are created instantaneously in the moment of performance.

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26 Cf. (Gibbons et al 1994) and (Nowotny et al 2003).

27 Design is not understood here in disciplinary terms as material design but is used as a metaphor for primarily pragmatic design methods.

It can therefore be said that musical production enters here into a structural relationship with aesthetic-experimental research processes, but in such a way that the research is about searching, not about finding or 'finding out' aiming to formulate a definitive result. The electroacoustic devices and their setups, together with their actants, thus focus on the generation of singular sensations, i.e. sound events that arise solely and uniquely on the spot in order to be continued and modulated again and again. Repeatability is not their telos, but rather a sort of 'strong commitment to the material' through specific signal processing, formalisation of the parameters and arrangement of materialities in concert with intervention practices that unpredictably affect and react to the settings and create a multimodality of rhythms, resonances, sounds and noises, transforming from moment to moment and communicating in a specific way with the elements in play and the audience, establishing a relationship *between* them. These are neither improvisations with machines nor computer compositions in the true sense of the word, but hybrid formations that at the same time suspend traditional musical distinctions. While the terms 'composition' and 'improvisation' are usually separated, even if improvisation is sometimes referred to as an 'instantaneous form of composition'[28], both diffuse, fold into each other and become entangled in complex knots, just as the vocabularies of music theory are likewise destabilised and expanded in order to adequately grasp what is happening.

Along with the electroacoustic transformation of musical practices, the forms of analysis are transformed as well, as they have to take into account technical conditions and operations as well as their installation, programming, spatial structure or their relationship to the recipients, who are often involved in the processes. In particular, the improvisational moment extends far beyond the narrower field of the musical and extends to the use of devices and work on their coding, just as these conversely require constant adjustment and thus induce ongoing communication with the corresponding algorithms. While in social theory and musicology 'improvisations' are associated with such disparate aspects as normativity, dependence on rules, the process of breaking and transgressing rules as well as instantaneity, spontaneity and unpredictability, the focus here is much more on practices of indeterminacy and emergence that continuously de- and rearrange the setting. There is no question that at the same time compositional effects are triggered, so that improvisation and composition dissolve into a dynamic 'in-between' bound both to the respective programming, codes and their effects, as well as to the network of actors with all their inhibitions and degrees of freedom, their obstacles and momentary ideas, which turn the live event into something highly changeable and uncontrollable that aesthetically can best be compared to the principle of the 'happening'.

28 On the concept of improvisation, see for example (Bertram 2022), (Matteucci 2022) and (Moruzzi 2022).

We are thus confronted with a complex system whose systemic properties are based on a perpetual *experimentum* that unfolds and continues to develop itself before our eyes and ears, as an ongoing 'experiment' (*experior*) that 'brings out' (*egerere*) the unknown in ever new ways and allows the musical *momentum* to emerge as something whose goal or end is not foreseeable. Significantly, the pieces therefore begin and end 'without beginning' and 'endlessly', i.e. they are 'set' and interrupted by the contingency of an entry, whereby each moment in time appears indeterminate and singular, each experiment is different and its artistic dimension consists in the permanent connection, linking and dissolution of manual and mechanical controls, which react mutually to each other without one part exercising 'leadership' or 'mastery' over the other. Rather, there is an ongoing relation between the human 'co-actors' and the devices as autonomous partners, which remains open and surprising throughout. It is a permanent, non-hierarchical flow of coded and non-coded elements, of events interspersed with coincidences and emergences between algorithms, recodings, interventions and interruptions, similar to a chronically unfinished and methodically unsaturated experimental arrangement, whose goal is not the research result, but the sensual exploration of 'phenomenal processes' in the sense of a *verbum*.

The concept of experiment and research is applied here in the sense of a *phenomenological practice* concerned with the sound matter itself, its possibilities of modulation and variation, its spatial characteristics and its environment, but above all with the relationships between all actors who partake in the experimental situation and follow it, who not only actively 'manipulate' it, but also passively inhabit it by listening, are touched by it, intervene in it, doing something different, unanticipated, from one second to the next, as it were. However, the question of the specifically *artistic* situation also becomes relevant, the particularity of that constellation that points beyond technical production in the narrower sense and describes the, so to say, 'added value' of research experiments. Once again, the status of *aesthetic reflexivity* becomes relevant, as it seems to be decisive for determining the *artistic nature* of art (Mersch 2015: 115 ff, 165 ff), for it is not the electroacoustic sensations and their intensities themselves that are decisive, but rather which practices and performances within the performance event allow the release of both reflexive and epistemic forces. In New Music, sound experiments are undertaken for the sake of a 'different', 'deepened' mode of listening, a reutilisation of the instruments, their counter-final use or the instantiation of extra-musical effects in order to highlight the indifference between sound and noise or the various dimensions and colourings of sounds, the characteristics of their perception and to make the inaudible audible or to increase the concentration of the senses. Live performances, on the other hand, where inversions, differences, incompatibilities or contradictions are staged *in praesentia*, are obviously about something more, namely the performative quality of the live situation and its setting itself, i.e. the potential to not only confront us with extraordinary acoustic sound ex-

periences, but also to *involve and include* us in the extraordinary nature of the existential situation. Live performances, and in particular their improvisational intensity, reveal what cannot be shown or performed in any other way: An additional epistemic potential that stems from 'liveness' and its interactivity, situated in an ecology of 'playing together'—with the arrangement, the instruments, peculiarities of the moment and place, the bodies and their localisation, and with other players and the audience—and gives them a literally risky meaning. In addition to the presence of the event itself, 'liveness' is always intimately related to what can be described as 'performative othering': the immediacy of a social event in which different participants are involved in different ways, be it as a dialogue with the machines, as a dialogicity of mutual operations, as an improvisational response or as an intervention or interruption by the audience. Think for example of free jazz concerts: every moment is decisive, and it can succeed as well as fail, which not only reveals the *existential exposure of each performer*, but also *creates an exemplary social constellation* whose tension testifies to a *shared* exposure and mutual dependence. In live electronics, we are once again dealing with a complication of this context, as the 'co-players' are now also connected to human-machine networks as well as to various forms of human-machine participations in which the technical things, the programs and their coding appear as autonomous actors and create a constantly changing web of a multitude of relations, simultaneously addressing an audience, 'playing' towards it, co-addressing it, overtaxing or involving it in order to be challenged by it in ever new ways.

5. Ethics and Sociality of Improvisational-Technical Live Performances

The latter point raises the question of the relationship between music and sociality and a possible ethics of live performances under technical conditions. The notion of 'sociality' should be taken in its broadest sense: as an ecology of means, materials, spaces, individuals and their relationship to each other and much more. This aspect is usually neglected in most considerations of live performances as well as electro-acoustic music, insofar as they mostly focus on what happens on stage and less on spaces, the audience and its potential to react. With regard to the entire spatio-temporal setting of live electronics, the complete ecosystem, so to speak, must thus be taken into account, including the relationship between the performers, the performance, the performed work and its reception, as well as its theoretical foundation and accompanying discourses. In the following, I will only be able to give a rough outline taking into account live electronic events, the question being where exactly and at what point the technical, compo-improvisational moments of the performance event turn into *interesting* aesthetic experiments, thus becoming an *artistic event* in the emphatic sense. In other words, wherein precisely lies the

difference between purely technical effects on the one hand—which Stockhausen castigated as an exhibition of pure sensations—and the actually reflexive character of artistic performances on the other? Or more succinctly: at what point does the transition from the spectacular to what could be described as artistic *epistēmē* take place?

There are many facets to this question, especially as regards musical sound events, which to a certain extent cannot avoid creating a social co-presence, a relationship between the actors and an audience that receives and interacts in equal measure, in addition to the aesthetic relationship. We have stated that live performances, including the technical structures of the involved live electronics, can only be understood if one considers the interplay of heterogeneous actors and their interconnectivity within the network, which at the same time constitute an experimental test arrangement whose *performative* character essentially consists in the fact that its 'outcome', as Cage put it, remains unpredictable (Cage 1971 e: 69). This also means that such experiments can always fail, that they may come to nothing, remain incoherent or 'fall apart' (*diabolon*) instead of constituting an 'assembly', a 'gathering' (*koinon*) or 'bringing together' (*symbolon*). According to John Langshaw Austin—the founder of linguistic speech act theory, who first introduced the concept of the performative as an analytical category into philosophical discourse—the possibility of failure is one of the essential characteristics of *performativa*. It confronts us with the finiteness of the conditions and the uncontrollability of the setting, and in particular with the aspect of alterity, as different people are always involved in the experimental events, unpredictably 'inscribing' their own finiteness into them. This is why all performative acts are associated with the fragile or ephemeral.[29] Live performances can therefore generally be regarded as precarious, especially in the eyes of those to whom they relate: Therein lies their appeal, their extraordinary power. Audiences will sometimes display a leaden passivity or an unwillingness to interact, or intervene in an unseemly way, something which had prompted Joseph Beuys to kick an audience member off the stage during one of the early happenings at the Aachen Technical University's 'Audimax'.[30] This also applies—despite or precisely because of the complexity of the technical arrangements and their seeming perfection, which can also fail—to live electronic concerts, which can entail contingencies in the experimental setup, dysfunctionalities or counter-finalities, even intimidate the audience and much more. The digital revolution and disruption has greatly increased such uncertainties due to the possibility of having complex installations, of the exigencies of programming and the actors' expectations with regard to interactive participation.

29 Cf. (Mersch 2017b).

30 Fluxus Festival at the RWTH Aachen in 1964. See also the exhibition 'ACTION! Platform Aachen – Action Art since 1964', Ludwig Forum Aachen Oct. 2015 – March 2016.

It is not unusual for installations to train the ears or overwhelm listeners, who then shy away and refuse any participation.

This extraordinary social force emanates from all music, so that every performance practice, even a passive one, embodies a specific *social ethos*, which is why the ancient system of *epistēmē* assigned *musika* the highest place in the cultural order of knowledge, even before mathematics and astronomy. It matters then *which* social ethos is constituted through the means of performances, and, to go one step further, it is part of the epistemic motives of artistic confrontations to make these the very object of reflection. This is particularly true of live performances and their electroacoustic equipment, whether it is achieved through a focus on immersion, drawing us into the event without will, or through the power of specific technical environments, through raised awareness of the active inscription of the human into the technical and the equalisation of human and non-human entities in relational networks, or, to cite another example, through the staging of Dionysian sound excesses in virtuoso rock concerts seeking to electrify the audience. According to Latour, in live electronics we are also dealing with 'distributed ensembles' or 'mixed collectives' (Latour 2017: 17, 103 ff), so that we are confronted with very different types of 'assemblies' (*koinōnia*), the realisation of which can be described with the ancient Greek term *koinōnia* and to whose peculiar energetic 'bonding' live musical events are able to contribute in a special way.

The interactive experimentalism of live electronic performances associated with the possibilities of computer networking aimed directly for an expanded *dialogue between music and the ecology of the social*, one which included technology, its programming and coding. In this, the *dispositif* and its order, the *oikonomia* of the technical in the true sense, as well as the structures of the musical and its laws, seem to play a lesser role than the aesthetic-musical koinōnia, the *community-building moment of experimental performance*, which at the same time has to be researched and reflected upon. Directly interwoven with this is the question of 'art in the technical age' apostrophised at the beginning: it concerns new forms of communitisation and the associated visions under technical conditions. The question can be answered in different ways and with different depths of focus—in rock music, to choose an extreme example, through bold and eccentric improvisations using technical feedback, whose specific sound corresponded with the sexual-masculine gesture of putting the audience into action or making it dance—Adorno would not have hesitated to castigate such mass events as 'fascist': His invectives against Igor Stravinsky may serve as an example (Adorno 1978: 127 ff, 142 f, 148 f)—in free jazz through the collective (*koinon*) concentration of individual improvisations that seem to reinvent the social *momentum* at every moment, or by means of digital sound production involving synthesisers or live coding with the technical itself entering the social fabric and the machines becoming quasi-autonomous agents of the unheard, which presupposes the augmentation and multipli-

cation of networking possibilities through corresponding interfaces together with all the required musical and technical learning processes.

These are just three examples; however, one should bear in mind that for live performances in general, and not just for live concerts or live electronics, there is yet another constitutive element that cannot be technically simulated: the moment of alterity. This concerns the multidimensional dialogical structure of the performance as a whole. The aspect of alterity must to some extent be contrasted with the actor networks privileged by Latour and others, to which a moment of othering is likewise attributed. For the technical apparatuses control inspirations that are stimulated, for example, by mathematical randomisation processes and therefore only *seemingly* represent 'an other', whereas the term 'alterity' means something different, since the other as alterity requests answers, while technical interactions or live coding require both instantaneous and reactive programming, something which is rather to be associated with the term 'affordance'. In other words: Alterity calls for responsiveness; it gives the performative and thus the social structure of the performance a distinctive note, provoking the audience's participation in a special way, whereas affordances act like impulses that can be responded to in different ways, so that the response's character is reductive. While there is also a technical side to both participation and participativeness, they similarly resist the seamless realisation of the technical. Technical networking is determined by relations and their modalities, which can be reinforced or reduced, so that we are dealing with formal relationalities that satisfy a graphic-diagrammatic order, while social relations, as they are also established in improvisations, have a 'different depth', insofar as they are first and foremost triggered and coloured *by the other*. Moreover, with regard to the actual technical arrangements and their distributed ensembles, one can speak of *topological regimes* that restrict rather than open up the possibilities of communicativity and interactivity, as they are represented by 'edges' and 'nodes' according to mathematical graph theory. Thus, musical *koinōnia* under technical conditions is fundamentally limited to the extent that the technological networks channel its possibilities, and in my opinion it is crucial for the artistic process and its reflexive aesthetic self-exploration to always expose such limits and to make them visible notwithstanding all of the live event's productive experimentalism if one wants to make what I call the 'leap' between 'aesthetic' and 'artistic' practice as well as between 'aesthetic' and 'artistic' research.

In conclusion, I would like to go a small step further in order to make clear what exactly is 'at stake'. What was previously highlighted by the concept of *koinōnia*, the always open, still to be realised and always precarious 'binding' or 'gathering' of alterities, and was addressed as the always new and unrealised sociality of the social in order to then transfer its problem to live musical performances, is described in posthumanist discourses as systemic environments of different human and non-human 'agencies' with a view to Latour's network theory. In contrast, I prefer the seemingly more antiquated term of the 'social', addressing an

entirety of different facets of relationship (rather than relations) because network environments always emphasise the aspect of the systemic with all the preliminary decisions of formal, functional structures.[31] The question then remains as to how the *system of relations* is to be understood with respect to live performances, what the distribution between disparate human and non-human entities looks like in concrete terms, how the relationalities are to be reconstructed in detail and what added value is generated by their merely relationalistic description. My assumption is that terms such as 'relation' or 'system' remain problematic as long as the specific nature of relationships and thus their modalities themselves remain unspecified. Latour assumes a symmetry or equality of all forms of relation and thus an *equality of the networks of actors* (Latour 2008), be they connections of apparatuses, performers or recipients, codes, programs and their relationisation. In contrast, an essential feature of 'social environments' is their relational character. Relationships, however, are configured in a genuinely asymmetrical way, as they essentially emanate from what they are related to. The moment of alterity thus always remains primary in them. In live performances, the question then becomes how this primacy is taken into account. If, for example, the performance itself is realised by the participating audience, with each mobile phone brought along functioning as a musical instrument of sorts, the question remains as to how the relationships between the *participating phones and participating actors* are established, whether each actor alone contributes their own, as it were individual, touch, how interdependencies arise and so on. No live performance setting works solely in the sense of an experiment for its own sake, or for the sake of a musical sensation, rather, such settings are always enacted with a view to the 'together' (*con*, *cum*) that includes all participants. The 'together', in turn, occurs at the same time from where it is directed: the actors, including the audience. The common ground is produced by their relationships—it cannot be induced solely by the actors on stage but is an effect of the 'inbetweenness' that holds all elements together. This determines the specific social ethos of the performance.

However, the distinction between human 'relationships' of that character, and formal relations is decisive, which are technically arranged and symmetrically structured, something which can also be demonstrated looking at improvisations. For there exist orgiastic solo improvisations of a self-referential, 'egological' expressivity that can be magnificent but isolated; and there are on the other hand concert improvisations that respond to each other in the sense of a spontaneous answer to what happens through the dynamics of the other players. But there are also improvisations that are realised in a dialogue with the audience and therefore require a high level of sensitivity to what the 'others' and the 'circumstances' of the moment 'give'. Being able to respond implies a mode of 'passibility', i.e. the ability to absorb or pay attention and its situational transversion—in whatever direction.

31 Cf. also (Mersch 2014: 137 ff).

This is contrasted by the multimodal relations between instruments, machines, the systems of 'coding' and live programming, which follow the respective time structures and thus already pre-dictate the entire experimental setting.

Certainly, an infinite number of possibilities of 're-action' are induced by relational interactions between different actors, but only according to their respective regularity, their arrangements and limits, so that the 'infinite' denotes something other than indeterminacy and openness. Relations only allow for certain references, namely in the form of assignments or single- or multi-digit links obeying a structural-systemic order; in contrast, social relations with their primary alterity are something else: they include the possibility of non-human relationalities, while, conversely, relations exclude their reconstructability as specifically *human* relations. This is why Latour designed his actor-networks—which are not networks of actors with an 's', i.e. systems of different, equal actors, but relational networks—in such a way that the human position never remains unoccupied in them. There is this primary positionality of the human *for* the human, which is why talking about 'social environments' is preferable to the concept of the always systemically pre-decided 'ecology', especially as regards live performances. The point here is not merely to accuse the technical structures in live electronics of reductive relationalism, but rather that 'art in the technical age' raises the question of the possibility to create commonality in a new way, and that in particular digital, electroacoustic sound research, requiring the technical equipment of the computer and its networks to carry out its experiments, is *simultaneously confronted* with the question of what kind of sociality and thus what sense and what vision of *koinōnia* they make possible.

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On the Epistemic Potential of (Live) Electronic Music

Germán Toro Pérez

Introduction

The following text was published in a preliminary version as part of an anthology entitled *Sounding Fragilities* (Lehmann & Palme 2022). The present and definitive version contains substantial additions and corrections. It is intended as a reflection on the status of contemporary electronic music. The wider context is the practice-based research on the performance practice of electroacoustic music conducted at the ICST[1] under my direction along different projects and bodies of repertoire between 2012 and 2023. It encompasses a wide diversity of aesthetic and technical approaches to composition, different practices such as the performance of historical tape pieces, works combining instruments and pre-produced electronic sounds, pieces for self-developed instruments and recent works involving live electronic systems.

Throughout all its phases and projects, this research has been based on two methodological premises: the exchange within a network of composers, performers, researchers, scholars, archives and institutions, and the development of our own performance practice in the rehearsal space, concert hall and recording studio. This has so far led to different output formats: a dedicated database containing articles about specific performance issues of individual works, essays and analytical texts, surround mixes of multi-channel works and of course live performances.[2] It is additionally informed by the ongoing composition and performance practice of the members of our team and by my continuous exchange with composition students over the past twenty-five years.

In addition to its practical use for performers, the specific research into *live electronic music*[3] conducted between 2018 and 2023 was envisioned as a chance to offer an updated view of the performance practice of music composed for instruments and electronics implying any sort of interpretation, of the conceptual approaches it is based on, the kind of aesthetic experience it offers to musicians and audiences, and the impact it might have on the development of contemporary art, as related to the expectations, premises and discourses which have emerged since the introduction of digital systems in the early 1980s.

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1 Institute for Computer Music and Sound Technology at the Zurich University of the Arts.

2 See (Bennett & Toro Pérez 2018), (Toro Pérez 2016–2021).

3 *Performing Live Electronic Music*, 2018–2023, funded by the Swiss National Science Foundation, https://www.zhdk.ch/forschungsprojekt/performing-live-electronic-music-558720

These discourses are based on the analysis of the potentialities of digital technology in relation to analogue electronic devices, as well as the extension of acoustic instruments, voice and body through electronic means. From its earliest beginnings, musicians envisioned the possibility of processing digital sound in *real time* as a way to expand the creative and performative limits of electronic means in terms of efficiency, agency and expression. *Liveness* and *interaction* became key concepts to describe and qualify musical practice involving computers, interfaces and electronic devices.[4] Moreover, though the impact of digital information and new forms of storage and distribution, *sampling* emerged as a fundamental practice in electronic music at the turn of the millennium. Broad access to technology and computers drove hybridisation and cultural pluralism among creators and performers. Simon Water's (1997: 6) reflections on the transformation of electronic music in the digital age make clear that an understanding of live electronic music today asks for a multilayered approach in which technique and technology are only two threads among many others, including: concepts, theories, traditions, performance attitudes, audience's behaviour, institutional relations and forms of access.[5]

From its very beginning, electroacoustic music has been closely related to research, even if it was soon integrated in the traditions and rituals of modern music. Its close relation to natural sciences (for example acoustics, physics, perception, computer science), its inherent experimental character, and the multiple forms of practical research, carried out by composers and performers in artistic contexts are unequivocal signs of the privileged epistemic vocation of electronic music: its ability to allow access to knowledge through our senses.

The debate about research in the arts in the new millennium—which coincides with a shift in the practice of new generations of composers and performers—has also awoken the interest of philosophers regarding the epistemic entanglements of artistic practice. Their insights, together with a wide corpus of cases and examples, allow us today to revisit the practice of electronic music in general, and of live electronic music in particular, taking into account its specific relation to knowledge. The work of Dieter Mersch thus constitutes a fundamental reference for this text. His book *Epistemologies of Aesthetics* (Mersch 2015; 2015b) contains several references to contemporary arts and music. His specific studies on the work of Alvin Lucier as a prime example of research through arts (Mersch 2017; 2018), provide specific elements for the investigation of live electronic music's constitutive vocation of giving access to knowledge through aesthetic experience.[6]

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4 See (Hagan 2016) for a critical and systematic review.

5 Waters argues that digital sampling techniques dramatically enhanced the impact of storage and recall, not only by being able to access any point on the disc in any order (random access instead of linear access with tapes) but through the amount of data being stored, leading to the emergence of large digital archives and access to them over the internet. He speaks of a digital *sampling culture* after an analogue *acousmatic culture*.

6 See (Toro Pérez 2009).

Accordingly, this essay is a reflection on the ontology, genealogy and current status not only of live electronic music in particular, but of electroacoustic music in general, as a practice exemplarily reflecting the growing entanglement between arts and sciences and the multiple and complex interrelations emerging in a technologised world. I argue that the epistemic, *horizontal* dimension[7] of electronic music is the place where new concepts, musical forms, representation systems, techniques, tools and practices have emerged, complementing and challenging approaches to composition in contemporary instrumental music. In fact, live electronic music brings together musical traditions that have been following parallel paths, such as electroacoustics, computer music and contemporary instrumental composition. It is additionally informed by other artistic practices and by research in natural and social sciences. The intention is therefore to understand live electronic music as a network of discourses, theories, technologies and practices in which the sensory exploration of phenomena becomes as important as otherwise predominant aesthetical categories, such as artwork, material, form and expression.

Nevertheless, the *vertical* dimension, where power relations manifest themselves, must equally be examined, since *composing* entails the act of taking decisions, *disposing* means, and even *imposing* behaviour patterns during the processes of performance and reception. This fact is not exclusive to artistic settings involving technology. It should therefore be asked how live electronic music as a social practice is able to redefine new attitudes, roles and identities of the artists and audiences involved through new forms of expertise, agency and access. A further level of research in the context of performance practice would be to introduce these enquiries in the context of performative approaches to specific works.

Finally, and from a broader perspective, this text aims at reflecting on the impact of what we could call the *epistemic mode*—the way in which musical practice unveils insight—on the understanding, creation and perception of musical form.

Aesthetic-explorative situations

The study of electronic music practice in relation to the production of and the access to knowledge forms the very core of this essay and leads to the main thesis: *(Live) electronic devices and setups*[8] *have an inherent potential to generate aesthet-*

7 The terms *horizontal* and *vertical* are borrowed from Jürgen Link's description of the interrelations between knowledge and power in regard to Michel Foucault's concept of *dispositive*, where Link mentions that the interdiscursive dimension of knowledge might be imagined topically as *horizontal* and the socially stratificational dimension of power as *vertical* (Link, 2014, p. 239). See (Mersch 2012) for a discussion of dispositives in relation to mediality and artistic practice.

8 See (Toro Pérez 2018a: 10–11) for a differentiation between *instruments*, *instrumental devices* and *instrumental setups*.

ic-explorative situations and expose our senses to a multiplicity of phenomena. As such, their configurations vary according to various parameters and the current conditions; they must therefore be tuned and adapted, rendering different, *perceivable* results each time, for each situation. Moreover, electronic devices and setups are engaged in the generation of singularities.[9] This is the sense in which the term *experimental* has repeatedly been understood in electronic music. The phenomena addressed can be related to acoustics, signal processing, space, body, gesture, touch, spectrum, materiality, form, formalisation, representation, perception, cognition, emotion, speech, communication, mediality, visuality, multimodality and social interaction, among many others. In the end, this can extend to all aspects of music and musicality, to all possible relationships involving sound and music. This implies that aesthetic-explorative situations are not only able to *access* knowledge through musical experience but to *produce* it as well. They allow phenomena to emerge, reveal and transform themselves before our eyes, to become audible, tangible, visible. They *show* what otherwise cannot be revealed.[10] This epistemic potential gives *liveness* (as a specific condition for the emergence of insight here and now) and *interaction* (as the agency to intervene in this process) an additional meaning. Moreover, *live* electronic setups expose their own experimentality: they not only show, they show themselves.[11]

Of course, epistemic potentiality has been present in every kind of musical instrument since the monochord. However, electroacoustic devices and systems, as well as their proliferation in the digital domain, have a specific constitutive *predisposition* in this regard. Through repurposing of any kind of technology—simple or complex—they build multiple, dynamic and heterogenous instrumental constellations in networks of micro- and macro-temporal relationships. Coding and mapping permit transformative and systemic relations with any digitally represented object. Therefore, electroacoustic instrumental constellations radically open up the scope of musical thinking and practice. This predisposition can be described as their *instrument* character in the sense of *measurement devices*, of tools intended to access knowledge and expand human perception, which are different from the *instrumental* character of musical instruments understood in a general sense as *means of expression*.[12]

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9 See also 'singular paradigms' (Mersch 2012: 33–8; 2015: 157–8) and 'singularity' (Vaggione 2010: 55–56).

10 See (Mersch 2015: 131) for a discussion of different modes of relation to truth in philosophy and arts through the difference between *saying* and *showing* [*sagen / zeigen*].

11 'At the same time, and this is a particularity of artistic epistēmai, they always also refer to their own mediality. [...] There is no work or conceptual statement that does not thematize itself.' (Mersch 2015b: 144)

12 Any acoustic instrument is fundamentally a sensing device. The difference *instrument-instrumental* is not intended here to the detriment of *expression* as aesthetic category.

Electronic devices and acoustic instruments

It is well known that electronic devices originally conceived and built as measurement tools were functionalised in the electronic studio as musical devices. The prototype is doubtless the sine wave generator. Bernd Alois Zimmermann's characterisation of the sine wave as 'pre-sounding' (*vorklanglich*) due to the absence of a spectrum and 'surprisingly reluctant to all differentiated transformation methods' (Zimmermann 1968: 56) is meaningful. On the one hand, he acknowledges its different behaviour as material, nevertheless, he has no doubt about its instrumental character and is willing to manipulate it as such (Zimmermann 1968: 56–57).

For anyone working with sine waves in the studio or in the classroom, their function as tools for exploring, understanding and explaining phenomena of acoustics, psychoacoustics and signal processing is evident. Sound waves, as artificially-generated ideal atoms of sound have an inherently epistemic character; as a tool of insight, they have the same analytical status as the ancient monochord. They also continue to serve as measurement tools for the calibration of electronic devices and systems. The same can be said, for instance, of noise generators and analytical devices such as envelope and pitch followers.

Of course, acoustic instruments also have the potential to activate epistemic insight. However, these instruments are understood commonly and in the first place as means of expression. This reflects the discursive foundation of western art music, in which speech articulated by instruments and voices has been a predominant model. In the German language, fundamental musical terms are homonyms used in grammar, revealing the impact of language on the very concept of music: for instance *Stimme* (meaning inter alia *voice* and *musical part* and *Satz* meaning *basic melodic unit*). These terms stress the model character of the voice as carrier of expression and meaning, a character that afforded vocal music a predominance in western art music lasting until the late nineteenth century.[13]

Perhaps this explains why it was a matter of course, even for composers with established experience in the electronic studio like B.A. Zimmermann, to consider electronic instruments as an additional instrumental family, as a further class in the organological tableau. However, what applies to the ondes martenot and perhaps also to the theremin, cannot be extended to a sine wave generator, a microphone or an envelope follower. It is no longer necessary to *elevate* electronic devices to the category of musical instruments for the sake of dignity or in order to claim their artistic validity. Musical systems integrating electronic devices have a different genealogy. Edgard Varèse (1962: 23) was aware of this fact and of the consequences this different nature of electronic devices—including the computer—would have on musical thinking and practice.

13 See (Dahlhaus 1986: 39–48)

The understanding of electronic instruments as a further extension of the hitherto available instruments is nevertheless a characteristic of modern electronic music. Although for the post war European avant-garde, electronic music became a symbol for the renovation of modern music, its epistemic potential remained secondary. The musical artwork and its constitutive elements such as musical language, material, formal disposition, composition technique, notation and playing technique remained mostly in the foreground, even if electronic music also served as a means for social critique and the representation of human utopias.

Pierre Schaeffer's approach was different. Although he was likewise interested in formal questions, such as the morphology of sound, he understood musical devices from the very beginning as part of experimental settings and used them to explore auditive phenomena within the context of an aesthetic practice intended as *recherche*. In North American computer and electronic music, this approach soon came to the fore, for instance in the work of composers such as Steve Reich, Terry Riley, Pauline Oliveiros, David Tudor, La Monte Young, Jean-Claude Risset, Laurie Spiegel and others. It constitutes the basis for an artistic practice that found its most distinctive expression in the work of Alvin Lucier, Maryanne Amacher and other composers of their generation. Live electronic systems and practices are here understood as experimental settings and used to create aesthetic-epistemic situations.

However, one must be wary of underestimating the epistemic aspect in early European electronic music. In the collaboration between Luciano Berio and Umberto Eco in the early days of the Studio di Fonologia, in Karlheinz Stockhausen's early live electronic music, or in the work of Iannis Xenakis, Bernard Parmeggiani and Luc Ferrari, we find examples of experimental projects in which phenomena have a fundamental form-building function, for example with language in Berio's *Thema. Ommagio a Joyce*, the behaviour of acoustic instruments in Stockhausen's *Mikrophonie I*, the exploration of the space between micro- and macro sound in Xenakis' *Analogique B*,[14] the relation between sound morphology and listening in Parmegiani's *De Natura Sonorum* or the exploration of everyday sounds in Ferrari's *Presque Rien*. Nevertheless, these phenomena remain side elements of a musical discourse—both in terms of the instrumental and the electroacoustic avant-garde—in which, in spite of experimental attitudes, traditional aesthetical concepts such as artwork, musical language and individual expression have been predominant. In fact, current electronic music practice today could be seen as a heterogenous field in which expression, representation and experimentation coexist, even within individual works.

14 See (Di Scipio 1998: 219).

Network and System

In the digital age, two concepts have emerged in electroacoustic music that help us to further look at instrumental setups in relation to their access to knowledge: *network* and *system*. Both have a remarkable impact on the disposition of technical means, sound material, formal concepts, composition processes, performative and reception modalities.

The concept of *network,* as introduced by Horacio Vaggione in the context of electroacoustic composition in the digital domain, is immediately related to *objects* in the sense of the elements of computer languages, which define a network's topology through their multiple interrelationships. Objects can include sounds, functions and methods as well as other objects at various levels. Different instances of objects can appear on different places in different timescales, including of course the micro-time level. Their transformations generate cascades of sub-classes.[15] Vaggione's object-network concept promotes a system of variations of materials and methods that yield figures and singularities. It enables composition processes where the elements can proliferate simultaneously at different places, instead of only being disposed along a linear causal logic. Non-linear behaviour is due to jumps in perception produced by changes in the time scale, an alternative view to serialist scale-based continuity.

System theory in general and *cybernetics* in particular have become fundamental paradigms for the description of performative systems—not only at the signal processing level—fostered among others by the theoretical work of Agostino Di Scipio. His interest in systems within the context of live electronic processes was motivated by a critical reflection on interaction forms limited to the action-reaction model. Inspired by the work of cybernetics researchers Heinz von Foerster, Humberto Maturana and Francisco Varela, and more recent writings by Simon Waters,[16] Di Scipio proposes the composition of interaction modalities by defining interdependencies within the elements of the system. This led to the conception of complex systems as *ecosystems*, integrating the real acoustic space and eventually the audience.[17]

Both *network* and *system* conceptualise manyfold approaches to electronic music composition and have several common features: first, the property of *emergence*, meaning that sound and musical relations result from the network relationships and the system behaviour themselves, rather than from a teleological formal conception or intention. Secondly, and in consequence, they have an inherent formal *openness*, even if the result is a fixed electronic piece, as for instance in the case of Vaggione's *24 Variations*.[18] Thirdly, their multiple and branched relations

15 See *encapsulation*, *inheritance* and *polymorphism* in (Vaggione 1991: 212).
16 See (Waters 2007; 2011).
17 See (Di Scipio 2003) and his text in this book, pp. 63–106.
18 See (Toro Pérez & Mouritzen 2017: 222–224).

result in *non-linear processes*. Fourthly, they change the *performer's function and agency*, which are strongly determined by the behaviour of the system, as in case of Di Scipio's *Modes of Interference / 2*.[19] Finally, the composition of networks and systems entails the integration of *iterative experimental processes*, in which observing and understanding the relationships and behaviors between their elements plays a fundamental role before a work (understood as a specific aesthetic and performative situation) finds its final state. An artwork results not only (if at all) from sound images, representation models and expressive intentions, but to a great extent also from the manifestation of the network and the system itself, as a constellation of acoustic and perceptual phenomena, musical materials, technologies, functions, methods and modes of representation as well as social relations and interactions in the physical world. We see here several fundamental elements related to aesthetic epistemic processes: *visibility*, *self-referentiality* and the *emergence of singularities*. From a wider perspective, we also see their impact in the redefinition of composing processes, performing and listening attitudes and the function of the real acoustic space. Different forms of curatorial practice and social interaction become visible on the horizon due to the integration of other—real and virtual—spaces, which opens up diverse forms of access, participation and institutional framing.

Analytical devices

A specific class of devices used in the studio and on stage has a particular relevance to our topic. In current live electronic practice, there are, in addition to all different kinds of microphones, devices capable of sensing and measuring signals, movement and touch, or, for instance, to detect light and electromagnetic waves. There are also tools used to measure amplitude and pitch, as well as to extract and quantify other sonic features in the time and spectral domain. Such analytical functionalities were foreign to composition and performance practice before electronic devices came into use, excepting the relevance of beats for interval estimation and the use of mechanical devices such as the metronome and the tuning fork. They are fundamental for the configuration of instrumental setups and systems and exhibit the abovementioned *instrument* character as a specific capability to give insight into sonic and other phenomena. These analytical devices opened up micro time and the spectral domain for composition and performance practice, bringing *perception* to the core of the artist's musical thinking and practice. Beyond their specific measuring functions, they act as interfaces between the material world and the world of signal and digital representation.

19 See (Bennett & Toro Pérez 2021).

Hybrid representation systems

The multiplicity of devices and interfaces has brought forward a variety of representation strategies. New formal devices and modes of interaction require not only an appropriate terminology but also corresponding forms of notation and communication. Current composition and performance environments consist therefore of hybrid constellations of notational artefacts—increasingly mediated through technology—including traditional symbolic and graphic musical notation, language, as well as multiple forms of acoustic, visual and haptic representation of sounds, signals, processes, structures, formal relations, performative actions and sonic results. The loss of engraving mastery, resulting in a reduced, average, if not poor graphical quality of current musical editions, reflects perhaps a shift in musical representation. The score has no longer a predominant status as the physical manifestation of the artwork. Other forms of data representation from mathematics, acoustics, or computer sciences, for instance, are in many cases more likely to conceptualise, display, access and convey the information necessary in composition and performance processes. The sonogram has become a fundamental tool for the analysis of electroacoustic music, which, far from being able to represent what we actually hear, and in spite of the unavoidable alteration of the source in the analysis process, gives access to a detailed technical understanding of its manifestation as a signal.

When speaking about music in electroacoustic music composition or analysis courses, or discussing with performers, or speaking to audiences, we find ourselves—often enough without noticing it—jumping between different types of language: highly formalised, as in mathematics or computer languages; stemming from natural sciences, acoustics and psychology, describing the physicality of sound and perceptual phenomena; technical, stemming from computer sciences, informatics, electronic and communication engineering; instrumental-technical, referring to performance techniques; technical-formal, as used in composition and music theory belonging to different traditions; reflective, as used in the humanities and philosophy; personal, subjective, descriptive, associative and emotional. We try to compensate the limitations of every language or conceptual level with words from completely different layers: physical descriptions of materiality with associations from everyday experience; timbral or harmonic qualities with subjective, affective associations, and so on. Hybrid representation systems correlate with equally hybrid terminologies and jargons.

New strategies for the representation of sound and musical relations impact the design of new instruments and interfaces as well, giving immediate insight into physical phenomena through the senses. The magnetic 'instrument-score' Stacco,[20] for instance, allows the performer to feel the interaction of magnetic forces by

20 See (Privato et al 2024).

manipulating magnetised objects with the hands. The shape and visual layout of the instrument help to understand the specific spatial disposition of the magnetic fields. Haptic, visual and acoustic feedback interrelate and impact the explorative performative process. Rather than personal expressiveness, the performance renders perceivable the qualities of, and the relationships between all involved agents: the performer, the physical interface, the disposition and behaviour of the invisible magnetic forces, the mapping between data and sound generation, the sound generation techniques, and the sounding result. The possibility to react in real time guides the performance, transforming it into a process of discovery, that, if aesthetically successful, can reach and 'touch' the audience as well. The multimodal, embodied performative experience enables a specific form of insight.

Conclusion: expanding musical form

Art is a different way of perceiving and experiencing the world, a '*different thinking*, *different-than-thinking*' (Mersch 2015: 53). In contrast to philosophy, art knows, 'not because it speaks but because it […] shows';[21] it is 'thinking as practice, as performance.' (Mersch 2015: 11). But to *show* always means to *show itself*; it is a condition that implies that, through art, knowledge both *emerges* and is *self-reflexive*. This applies to any artistic practice. The questions are therefore: What are the foundations of the specific epistemic force of (live) electronic music? How does it manifest itself in every singular work?

The origin of some electronic devices in measurement tools reveals a predisposition: electronic music is based on experimentation through which the very nature of sound and perception become visible, audible, tangible. Live processes allow the experimental settings to expose *themselves* as epistemic situations. This could even be said of purely generative situations—without human intervention—that produce singularities here and now, allowing us to perceive difference.

The topos of *otherness* in electronic music, hinted from its beginnings to our days by similes like 'second dimension', 'difference', 'shadow', 'presence', etc. indicates a further epistemic pathway. We must ask what it consists of, what it shows, what it 'says', or following an alternative music-language model, what these interacting 'sonic utterances perform'.[22] An early piece such as Bruno Maderna's *Musica su due dimensioni*, when realised today as an open form as it had initially been

21 'The parallelism philosophy and art ends here, because art's sovereignty is something other than philosophy's insistence on the concept. Art does not know because it speaks, instead it makes recognisable by showing.' (Mersch 2015b: 115)

22 See (Chung 2019). Based on the work by John Langshaw Austin ('performative utterances') and Ludwig Wittgenstein's *Philosophical Investigations*, Andrew Chung proposes an alternative 'music-language analogy' to the 'Saussurean signifier-signified relation' based, or 'meaning-as-mapping' model. Here, language means by 'doing things with signs' (Wittgenstein, Austin), it 'performs' actions, called by Austin 'illocutionary acts'. In analogy, music meaning,

conceived,[23] informs us about a multiplicity of issues that go beyond what is actually found in the score and the tape fragments, and of what is strictly considered as the musical form. The 'encounter'[24] between the sounds of a modern flute and its electronic ever-changing correlate—if only by having been recorded at a different time by a different performer with a different instrument in a different space—enacts the increasing historical distance. It weaves several other audible threads, not only spectral, acoustic, and technical, or regarding instrumentality (different ways of playing the flute), the specific hybrid composites generated by chance, or the way instruments and recorded sounds behave and interact—how they 'do'—in a real space, but also regarding how recording and playback technology evolves and impacts our cultural environment.

Even early analogue live electronic systems—I argue that Maderna's piece was conceived as such—exhibit to some extent several of the above mentioned epistemic 'markers' (self-reflexiveness, emergence, openness, non-linearity, system-dependent performative agency, experimentality, integration of measurement devices and hybrid notational constellations). A similar analysis could be done of pieces like *üg* by Mark Andre regarding for instance the 'encounter' between real, acoustic, cultural and sacred spaces mediated through convolution and sampling; or between materialities in *Shiver Lung* by Ash Fure; or between real and sampled, acoustic and visual gestures in *Exit to Enter* by Michael Beil, etc. The 'second dimension' discloses a multiplicity of *other* musical, visual and haptic materials, relations and situations, equally active in the generation of form as for instance rhythmical and spectral relations.

The concept of musical form radically expands. Modern art had opened up the artistic experience to the very core of its abstract materiality—sound, colour, space, light, movement, language, touch. In the musical realm, modernism liberated musical form from an established canon. The irruption of technology in the arts is perhaps its next major transformative moment, at least in the musical domain. The impact of early research on perception in electroacoustic music on the further expansion of musical form, for instance, cannot be underestimated. Musical form as the manifestation of musical sense, *shows*, lets the complex acoustic and psychoacoustic phenomena involved in the perception of sound be experienced in multiple variations. *Showing*, according to Mersch, means *knowing.* It is musical form in action. Meanwhile, this epistemic mode of art can potentially impact all areas of music and musicality. It will continue to expand the way musical form can be thought of, emerges and becomes expressive.

Although dichotomies such as expression / experience, instrumental / instrument, linearity / non-linearity, determination / emergence, etc. are useful for our

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instead of being the result of mappings, is articulated through the specific use of sonic or 'musical utterances'.

23 See (Toro Pérez 2018b).

24 See (Meister & Nancy 2021).

discussion, they suggest sharp boundaries between musical traditions, cultures and practices. It must therefore be pointed out that there is some degree of overlap among these categories. I therefore prefer to speak of potentialities that are manifest in different proportions in every case and situation, defining how musical form is created and perceived. They define a dynamic field of forces in which art in general and electronic music in particular appear. The close foundational proximity of electronic music to interdisciplinary *research*, as well as the existence of sound as *signal* and *digital code* in systems and networks, define electronic music itself as an *interface* between modes of perception, artistic practices and genres, cultural phenomena, forms of representation and communication—between the material world and our senses. Practices in composition, performance and reception involving technology open up a field which is acted on by expressive *and* epistemic forces. Any precise estimation of their impact must be made through the analysis of specific works and performative situations, while also taking into account their connection to other forces related to social interaction, identity and the construction of reality.

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'Live Electronic Musicking'

Simon Emmerson

Introduction and Grounding

First setting for this paper must be background: where do the approaches I shall discuss come from? To describe and reflect on my experience of 'live electronic musicking' must necessarily include a historical (autoethnographic) element. How and why anyone engages with electroacoustic sound—especially when produced 'live' (a term which itself will need some unpacking) embodies an evolving relationship as time passes. All aspects of my initial encounter with this sound world have changed profoundly since my earliest experiences over fifty years ago.[1] Changing technology means changing affordances for all practitioners and participants—as well as changing terminology.

I had the good fortune to study and later work with two composers while I was at Cambridge University (1968–1972)—Roger Smalley (1943–2015) and Tim Souster (1943-1994). In 1969 they had founded the live electronic music making ensemble *Intermodulation*. Core performance instruments—though there was quite some flexibility for 'free scores'—were piano, keyboards (Smalley), viola (Souster), bassoon (also soprano sax) (Robin Thompson) and percussion (Peter Britton). All performed additional electronics, mostly provided by very recently available VCS3 synthesisers (EMS Ltd., London 1969)—used as much for microphone feed transformations (filter, ring modulation, enveloping etc.) as for synthesis proper. Based in Cambridge, the ensemble rapidly gained attention, performing for the BBC, WDR (Köln) and other German radio stations and festivals, as well as throughout the UK. Their repertoire was an eclectic mix of experimental music from European and American traditions. They were part of Karlheinz Stockhausen's early performances and recording of his multi-ensemble work *Sternklang* (1972) (Souster 1971; Emmerson 1991; Stockhausen 1992).

1 My first experience of electronics was in June 1969 in London: Roger Smalley's *Pulses* for five groups of brass and percussion instruments with live electronics, performed by the London Sinfonietta.

My first personal reflection starts by placing some markers in time—these prompt the fundamental questions and themes of this contribution. There has not been much change in one important respect over the time I have been writing on this subject. In the English (first language) speaking communities electroacoustic music has (with some significant exceptions) developed a *practitioner-led* musicology. In the mid-1980s I curated and edited *The Language of Electroacoustic Music* (Macmillan, 1986). The overall aim was to reveal more about how the *music* 'worked', placing less emphasis on the technology of how it was composed. Studio (acousmatic) works tended to be the focus though with an important contribution from 'mixed' electroacoustic music—strictly 'live electronic' was represented relatively little. All ten contributors were composers—though most did not focus on their own works.

Thirty years later, by the time of *Expanding the Horizon of Electroacoustic Music Analysis* (co-edited with Leigh Landy, Cambridge University Press, 2016) there had hardly been any change. Probably 16 of the 18 contributors were composers—only two might claim to be primarily musicologists/writers. As suggested by the title the aim of the volume was to broaden the range of genres addressed in analytical discussion. Live electronics, improvisation and experimental practices were represented. Thus, while the musical field examined had broadened the contributors remained predominantly practitioners.[2]

While I come to this subject as a composer and performer, it is also of great importance to my motivation to reflect and analyse, that I am a teacher of *others' practice*. In fact the first text listed above (1986) came about from that impulse to explain to students and fellow practitioners what was going on. Throughout the 1960s and 1970s texts had mainly been focused on the *how* of music making with technology. There had been little on *musical questions* and *why* the musicking had taken place—its aesthetics. Composers may not feel the need to explain their motivations in their day-to-day work—but teaching others often encourages a much more reflective approach.

This was an even greater motivation for *Living Electronic Music* (Emmerson 2007). While there was by this new decade a great deal of writing on media and its effects on music, there was relatively little on the 'liveness' within live electronic musicking—and importantly how best to understand the various tools and their influence on approaches to making music in performance, as well as how we

2 This leads me to propose further questions which I suggest impose specific constraints on this discourse: Why has electroacoustic music practice remained (in large part) so separate from other forms of instrumental contemporary music? Why has it remained quite neglected by the musicology community (at least in the English speaking world)? Conversely, why has its own musicology—or any aspect of its study—failed to make much impact in more mainstream musical discourse?

apprehend the live in the musical flow. Again, there was a practitioner-focus to encourage a reflective practice.[3]

I shall draw on this now half century of reflecting on practice to discuss ideas and practices around live electronic musicking: this is divided into two themes. Firstly, a discussion on what exactly it is we want to examine—a work, a performance? And then how we might grasp it somehow to examine it. Secondly, very explicitly for live electronic music, what is our relationship to the machine, to other agents we perform with, to feeling 'liveness'? How does this give the experience meaning? I shall try to extract and contrast some ideas and tools from work by Alan Turing and Christopher Small.

What are we examining? Nattiez—tripartition

I shall take as a basic description of our encounter with the music the tripartition best presented by Jean-Jacques Nattiez (elaborating Jean Molino's original model for the 'total musical fact').

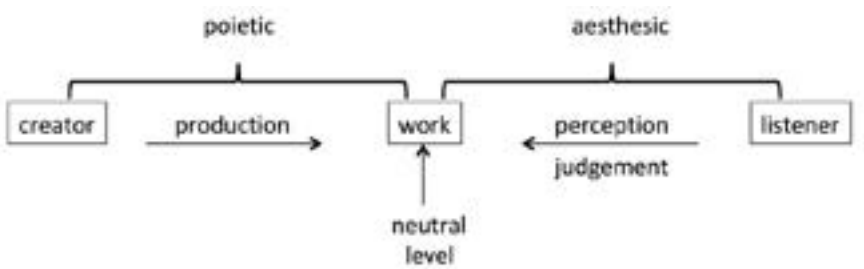


Fig. 1 The tripartition (after Nattiez 1975: 52)

First a summary (see Fig. 1):

The tripartition designates the 'neutral level' ('niveau neutre'), an existential entity (the 'music itself') addressed from one 'pole' (direction) by its creation (poiesis) and from the other by its reception (aesthesis). The poietic pole is constituted of all the compositional and creative inputs, while the aesthesic pole includes the effect on the receiver (including interpretation ('meaning') of the music). The English translation (Nattiez 1990) simplifies this diagram and replaces 'neutral level' with 'trace'—though the original term is much used throughout the text.[4]

3 This distinguishes much of the published work I refer to here from the discipline of 'sound studies' which strikes me as much less related to applications in practical teaching.

4 This was nearly always in practice interpreted as a kind of score—with some ambiguity as to whether this was prescriptive (used as the basis for performance) or descriptive (a transcription from performance). Both kinds are used by Nattiez in his extensive writing.

This was much debated in the years following publication and importantly for our discussion deeply criticised and rejected by the French musicologist of electroacoustic music François Delalande.[5] Delalande observed that—at least for music that has no *prescriptive* score—we can *only* create a transcription through perceptual information from a listening that is inevitably part of an aesthesic process. Delalande concludes his article with a section headed: 'With electroacoustic music, neutral analysis is impossible' (1986: 57). Transcription itself cannot be 'neutral' or 'objective'—even machine transcription.

The recording *seems* to capture the in-time to store apparently outside time. But the final fall back position that the 'scientific' representation of the acoustic signal[6] represents objectively the 'work in itself' becomes problematic *the moment it needs to be examined to extract information*. As soon as we need to break it up into operational units, defining events, time structures, let alone psychoacoustic interpretants, our decision and evaluation filters can no longer be described as neutral. Yet declaring there is no neutral (level) analysis will not solve the immediate problem. We have not abolished all concept of 'the work', and certainly not at all that of the flux of the performance which we seek somehow to understand *beyond the time of the experience*. We glimpse the live flux fleetingly as it passes. How can we grasp this 'thing' that flows through our fingers as we try to hold it so we can examine it?

Flux, flow, the river

I suggest an adaptation of Nattiez's 'trace' of the work to be thought of as 'flux, flow, the river'. To understand this metaphor I shall go back to the Greek philosopher Heraclitus. Heraclitus's work exists only in fragmentary form and through the quotations of others. His most common aphorism has been much simplified and effectively misquoted. Scholarly sources list up to three statements—the one which is clearly the origin of the later misquotations might best be translated: 'For, according to Heraclitus, it is not possible to step twice into the same river …' (Diels–Kranz B91 tr. Robinson 1987)[7]

This citation is clearly written by someone else (though in the same era) *ascribing* the remark to him. It is this version that seems to have become the locus of this strand of thinking, and is addressed by Ludwig Wittgenstein in the mid-20th

5 This summarises longer discussions in (Emmerson 2021; 2022).

6 Now almost standardised as amplitude and fft-spectrum vs. time displays although there are many newer innovative scientific representations of sound/music signal developed using 3D effects in 2D, colour and intensity, as well as polar representations.

7 Diels–Kranz (DK) numbering is the standard recognised system for referencing the works of the ancient Greek pre-Socratic philosophers, created and revised over the first half of the 20th century by Hermann Alexander Diels and Walther Kranz.

century—'The man who said one cannot step into the same river twice was wrong; one *can* step into the same river twice.' (Wittgenstein 2012: 304)

Imagine the real Heraclitus saying 'tomorrow I shall step into the river Kaystros'—this statement does not cease to have meaning when spoken again after that event. The statement is a play in a 'language game' that only has meaning within its context. Commentators suggest that Wittgenstein placed Heraclitus' assertion in the category of a *rule statement* rather than a *language game statement* of what is actually—or might be—the case.

There is however a more extensive version of the statement that makes a much more nuanced point—and seems to be written in the first person (by Heraclitus himself, perhaps, although it comes to us via the citations of others): 'On those who enter the same rivers, ever different waters flow.' (Diels–Kranz B12 tr. Barnes 1987)[8]

This demonstrates the (Ancient Greek) philosophy of the 'unity of opposites'—bound together by the *logos*. Something is the same (the river), something is different (its flowing water). That which holds things together are the banks and the riverbed. These for Heraclitus form the *unchanging* logos—a rational structure giving us the sense for 'logical' discourse, which also articulates its identity.

But this is not so simple for Wittgenstein:

> 97. The mythology may change back into a state of flux, the river-bed of thoughts may shift. But I distinguish between the movement of the waters on the river-bed and the shift of the bed itself; though there is not a sharp division of the one from the other.
> […]
> 99. And the bank of that river consists partly of hard rock, subject to no alteration or only to an imperceptible one, partly of sand, which now in one place now in another gets washed away, or deposited. (Wittgenstein 1969, nos. 97, 99)

There are two 'real times' at work in Wittgenstein's image: the time of the flow of the river and the time of the erosion or depositing of the banks and river-bed. These correspond neatly to what I shall discuss further below—the real time of performance (the flow of the river) and the (much slower) time—often referred to as 'outside time'—of the creative (poeisis) and the receptive and reflective (aesthesic) process that hold this in place.

I shall try to apply the insights of this pair of philosophers in our attempt to grasp the work in its unfolding. But as an introduction to building my proposed model[9] I shall cite Tim Ingold's definition of *wayfinding* which shifts our perspective away from focus on the idea of the map (or plan) and towards an experiential

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8 Heraclitus is also given disputed credit for the phrase *panta rhei* (πάντα ῥεῖ—'everything flows')—an observation of the perpetual state of flux or becoming. This citation is (as we shall see) incomplete in a philosophical sense but very poetic.

9 I first built this model for my keynote address to EMS Network 2021 (Emmerson 2021) although here revised and related to other arguments in a different way.

narrative or journey—finding the way. Once again this is a shift from an apparent 'outside time' objectivity to a more 'in time' subjective experience.

Wayfinding—perspective

> I argue that while dwelling in the world entails movement, this movement is not between locations in space but between places in a network of coming and going that I call a region. To know one's whereabouts is thus to be able to connect one's latest movements to the narratives of journeys previously made, by oneself and others. In wayfinding, people do not traverse the surface of a world whose layout is fixed in advance—as represented on the cartographic map. Rather, they 'feel their way' *through* a world that is itself in motion, continually coming into being through the combined action of human and non-human agencies. (Tim Ingold, 2000: 155)

It seems to me that wayfinding is constructed from a viewpoint within the experience where mapping is constructed from above.

So how can we grasp what we seek to examine? From metaphor to model

Fig. 2 is a representation of our experience; it may be constructed from its elements in sequence: The river's flow represents performance time—we (in the boat) navigate its flux as we perceive its presence unfolding. The river is held in place by its two banks and the river bed. This in turn is held within a larger environmental, ecological and social framework.

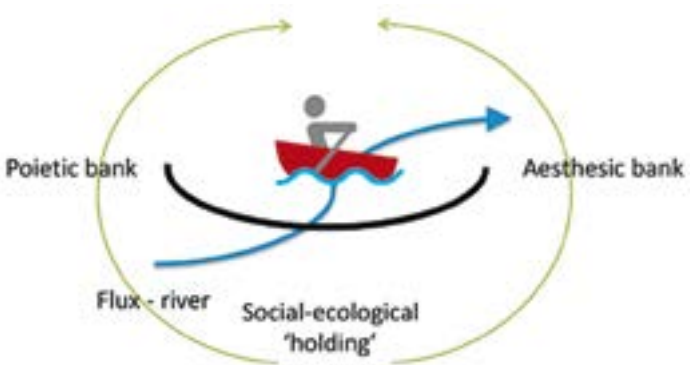


Fig. 2. The basic model (boat/river/banks etc.)

Now we can build the metaphor/model outwards to greater timescales before and after performance time. One bank is the poietic bank, that of the creation of the performance, the other is the aesthesic bank, that of reception and reflection after the immersion of the performance (flux) itself. The further away we are from the bank, the further we are away from the time of performance. Thus, creating the performance starts at some distance from the bank;[10] as we sketch, elaborate and clarify what will happen we approach and jump into the flow as performers and listeners.[11] Conversely, on the aesthesic bank we can move from various kinds of almost real time transcriptions of our experience, then, as performance time recedes from us, examine the 'data', gaining increasing overview and understanding of how the experience has been shaped and affected us.

'In time' and 'outside time' are a useful pair of terms which came to prominent use in discussing contemporary music from the 1950s on. The collection, tabulation and preliminary manipulation of materials was often considered quite separate from their applications in the final time-ordering of performance (usually, though not always, via a score). This was most explicitly rendered in the writings of Iannis Xenakis. Nothing of course is outside time—but if we make explicit *performance* time then this kind of distinction becomes useful. What has been called outside time then becomes simply represented by this greater distance from the flow. Furthermore we may see a mirrored form of the original meaning on the analytical (aesthesic) bank of our model (see Fig. 3).

This may finally be synthesised into a composite diagram (cited here from (Emmerson 2022)). While it is speculative, it is built from elements already widely used in research on music. This is widely multi-disciplinary and intended to create a kind of 'analytical ecology' and is clearly centred around the flux of the performance.

The poietic bank may well need to combine the chaos of creativity with the rationality of understanding. This example includes video of a Max patch that helps run the performance—part of the outcome of a substantial collection of materials and ideas, progressively worked at towards the performance. The representation of the river here is traditional—frequency and amplitude traces over time. It cannot claim a neutral status—we shall need to use a wide range of tools to gain useful information which may then need to be mapped to causes and effects further away from the time of experience. For example, it does not represent in any way our *experience* of the flow. Then over to the aesthesic bank. Videos of per-

10 I do not assume a particular genre—this might be scored, improvised etc.—and might in our real world be distributed in media space but 'drawn together' into the flow.

11 Before the performance itself there may be various forms of preliminary hearing, imaginary or real (in the studio, live performers in rehearsal). The creators become first listeners. The creative imagination starts building a model of the performance. We might see this as a kind of *Doppelgänger* (mirror) receiver on a preliminary (prototype) of the aesthesic bank of the performance.

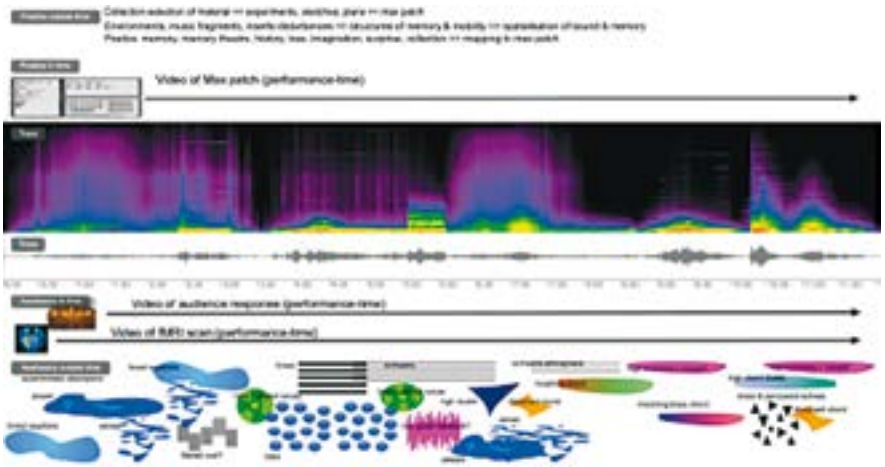


Fig. 3 Simon Emmerson, *Memory Machine* – poietics, trace (of flux), aesthesics [EAnalysis image] (Emmerson 2022: 120)

formances are now a commonly used tool of study; fMRI scans from such a public event are not yet feasible although use in fixed listening tests is well established. I suggest the new research in the neuroscience of sound and music perception will have a major role in the future (Thompson 2013; Thompson et al. 2013). Evocative transcription[12] moves to parse the flow into meaningful events and may lead us to understand emergent patterns of choice and direction. There are many further annotations and additions we might think of to enrich this river view. We shall see emerge new methods of revealing and showing the creation and reception of the music—and perhaps new ways of capturing and representing the flux itself.

Let us assume we start as listeners who encounter the flow—but more, as asking more extensive questions (musicians or musicologists for instance, but this should not exclude a much wider community). The first thing we need to be aware of is our *perspective* on the flow—in many cases during a performance we are a 'drone' observer, hovering above the flux of experience. It is as if we are looking down on a field of view—the position is relatively distanced from the greater immersion of some listeners and most performers.[13] A form of mapping (in Tim Ingold's terms) is constructed from this more remote perspective, while *wayfinding* is constructed from a viewpoint closer to (even within) the experience. 'To use a map is to navigate by means of it: that is, to plot a course from one *location* to another in *space*.' (Ingold 2000: 219)

12 Discussed in (Emmerson 2021). Evocative transcriptions have been a key tool in traditions of electroacoustic music that retain an element of performance, and in analysis approaches that work from a visualised 'score'.

13 This is accurate—as critics, musicologists, academics, we may listen in a more detached way, less immersed than our idealised performer or listener 'in the zone' (flux).

From this elevated perspective in terms of observing the performance flux the future lies upstream, the past downstream. We are free to hover down to ground level to visit the poietic or aesthesic banks at other times. However, we are beginning to have the tools to move away from a mapping of place to place which has dominated analytical traditions until recently. As we adopt ideas of wayfinding we move from a more architectural and structural viewpoint towards one of an organic, environmental and ecological journey. By using a true time domain 'movie' model—on both banks of Fig. 3 there are examples of these —we can at last harness new media more fully in this discussion to try to capture experience unfolding.[14]

Where lies musical meaning?

> I emphasize the importance of relationships because it is the relationships that it brings into existence in which the meaning of a musical performance lies. […]
> 1. What are the relationships between those taking part and the physical setting?
> 2. What are the relationships among those taking part?
> 3. What are the relationships between the sounds that are being made?
> (Small, *Musicking* (1998: 193))

I would like to add one to Small's list:

What are the relationships of those taking part to the sound production (means and methods)? This is a fundamental question for those of us concerned with live electronic musicking—composer, performer, listener—those who encounter. This is the next theme.

Human-machine relationship

Human-machine relationships as evolved in music making in the second half of the 20th century have often been seen as articulating two paradigms (Emmerson 2009: 168–170). Simplified, we might describe the first as extending the performer's embodied capabilities—a physicalist, prosthetic function, extending reach in every sense, enhancing performance agency in space, complexity, sound transformation. The second paradigm, however, offloads some of the performer's agency,

14 Pierre Couprie's *EAnalysis* software is designed as a time-based tool in which video scrolling (or a playing video window) of any kind of representation is the norm. See also (Clarke, Dufeu & Manning (2020)), which has as its core method the ability to test the composer's options through user-defined resynthesis *in performance time*.

establishing what may be perceived as a separate performing entity—however (apparently) dumb or intelligent.[15]

Increasing the number of such performing nodes creates exponentially more complex options. If we scale up to ensemble music with electronic interaction—ensembles which operate as more of a network of (almost) equal nodes—the result emerges as an immanent property of the group.[16]

However, in our new world some of these nodes may not be human—but they increasingly appear to have operational agency within the music. Thus, ideas from Actor Network Theory (Latour 2005) seem rapidly to fall into place in this characterisation. A network of interacting agencies eventually constitutes an *ecology* of live electronic musicking (Waters 2007; 2011; Di Scipio 2018). I shall now turn to some of the tools we might apply to explain some of these relationships—as we shall see, they have recently become more ambiguous and problematic.

Turing—The Imitation Game (1950)

Alan Turing's invention of the 'The Imitation Game' (Turing 1950) was an early and influential attempt to give us a handle on what might constitute intelligent machine behaviour.[17] It is a kind of 'acousmatic' game. A curtain separates you ('The Interrogator') from your two co-players; the game is one of sending and receiving text messages. The rules of the game are to ask questions in turn of these two entities and to distinguish between them—you are told that one tells the truth and is helpful, the other lies and is obstructive.[18] At the conclusion of the game you state your judgement which is which. There is an Adjudicator who notes the Interrogator's answer and knows the correct answer. The game is repeated many times.

Unknown to the Interrogator the liar is replaced by a machine for a number of these tests (the Adjudicator is aware of this). The tests conclude and are then analysed—the questions asked have binary right/wrong answers and may simply be counted, possibly automated. The key question now asked of these results is: has the Interrogator assessed correctly the truth/liar distinction *better* or *worse* for the games *when the machine played instead of the human liar*? Remember - the task

15 This is best shown through the quality of *negotiation*. No one in a real relationship gets their own way all the time: responses, challenges, demands, restatements, compromises. Our paradigm 1 performer has no such negotiation. Our paradigm 2 performer might have a considerable amount.

16 And may often produce very complex interactions. See the publications of the NTNU Trondheim project 'Cross adaptive processing as musical intervention' (http://crossadaptive.hf.ntnu.no).

17 'The Imitation Game' has come to be known as the 'Turing Test'—though strictly inaccurate it has become impossible to avoid the use of this phrase.

18 I have simplified some of the description here, removing the specifically gendered descriptions of the original which I invite the reader to seek out. They are possibly of great relevance to Turing's personal history, and of this and other subject fields.

for the machine liar was to get the Interrogator to make an *incorrect* assignment. So if the Interrogator performs *as well or worse* for the machine instances, the machine is performing *as well as or better than* a 'real' human in the game. Ignoring (for now) the *degree* of success for the machine we might summarise Turing's conclusion as it is most often given: If the responses of the machine were indistinguishable from those of an intelligent human then the former might be said to be displaying intelligence. We remain confined to a behaviourist model where only the observation of players' responses was pertinent to the question—it would not matter if the method of generating those responses when the machine was in play was entirely different from the 'real' human.[19]

The Imitation Game (adapted to music performance with technology)[20]

Can the Turing Game be adapted to music? There have been many such discussions over the years, often using a somewhat simplified shorthand for the Turing 'test'—is the machine behaving in a way I cannot distinguish from a human? Is the machine behaving in an intelligent way?—these two questions are not quite the same. Let us set preliminary constraints: perhaps start with an improvising duo—which might be human-human, or perhaps human-machine. In (Emmerson 2012) I did not suggest 'machine-machine'—which must now be added. If we try to capture the subtlety of Turing's original, we aim to set a task which is *not* the question 'are you a machine?' but the results of which *illuminate* this question.

There are clearly mapping problems when adapting the Imitation Game (Turing test) to this scenario. The original was based on text exchange; in fact, the creation of scored music by machine is now one of the oldest approaches and a form of this test has been standard if not explicit, usually matching a machine work in (say) Mozart's style with the original (Cope 1991[21]). This is not the kind of musicking we address here which must include a performance experience and need not have a written form. Furthermore this model allows the two behind the curtain performers to play both solo or together—but there is no text equivalent to polyphony!

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19 Turing did not pose the question: 'can machines think?' but replaced it with the behaviourist reframing—'can machines behave like a human (in terms of intelligent response)'—he also does not (*prima facie*) use the term 'artificial intelligence' but titles his paper 'Computing Machinery and Intelligence'.

20 I first discussed this fully in (Emmerson 2012), this discussion is revised and related to other themes differently.

21 (Cope 1991) is an excellent compendium of this first generation of style analysis and recreation by computer. While Cope does not explicitly invoke Turing-like testing it lies behind many of his publications—how well has the programme done at convincing the listener this is 'by' this composer or authentically 'in' this style.

Even more importantly, the Interrogator has not got a simple binary decision to make but a qualitative judgement.[22] In (Emmerson 2012) I proposed two alternative triangulations of this mapping dilemma:

Version I: the role of the Music Interrogator is to assess (through acousmatic listening—we cannot see the sources) 'how good the music is' when the duo plays. The second layer assessment then analyses those results and decides if the machine 'did as well' as a human performer.

Version II: the game is reconfigured—the Interrogator joins in the performance. They play with each participant in turn (with no visual contact), then make an assessment of the performance. This version re-models the text exchange as 'music exchange'. Second layer assessment as before, only here the Interrogator's point of view is from *inside* the performance.[23] The binary decision has been replaced by a general assessment 'how good is the music?' (some kind of 'assessment criterion' no doubt needed)—maybe 'how meaningful is the interaction'?

(Re)locating the 'work'

A straightforward application of the ideas of either Turing or Small would locate the essence of the work (and the basis of its meaning) in different domains—and I fear we inherit this confusion in our discussion. Let us examine this in more detail.

Turing's behaviourist approach applied to our field of music suggests and follows the tradition that the identity and meaning of the work is constituted fundamentally by its *musical (sonic) relationships and behaviours*. For Small, however, musical meaning is crucially based on relationships to the other performer(s) (actors, better), as well as to location and audience (as cited above). The relationship of the sounds to one another is one of several components of the totality of the work's meaning. This uneasy difference is felt within our discussions here: live electronic music making often inherits the traditional practices of the acousmatic. Sound transformations may readily remove the sound from its original source and cause bonding. A residual time proximity *may* be available to our perception but is easily obscured. Thus much discussion on the effect, expression and meaning of this music tends to the 'concrete' perception of the sound of the performance—in

22 This is a debateable and problematic assertion. Might there be an AI entity available soon that can 'mark' (numerically) our instrumental performance examinations against an agreed set of criteria which can be analysed from the signal?

23 'Behaving like a human'?—does the machine show delight, frustration, anger, patience …? The role of the 'trickster' (in Turing's original game) is not modelled. Is there an equivalent somewhere? Creativity? The unexpected? The unwanted musical event? Trying to put you off your stride, testing you?

truth part of a longer tradition of 'absolute music' which acousmatic music tends to follow.[24]

At the time of writing the debate and discussion around matters of AI applications, 'deep fakes' and the like are accelerating. This is clearly set to change radically the relationships that have been established so far in our live performance with technology—live electronic musicking. In Turing's terms machines are set to 'do better' at convincing us they are just as good as humans at producing the music—until we cannot hear the difference, or maybe we can hear the difference but think the machine does better. In Small's terms this inevitably changes the *meaning* of the music in performance—even if sonically something may be identical, if produced through a different set of relationships, that meaning has shifted.

Performance acousmatics

As we remarked above, if we consider live electronic *ensemble* performance (of any genre), there is an exponential increase in complexity; it becomes easier to lose any sure sense of agency—the contribution of each individual actor within the network becomes more ambiguous. Hence the relationships needed for understanding Small's model of meaning become more difficult to ascertain. There is a tendency to push our thinking back towards Turing's behavioural approach.

In this case Turing test-like procedures become much more holistic and inevitably deal with emergent qualities of the music. And if live 'musical exchange' is reduced to the medium of sound alone this becomes a 'performance acousmatics'—the equivalent of an acousmatic curtain descends progressively between listener[25] and sound—source unseen and unsure. Thus the live electronic and the acousmatic practices blend perhaps creatively but increasingly ambiguously. While this might seem to be no problem to our communities of practice—who just 'get on with it'—there are profound consequences to Small's model of meaning as the ensemble relationships of performance become blurred.

Most importantly for a participant (performer), if live electronic music becomes acousmatic we may not know whether we are performing with human or machine. The term acousmatic itself is made even more problematic by distributed (network) performance and AI applications. The absence of 'knowing exactly the source of a sound' has become effectively unsustainable as a significant applicable concept. The question whether the partner I perform with is embodied (live) becomes ever more unanswerable. For Turing's machine this is a matter of behaviour: 'if it behaves as if human', you won't know. But for Christopher Small a

24 As we have known for 150 years—all recorded music becomes acousmatic. We tend to trust (and believe) that there is a live performer—even if no singular live performance.

25 That listener might be another performer within the ensemble.

matter of ethics intervenes—*meaning* changes depending on the answer. I suggest that we do search out for 'liveness'—whether real or artificial. Let us look further at ideas of 'living presence' and what clues and cues we might use to determine the nature of the agent we listen to.

Living presence

I suggested (Emmerson 2007) a simple three-part schema for our perception of 'living presence' in live electronic music:

1—Physical presence: action and agency

2—Psychological presence: will, choice and intention

3—Personal and social presence: what you mean to me, where I am and who I am with. This strictly speaking wraps around the first two (Emmerson 2007: 3).

The first is challenged by acousmatic practices—whether those of the studio or of the live electronic systems of sound displacement from source, as well as by distributed performance, virtual reality systems and AI developments.[26] The second relates to Alan Turing's world of observed *behaviour*—what kind of agency do I believe is 'out there' relating to me. The third is nearer the world of Christopher Small.[27]

It is clear now fifteen years later that these distinctions have become problematic—we simply do not know (in some cases *cannot* know) exactly what is causing the environment in which we place and sense our own performance or listening. Thus this initial paradigm is in need of revision.

Knowing/not knowing/believing/maybe/not caring

Does it matter whether I know the nature of others I am performing with (human or machine)?

Perhaps I am performing with a machine believing it is a human—this would probably not matter if it gave me a very positive response. Conversely, I may be performing with a human believing they are a machine … the same would apply. In practice there is a continuum of certainty/uncertainty—maybe one or the other? I may simply feel I cannot decide—there's not enough evidence. The 'I don't know' relationship *is a new kind of relationship*—it might even generate a new kind of music. I suggest that this entire set of options might collapse into a singular 'I don't care' relationship in which this question is ignored or not addressed. Progressively such issues of liveness have been replaced by the need for 'meaningful

26 Challenged by no eye contact because no eyes, no body.

27 In addition to the work cited here Small wrote on social musicology and ethnomusicology.

response' in the musicking between the different agents in the performance (Emmerson 2013). We search for meaning—from whatever source.

Summary and conclusion

Let us return to our metaphor of the river—a flux of performance activity. We have placed this between the banks of creation and reception, all held in an overall ecosystem of the world around. Within the flux lie the agents of performance, acting and interacting with each other. Neither the performers while interacting, or the listeners attending can always be sure what agencies contribute what elements to the flux—within the emergence of the totality we seek meaningful response. Increasingly, to understand this phenomenon we come down from a map-creating drone's eye view to a position much nearer the wayfinding of our experience. Thus we construct our model from a wide range of disciplinary tools to envisage the totality - from creative distance, through fleeting experience, to reflective reception.

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Live Electronics as Posthuman Performance Practice

Agostino Di Scipio

We perform and we are performed every moment
(Ihab Hassan 1977)

Two quick premises

First, naive as it may sound, in these pages I am concerned with notions of music not in the least to be mistaken for the production of music entertainment and consumer goods; likewise, when mentioning creative work in the sound arts, I do not mean artefacts duly crafted to be prized and traded on the contemporary art market. Not that the topics I'd like to address might not be pertinent and useful in those or other contexts, but my take on them originates from personal (and thus partial and partisan) commitment to horizons of artistic practice usually marked by a much reduced economy of means (and perhaps by a greater and auditorily discernible creative responsibility) (Di Scipio 2010; 2017a).

Second, in writing the present paper, I do not contend that the sounds, technologies and conceptualisations I am about are anything specially new: pondering artistic endeavours (past or present, mine or others') that seem to feature something unprecedented in their times, in itself does not align me with the euphoria of *new* technologies, *new* economies, *new* lifestyles...—or *new music* for that matter (itself an old trope). It is known that all too often 'the potentially innovative, de-territorialising impact of new technologies is hampered and turned down by the reassertion of the gravitational pull of old and established values…' (Braidotti 2018: 24) In this paper, I just try to clarify some ideas on the materiality of a kind of artistic work which—regardless of older or newer technical and conceptual designs—awaits to be contextualised in broader phenomena marking our zeitgeist and preparing the ground for further creative *and* critical work (I share the view that 'critique and creativity work in tandem' (Braidotti 2022: 77)). If something new is in order today, then it's perhaps a different ethos in musicking as well as in thinking music, whether old or new. Discussing live electronic music practice may prove especially useful in that regard. I am grateful to the organisers of our Zurich meeting for providing the opportunity for that.

Posthumanism as Matrix of Contemporary Performance

In 1977 literary theorist and philosopher Ihab Hassan introduced the neologism *posthumanism* to characterise 'lineaments of an emerging culture' defining the 'matrix of contemporary performance' (Hassan 1977: 831). He argued that the worldview of humanism—which for some centuries had affirmed human-centred ways of experiencing and conceptualising the world ('our' world)—was now coming to an end under the pressure of complex cultural dynamics arising in the encounter and mingling of scientific work, technological developments, and artistic imagination. At the time of his writing, the 'posthuman' probably seemed 'a dubious neologism', even 'the latest slogan' (Hassan 1977: 843), maybe useful for post-modernistic elaborations of earlier dystopian views and the allegedly dehumanising and nefarious impact of electronic media and technologies indeed often postulated with regard to artistic experience.[1] Hassan did, however, not intend to fuel dystopian views (nor would he have endorsed the preposterous *transhumanist* utopia today professed in some Silicon Valley corporate circles): he limited himself to noting the overriding process implying a profound reworking of what it means to be human. There is nothing anti-humanistic, he wrote, in the process by which 'humanism transforms itself into something that we must helplessly call posthumanism.' (Hassan 1977: 843) 'Posthumanism is not inhumanism.' (Braidotti 2019: 60) From a rather general perspective, it signals the overcoming of a certain idea

1 According to (Dyson 2009: 146) 'experimental music and audio art often express the techno-utopic and dystopic narratives rumbling beneath the sheen of modernity and have often been associated with both the posthuman, and the inhuman.' It's interesting to point out that musicologist Walter Riezler in 1955 hypostatised the nascent 'electronic music' (composed and synthesised at the Studio for Electronic Music in Cologne) as 'an inhuman monstrosity' (Di Scipio 2021b: 7, 111). In doing so, he was clearly not alone, and perhaps inadvertently joined philosopher José Ortega y Gasset's view on modernist abstract painting as a 'dehumanisation of art', dating from as early as 1925 (Wamberg & Thomsen 2016: 162). Riezler sounded his anti-technological claim in the context of a conference on 'The Arts in the Technological Age' held in Munich—the same conference in which Martin Heidegger gave a lecture later to become a well-known essay, *Die Frage nach der Technik* (Heidegger 1977). In his later works, by way of overcoming a purely instrumentalist theory of modern technology, Heidegger held that cybernetic rationality and electronic media were now setting a new historical-existential framework—or *Gestell*—to human being. His was an ambiguous and problematic reading of modern technology, as is known, but it provided valuable insight and conceptual tools to think matters of art *and*—and *as*—technique (Di Scipio 1998). A little later, and independent of the 1955 conference, writer Günther Anders published his book *The Obsolescence of Man* (1956); he elaborated the common trope that humans are no longer in control of the machines they are able to build, being 'surpassed' by their technological *alter ego*, but he also added that this could not be undone and thus demanded of humans a new ethos of living with and within the scenario thus opening up. Anders' view was shared by others in the germanophone world, including philosopher Hans Jonas and the early cybernetician Gotthard Günther (author, in 1957, of the prophetic book *Das Bewusstsein der Maschinen*, The Consciousness of Machines'). Inspired by Anders' words on atomic weapons, Herbert Eimert—founder and former head of the Cologne studio—composed *Epitaph für Aikichi Kuboyama* (1962), a tape work made solely of human speech electronically distorted beyond recognisability.

of subjectivity along with a much-needed reassessment of the very notion of being human. From a more specific perspective, it 'directs our attention to encounters between human and nonhuman agency.' (Pickering 2001: 174)

For N. Kathrine Hayles

> the posthuman does not really mean the end of humanity. It signals instead the end of a certain conception of the human, a conception that may have applied, at best, to that fraction of humanity who had the wealth, power, and leisure to conceptualise themselves as autonomous beings exercising their will through individual agency and choice. (Hayles 1999: 286)

It also points to 'a dynamic partnership between humans and intelligent machines (which) replaces the liberal humanist subject's manifest destiny to dominate and control nature' (Hayles 1999: 288), thus demanding different notions of subjectivity, agency, and power. In a posthumanist view, 'agency is not aligned with human intentionality or subjectivity.' (Barad 2003: 826, Barad 2007: 177) The idea of subjects extending beyond the human individual to include various kinds of nonhuman entities, and the very notion of 'extended agency', besides raising questions about the source and site of action, bring forth hard-to-tackle issues of intentionality, free will, and individual and collective responsibility (Hanson 2009). These are issues that ultimately interrogate us as citizens but also as artists, musicians and researchers whose practice is inhabited and articulated by a multiplicity of agencies.

In recent years, 'the notion of posthumanism has developed, multiplied and proliferated throughout the humanities and the art' (Stalpaert *et al.* 2021: 1), perhaps becoming 'by now already a cultural cliché often lacking definitional consensus' (Clarke & Hansen 2009: 7). Yet, the 'posthuman turn' is widely accepted as key to examine the complex materiality of ongoing ecological, socio-cultural, and politico-economic changes, and how they are conceptualised and reconfigured in contemporary intellectual work and artistic practice. Crossing with broader cultural and political agendas (such as post-feminist and post-colonial studies), 'posthumanists' merge science and technology studies—including topics of modern physics methodology (Barad 2007), constructivist epistemologies and cybernetics (Hayles 1999; Hansen 2000; Pickering 2010)—with the production of bodies and the situatedness of subjectivity (developing from post-structuralist thinking) as re-contextualised by modern and post-modern technologies (Haraway 1991; Plant 1997; Braidotti 2019; Braidotti & Bignall 2019). These various lines of inquiry eventually intersect environmentalist and 'deep ecology' concerns, they foster a broader notion of relationality interweaving questions of environmental, psychic and social ecologies (taking over from Felix Guattari's 'three ecologies') and ending up in post-anthropocentrism—i.e. the dismantling of the belief that value lies

in human beings only, in their intentionality and morality, treating other beings as means to human ends.[2]

Meanwhile, such general concerns have also become relevant to several developments in the experimental arts, especially in endeavours implying a critical reconceptualisation—or a 'phase transition'—of what it means to engage in creative work in the face of the complex challenges that characterise today's world (Solomos *et al.* 2016; Barbanti *et al.* 2017; Barbanti 2017; Solomos 2023). Overall, it seems definitely appropriate to ask 'what role has music played [over the last six or seven decades] in developing and challenging the concept of the posthuman?' (Barrett 2023: 1)[3]

For (Braidotti 2019), the 'posthuman condition' is defined by the convergence of the general ecologisation of technology and post-anthropocentrism.[4] The former—i.e. the question of the 'technological condition' (Hörl 2015; Hörl & Burton 2017)—is clearly of more immediate interest to our discussion. But just as crucial is the coupling of humans and nonhumans to their environmental niche, together with the whole array of nonlinear dynamical transductions taking place in and through that coupling. The *devenir-milieu* (becoming-environment) of modern media and technologies, key to the contemporary ecology of music experience (Di Scipio 2014, 2020, 2021a), ultimately lies at the very heart of posthumanism. After all, it is part of the (all too human) overruling techno-economic dynamics that have caused or propelled the environmental and humanitarian crises of these last decades, today heatedly debated in terms of terrestrial climate change and mass migration.

It may (again) sound naive, but it seems clear that these broader dynamics demand critical efforts towards a new creative ethos—what Braidotti, following Gilles Deleuze, calls 'affirmative ethics' (Braidotti 2022: 165). Appropriating and practicing the mixed ecology of music performance is, for some of us, the place to start from. In line perhaps with 'new materialism'—a philosophical perspective moving beyond the apparent binary opposition of passive, material objects and active subjects—we should consider a posthumanist account of performance.[5]

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2 Remember Protagoras' dictum, 'man is the measure of all things.'

3 See (Stalpaert *et al.* 2021; Patti 2023) for recent examples of artistic practice addressing the 'posthuman' in contemporary theatre, inter- or multimedia art, and (Clarke 2008) for a discussion of the posthuman from a literary studies perspective.

4 *The Posthuman Condition* is the title of an essay by Robert Pepperell (1997) and a recurring expression in various authors, including (Braidotti 2019). Either implicitly or explicitly, it echoes *The Human Condition*, the title of a 1958 essay by Hannah Arendt (philosopher, early student of Heidegger and later acquaintance of Anders). It also evokes the title of a novel by André Malraux (1933) and some paintings by René Magritte (1933-35).

5 Around the year 2000, I started working on 'audible ecosystems' as hybrid designs of live electronics performance, meant for either concert performance and sound installation contexts. (Di Scipio 2003) My approach emphasised self-regulating and adaptive digital signal processing algorithms, but other musicians and sound artists were exploring parallel routes with different technical designs and conceptualisations (Bowers 2002; Bowers & Archer 2005;

Among the 'regions of contemporary culture' most expressive of the inception of posthumanism, Hassan mentioned 'the *incorporation* of technology into the arts', particularly including 'cybernetic art [...] electronic music, video art [...]' (Hassan 1977: 839, 841, my emphasis). It's hard to say what exactly he meant by 'cybernetic art' and 'electronic music', yet I consider the quote especially interesting in that the term 'incorporation' seems suggestive of questions of 'embodiment' and may thus lead us to consider peculiar embodiment phenomena involved in playing any of the innumerable electronic music instruments and digital interactive devices used in performance contexts (Magnusson 2019). Or rather, it leads us to consider a larger historical reframing of the musicking body, with musicians, engineers and technical assistants working together inside the walls of acoustically well-insulated and highly technologised environments—either 'recording studios' (from the early 1900s onwards) or more specialised workshops such as electroacoustic and electronic music studios (since the 1940s), computer music labs (since the early 1960s), or even infrastructures such as 'production' and 'post-production' studios typically serving productive patterns in the entertainment and digital media industries.[6]

Regardless of technical designs and working contexts, a *studio* may be 'a tool' or instrument (Eno 1983) but it is primarily an 'electronic environment' (Schnell & Battier 2002), a separate enclosure filled with technical systems and duly 'soundproofed', i.e. acoustically decoupled from the surroundings. It amounts to a 'system of technics […] serving as an environment' to creative musical work (Magnusson 2019: 62). The studio environment 'embodies' musicians which in turn embody some of the equipment available therein. One may call it a 'task environment' (Laske 1989), the notion coming from the social sciences and suggesting that the accomplishment of any action plan or 'task' always entails the 'structuring of the environment' (Quéré 1997: 173; Laville 2000: 1319). What this 'structuring' yields is a techno-cultural assemblage (in French *agencement*) whose affordances and resistances are in no way neutral or innocent with respect to actually pursued tasks. Any arrangement of studio conditions cannot but facilitate and promote certain activities and practices, while hindering or revising others.

Waters 2007). As far as I know, such efforts were not aware of the issue of 'posthumanist performativity' elaborated at about the same time in philosophically oriented science and technology studies (Barad 2003). A direct comparison would of course be arbitrary, given the different contexts of discourse, but an attempt to consider shared theoretical implications is perhaps admissible and useful.

6 For the historical-technical developments of the 'recording studio' and similar productive infrastructures, see (Chanan 1995). I have elsewhere attempted to sketch a discussion of the 'electronic and computer music studio' or other such equipped and soundproofed workshops, understanding them as peculiar instances of experimental setups, innervated by a techno-logic of automation as well as by a politics of sound objectification and noise reduction (Di Scipio 2020a: 39–80).

In times of 'cognitive labour and recombinant capitalism' (Berardi 2003; Fumagalli 2011), the functionalities and the very concept of a musical studio have been systematically challenged by a kind of permanent technological innovation, with working conditions changing ever so frequently and never really stabilising. A growing interest in the effortless displacement of production means (from the 'mobile studios' of the 1970s and 1980s to the portable 'digital studios' of recent decades) gradually resulted in the trading of stable and highly specialised apparatuses for much more flexible and cheaper designs (maybe well captured in the oxymoronic notion of the 'live studio'). Along with that, however, a kind of regressive process ensued, involving the increasing de-specialisation or 'democratisation' of music labour: the availability of more affordable but efficient computing and electroacoustic equipment has enabled easier and more widespread access to productive schemes,[7] but this apparent logic of empowerment has also fostered a significant de-skilling of professional practice, accompanied by an over-simplification of technical (and musical) competences. All that occurred quite naturally, so to say, in the framework of the extreme fragmentation and precariousness of labour relationships, nowadays structural to radically neoliberal economies.

Through repeated and profound reconfigurations (electromechanical devices, various forms of analogue and digital electronics, down to recent assemblies of wireless and digital apparatuses), the overall 'incorporation of technology' into music spurred a multiplication of languages, genres and subgenres, with a remarkable diversification of related discourses. Such is at least the typical narrative offered in musicological and music history publications. In spite of the implicit and ubiquitous technological determinism, anyway largely unquestioned and indeed hegemonic in mainstream cultural patterns across the decades, so many musicians and artists have themselves actively contributed to those technical reconfigurations, not just as beta testers for manufacturers and engineers, but also as music researchers infiltrating technical faculties or as talented mavericks at home with circuit bending, electronic bricolage, computer programming, interface design, etc. In doing so, they have pointed out alternative routes and imaginative if perhaps idiosyncratic technical developments, thereby also unveiling new territories of practice or revealing little-known aspects of old ones. Even today, new creative skills and attitudes—i.e. emergent forms of creative subjectivity—are transpiring from various music and artistic research communities, not without a simultaneous re-evaluation of the legacy of earlier experimental art practices. It's in such contexts, albeit marginal and little-known, that significant audible figurations of the posthuman are being sounded.

7 Basic studio gear today is easily moved and reinstalled almost anywhere. For better or worse, to musicians and producers this also means that they 'always' stay in the studio.

It seems fair to say that, through various forms of 'incorporation of technology', notions of music have hugely diversified and have taken on a fluid, turbulent and ever-changing state, eventually opening to artistic sound practices no longer experienced as 'music'.[8] We could frame things differently, however, and suggest that what really has been (and is) at stake in those technological and conceptual dynamics are the basic conditions themselves against which *making music* does indeed *make sense*. After all, in the larger historical scenario, it was not just music-making and -listening practices that eventually materialised as thoroughly structured environments, integrated by digital (and other) technologies,[9] but virtually all of our existential milieus. Most domains of individual and collective human experience are now intricate constructions including all sorts of entities and agencies. That circumstance—the ecologisation of mediation technologies—is critical for inquiries into contemporary performance.

I claim that there is indeed more to the mentioned 'incorporation of technology' than the interactional dynamics of human bodies and instrumental and machinic apparatuses, for all such dynamics are in fact situated and coupled (embodied, if you like) in a larger, physical and socially shared environment—itself a bundle of technical layers and communicative designs experienced as a milieu of peculiar agential capacities. Focussing only on man/machine interaction (as it was customary for decades, except perhaps in circles exposed to systems theory and cybernetics) ultimately seems to reaffirm a humanistic bias. The man/machine couple is itself only a part belonging to a larger domain of man/environment and machine/environment relationships. In short, pondering the 'incorporation' of technology is of little significance without also taking into account its 'environmentalisation'. A conceptual shift towards a more encompassing domain of posthuman relationality is in order.

That shift demands that notions of *embodiment* and *agency* be reconsidered. Embodiment is usually understood as the human sensory-motor and cognitive system's construing of the sense of 'being one' with some external means (e.g. a musical instrument), the latter being somehow perceived as an organ internal to the human body and becoming part of its cognitive and sensorial dynamics (thus entering the human subject's tacit and situated knowledge, hence the subject's personal history of sensorial experience, too).[10] But that movement inwards

8 There I am of course alluding to a vast array of sound practices that through the decades have developed their aesthetics beyond received notions of music—e.g. 'radio drama', 'sound design', 'soundscape composition', 'sound installation'.

9 Whatever device, system or infrastructure defined as 'digital' is always and anyway 'an assemblage of technologies of diffuse origins' (Magnusson 2019: 62).

10 As remarked in (Auslander 2009), issues of embodiment linking instrumentality, agency and technology may be critical to the construction of the musical self (and its public *persona*).

never comes alone, it rather crosses and interferes with a concurrent movement outwards, notably with the process of distributed cognition (the externalisation—or *exbodiment*—of memory and knowledge, typically displaced into and made available in technical objects or systems), and the delegation of decisions to others (humans or machinic agents). Both being part of one and the same sensorial and cognitive dynamics, embodiment and exbodiment capture the *embeddedness* of bodily action and related issues of subjectivity. Such double register of relationality is nothing new, as it resounds very early work in biosemiotics (e.g. Jacob von Uexküll) and later phenomenological views (e.g. Maurice Merleau-Ponty and Michel Foucault), which in fact describe bodily performance as involving 'the mutual incorporation of the instruments used to perform a task into the body *and* the dilation of our "being-in-the-world" into the instrument, thereby undermining the taken-for-granted distinction between the inside and outside of the body' (Barad 2007: 157, my emphasis). Except that 'instrument' has long since ceased to be a viable working concept and 'being-in-the-world' now implies 'being-of-the-world' and—more particularly—inhabiting overly technologised environments.

Critical in shifting from prosthetic to medial notions of embodiment and technology is a view that necessarily includes the environment and accordingly understands agency not only as 'extended' but also 'situated' in the environment: agency belongs to the coupling of environment and technology, it is situated in that which extends it. The environment appears both as a niche possibly populated with several nonhuman agents (biotic and abiotic, including machinic), and as a shared medium to which agents are structurally coupled, in different degrees and different ways. Agency is never independent of the environment, especially when the latter is defined as a spatial niche so 'saturated with technological interventions in all possible scales' as to exert 'a new kind of pressure on the human body' (Wamberg & Thomsen 2016: 151). The environment is conditioning and conditioned, endowed with agential capacities representing affordances and resistances to agents involved. We may say that the environment is structural to and constitutive of agency.

Confronting questions of performance, we cannot waive the mentioned double register of relationality (embodiment/exbodiment). Nor can we do without considering that the two movements, inwards and outwards, are enacted in various feedback loops, starting with the 'action-perception' loop (*alias* sensory-motor system) that is *sine qua non* to cognitive phenomena and defines any cognitive system as structurally coupled to an environment.[11] What we call the 'body of performance' is not the human performer's, albeit augmented or extended by prostheses or other resources; it is rather the larger dynamical ensemble of situated agential

11 A view in agreement not only with Merleau-Ponty's phenomenology of the senses, but also with Heinz von Foerster's cybernetic epistemology of self-observing systems, Humberto Maturana's biology of cognition, Francisco Varela's enactive neo-phenomenology, and Mark Hansen's and Bruce Clarke's neo-cybernetic views.

components—human and nonhuman, physical and virtual—constituted in a relationship of co-dependency, weaved together through multiple feedback loops. On the one hand, 'the human body is no longer the privileged place of an idealised (autonomous) subject.' (de Assis 2018: 260) On the other hand, a revised notion of embodiment brings us closer towards a posthumanist notion of the performance body. In the following, I try to characterise the latter in a way that addresses the 'distributed, situated and embodied phenomenon' we call music (Impett 2001: 108). In that regard, live electronic music seems a highly valuable context where we experience that 'it is not a question of leaving the body behind', advocating its dematerialisation or virtualisation, 'but rather (one of) extending embodied awareness' (Hayles 1999: 291).[12]

Questions of embodiment are 'not a mere artefact of the new technologies', yet it seems plausible that some of the latter indeed 'have a way of bringing [such questions] into greater relief' (Barad 2007: 158). I argue that live electronics performance counts among such contexts. I suggest that *live electronics* practice can offer a more vivid and significant instance of Hassan's 'incorporation of technology', in that it exhibits *in vivo*—not *in vitro* (as in music produced within isolated labs and studios)—a more tangible relational dynamics of human (performers, assistants, listeners) and nonhuman agents, the latter including not only technical (mechanical, analogue, and digital equipment) but also physical-environmental ones (acoustics and logistics of socially shared spaces, with related cultural connotations). As such, it may be seen as practice-centred research addressing the question what it means for humans to live with and through thoroughly artefactual, machinic milieus, thus eventually providing audible figurations of the posthuman.[13] Artistic research of the kind seems to tune in with what Braidotti calls 'critical posthumanities' (2019: 100). The latter present themselves as 'hybrid creative practices that go beyond the study of cultural and social phenomena as a purely human domain' (Borowski *et al.* 2021: 288). They elaborate 'a posthumanist role for the human' (Barad 2007: 168-172).[14] In my view, live electronic music practices belong

12 Note that in this paper I deliberately steer clear of a certain 'disembodied posthumanism' (that in fact Hayles and others contest), probably better characterised today as 'transhumanism'.

13 In this regard, live electronics practices involving vocal performance may be especially relevant, the human singing voice being of course archetypical of bodily musicianship and auditory subjectivity—intrinsically embodied, apparently 'non-distributed' and 'non-mediated'. In actuality, as emphasised in the nascent niche of 'voice studies', music vocality is a field of 'physiological processes and corporeal practices in which biology and culture dynamically intermingle' (Fast & Tiainen 2018). By intervening in that field, a variety of technical mediators enter directly into the action-perception loop of embodied musical experience, as it happens in several creative performance practices (Di Scipio 2008; 2023a). They provide peculiar sonic evidence that the voice phenomenon is actually to be located 'within a broader nexus of relations between organic and synthetic bodies, actors, and forces' (Thompson & Tiainen 2017: 382).

14 In this paper, when quoting from (Barad 2007) or other 'posthumanists', I am concerned with general implications one can draw from their texts, leaving aside topics more specific to their analysis (in Barad's case, science methodology and the materiality of scientific apparatuses of

to such a perspective and render it into inventive sonic figurations. In fact, they have done so for several decades now, at least since the early 1960s (in any case well before Hassan's publication): on a historical level, live electronics is a significant 'pre-figuration' of the posthuman.[15] This is a field of musical practice that 'both construct(s) and respond(s) to the contemporary posthuman' (Barrett 2023: 2).

The next section offers a detour to better circumscribe actual live electronics practice, to be specially characterised 'as a network of discourses, theories, technologies and practices in which the sensory exploration of phenomena becomes as important as otherwise predominant aesthetical categories, such as artwork, material, form, and expression' (Toro Pérez 2022: 223). To do so, I will then address the 'performance ecosystem' as a conceptual framework and as a 'unit of empirical analysis' to understand live performance. Surveying the hybrid, situated and distributed dynamics of the live electronics performance ecosystem may clarify the main thesis of the present paper, namely that live electronics provide highly significant instances of posthuman performativity.

Live Electronics as Practice

I consider *live electronics* to be eponymous of a wide range of practices that have emerged in the historical transition from late- to post-modernism, and today keep developing and branching in further directions. The term is broadly accepted to imply that sound and music are generated by various means including notably synthesis and/or processing equipment, in real time but also in 'real space', i.e. in

knowledge production). My paraphrasing is perhaps not entirely arbitrary, in the extent that the broader agenda of Science and Technology Studies is today deemed promising to also investigate 'the activities of artists and composers who use and assemble technologies as part of their practice creative' (Pigott 2020: 97), and to understand such practices as sites of human and nonhuman agency.

15 John Cage's *Cartridge Music* (1960) is often named as the first canonical example of live electronic music, followed by other pioneering works such as *Spazio a 5* by Franco Evangelisti (1959–1961) and the much better known *Mikrophonie I* by Karlheinz Stockhausen (1964). Dating from before 1960 are Gordon Pask's intermedia work *Musicolour* developed in the mid-1950s (Pask 1971; Pickering 2007; Pickering 2010: 309–378; Pickles 2016: 80–86) and more works by Cage himself, including *Radio Music* (1956) and some of his earlier five *Imaginary Landscapes* (1939–1952). Collectively, the latter calls for a variety of sound sources, such as electroacoustic transducers, radio receivers, record players, besides musical instruments or extra-musical mechanical and electric appliances duly recycled as 'found' instruments. Dating from the 1930s is music (more and less conventionally notated) meant for electronic instruments (or for musical ensembles including electronic instruments) by composers such as Edgard Varèse, Oliver Messiaen, Johanna Beyer, and Percy Grainger, among others. Although regularly cited in textbooks and scholarly essays, the latter represent a repertoire of 'historical precedents' that not all authors consider integral to live electronics: playing and mastering music *instruments*—technical systems producing sound electrically or electronically—is not necessarily like playing *electronics*. In any case, the distinctions can be subtle, we don't need to go into detail here.

underdetermined public spaces not necessarily acoustically suitable nor noted as 'musical' venues—and maybe with equipment re-arranged or re-installed for each ensuing occasion.

While the eponym is often taken to mean a range of endeavours at the fringes of contemporary music or intermedia art, it is also regularly used to refer to well-known masterworks of musical modernism (e.g. some of Karlheinz Stockhausen's works from the 1960s, Luigi Nono's works from the 1980s, Pierre Boulez's *Répons* from 1984, etc.) as well as to highly representative names of sonic experimentalism (e.g. David Tudor, Musica Elettronica Viva, Hugh Davies, the early Alvin Lucier, The League of Automated Composers, George Lewis, etc.). Univocally agreed-upon definitions seem impracticable, even more so in consideration of the blooming of so many different developments in more recent decades,[16] including 'robotic instruments', 'live coding' and what not (not to forget certain popular music practices (Waite 2019)). Numerous expressive perspectives have been developed, some centred on motivic, harmonic and other pitch-based structures, others more concerned with timbral, textural and atmospheric properties of sound and noise phenomena, with pitch relationships of tangential or secondary relevance; some biased towards extant composing and performing schemes (score-centred and using standard music notation), others towards improvisation (from closer to jazz idioms to non-idiomatic, 'radical' electroacoustic impro and *noise* music); some involving common and uncommon music instruments and maybe indulging in the sonic potential of 'extended playing techniques', others involving electronics only, either analogue or digital, either commercially available or purposefully designed and self-made; some developed in well-funded public or private institutional contexts, others in independent, 'alternative' circles and self-funded initiatives. Not to mention the continuum of intermediate possibilities between all such binary oppositions.

The difficulty of giving a definition is itself significant. I consider it symptomatic of a domain of musical practice evading notions of genre or definitions based on formal features ('style'), and drawing attention to criteria relative to the heterogeneous materiality of practice, to the dynamical and indeed musical entanglement of the bodily and the technical sphere. We may perhaps understand live electronics as an 'art form' in a generic sense—anyway, more an artistic medium than a *genre*. And certainly as a horizon of empirical, practice-centred artistic research.

16 See (Bertolani & Sallis 2016; Sallis *et al.* 2018: 1–13) and more extended discussions in (Emmerson 2007; Di Scipio 2020b; 2021a). The diversity of recent and not so recent orientations is manifest in volumes addressing different topics (Van Eck 2016; Gottschalk 2016; Sallis *et al.* 2018; Magnusson 2019) and can also be traced in a long list of contributions including (Bernardini 1986; Battier 1999; Aufermann 2002; Melbye 2022) *inter alia*.

Yet, once aesthetic and stylistic criteria are set aside, the question remains: how are we to identify this medium as a specific albeit porous and elusive cluster of creative practices?

The fact is, live electronics approaches do share some general assumptions, however poorly captured in compact and suggestive descriptors. In the first place, this is a domain of *performance practice*—that seems trivial to say, but we will have to ask what that may exactly mean considering the variety of agencies the actual performance process might involve. Secondly, and perhaps more crucially, live electronics generally involve some relevant commitment to the materiality of actual performance conditions, including a special care with regard to the technical and operational layout and the related logistics. I mean performance schemes in the preparation of which practicing musicians devote a varying but significant amount of time and creative effort to sketching, prototyping, testing and even assembling the performance setup or significant portions of it, including various technical apparatuses ('possibly requiring non-standard components to be custom-built' (Emmerson 2006: 209)), notations and other symbolic codes (scores, software, programming languages, etc.), mechanical devices (musical instruments, for example) and other instrumental appliances—beside more or less definite action plans to be accomplished either by human beings (musicians, assistants and others joining the process in various capacities) or machines (e.g. computer programmes and automations, from the bare 'sequencing' of pre-determined event lists to adaptive algorithms capable of real-time event scheduling dependent on time-varying and site-specific contingent factors).

Crucial are also the time and effort devoted to devising and rehearsing the routes and channels by which energy (sound, pressure, physical effort or strain) and information (commands, signals, data) are transduced and exchanged among nonhuman resources, enabling them to affect and be affected by each other, besides affecting and being affected by human performers. Crucial is therefore a focus on the relational and interactional dynamics of the whole performance process, and a commitment to designing the interface and 'composing the interactions' (Di Scipio 2003).

Overall, such a perspective ultimately challenges rigid views of what 'composing' means. In certain cases, 'composition becomes systems design which involves integrating an assemblage of heterogeneous elements—hardware, code, protocols, and standards.' (Magnusson 2019: 120) This might perhaps represent 'a decentring of the composer, in favour of an acknowledgement of other generative and productive forces' (Thompson 2017: 153). But I would say it rather implies a significant reworking of what it means to be a composer—and a performer, for that matter (assuming the distinction can still be made). It's a question of understanding 'composition' and 'performance' as practice domains involving a mix of different agencies, overlapping or intermingling in actual work. It is typical for such a 'performance-intensive art form' (Bernardini & Vidolin 2005; 2019) that clear-cut

distinctions of roles (composer, performer, technical assistant—and listener!) are often blurred. Recent history shows

> a multiplicity of practices where lines that might previously have been clear are fading. The instrument merges with a sound installation, the performer live codes their instrument, the composer becomes an instrument maker, the audience participate in […] a piece with networked devices, the instruments learn from their players and exchange information, the music changes depending on social and spatiotemporal parameters… (Magnusson 2019: 240)

Clearly, even thus characterised as instances of a peculiar practice, live electronics approaches do not really decrease in number and variety. Still, we can now circumscribe them from a more pertinent perspective that shifts the focus away from purely formal dimensions of aesthetic language and 'genre' towards the materiality of performance—without necessarily prioritising either one.

As is well-known, 'a synergy of design, composition and performance in live electronic music' emerged already in the work 'of pioneers such as Gordon Mumma and David Tudor' in the late 1960s (Nyström 2021a).[17] In the late 1970s, composer and performer Joel Chadabe described his personal approach as 'a two-stage process', consisting of building an interactive music system and then the exploration of its potential in public situations (Chadabe 1984: 23). In actual work it's hard to make too neat a distinction between the two mentioned 'stages', for there is always substantial feedback between them, making the whole process much less binary and linear than it may appear. But Chadabe's account certainly attests to a widely shared attitude. The inherent dual pattern is evident also in other musical contexts. Think for example of the technical instructions included in many composers' scores meant to describe or prescribe the electroacoustic chains involved in the *Klangregie* (sound diffusion) equipment, sometimes also including electroacoustic specifics or even digital signal processing algorithms. While not adopted on a regular basis, with the passing of time this is becoming a recurrent documentary practice, one that would deserve greater attention than musicologists have so far accorded to it.[18] This is a clear symptom of the non-subsidiary role that should be attributed to purposefully designed technical apparatus in actual performance processes.[19]

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17 We could add the names of other musicians and sound artists, such as Hugh Davies, David Behrman, Qubais Reed Ghazala, Mario Bertoncini, and then also Godfried-Willem Raes, Jon Kuivila, John Bowers, Zimoun and several younger ones (Andrea Valle, Owen Green, Matt Rogalsky, Lauren Hayes, Marianthi Papalexandri-Alexandri, Paul Stapleton, Tom Davis, Adam Pultz Melbye among others).

18 Examples could be taken from scores by noted composers such as Luigi Nono, Pierre Manoury, Karlheinz Stockhausen or David Behrman—not to mention Simon Waters, Michelangelo Lupone, Simon Emmerson, and younger ones (Ash Fure, Luc Döbereiner, Daniela Fantechi, and many others).

19 I should add that the availability of technical documentation—often including a variety of media—is crucial to the 'portability', 'preservation' and 'sustainability' of live electronic music

In the context of this paper, we don't need to pick up specific examples. Moreover, we don't need to subscribe to the commonplace musicological distinction between (American) 'experimental' electronic music currents, and (European) 'academic' or 'research' currents (the former are—perhaps not surprisingly—more often connected to discourses on the posthuman (Barrett 2023)).[20] We only need to take note of a domain of artistic practice in which musicians appropriate and creatively elaborate the materiality of the performance process, as the latter is experienced as more than just instrumental in the achievement of sounding results. The constitutive feedback loop whose emergence we might call 'music' is already there: ends do not justify nor precede the means, as the latter themselves do not justify nor precede the ends...

One may legitimately wonder: in what capacity and in what measure can practicing musicians piece together audio equipment, computer software, and other resources as active components of their performance setup, provided that the handling of their specifics calls upon types of expertise (such as electroacoustics, analogue electronics, signal processing, computer programming, computer graphics, and what else) that few would consider of musical pertinence? What does the fact that the work of musicians and artists begins with taking care of the material conditions of the performance process, at least in some non-marginal measure, really mean? We can tackle the question in a later section. Meanwhile we should briefly dwell on notions of *practice*, *performance* and *agency*, ending up with a conceptual framework that might possibly enable us to thread them together.

Scholars agree that 'practices are arrays […] or nexuses of human activity' that also include 'the activities of nonhumans such as machines' (Schatzki 2001: 11). Practices are clusters of behaviour regularly if not routinely pursued in a given context of action, mediated and connoted by specific tools, representations, competences, and values. Artistic practices can be more precisely connoted as *epistemic practices*, in the sense that they 'assemble materials, tacit knowledge, bodies, and aesthetic judgments in experimental setups' (Burri 2021: 181). Practices defined

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repertoires. (Bernardini & Vidolin 2005; Polfreman *et al*. 2006; Emmerson 2006). When some kind of software is also included, the question extends to issues of ownership of information and related politics of knowledge. Today several composers (myself among others) consider part of their practice to document the real-time algorithmic schemes involved in their works, or make them available as open access software. The latter is ideally the case with 'live coding' performer communities. Anyway, different legitimate positions exist on this matter, in consideration of a variety of technical, practical and legal issues. And yet, regardless of individual positions, it is clear that these are not marginal issues and should not be deemed void of cultural implications for the politics of contemporary music and technical practice.

20 Upon careful analysis, and in contrast with established historical-musicological views, it is safe to say that there have been (and there are) pathways of sonic experimentalism in Europe and South America, as well as pathways of academic musical modernism in North America (Di Scipio 2021b: 337–340). The unquestioned acceptance of a clear-cut distinction of American experimentalism and European academicism is a cliché that would need to be investigated and deconstructed.

as 'epistemic' instantiate 'a form of relationship [that] transforms itself and the entities formed by the relationship' (Knorr-Cetina 2001: 194). In other words, this is not practice as recurrent or packaged patterns of action, involving 'the embodied acquisition of preferences, perceptual schemes and dispositions', but rather as a relational dynamic 'that extends itself into the future in creative and also in disruptive ways' (Knorr-Cetina 2001: 196). Elsewhere, in a different context of discussion, it occurred to me to suggest that all art is ultimately made by working and reworking the very means of art making, as relative to the broader historical and social scenario: while yielding in separate works or other aesthetic instances, art is indeed a kind of autopoietic practice—it produces its own conditions of possibility before producing works of art (Di Scipio 1998, 2013).

Furthermore, artistic practices and related competences are hard to compartmentalise, especially in the larger scenario of modern technologies and media. As is clear, live electronic music performance defines a field of mixed praxis often involving a joint effort of several people with different expertise. This is a practice where received patterns in the division of music labour are often challenged, where disciplinary boundaries are regularly crossed. The kind of interdisciplinary work pursued may of course involve people from different backgrounds, not just musical, working in coordination and cooperation.[21] On the other hand, most practitioners themselves have a varied and mixed background: they embody 'interdisciplinarity in one person' (Barry *et al.* 2008; Barry & Born 2013). While this model of interdisciplinarity is attributed to the increasing availability and affordability of laptop computers, tablets and other popular computing devices, I would personally consider it peculiar to artistic research in general, regardless of the technological context (can't people like, say, David Tudor, Pierre Schaeffer, Gordon Pask, Hugh LeCaine, or Iannis Xenakis be called 'interdisciplinary' just because they never used laptops or smartphones?).[22] Furthermore, 'interdisciplinarity in one person' seems to go hand in hand with a more general attitude of DIY (do-it-yourself). In actual practice, however, such attitudes inevitably merge with or melt into forms of collective work: they do not necessarily imply a solipsistic approach and often come along with an attitude of DIWO (do-it-with-others). Albeit distinct, these are

21 However subtle, the distinction between 'coordination' and 'cooperation' establishes a dualism that accounts for different models of interdisciplinary work in electroacoustic music and computer music institutions. In a section of (Di Scipio, 2023), the difference is elaborated by contrasting the different policies of institutions in their specific historical-technological context—say, for example, on one side the Institute de Recherche et *Coordination* Acoustique Musique (IRCAM, Paris, established by Pierre Boulez in the late 1970s) and on the other the *Cooperative* Studio for Electronic Music (CSEM, Ann Arbour, established and led by Gordon Mumma and Robert Ashley, 1955-1964).

22 In (Barry *et al.* 2008), 'interdisciplinarity on one person' is referred to specific experiments in higher education programs (in the arts, computation and engineering), designed to transcend the disciplinary division of labour. It seems safe to assume, however, that true interdisciplinarity—however maybe self-developed outside of academic programs—is paradigmatic of the personality of numerous celebrated polymaths in modern as well as in pre-modern history.

not incompatible or contrasting attitudes, quite to the contrary, they often overlap. In fact, live electronics performance is essentially teamwork, even when a single performer or 'soloist' takes centre stage, even when no human is around (as in live, adaptive and unsupervised sound installations). As a cluster of different practices, it provides a kind of contemporary (and indeed posthuman) notion of 'chamber music', in both a literal and a more emphatic sense. Questions ineluctably arise: How is this 'chamber' arranged and turned into an overly-technologised environment suited to subjectivities and agencies that musicking today calls for? Who (or what) is the chamber host? Who (or what) are its guests?

No individual component (human or nonhuman) taking part in a performance can be assumed to be the only site of agency—nor to be *a* site of agency, to start with. On the one hand, 'agency is always relational and distributed.' (Hayles 2006: 161) On the other hand, particularly in the performing arts, agency cannot be assumed to exist 'prior to the cultural field that [performance] negotiates' (Butler 1990: 142). The agency exerted by a human performer within an ecology of sonic relationships (Di Scipio 2018) is only revealed as the performer actually situates him- or herself in a concrete setting and acts on it. No matter how duly trained or prepared beforehand, the performer's agential capacity is defined as such not prior to nor outside of the contingent flow of action of performing, but in the moment he or she acts in, through and upon entities available in the shared environment (themselves capable to exert some kind of agency).

Such a view of the performance ecology may hold regardless of the particular performative context. Nonetheless, live electronics and intermedia performance practices seem to epitomise that view as they more directly raise questions with regard to the agency exercised by nonhumans—including technical systems and the physical space in which a performance is takes place. In thus constituted artefactual environments we find evidence that 'the posthuman subject is an amalgam, a collection of heterogeneous components, a material-informational entity whose boundaries undergo continuous construction and reconstruction.' (Dyson 2009: 227)

Now, if performance agency cannot be determined except as embodied and situated in a specific yet always different performative context, and if the latter presents itself not as a set of separate tools assembled in a neutral space, but as a physical niche inhabited by several humans as well as by purposefully designed technical agents with some dynamical relationship between them, it would seem inadequate to abstract human and nonhuman performative agencies into individual categories, each with their own separate dynamics. I view live electronic performance setups as 'visible sites of encounters of human and nonhuman agencies' (Pickering 2001: 174). Studying such sites requires, each time anew, empirically defining what might constitute the 'unit of analysis' of our observation. In the jargon of cybernetics and systems theory, we can never consider the 'organism'—or 'system'—alone, but rather the ensemble 'organism plus its environment'. According-

ly, we can think of it as an *ecosystem*, a term useful to acknowledge the role of the environment as constitutively integrated within the performance dynamics. From a practitioner's perspective, 'the whole performance setting becomes the unit of analysis, design and evaluation.' (Bowers & Archer 2005: 5) This unit, however, is nothing that might show temporal stability, as it is bound instead to vary or to be reworked at each performance iteration; it is 'not given, but [is] to be found in any specific instance' of empirical analysis (Pickering 2010: 427).

Enter the Performance Ecosystem

The notion of *performance ecosystem* has been elaborated by composer, performer and music researcher Simon Waters as a conceptual tool 'for the understanding and analysis of current musical activity', and more particularly to investigate 'contiguities between composition and performance, performer and instrument, instrument and environment' (Waters 2007: 1). For the purposes of the present paper, I take the generic 'instrument' in the latter quote to actually mean any ensemble of technical means—as 'technics' in general. That way, the 'performance ecosystem' may more explicitly refer to a wider media ecology and thus prove itself useful in the 'observation of technically-distributed cognitive operations of system-environment hybrids' (Clarke & Hansen 2009: 96) in music and sound art contexts.

As a conceptual tool, the performance ecosystem's function is indeed to capture 'assemblages consisting of heterogeneous elements which afford both designed outcomes and, through their configuration and complex interpenetrative behaviours, emergent outcomes' (Waters 2013: 129). Its scope is rather broad and can extend to other performing arts, beyond music.[23] Waters is keen to describe it 'as a tool for understanding the complex interconnectivities in *all* musical activity' not only 'involving highly technologised situations or digital technologies' (Waters 2021: 133). It is no coincidence, though, that he first discussed it as a way to survey creative experimentations thematically addressing the techno-ecology of contemporary musical performance, including (Impett 2001; Bowers 2002; Di Scipio 2003; Collins 2006), besides his own and other electroacoustic and computer music practitioners'.[24] In a way, and rather remarkably, the performance ecosystem conceptual framework is the outcome of several artists' self-reflective practices.

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23 'Various theorist-practitioners in theatre (since the late 1960s) and many performance artists' have discussed their performance ecologies (Waters 2007: 6).

24 A 'relational understanding of the performance ecosystem' is further discussed in (Davis 2011). A variety of pertinent case studies are overviewed in (Waters 2011) and further discussed in (Stapleton & Davis 2021; Melbye 2022), *inter alia*. Looking back at less recent historical developments, I would also include earlier proposals by Rolf Gehlhaar (1991) as well as installations and performative designs recurrent in the work of Gordon Mumma, David Tudor, Alvin Lucier, Hugh Davies (*Quintet*, 1968 (Mooney *et al.* 2022)) and Mario Bertoncini (*Chain Reaction*,

One may view it as a token of ethnomethodologically-informed artistic research turned into a discursive framework for discussing the complex of cognitive and affective relations 'that occur between performing bodies, instruments, media technologies and environments' in creative experimental praxis (Thompson 2017: 150).

In this view, music is indeed understood as 'a complex set of different relational factors, irreducible to a single human behaviour', including dynamical and 'unstable relationships between people, technologies and spaces' (Walker 2021: 5). Performing music is construed as the situated unfolding of a 'network of interdependencies among system components' (Di Scipio 2003: 269), as the staging and making audible of 'a dynamical complex of interacting situated embodied behaviours […] physical or virtual, composed or emergent, (all interacting) in the same space by a process of mutual modelling, re-description, and emergent restructuring'. (Impett 2001: 108) While acknowledging that 'acoustic conditions and aggregates of bodies [are] critical for much musicking' (Waters 2007: 5), this view also offers some guidance for 'for thinking through music as a model of environmentally situated interactional behaviour' (Walker 2021: 5).

Crucial to this discourse is an ecologically-oriented reconsideration of sensorial experience as indeed inherent to all music making. Any musician who is serious about playing an acoustic instrument typically develops an ability to also 'play the room': to varying degrees (unfortunately nowadays becoming smaller and smaller), classic music instrumentalists 'play with (not just in spite of) the space', with its acoustics (size, volume, geometry), in some instances even 'with its fluctuations in temperature, pressure and humidity' (Thompson 2017: 150). Clearly, the 'room' to play with has changed over time and today makes for a really different environment, for a different 'chamber music', and for a different sociality.

The Performance Ecosystem as Unit of Empirical Analysis[25]

Every concrete instance of a live electronics performance ecosystem includes a different mixture of the following resources:

– an apparatus of technical equipment including various devices—musical instruments (or other appliances used as instruments), scores and notations, microphones and other sensors, sound amplification systems and other actuators, sound diffusion systems, software and various computational devices, screens,

1973–74 (Mastropietro 2020)). Born (2022) surveys several recent digital art music practices intersecting with live electronics performance and related discourses.

25 In this section, I summarise issues more analytically discussed in (Di Scipio 2021a).

controllers, interfaces, etc. (and maybe further assemblages, such as visual or haptic media, internet connections, etc.);

– one or more human performers and their repertoire of actions, as they *act upon* one another, and as they *act upon* and *are acted upon by* nonhumans—including the above technical apparatus and further sound sources in the local environment;

– a delimited space—stage or larger performance arena, or any other partial niche in larger theatres or open spaces—within which apparatus and performers (moving or still) are situated, depending on designed plans or on practical decisions of logistics and acoustics, and of course depending on cultural and social connotations particular to the place. This physical performance environment may extend through connections to remote physical spaces or to virtual (synthetic) spaces, e.g. in the 'multiverse'.

These three terms—equipment, performer, environment—are taken here to actually define distinct domains of agency. However, both their being distinct agential domains and the kind of agency they can exert need to be clarified. Particularly when tackling issues of performance practice, a generic notion of agency won't do. Agency over what? In our case, I argue, the crucial idea is not that things or humans might have or 'demonstrate having agency *over the music* being performed [or] *over a piece of music*' (Waite 2019: 115, my emphasis), but that they exert agency *over each other*. Once we acknowledge its situatedness, agency is always inter- or co-agency, i.e. involving a reciprocal relationship with and through other sources of action (of the same or of different kinds) in an environment (physical and virtual). In live performance, music is *not* there to be acted upon just because it is not already there in the first place (this in a sense also holds for score-centred music, as well as for sound recordings played back in live performance). Performance makes a 'dance of human and material agency' resound (to use Andrew Pickering's expression (1995: 51)), and this 'dance of agencies' takes place in the contingencies of real-time real-space conditions. No agent can possibly generate sound and music except in that dance, i.e. through, with, and despite other forces acting over it (whether the latter are deliberately intended to do so or not).

Therefore, as they are conjointly involved in real performance conditions, the three above-mentioned domains define in actuality three inter-agential fields:

performer ↔ apparatus,
environment ↔ performer,
apparatus ↔ environment.

(The bidirectional arrow means 'sending something to' and 'receiving something from', or 'doing something to' and 'being done something by').

These are three subsets of interlocked recursive processes. The first may be loosely taken to involve classic notions of embodiment as in instrument playing (the sense of 'feeling one' with the instrument), but also extends to include the working of controllers and other tools separately handled by performers in ways

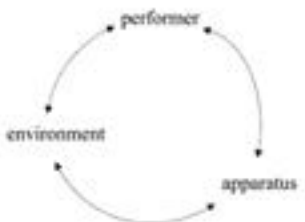
depending on size, shape and building materials. Hence it also concerns questions of ergonomics and 'ergodynamics' (Magnusson 2019: 10–12) of instruments and other tools. In actuality it concerns more general issues of man/machine and human/computer interaction (since long topics of theoretical work (Pickering 1995), beside innumerable research contributions). The general implication is of course that both human performers and (parts of) the apparatus exert some kind of agency, however different between them (Emmerson 2007). The second subset concerns aspects of the tacit knowledge that music making is generally said to involve, such as a special sense of timing as well as room acoustics and the proxemics of body-instrument (and body-machine) relationships, plus of course the proxemics of ensemble playing. The third seems to define an area never really theorised and only informally researched by practitioners interested in autonomous, self-regulating sound generating systems, running unsupervised by humans and yet dependent on site-specific contingencies (Dunn & van Peer 1999; Di Scipio 2003, 2008, 2011; Hayes 2019; Di Scipio & Sanfilippo 2019).

Computational resources included in the apparatus may of course exert forms of 'algorithmic agency' (Rutz 2016), thus making the performance a place in which to experiment with the 'materiality of informatics' (Hayles 1999: 192), in contrast to ideologies of the 'immaterial' and the 'virtual' that software is generally considered to pursue and celebrate. On the other hand, I should also note that the general notion of the performance ecosystem does not necessarily resonate with the multi-agent systems as practiced in Artificial Intelligence research and related developments, for the latter do not usually acknowledge the situatedness of agents in the physical space (rare exceptions include (Borgo & Kaiser 2010; Di Scipio & Sanfilippo 2019; Gioti 2021).[26] We instead 'cannot ignore the agency that is wielded by the environment' (Hansen 2009: 114). Following a neo-cybernetic view, live electronics performance ecosystems shall be considered 'system-environment hybrids' (Clarke & Hansen 2009) and their agency described as distributed agency of hybrid constitution. In related work, a preliminary attempt is made to provide a consistent definition of *ecosystem agency* (Di Scipio & Sanfilippo 2019; Di Scipio 2020a: 77-80), also drawing on efforts in ecosystem theory and engineering (Jørgensen & Müller 2000; Prominski 2007).

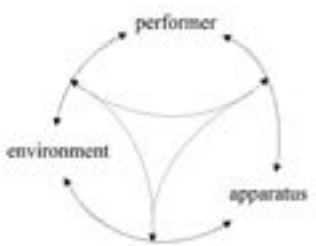
26 Multi-agent musical systems are documented in (Bown *et al.* 2009; Bown & Martin 2012; Bown *et al.* 2014; Tatar & Pasquier 2019; Sanfilippo 2019).

Ecosystem Agency, Inc. (or Distributedness & Situatedness Associated)

It should be clear that the three inter-agential fields of the performance ecosystem can be taken as distinct relational dynamics for the purpose of simplification only. In the here-and-now of performance, they work as structurally co-dependent looped couples:



In addition, higher-order interactional dynamics are in place, as in fact the exchanges taking place within each couple are themselves dynamically dependent on the interactions taking place in the other two: significant events in one interactional domain may affect the unfolding of the other two interactional domains, albeit in different and maybe time-varying degrees:



Overall, this makes for an intricate tangle of inter-dependent relationships through which innumerable parallel and cascaded feedback loops are made and unmade, overlapping and interfering with one another. Dispersed at multiple levels across the performance ecosystem, these feedback loops include humans and nonhumans and take place also within and between humans, as well as within and between nonhumans. As a conceptual tool, the performance ecosystem analysis is not to undo this tangle and isolate the featured components, but to understand its ensemble dynamics, at both a local and global level. The bundle of multiple transductions and interrelationships typically entails recursive nonlinearities and thus yields emergent behaviours—a typical feature of complex system dynamics,

along with 'distributed causation' (what/where exactly is the source of action? what/where is the cause of effects taking place?). In this 'ecology of action' (to use Edgar Morin's term), not everything is necessarily at human reach or under direct human control. Events that do count as musical performance would be excluded if we were to consider direct human control as the sole site of agency (Godlovitch 1998; Canfer 2019).[27]

Multiple feedback dynamics are more thematically worked out in specific live electronics practices (Di Scipio 2008, 2022; Sanfilippo & Valle 2013; Melby 2022; Sanfilippo 2023). More generally, however, all performance ecosystems are feedback networks, and that seems especially relevant because it means that signal nonlinearities and resistances to human control, whether deliberately designed or inherently 'built into' the technical apparatus (Mudd *et al.* 2019; Waters 2013), are recursively applied, making the whole apparatus a complex dynamical system. This is manifest in specific practices (including e.g. Tudor's hand-made electronics or Toshimaru Nakamura's 'no-input mixer' approach and many others, past and present). In actuality, however, multi-layered and mutually integrating feedback loops (of energy and information) ultimately construe the inherently relational ontology of performance in general, not just in 'feedback music' so to say. It is a ubiquitous feature of the materiality of performative assemblages. In the actual unfolding of multiple feedbacks, the affordances, resistances and nonlinearities featured in technical components and the latter's cultural (ideological) biases, end up constituting sources of technical agency: they make for agential capacities that we can count as performative agents to the extent that they exhibit 'a capacity to adapt dynamically to [given working] conditions and environment' (Waters 2013: 126), and feed through other agencies, thus eventually supporting the emergence of 'local and "evolutionary" development and change' (Waters 2013: 126). In this context, adaptivity—the mentioned 'capacity to adapt'—is basically to mean the sensing, understanding and translating of input (sound, energy) into information and control (data), an thence into behaviour (dynamics): this is not a capacity that only humans have, as many musical-technical designs include (at least since the 1980s) 'intelligent' real-time algorithms somehow capable of sensing (segments of) the external world and change their behaviour accordingly (that implies 'signal analysis', 'feature extraction', 'control signal processing'). This is itself a full-

27 In actuality, the very idea of 'human control' (either deterministic or stochastic) seems problematic in a context of distributed and nonlinear causation. In Hayles' radical posthumanist terms, 'control' is an illusion that 'bespeaks a fundamental ignorance about the nature of the emergent processes through which consciousness, the organism, and the environment are constituted' (Hayles 1999: 288). In instrumental theories of technology, any technical means introduces a rational economy of action, a certain 'machinic' linearity or predictability, and yet the more densely interconnected and technologised the environment, the more the ecology of causes and effects becomes multilinear, dispersed, fragmented—especially in the (inevitable) presence of feedback, in which case we can either say that control is decentralised or relinquished to a number of agents; or that it is difficult, partial or indeed illusory.

fledged domain of research and creative experimentation, as made manifest in a variety of endeavours (at least since Mumma's 'cybersonic' analogue electronics in the late 1960s (Mumma 2015) and Morton Subotnick's 'ghost scores' in the 1970s (Hanson 2010); from academic computer music research into 'score following' (Boulez & Gerzso 1988; Cont 2012) and 'machine listening' (Rowe 1993) to more recent autonomous or semi-autonomous systems (Di Scipio 2003; Sanfilippo 2019; Di Scipio 2022; Nyström 2021b)).

Concerning matters of 'extended' and 'distributed' agency, it seems important to stress that the bundle of hybrid loops of nonlinear transductions is not simply duly positioned somewhere within the performance site, but it is structurally coupled to it. In the time-space framework of performance, the extended performance body *belongs* to the local environment. 'What appears to an individual [such as a human performer] as an immediate, local environment includes practices developed over generations and shared across social groups.' (Linson & Clarke 2017: 55) This supports the pertinent notion of embodiment mentioned in an earlier section, dialectically entwined with exbodiment (distributed cognition). Only in a manner of speaking can we describe body and environment as distinct and separate. The classic 'body/environment dichotomy' (Emmerson 2007: 92) has 'body' to imply 'human body'. Yet, as we have seen above, the performance body is rather a larger and hybrid dynamical composite, one that constitutively includes the local environment.

In actuality, there exists a continuum between 'body' and 'environment' through a relational bundle of nonhuman couplings and transductions. At every new iteration, the performance site will feature culture-specific material contingencies bound to mediate, modulate or negotiate the agency inherent to technical apparatuses, whether or not the latter is overtly acknowledged by humans involved (composer, performer, assistants, engineers, etc.). Listeners themselves 'co-constitute the musical event within its historically situated context' (Linson & Clarke 2017: 56).[28] Adopting the conceptual framework of the performance ecosystem, we emphasise not only 'the environmental embeddedness of the human within wider biotic and metabiotic systemic frames' (Clarke & Hansen 2009: 2), but also the environmental and social embeddedness of the technical apparatus. Furthermore, besides the agential capacities of the performance ecosystem's human and nonhuman components, we need to eventually acknowledge the more encompassing agency of the performance ecosystem as a higher system unit. An agential capacity that, as anticipated above, could be tentatively defined as 'ecosystemic agency'.

Notions of extended and distributed agency imply of course that 'actions are undertaken by subjects that extend beyond the human individual to include other

28 In this article, the audience (listeners or visitors, in the case of an installation) is considered as being among the agential sources present in the environment. Clearly, their involvement is especially important for the live character of a performance. However, this point would require a separate discussion.

human beings and any number or kind of nonhuman entities.' (Hanson 2009: 92)[29] This problematises human agency in the first place. For 'if an action can be accomplished only with the collusion of a variety of human and nonhuman participants, then the subject or agency that carries out the action cannot be limited to the human component but must consist of all of them.' (Hanson 2009: 93) An ecosystemic view attributes agential potential to humans and nonhumans hosted in the specific spatial niche according to its logistics, acoustics, and technical infrastructures. However, it also suggests that as a result of complex inter-agential dynamics the 'subject' carrying out the performance action is the hybrid performance ecosystem 'itself'. The human agent—still retaining its freedom of intentional action—is itself revealed as *being of* the ecosystem, more than intruding and governing it and all that is available therein.

Clearly, each single live electronics approach will involve different priorities and differently nuanced blends of (several instances of) the three inter-agential couples of the performance ecosystem. The actual ecosystem dynamics will be determined by *how* and *how many* recursive subsets are integrated and experienced as agential partners in performing. Different approaches will attribute (intentionally or unintentionally) stronger or weaker roles to both the humans and the nonhumans involved, thus also providing different images of humans situating themselves—and 'taking position'—*vis a vis* broader techno-ecological issues and related political scenarios. Analysis of such distributed and situated dynamics in my view is crucial for characterising the materiality of *liveness* with regard to highly technologised performance ecologies (Emmerson 2007; Auslander 2008; Sanden 2013). On the one hand, different notions of liveness are practiced and experienced in different live electronics approaches, depending on the particular blend of agential weightings (Di Scipio 2020a, 2020b).[30] On the other hand, performance ecosystem analysis puts questions of liveness in a peculiar light, tracing it back to auditorily and bodily sensed phenomena emerging from energetic and informational exchanges in the ecosystem dynamics and its partial components (performers, equipment, environment): the supervening agency of the former (ecosystem) binds and fosters the agencies of the latter (components) which themselves

29 Consistent with current interest in 'new materialism', a technological notion of extended agency has it that 'the possibilities for action depend not just on human beings, but on the available means of action as determined by the relationship of humans with technology and/or other [...] agencies.' (Hanson 2009: 8) In that respect, new materialism is loyal to a good old Marxian tenet—'the subject is defined by its means of action'—but gets rid of its implicit reductionism and determinism by a view substantially merging situatedness, distributedness and nonlinearity (complexity) of cultural practice and the production of subjectivity.

30 It may be significant that, in this paper, I prefer the expression 'live electronics' to others (e.g. the much more usual 'live electronic music') not just because it is adopted in some circles of experimental music practice, but especially because it attributes *liveness* directly (albeit paradoxically and provocatively) to electronics—*not* to the music.

concurrently bind and foster the former… (emergent phenomena and downward constraints feed each other, as is typical of complex dynamical systems).

The performance ecosystem, in summary, is not just a set of separately active systems and processes, but a bundle of mutually entangled physical and cognitive relationships of human and nonhuman entities arranged so as to yield a hybrid embodiment of multiple, inter-dependent agencies. As a conceptual tool, it is meant to describe what counts as the 'performance body'—or better, what counts as the body produced in and through the performance. As a framework of creative work, it is crafted as dynamical assemblage whose scope and dynamics inevitably transcend those of separate agencies and is thus inscribed in—or composed into—the very materiality of performance conditions and actions. According to (Waters 2007), the notion of performance ecosystem is to undo the idea that 'goal-orientedness' (technicity), 'corporeality (bodilyness)', and 'otherness' (environment) might be experienced as understood as separate domains of experience. Waters asks what is *lost* in reiterating too sharp a distinction, 'what is masked, covered, generalised away in the mute acceptance of these separations?' (Waters 2007: 2) One may argue, tongue-in-cheek, that what is lost is their inherent belonging to each other—or 'composition'. Anyway, we will return to this question.

It is important to emphasise that, as experienced in performance conditions by practitioners and attendees, the distributedness and situatedness of the performance dynamics makes it hard to draw hard boundaries between individual agents and related roles or functions. This is not to say that boundaries do not exist, nor that distinctions are not in order, but that boundaries and distinctions are worked out and made sensible in and through performance: the unfolding of action in the here and now is indeed 'performative' as long as it produces or construes differential boundaries, however destined to remain unstable, bound to vary and be reworked with varying performance situations and a variety of contingent factors. Agency is co-dependent (constraints) but also co-productive (emergence). To start with, a posthumanist view refuses to take the human/nonhuman distinction for granted: according to Barad, analysis of practice should not be founded on presumably fixed categories and address itself instead to how 'humans and nonhumans are delineated and differentially constituted' (Barad 2007: 32). 'Holding the category "human" [or "nonhuman"] fixed excludes an entire range of possibilities in advance, eliding important dimensions of the workings of agency.' (Barad 2007: 178) 'A posthumanist account of performativity' focuses on 'how these crucial distinctions are materially and discursively produced' (Barad 2007: 32).

The larger, hybrid performance apparatus become a performative posthuman body only in the actual proceedings of the performance action, *not* in advance. Agency, including nonhuman agency, is constituted as *performative* agency only in and through the real-time, real-space unfolding of the multi-levelled inter-agential dynamics. Human agency is itself defined as performative in the process, expe-

rienced through its distributed, yet situated 'dancing' with other agencies.[31] Inter-agency redefines, in situated conditions, the performance ecosystem components and blurs the boundaries of their actions. This bonding of

> human as well as nonhuman composites […] in a nonbinary constellation […] cancels the subject-object divide and hence challenges oppositional thinking [; it] is more than merely relating; it demands an intimate coupling in movement […] and perception. (Stalpaert *et al*. 2021: 8)

Here again we grasp something of the far-reaching implications of merging embodiment and exbodiment dynamics.

Hybrid apparatuses of live electronics are called here performance 'ecosystems' as they comprise matter biotic (living), abiotic (non-living) and metabiotic (cognitive, symbolic, cultural, i.e. emergent from the living and distributed across the non-living), whose interactional reciprocity defines the relational field embodied in performance. Not a cyborg (a living entity with prosthetic organs, whose environment is the biological—and cultural—body (Haraway 1991)), nor a multi-agent system (an assemblage of independent agencies, distributed yet typically not situated). It is rather a field of distributed *and* situated inter-agential relations whose extended performance agency emerges as a singularity in the unfolding of a complex and hybrid dynamic. For (Hayles 2006) and other authors, 'the cyborg as an explicitly technological frame might not suffice' (Stalpaert *et al.* 2021: 6) to conceptualise practices where embodiment dynamics are interwoven with the distribution of cognitive process in the environment. Hayles does not require the posthuman subject to be a biotic plus abiotic assemblage for it to be 'deeply inter-

31 An instrumentalist entering into a relationship with, say, some signal processing algorithm that somehow transforms the instrument's sound, ceases to act on the instrument as if the algorithmic transformation were not there; as the algorithm becomes embodied in or with the instrument, part of the instrumentalist's agency is *de facto* remitted to a piece of software (and necessary hardware). But that holds for the signal processing algorithm too, provided it consists not of *any* sound transformation but of a purposefully implemented one meant to go with the particular instrument or with the particular instrumentalist in a specific performance context. The way in which one acts with or upon the other is not independent of the way in which the latter is expected to act with and upon the former: in the context of the relationship, the two exert different agencies, of course, but neither one can be defined independently of the other. Now, that example replicates—in the here and now of a live performance process—a more general and well-known musical-cultural dynamic a classic example of which stems from the early days of audio and music technologies: in the early and central decades of the 20th century 'singers' turned into 'vocalists' by modifying their vocal techniques in the presence of microphones (plus sound amplification and diffusion systems), both in recording and performing contexts: on the one hand, the active mediation of the microphone (and actually of the whole electroacoustic chain) has been critical to the emergence of a number of modern vocal styles (in popular music and in various forms of experimental music); on the other hand, the imagination and bodily involvement of vocalists have in turn instigated the reengineering of voice microphones and 'public address' sound systems. Styles of embodiment define musical genres and social practices, just as the developments of the latter instigate or demand new technics and new forms of embodiment...

pellated by digital technologies' (Cecchetto 2013: 80). The performance ecosystem provides an alternative conceptual persona, at least in the specific context of live electronics and intermedia endeavours. It belongs to a logic 'focusing on interactivity rather than implants, reciprocity rather than augmentation' (Dyson 2009: 159). It fosters a perspective that resists the spectacular 'denial of embodiment (articulated by artists like Stelarc and scientists like Hans Moravec) without resorting to the (equally dualistic and ultimately disembodied) concept of the liberal autonomous subject—the product of humanism' (Dyson 2009: 156). A conceptual and empirical move from 'bio-technological hybrid organisms or prostheses' to 'human embodiment and consciousness as distributed processes' (Nyström 2021: 32) is in order to characterise the hybrid (biotic, abiotic, and metabiotic) performative body.

What is masked or covered in the separation of body, environment and technics is perhaps that performance is the place and time where they actually (but temporarily) produce or define each other; the place and time where they perform each other. They are what performs only to the extent that they are what is performed. Of Karen Barad's characterisation of scientific experiment apparatuses, theatre scholar Stefanie Wenner says what I would say of live electronic music ecosystems: they are not mere instruments with which to make something happen, but 'practices to create new borders in order to materialise specific material (re) configurations of the world' (Wenner 2021: 103), not instrumental assemblages but 'open-ended practices, iteratively refined and reconfigured'. (Barad 2007: 167), the crucial implication also being that 'humans become part of the reconfiguration.' (Rutz 2018: 173) In as much as it is constituted in a hybrid ecology of humans, technics and environments, live electronics practice creates singular instances of posthumanist relationality, which capture, configure, and make audible the coming into being of performative and posthuman subjectivities.

Hybrid Composite Bodies, Posthuman Prototypes, and their Shared Audible Traces

Because of the 'ecosystemic nature of music practice', one can 'approach composition by consciously designing a complex socio-technological system' (Walker 2021: 5). While providing analytical insight, the performance ecosystem presents itself in the first place as a deliberately construed hybrid assemblage, an outcome of composition (whether this 'composition' is pursued by a composer alone, or in joint work with performers, engineers, technical assistants, etc.). As emphasised above, live electronics generally imply work meant to compose the performance ecosystem. Different arrangements will thus act as different 'scripts for action' (Green 2013: 69), somehow managing the role and the action range of the agents involved, thus making room for the 'dance of agencies' unfolding in per-

formance. Apparatuses are 'latent performances' (Gubbay 2021), 'discursive practices', 'boundary making practices' (Barad 2007: 148): any particular performance ecosystem specifies or 'embodies' the boundaries and the potential peculiar to a performative practice—and to the discourses it airs.

So, again, how are we to understand the fact that some musicians and sound artists take charge of the material conditions of performing, at least in some non-marginal measure? Many will say that musicians and artists can only work out the technicalities of audio equipment and other performance resources in rather approximative or fanciful ways, presumably not entirely compliant with audio engineering criteria and maybe disregarding professional standards. To a certain degree, this is actually true! (in reality, it does vary greatly for individual cases). But this does not imply that their designs are worked out without care and technical expertise, however open to informal and flexible criteria or untidy and provisory arrangements. By assembling and publicly practicing one's own designs as provisory *ad hoc* hybrid arrangements of sorts, perhaps idiosyncratic and hardly 'performant' *stricto sensu*, musicians and sound artists in some measure appropriate the working conditions for their public exposure and statements. The reduced scope and efficiency of less-than-optimal but specially composed apparatuses may gesture a 'small act of resistance […] to modernism's configuring of us as efficient and productive subjects' (Waters 2013: 129–130). In any case it contrasts with the efficiency, functionality and robustness required of technical objects and professional services used in daily life. It ultimately contrasts with the idea that optimal technical criteria are *sine qua non* of performant action in practically every domain of experience—almost as a guarantee of empowerment and freedom of expression, if not as a fatal proof of existence.[32] It's a different economy of means (and that of course comes with different ends…).

Instead, what is exposed is performance that works through contingencies and difficulties not *despite* but *thanks to* less than optimal working conditions. Or, conversely, not just *thanks to* embodied or 'naturalised' technical practices and absolutely reliable technical apparatuses, but *despite* the latter being only loosely and temporarily arranged. Some are explicit about their 'dirty electronics' (Richards 2016), opening to punk and provocative political attitudes. And yet, independent of specific radical stances, it seems clear that the intricate and nonlinear ecology of 'humans, technology and the socially/technologically mediated environment' (McCormack 2012: 56) makes live electronic performance bound to remain more exploratory and tentative than productive and conclusive in the achievement of goals (either determinate or indeterminate). Against politics of audio culture based on engineering principles that make of music an object of sound control and treat-

32 It is a well-known symptom of the 'posthuman condition' that in everyday life people have become as 'dependent on technology [as to] consider themselves seriously handicapped without it' (Wamberg & Thomsen 2016: 153). People 'are more likely to feel the absence of these technologies than their presence' (Cecchetto 2013: 4).

ment, live electronic performance may enact 'a logic of ontology in which non-human, human and environment collaborate in live, self-organising performance processes that overdetermine the aesthetic' (Born 2022: 348). It sets in motion feedback systems between machine, humans and environment, enabling music spreading out from text, or software, or analogue equipment, or mechanical appliances 'to become enmeshed in further flung social and material networks' (Green 2014: 60 and 62).

I deem it equally important that this kind of practice exposes a shift of creative focus 'from designing musical *instruments* to designing *contexts for musicking*' (Waters 2021: 133, my emphasis). On the one hand, the sociality of shared experience (performing and attending) becomes itself an integral preoccupation of creative work, sometimes taking on main thematic relevance (as paradigmatically in 'relational aesthetics' art practices (Bourriaud 1998)). On the other hand, what is presented to listeners or visitors is the impossibility to invent or engage with a specific technical object or system without also duly considering the cultural (technical, musical, social) ecology in the context of which the particular object or system reveals itself valuable or useful: designed objects or systems do not stand alone, their designers cannot hypostatise the internal structural functionalities as if they were self-sufficient logical machines, independent of the dense materiality of a contextual performance ecosystem.

The messy but competent creativity involved in that gesture offers a modest yet significant token of 'critical technical practice' (a notion proposed in (Agre 1997) to comment on early research in Artificial Intelligence, recently reworked in the context of artistic research in music (Impett 2021)). Several instances of live electronics developed over the last fifty years can be seen as a kind of practice-centred research meant not only to create sensible and 'aesthetically potent' (Gordon Pask's term) figurations but also to understand and problematise what it means to be creative practicing artists and citizens. By exposing and resounding the performance setup that they themselves elaborate, they end up defining political positions, either overtly or implicitly. The gesture of appropriating the performance conditions often causes friction when practitioners prepare to present their work in contexts normally adopting more common patterns in the division of labour and expertise, which may explain why, all the more often today, some prefer to present their work in 'hands-on workshops'—which amounts to sharing with small audiences, for some hours or some days, a flexibly reconfigurable but limited and situated performance infrastructure—as a viable alternative to more rigid public rituals such as concerts or other forms of public display.

In short, this is a performance practice whose sounding appearances amount to the auditory experience of deliberately and maybe idiosyncratically composed apparatuses. What resounds through the latter is their being composed as well as their being provisional, specially devised temporal arrangements. This is indeed an outstanding example of contemporary performing art that renders what (Stal-

paert *et al.* 2021) call hybrid *composite bodies* and *posthuman prototypes*. These are hybrid composites not just because they are assemblies of entities human and nonhuman, biotic and abiotic, but because each source of agency involved is itself revealed as heterogeneous and plural. Overall, human subjectivity hybridises the (otherwise entirely nonhuman) performance ecosystem as nonhuman agents involved therein hybridise the human. This mutual hybridisation is a dynamical relationship not to take place of course without an environmental niche to which the various agents are structurally coupled, for in fact that niche is a constitutive part—a constituent—of performativity.

Commenting on Hassan's 'incorporation of technology', I anticipated that embodiment dynamics peculiar to overly-technologised performance define the performing body as composite, not limited to the human body but distributed as well as situated in an environment. As something carefully (albeit more or less accurately) composed, an instance of live electronics performance ecosystem 'can never turn into an exemplum, into a model to be traded for more efficient use', it is bound to remain very much an *ad hoc* design, one that serves little more than specific musical ideas and specific performance dynamics—*not* as a device for general use. 'With every new performance context—or even, with every iteration of a performance—a new composite of bodies is inaugurated.' (Stalpaert *et al.* 2021: 10) A prototype provides an early, temporary model, maybe useless in most or all other contexts, and certainly 'too complex, too delicate and too clunky to ever be considered for mass-production' (Carels 2012: 178). In different ways and to different degrees, the electronics of Cage's *Cartridge Music* (1960), Nono's live electronics and sound diffusion schemes for *Das Atmende Klarsein* (1980–1983), Tudor's circuit diagrams for his *Rainforest* installations (1970s), Stockausen's assembly of percussions, filters, and everyday appliances (*Mikrophonie I*, 1964), Bertoncini's electromechanical and sculptural constructions (*Chain Reaction* 1973–74), Simon Emmerson's 'variable tape-delay system' (*Spirit of '76*, 1976), the computer-actuated ensemble of recycled appliances in Andrea Valle's and Marco Lanza's *Systema Naturae* (2016), Toshimaru Nakamura's no-input mixer, or the environment-mediated signal processing of my own *Audible Ecosystemics* (2003–2014) and the *Machine Milieu* project (Di Scipio & Sanfilippo 2019)—to mention only a few examples—are more or less determinate prototype assemblages bound to nothing except the music and the world of sound whose conditions of possibility they implement.[33] Many custom-built electronic instruments in the history of live electronic music actually constitute prototype systems (from Hugh Davies' electromechanical instruments to Hugh LeCaine's specially built synthesisers, from Salvatore Martirano's SALMAR construction to Paolo Ketoff's Synket—to say

33 The notion of prototype apparatus rehearsed here should compare with what Hans-Jörg Rheinberger calls 'experimental system' in the scientific research context. See (de Assis 2014; Schwab 2014) for an understanding of 'experimental systems' in artistic research contexts and music performance.

nothing of more recent ones, from Lupone's 'feed-drum' (Lupone & Seno 2005) to Melbye's 'semi-autonomous double bass feedback instruments' (Melbye 2021, 2023), and many others.

Emphasising the prototype status of live electronics apparatuses is important in order to leave behind purely utilitarian and instrumental notions of modern technologies. Personally, writing about hybrid networks of sonic interactions and related ecosystem dynamics (Di Scipio 2003, 2008, 2011) served also as a critique of too narrow and misleading notions of interactivity as also practiced in music and the arts, and always inevitably claimed to provide 'innovative' and 'unprecedented' possibilities.[34] Writing about performance ecosystems for Waters himself was 'to counter a tendency to present technologised musicking as inevitably innovative […] in the face of considerable evidence that this was not, or at least not often, the case' (Waters 2011: 95). A view of contemporary performance needs to leave behind ubiquitous and false celebrations of the technological, so demeaning of music as a practice and reductive of the variety of 'cultural and historical factors [involved in] the distinctions between performer, instrument and environment' (Waters 2007: 2).

This notion of 'prototype' also implies that the music thus performed takes on peculiar sonic nuances, due to the fragile, temporary and idiosyncratic apparatus and to the unstable and nonlinear interactions of human and nonhuman performance agents. Taken individually or arranged in developing sonic patterns, sounds may be presented to listeners for what they are—'in' and 'of' themselves, as 'sound objects'—and yet performing ultimately is a process that makes audible the performance conditions, makes listeners feel and participate in the actual (often far from ideal) working conditions. The working conditions leave behind audible traces that are critical for the experienced liveness of performance. This is how performance puts us 'in contact with still other elements beyond sound matter'. (Waters 2013: 131) Nowhere do 'sounds […] reveal a chain of mediations' as they do in live performance (Kane 2014: 135, *après* Hans Jonas), thus also exposing themselves as *being of* a situated and distributed dynamic in a shared spatial niche. When it refrains from reiterating the acousmatic separation of sound from cause and from environment (Di Scipio 2014, 2015), live electronics has the potential to listen to the event of sound as an event of shared material relationships—a 'vibra-

34 To overcome the reductive implications of a cursory notion of 'interaction', some authors—among them (Rutz 2016; Arlander 2018; Nyström 2021b)– resort to the notion 'intra-action' elaborated in (Barad 2003, 2007). While 'interaction' 'presumes the prior existence of independent entities or relata', Barad's 'intra-action' implies that boundaries and properties of entities become determined as their relation is practiced, i.e. 'locally' and 'performatively'. To avoid terminological confusion, I still use 'interaction' in my writings, but wherever appropriate I replace it with cybernetic jargon ('structural coupling', 'reciprocal action') or other meaningful wordings ('mutual determination', 'co-dependent action', etc.), emphasising bi- and multi-directional connections. It is important to retain the essential relationality of material bonds.

tional event that connects spaces, bodies, and media' (Döbereiner 2020: 603). This connecting is composing—materially.

Final remarks. Live Electronics as Discourse

Minding the materiality of the surrounding space and the relationality of the performance apparatus; working *in spite* and *thanks to* the contingencies of real-time and real-space hybrid agential couplings and material transductions; happening through experiential dynamics that are as much *embodied* as *embedded*, as much *situated* as *distributed* across the composite performance body—live electronics practices *perform* rather than merely *describe* the posthuman.[35] They offer instances of performativity that ask 'what [it means] to be posthuman' (Hayles 1999: 283). The sound worlds they bring forth, however varied between them and irreducible to shared aesthetics, make us sensorially and conceptually grasp that humans do not merely assemble different hybrid apparatuses for pursuing their projects; rather, they are themselves 'part of the ongoing reconfiguring of the world' taking place in and through those apparatuses (Barad 2007: 170). My attempt to characterise the live electronics performance ecosystem amounts to testing a possible 'posthumanist elaboration of the notion of performativity' (Barad 2007: 66) from a situated artistic research perspective. As pointed out at multiple spots above, a critical prerequisite for the attempt is of course a non-instrumentalist and non-substantive account of technology, one that understands and experiences modern technologies and related media not as mere means to specific ends nor as devices or appliances extending or augmenting human bodily abilities and cognitive faculties, but as a reconfigured milieu or medium of existence, an environmental niche almost entirely innerved by multiple domains of techno-ecological relationality. Consistent with this is a notion of performativity relative to an entwining or entanglement of hybrid relational practices that makes it possible to displace and rework the differential boundaries between agencies counting as 'human' and those counting as 'nonhuman': no obvious or pre-defined differences can be postulated independently of situated performative bonds as they are actually practiced.

Now, these are fairly general and yet pertinent implications that empirical analysis would somehow trace down in the creative commitment of so many musicians and sound installation artists more and less known. On the other hand, they capture a *discursive practice* implicit in live electronics. Following Barad's Foucauldian view 'Discourse—is not a synonym for language […] is not what is said; it is that which constrains and enables what can be said. Discursive practices define

35 Here I am obliquely quoting from (Wamberg & Thomsen 2016: 158); these authors use those words in connection to 'avant-garde art', too generic a notion (for me) to talk about concrete instances of artistic praxis.

what counts as meaningful statements.' (Barad 2003: 819) To design, compose, practice and document one's own performance ecosystem is to convey meaningful statements—say, on technology, environment, posthuman subjectivity and agency, interactivity, situated knowledge, distributed cognition, inter- trans- and post-disciplinarity, emergence and causality *inter alia*—and to render such statements in sound, music, and bodily experience.

Live electronics is a domain of performance practice highly representative of the larger historical scenario of the 'posthuman condition'. Its discourse is to bring forth visions, statements, positions, practices redrafting today's conditions of possibility of performing in the medium of sound and music (or in other media, for that matter). It concerns modes of creative (and critical) subjectivity constitutively embodied, embedded, situated and mediated by a multiplicity of stratified nonhuman agencies. Taking that view a bit further, we might say that live electronics performance makes tangible—or better audible—what it means in our times to live as humans dwelling in utterly technologised ecologies. The peculiar phenomenology of liveness it allows to explore opens us to different 'politics of sound' and 'biopolitics of music' (Di Scipio 2014, 2015), not to mention broader issues of listening (listening is itself practice) (Di Scipio 2011, 2015). What becomes audible—what is sounded—are ultimately the *material conditions of being human* in posthuman times. This is the case to the extent that they expose the relationality of different agencies, none of which is defined as *performative* outside the performance space-time framework, without participating in the real-time and real-space inter-agential dynamics characterising the performance ecosystem. The potential of live electronics practices lies in the chance to reconfigure and render audibly porous the boundaries of human and machinic bodies, while in fact working out the transductions that couple the one to the other and that couple both to the physical environment. The corporeality of performance—no more unquestioningly epitomised by the human acting in the middle and in control of more or less intelligent machinic servants—is then presented and sonically revealed as an indeed hybrid site of posthuman embodiment dynamics.

Creative and critical practice is 'performative' not just because it describes or mimics a discourse through performance, but because it is concerned with how performance may enact (rather than represent) what it signifies. In live electronics performance, we don't hear music that describes or is about living in posthuman times; rather, we hear people listening to each other or to a machine's output, writing code, manipulating the mixer controls, handling microphones, piezos and other sensors, singing into metal sheets, displacing loudspeakers, reading scores, attending screens, typing commands and awaiting computer feedback, introducing earpieces into a cello or smashing piano strings, blowing into an air pressure controller or wearing scalp electrodes, bowing a carton, whistling into a flute while attending computer-transformed whistles to come back over here or there, handling printers, inspecting internet data lists or repositories, enabling

data streaming… A performative understanding of practice is to 'call into question representationalism' (the claim that there are 'representations, on the one hand, and ontologically separate entities awaiting representation, on the other' (Barad 2007: 49)). I consider this a conceptual element underlaying live electronics in general, albeit less evidently (if not even contradicted and contrasted) in some musical approaches (still marked by a certain aesthetic modernism).

The overall picture outlined in these pages is perhaps well summarised as anticipated at the beginning of this paper: with its diverse and always changing array of experimental creative efforts in music and sound, live electronics practice provides meaningful figurations of posthuman performance and vivid sonic images of the frail coupling of humans, machines, and environment. Not coincidentally, they historically emerged along with the transition to post-modernity and the present, in a time that can be described as bearing the 'technological condition' (Hörl 2015), or indeed the 'posthuman condition' (Pepperell 1997; Braidotti 2019). With the materiality and the situatedness of their hybrid embodiments, and regardless of specific aesthetic inclinations, live electronics signify and resound the general ecologisation of technology, which can indeed be called the *devenir-milieu* (becoming-environment) of electronics and digital media. By qualifying live electronics as posthuman practice, I also imply that—paradoxical as it may appear—this is a 'post-digital' practice—unless we rethink 'digital media' themselves as technical hybrids (as I think should be correct): conductor microelectronics, digital connectivity, information processing and software are useless without multiple layers of highly efficient analogue converters and a variety of electromechanical sensors, actuators, and other transducers.

What is being produced in the context of a practice thus defined, are highly emblematic figurations of a historical scenario in which subjectivity and agency can no longer be attributed solely to an abstract, idealised human being (the autonomous liberal subject mastering his own actions, separate and frontally detached from technical and environmental nonhumans). The picture is rather one where the human strives to negotiate its position in the environment, experiencing itself as being part of a larger performing body, literally 'alienated' (altered, made other, reworked, reframed) by that which it appropriates and thus alienates. There is nothing bad about this 'alienation', for being human has in fact always involved embodied and distributed biological, cognitive, affective, and cultural dynamics (perhaps we are 'natural-born cyborgs' (Clark 2003: 6), but more correctly 'we have always been posthuman.' (Hayles 1999: 291))[36] Accordingly, subjectivity and agency are reconceptualised not so much as 'attributes' or 'properties' of the human,

36 '[T]he human has always been posthuman in the sense that it has always involved an exteriorisation or evolution by means other than life', yet 'the massive contemporary acceleration in processes of posthumanisation poses the prospect of a qualitative shift' in the human/machine/environment entanglement (Clarke & Hansen 2009: 7–8). This is the main focus of a theoretical and empirical research perspective that Clarke and Hansen call 'neocybernetics':

but rather as relational capacities performatively emerging in and from hybrid entanglements. This is what live electronics practice *performs*, and what this performance makes audible through the variety of sound materials, patterns, gestures, textures, or atmospheres it leaves behind.

The performative entanglement of nonhuman agents only, as in non-supervised autonomous musical systems either rehearsed in musical contexts or in sound installation contexts, only clarifies the perspective in a more radical manner. This represents the closest possible musical rendering of the prospect of computers creating 'a fully independent structural coupling between a reality they can construct and psychic or communicative systems' (Luhmann 1997: 117–118). However, in my view, that is really only the case with system autonomy achieved through the environment, i.e. as concretely situated and made sensitive to (or dependent on) the environing space: a purely machinic view is to be overcome just as a purely humanistic one (the two are essentially the same, seen from two opposite endpoints).

We have to admit that when no human is directly involved in the unfolding of the performance process—when time-varying control and decision making is relinquished to nonhuman agents (either in the technical apparatus or in the local environment)—'the notion of performance undergoes major change', suggesting the emergence of 'a distinctive synthetic form' of performance art (Godlovitch 1998: 97). I would argue that such a 'synthetic' but dynamical and embedded (real-time and real-space) practice, no matter how distinctive, only epitomises a radical posthuman performativity. Asking 'how much direct and visible human agency' is needed 'to make the event count as true musical performance' (Canfer 2019: 104) is, in this perspective, misleading and unsuitably normative. Likewise, when performers are involved but their 'gestures do not necessarily correlate to sonic gestures', this is less of a 'well-documented problem of live electronic music performance' (Waite 2019: 114) than a circumstance that is (however disturbing to many) reasonably consistent with the posthuman elaboration of performance practice, particularly in consideration of the 'web of causal complexity' (Clark 1997: 165) and distributed nonlinearities that may eventually characterise the performative dynamics.[37]

Being human (and 'staying human') is of course not as stable and immutable a condition as granted in humanistic views, but a process bound to change in time: being human changes with changes intervening in the environment, that humans themselves have changed and are changing into an increasingly inextricable man-

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without it, 'the contemporary understanding that the human is and has always already been posthuman could not have emerged' (2009: 24).

37 In (Clark 1997), the phrase 'web of causal complexity' is used to refer to the ecology of jazz improvisation practices. On their side, (Linson & Clarke 2017) discuss the dynamics of 'free improvisation' (non-idiomatic) in terms of distributed creativity and embodied cognition. Of larger theoretical interest is their treatment of embodiment as distributed and situated at the same time.

gle of natural, cultural and technological conditions. As always, the former (humans) define the latter (environments) which define the former… '[E]nvironments and bodies are intra-actively co-constituted.' (Barad 2007: 170) But this is admittedly little more than a reformulation of a venerable and fundamental assumption of systems theory, according to which 'the organism affects the environment, and the environment affects the organism: such a system is said to have feedback.' (Ashby 1960: 37) That indeed says it all—except that 'organism' and 'environment' cannot be taken for anything 'natural' and 'feedback' implies more the entanglement of multiple agencies and structural couplings of energy and information than a direct, discrete point-to-point interaction. So perhaps it says nothing. Nothing that we may not rewire and reconfigure, either in theoretical perspectives or artistic practice.

In the measure that they themselves design or customise the apparatus of their performance ecosystem; and in the measure that they value and expose the latter as creative labour, live electronics musicians and sound artists emphasise that performance is the embodiment of a variety of technological transfers, operational loops, cognitive skills and affective bonds. Along with that, they auditorily reveal that the naturalisation—or in fact the ecologisation—of the electronic environments within which we live ends up making the latter ineffable, unseizable—and thus invisible, or better inaudible. Their becoming naturalised amounts to our becoming desensitised (to them). Appropriating the live electronics performance ecosystem therefore represents a gesture of powerful dialectical meaning: by turning hybrid techno-ecological dynamics into sensible events of sound, live electronics resound the posthuman condition—and its thoroughly human sources.

Acknowledgements

I am grateful to Lucas Bennett and Germán Toro Pérez for helping me revise the draft version of the present paper.

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Animism and Digital Expression: Thinking through Human-Object Relations in (Post-)Instrumental Performance Practice

Rama Gottfried

Introduction

The following article is adapted from a lecture given as part of the 'History and Practice of Multimedia' series hosted by the Music Technology Online Repository (MUTOR) at the Hamburg University of Music and Theatre.[1] In the talk I give an introduction to my thinking about performance practice and instrument design in the context of *expanded* (Ciciliani 2017), or *post-instrumental* (Stene 2016; Devenish 2021; Moore 2024) composition; focusing on the *instrument system* as a conceptual key for understanding the intertwined methods, meanings and motivations that drive contemporary performance with technology.

As a framework for thinking through these ideas, I am drawing on my own artistic practice and the research that went into a course called 'Situated Instrument Design' that I developed some years ago at the University of California, Berkeley's Center for New Music and Audio Technologies (CNMAT). The class was based on the instrumental system design research of David Wessel and Adrian Freed at CNMAT and their work in the areas of human computer interaction and real-time sound synthesis, informed by Wessel's background in cognitive science and free improvisation. Like Wessel, my own background in music came largely through the practice of improvisation, and in many ways I think of composition through the lens of the tactile experience of performance with instruments, objects and spaces.

Performance is by nature an expression through a *medium*—an interaction with a system of mediation that aids (or hinders) the performer in an act of expression. The mediating *instrument* is a symbolic object that represents the human desire to access particular modes of expression. What is the agency of the instrument in our aesthetic, social and functional thinking? Moving beyond questions of technical construction and media production, the following discussion explores the aesthetic, semantic and emotive implications that are embodied by interactive instrument systems. Applying insights from anthropology, ecology, human-computer interaction, political and media theory, the lecture examines the complex relationships we form with our tools and environments; and explores the con-

1 https://mutor-2.github.io/HistoryAndPracticeOfMultimedia

nections between instruments and questions of identity, digitality and artistic expression—towards what I think of as a *scenographic,* or *ecological* (Di Scipio 2003) approach to performance.

Instruments, tools, an embodiment with things

> Life on our planet can be arranged, more or less, into autotrophs and heterotrophs, organisms that exploit energy from the sun or chemical reactions, and organisms that take energy from those who've already captured it. What is unusual about our species is that we've been able to use more and more energy without having to evolve into a different species. We've achieved this through a combination of social learning, complex culture, and technologies. We don't have to speciate to gain the claws of an allosaurus; we can share information to design a warhead or a power station. In other words, we change our tools rather than our bodies.
>
> (Challenger 2021: 15)

Throughout the history of evolution, creatures like humans and crows have developed the use of objects as *tools*—specialised *instruments* for performing a desired task, which have provided us with vast capabilities for action and utility. Developed through millennia of experimentation and social learning, we rely on these technologies, which become physical and cognitive extensions of ourselves. As Marshall McLuhan writes: 'During the mechanical ages we had extended our bodies in space. Today, after more than a century of electric technology, we have extended our central nervous system itself in a global embrace' (McLuhan 1964: 3).

Artists think, imagine, feel and create forms through the mediation of objects and tools. We call performing musicians, *instrumentalists,* who spend much of their lives devoted to the nuanced control of one particular type of expressive tool. Each art form has its own set of instruments—paintbrushes, knives, glue—and I think we can consider every artist as a kind of instrumentalist. For some artists, like dancers and vocalists, the body is the instrument. In other media, like works of relational or participatory art, the conceptual framing of the situation and social context might be created through the instrument of language or architecture.

Each instrument can become a kind of lifestyle—we tend to identify with our instruments in an intimate way. They are symbolic of different modes of expression, influencing our perspectives on articulation, and like language, *mediate* our thinking about how different kinds of actions might fit into different social situations.

Our bodies also physically change through this close relationship with our tools. String players develop calluses on their fingertips from the pressure of the strings; violinists and violists will often have a little red mark on their chin, and so on. The actions required to perform with an instrument can also cause damage, for example embouchure collapse due to mouthpiece pressure in brass instruments technique (Fry 1988). Instrumentalists will also sometimes do dangerous exercises in order to improve technique, like Robert Schumann, who famously ruined his career as a pianist by using extreme finger stretching technologies meant to improve speed and flexibility (Jerold 2021).

The intensity of an artist's relationship with their instrument reflects the intensity of the potential throughput of expression in the synergy of tools with our intentions and gestures. This is deep *incorporation*—stemming from the Latin *in corpus*: into the body. When we reach a level of fluency with a tool, we don't think about it anymore—we know without thinking—it becomes part of us, an instinctual extension of agency, or *embodied cognition* (Leman 2007; Varela, Thompson & Rosch 1993).

In the 1980s, neuroscientist Benjamin Libet published results from a series of EEG experiments that showed that in some cases the brain receives the impulse to perform a movement *before* the conscious decision region of the brain becomes active. The accuracy of the experiment has since been contested, however, the study was used by some theorists as proof that there is no such thing as free will, since the body appears to act before the mind has time to understand and react consciously (Taylor 2019). We can also see an intuitive connection with musical performance, where the speed of reaction on an instinctual level is an important part of instrumental practice; some aspects are conscious decisions, but others are ingrained motor programs that the body has *encoded* as response mechanisms.

This extension of human intention through objects can potentially be traced back to the practices we developed as hunter-gatherers. Historian and environmental philosopher Melanie Challenger writes about studies on the South African San people, one of the last remaining hunter-gatherer societies:

> What began to fascinate anthropologists who studied the San was their meticulous imitations of the animals they hunt. The hunters, in some sense, become animals in order to make inferences about how their prey might behave. This spills over into ritual. The San use hyperventilation and rhythmic movement to create states of altered consciousness as part of a shamanistic culture. In the final stages of a trance, Lewis-Williams writes, "people sometimes feel themselves to be turning into animals and undergoing other frightening or exalting transformations." For anthropologist Kim Hill, identifying and observing animals to eat and those to escape might merge into "a single process" that sees animals as having humanlike intentions that "can influence and be influenced." […] [H]umans are also mindshifters. Not only can we see other things in a single image, we can also see other minds in other things (Challenger 2021: 102 f.).

The tools we use are an extension of ourselves, but they are also autonomous objects, complete within themselves. I would speculate that our relationship with objects is based on *social understanding*, that other things can be entities with their own agencies. Like relating to other people, relating to other *things* may also require the ability to read the intensions and actions of other nonhuman entities. In Challenger's description of hunter-gatherer shamanic practices, the hunter-artist performs a transformation into the prey (or in other cases predator), through an intense process of identification and empathy, which allows the human to predict the actions of the Other, through, in a sense, *being them*.

Presence of things, affordances and constraints

As we learn to influence and perform with a tool, we are learning to understand its unique character as an *entity*, learning how it responds when we interact in one way versus another. Michelangelo famously described his sculptural work as a process of liberating the figures already present in the stone—a kind of empathy with the natural structure of the material (Gardner Coates 2016). As Niklas Luhmann writes, artistic forms 'arise through the concentration of relations of dependence between elements, i.e. through selection from the possibilities offered by a medium' (Luhmann 1987: 102). Similarly, in human-computer interaction, the unique agency and characteristics of an object (or system) is often referred to as its *affordances* and *constraints*, which describe the ways certain types of actions are encouraged or discouraged by a design (Gibson 1977).

Improvising musicians often speak about their relationship with tools in a similar way. Derek Bailey refers to the instrument as an *ally*, not a tool to be mastered:

> Although some improvisers imply a high level of technical skill in their playing, to speak of 'mastering' the instrument in improvisation is misleading. The instrument is not just a tool but an ally. It is not only a means to an end, it is a source of material, and technique for the improvisor is often an exploitation of the natural resources of the instrument (Bailey 1975: 99).

We can view an instrument system as a network of negotiating agencies: the intention of the 'instrumentalist,' the energy of the action, the tool that extends and modifies the energy of the action, the medium substrate that receives the impact of the action and its characteristic reaction to the energy, and the spaces, surrounding and framing the interaction between the instrument and medium, physically, perceptually and socially. When an artist makes an expressive gesture, they are interacting with this system of agencies, and engaged in an immediate process of experimentation, interpretation, prediction and intention.

In his writing on instrument design, David Wessel draws on the *embodied mind* perspective developed by Francisco Varela (and others) to view the process of instrumental learning as an *enactive* process, which emphasises the role of sensory-motor engagement in musical experience towards the formation of a *human-instrument symbiosis* (Wessel 2006). A key element he identifies in the process of instrumental learning is *babbling,* named for the exploratory vocal experimentation in the development of speech in infants, as they learn to connect sounds with a distinct physical process.

Another mentor of mine in instrument design was the late Joel Chadabe, who expressed a similar contextual perspective of learning through action, which he likened to 'sailing on a stormy sea,' where the sailors have to adapt, through learning how to balance, and attempt to steer the ship as waves and winds toss and turn around them. Chadabe and Wessel both describe a *bottom-up, embodied* process of learning, where knowledge is gained first through experimental action and evaluation of the results, viewed in relation (sometimes opposing) to a *top-down,* more abstracted perspective where plans and ideas are first constructed and then executed, which Wessel refers to as *intending.*

In his book *A Million Years of Music* (2015), musicologist Gary Tomlinson similarly discusses this embodied view of learning in the context of one of the oldest known tools of the Palaeolithic era, the Acheulean biface. The remarkable symmetries formed in these chiselled rock hand-axes seem to imply a high level of memory and planning, which would be required to achieve the level of ornate detail and seemingly aesthetic sense of formal balance. These tools originate from around the same time as the development of language, and experiments have shown that the same regions of the brain are activated in the planning stages of biface production as in language tasks, leading archaeologists to speculate that the development of language may have arisen in connection with the technological development of the biface (Uomini & Meyer 2013). Paralleling the comments by Bailey and Michelangelo, Tomlinson points out that the 'preconceptual actions' in the creation of the symmetries in the biface are

> structured according to these material affordances, the energy required in working them, and the biomechanical limitations of the worker; […] it is the body-stone interaction from which symmetries (and perhaps even the mind) emerge. The variability of raw materials, more than varied conceptual plans, will lead to variability in tools produced as well as varied embodied thought. […] It is not that stone tools are proxies of mind but something closer to the reverse: mind as an outgrowth of the body-stone interface. (Tomlinson 2015: 67 f.)

Tomlinson speculates that the human development of mind itself might be the result of an enactive performance practice—a form of '*embodied cognition* that resists the Cartesian separation of thought from matter and emphasise the situat-

edness of cognition in material matrices extending out from the body' (Tomlinson 2015: 62).

As we move through the world, exploring the connections between our bodies and our tools and environments, we are feeling our way through, learning by trial and evaluation of material; forming a cognitive system that connects details of action with higher-level thought processes. When we perform with an instrument, we are in a way creating a new symbiotic body, or what Tomlinson refers to as *material matrices*—relational networks (Latour 1987) woven together into an assemblage of objects and entities (Deleuze & Guattari 1987), where each element has its own character, ways of moving, affordances and constraints, and its own layer of agency in the system.

Body-instrument persona

Our bodies themselves also function through a symbiotic network of many different lifeforms. In fact, 'nonhuman' cells in our microbiome (bacteria, fungus, virus, et al.) outnumber the human cells, and the process of biological evolution has often been driven by horizontal gene transfer, where genetic material moves between different species (Crisp et al. 2015; Quammen 2018). Yet our minds generally produce a unified experience of the world. In a way, we might read our deep involvement with objects as an externalisation of this inner experience of symbiosis, where our minds subtly include other life and objects into an expanded sense of self. The history of human ritual and mysticism is full of examples of people finding ways to extend and access different parts of themselves through use of tools—masks, costumes, painting, dance and music, which are all processes that act to embody the subjective self into an expanded body-instrument persona.

In their recent book, *The Dawn of Everything: A New History of Humanity*, anthropologist David Graeber and archaeologist David Wengrow explore how these identity-shifting rituals were used as methods to experiment with new social organisations and class relations (Graeber and Wengrow 2021). The expansive experience of human-object symbiosis can also be a tool for fighting for agency in situations where one's physical body has been 'instrumentalised' and subjugated by an oppressive force, as addressed in feminist cyborg/posthumanist (Haraway 1985; Hayles 1999) and postcolonial theory (Spivak 1988).

In the context of music, we can view the early Afrofuturist work of Sun Ra, Lee 'Scratch' Perry and Parliament Funkadelic as expressions of these ideas, as well as the cultural emergence of hip-hop, beat-boxing, turntablism and techno music (Fisher 2013). As Sun Ra explains in his film *Space is the Place* (1974): 'I'm not real, I'm just like you. You don't exist in this society. If you did your people wouldn't be seeking equal rights.'

Philosopher Achille Mbembe describes the origins of Afrofuturism as a reaction to being objectified and instrumentalised through the history of slavery. He writes:

> Afrofuturism is not simply content on shattering the illusion of the 'properly human.' Rather, according to them, the black experience defeats the very notion of the human species. Produced from a specific predatory history, the Black is essentially a human refashioned into a thing, forced to endure the same fate as that of an object or tool. […] With such a rereading in hand, the Afrofuturist movement declares humanism henceforth obsolete. If one wants to adequately grasp the contemporary condition—the Afrofuturists contend—one must do so from all the assemblages of human-objects and object-humans, […] there is no longer a 'human' who is not already enmeshed in the 'non-human,' the 'more than human,' the 'beyond human,' or the 'otherwise-than-human.' […] Drawing on imaginative literary forms, science fiction, technology, music and performance, Afrofuturism tries to rewrite this black world experience in terms of a series of more or less continuous metamorphoses, multiple inversions, plastic transformations (anatomical or otherwise), and necessarily machinic bodies (Mbembe 2018).

In this way, we can read Afrofuturist and posthuman engagement with the *non-human* and *more-than-human* as ways of de-centring the 'human' which has been defined by a culture of oppression—and a searching to find new modes of agency and empowerment through redefining the self as a collaboration with other things and objects joined together into a new form of being.

Similarly, in critical ecology and animal studies, there is an effort to correct the unconscious anthropocentric bias that is encoded into almost all aspects of modern culture (Nagai, et al. 2015)—working to counter the myth of human supremacy found in many religions, which, as Challenger discusses in depth, suggests to anthropocentric humanists that humans are fundamentally superior to the other animals.

Origins of logistics and data science: homogeneous data, capitalism, containerisation

As we have learned from history, our collaboration with objects and other nonhuman agencies has been a key factor in our evolution as a species, yet historically there has also been a tendency to work towards a reduction in the perceived agency in nonhuman things. This bias of human exceptionalism and supremacy seems wrapped up with our instinct toward tribalism, which has benefitted our species in its defence against competing tribes and predators, and acted as a catalyst in creating strong social bonds and collaboration within a trusted community (Graeber & Wengrow 2021).

With the advent of agriculture around 10,000 BC humans increasingly applied a logic-based methodology to harvesting their food (Harmon 2009). As techniques

were perfected, the relationship between humans and the environment seems to have shifted from an interaction of equals, where humans and nonhumans were understood to both have agency in their encounter, to a more objectified, strategic mode of thinking which aimed to optimise and domesticate previously wild plants and animals into instruments of production. This process continued until a point where humans viewed themselves as separate from the rest of the earth—an alienation between human society and 'wild nature,' which eventually led to a bias of human supremacy.

Environmental philosopher Timothy Morton speculates that the development of agricultural logistics created a 'severing,' which describes 'a foundational, dramatic fissure between, […] *reality* (the human-correlated world) and *the real* (ecological symbiosis of human and nonhuman parts of the biosphere).' Morton uses the term *severing* to define the gap between the bottom-up, *embodied* approach we have been exploring, as opposed to a top-down, 'agrologistic,' Cartesian approach. In parallel to Afrofuturism, he views this *severing* as 'a trauma that some humans persist in reenacting on and among ourselves (and obviously on and among other lifeforms)' (Morton 2019: 13). The agrologistic approach isolates the parts of a process, so that each element can be logically reasoned, strategically organised and controlled to produce a desired outcome (e.g. harvests, profit). This has proven to be an extremely powerful way of thinking and provided the basis for the eventual development of computational systems. However, when combined with biases of human and cultural supremacy, the logistical approach can also lead to an instrumentalisation of oppression and devastation—as witnessed in the atrocities of ecocide and slavery.

Returning to Achille Mbembe's text on Afrofuturism, he reflects that:

> [S]ince the start of the modern era we have dreamed of becoming masters and owners of ourselves and of nature. To achieve this, we needed to know ourselves, to know nature, and to know the world. From the end of the Seventeenth Century, it was thought that the best way to do this was to unify all domains of knowledge and to develop a science of order, of calculation, and of measurement that would facilitate the translation of natural and social processes into arithmetical formulas.
>
> With algebra having become the means by which one models nature and life, a modality of knowledge has gradually been imposed that consists essentially in making the world flat, that is, to homogenise the entirety of all living things, rendering these objects interchangeable and manipulable at will. This process of flattening the world, spanning many centuries, has been the governing motivation behind a substantial part of modern knowledge and cognition (Mbembe 2018).

Mbembe goes on to describe how this 'flattening' developed at the same time as the establishment of capitalism and economic globalisation beginning in the fifteenth century through the slave trade, and later through the emergence of the proletariat in the industrial era. This flattening of objects through top-down logis-

tical calculus and data science allows for larger and larger sets of objects to be combined into instrumental systems.

Another concrete example of this flattening process of homogenisation is described by Gavin Mueller in his discussion of the impact of containerisation in commercial shipping. The introduction of uniform metal containers on ocean shipping vessels meant that piece-by-piece loading and unloading of cargo was no longer necessary. Containers could be easily moved between ships with trains and trucks, much faster than loading goods by hand. Fewer docks were needed, and with the ease of transport, production could be moved to where labour wages were lowest. Further, the move towards containerisation of shipping was driven not only by industrial needs for efficiency, but also facilitated military operations. After delivering weapons to Vietnam, ships would stop by Japan to fill the empty containers with electronics before returning to the U.S. (Mueller 2021). As a result of containerisation, the dock workers no longer needed to know what was inside the boxes. Their focus shifted from managing the direct transfer of the content, to a top-down, *mediated* transfer of standardised containers. And it is this same process of containerisation that is the foundation of computational systems of data processing.

In the context of digital systems, the principle of homogenous flattening is even more apparent. Values are represented in binary as sequences of bits (0 or 1). Each bit of data is only an abstract value, it has no context by itself once stored in memory. Declaration of what *type* of data is stored at a memory location is stored in another memory location. Different types of data require different interpretations of the underlying bits.[2] If memory is read as an incompatible data type the interpretation of bits will produce nonsensical information,[3] leading to 'undefined behaviour' in the program. In some cases, the operating system will try to protect the functioning of the system by policing memory access operations. If a program tries to read or write in a protected area of memory, the operating system will produce a 'segmentation fault' and terminate the program (Kernighan and Ritchie 1988).

The digital environment within the computer is purposefully abstracted for the purpose of maximum efficiency and computational flexibility through the polymorphic nature of homogenised storage containers. This characteristic flatness of data creates blurring of media boundaries. Like shipping containers, or the way a synthesiser keyboard can switch from one sound to a completely different sound by selecting a preset. Gestures stored in data can just as easily be interpreted in a totally different media context (albeit with differences of aesthetic results)—for

2 Signed and unsigned values, characters and numbers, all use different interpretations of bit sequences.

3 E.g. random sequences of characters, or extremely large numbers.

example the famous Aphex Twin track using MetaSynth[4] to interpret a photograph of a face as a frequency spectrum (Kahney 2002).[5]

The history of computation is also closely connected with musical instruments. In 1725, Basile Bouchon, the son of an organ maker, developed a binary hole-punch technique to represent patterns for mechanical loom operations. The mechanic loom was further developed by Jacques de Vaucanson, who was well known for creating automata of a flute player (as well as his infamous digesting duck). The loom hole-punch system was later modularised in the developments of Joseph-Marie Jacquard, who in 1804 patented a system that used interchangeable cards to create a sequence of threading patterns (Science and Industry Museum, 2019). The same punch card technology was used to represent data and program instructions in early computers, and gradually developed into smaller and smaller form factors, until becoming the modern silicon integrated circuit.

Like the introduction of shipping containers, the Jacquard loom created an abstract mediation layer between the worker and the resulting product by providing a fully automated mechanism for producing highly detailed textiles. Arriving just after the Napoleonic Wars, this further aggravated the struggling livelihood and culture of French silk weavers who 'greeted the arrival of the Jacquard loom by attempting to assassinate its inventor and destroying the device publicly in Lyon' (Mueller 2021: 13). The mechanism continued to spread however, and was a driving force in the industrial revolution, causing major upheaval and devaluation of traditions of master weavers in the name of industrial production—and capital, which flowed upwards to the owners of the machines. Skilled artisans where no longer needed, as unskilled, low-wage workers could now be employed in industrial production, eventually resulting in the hollowing out of the middle class still visible today.

The Luddite movement in early 19th century England formed in reaction to this top-down mechanisation and devaluing of artisan skilled labour, covertly destroying factory machines in protest—clear evidence of the intimate connection and identification of artists with their tools. The Luddites valued embodied expressivity through direct action instead of top-down carrying out of preprogrammed instructions. Would they have similarly protested if they were the programmers? If the machines were not industrial factories but shared, *opensource* techniques for customised individual use, perhaps the artisans would have adapted these new tools as part of their own practice?

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4 https://uisoftware.com/metasynth/

5 In this case, the low-level data stored as bits is correctly interpreted to read its value from memory, but the abstracted values are interpretated in a different context. The matrix of colour image pixels is *mapped* to audio spectrogram values; the pixel colour becomes amplitude, its vertical position location becomes frequency, and the horizontal position becomes time.

Encoding of knowledge

The knowledge of how to move between different sequences of woven thread was encoded into a binary punch card representation, which was then performed by the mechanical loom. This is one of the first examples of what eventually became computer programming. Like the automated loom system, a computer stores programs as sequences of binary instructions which are executed to produce a desired outcome. Electronic instruments work in the same way, and like the mechanical loom, we can see that the designer of the system is also encoding their own understanding, aesthetics and desires into the tool's inner functioning. As Thor Magnusson writes:

> The objects around us—the technologies that serve as props in our thinking and music making—are stuffed with people and their ideas; in them we find programmes of action, manuals of behaviour, and political and sociocultural constructions, including aesthetic tendencies (Magnusson, 2009: 170).

Each object around us has a backstory contained within it, that gives it its character. A simple candy wrapper lying on the ground has already been the subject of so many processes, time and consideration—the raw materials, paper and wax, all have their unique histories, the design of the wrapper's shape to enclose the candy, the machines that make the wrappers, the graphic designers, the kids choosing the candy at the store, unwrapping, and then falling mistakenly onto the ground. When we study the forms and meaning of objects and instruments, we are also necessarily examining this embedded history, its embodied knowledge, which *situate* our ideas about the nature of the object and how it might function in various social-physical contexts.

Instrument system components

In an acoustic instrument system (Fig. 1), the performer uses their body to interact with the instrument's interface. On a violin, this might mean using the right arm, hand and wrist, to draw a long strand of rosined horsehair across a wound metal string causing it to vibrate, while pressing the fingers of the left hand downwards on the string so that the vibrational length of the string is shortened, altering the string's oscillation frequency. The energy of the string vibration is transferred through the bridge and sound post to the body of the instrument, which resonates, amplifies and converts the energy into air pressure waves radiating spherically outwards, into the surrounding space.



Fig. 1. Cause and effect sequence in an acoustic instrument system[6]

Each type of instrument has different modes of activation, resonance and vibration, which give it its characteristic timbre and haptic experience. The tactile feeling of a violin string pressed into a fingertip is very different than pressing a smooth metal key on a flute; and there is a significant difference in experience between using the lungs and lips to shape air flow to vibrate a column of air, compared to using a bow to vibrate a string.

Each modality of an instrument contains a different set of *affordances*. For example, flutists control the speed of air flow and shape of air resonance though manipulating the tongue and embouchure. As a note is sustained the flute provides an interface between the wind control system of the body and the vibration of a resonant tube. The nature of the air and embouchure techniques have the affordance for highly nuanced variations of timbre, while the flute's key mechanisms provide other affordances, like rapid trill figures, or key clicks. A *constraint* of the flute design is that you have to hold it in a certain way, and focus the air flow in a specific way to trigger the vibration in the air column. An *affordance* of the violin is that you can play more than one note at a time, since there is more than one string, whereas this is a *constraint* of wind instruments in the traditional sense (ignoring multiphonics for now). Another affordance of the violin is the smooth shifting between notes, since there are no frets, the finger can slide along the strings to create glissandos, and so on.

Key and valve mechanisms are some early technologies for expanding the playable range of wind and brass instruments by extending the reach of the human hand. The finger controls the keypad at a distance through the *mediation* of the mechanism.

Keyboard instruments like the organ, clavichord, harpsichord and piano, are perhaps the clearest examples of mediation in instrument design. The keys are an interface for triggering a set of secondary mechanical actions, which perform the actual physical activation of the sounding objects. As with the automated loom, the performer no longer needs to know about or directly manage the activation

6 Note that the listener could be an audience member or the performer themselves.

and resonance of the instrument. Rather, the performance technique shifts focus to pressing the right keys at the right time—the mechanics of the instrument take care of the rest. In early organs an additional *person* was required to work behind the scenes pumping the bellows.

Figure 1 diagrams the chain of cause and effect in an acoustic instrument system, however any part of the system could be replaced by an electromechanical element or digital process. As in mechanical systems, digital instrument systems function through a mediation of data between the interaction interface and media production. In digital instrument systems the performer interacts through a *motor action* with some kind of sensing device (*material interface*), which converts the gesture information into voltage, which is then sampled and quantised to produce normalised data, which can then be interpreted by the computer. A computational algorithm interprets and responds to the sensor gesture data to produce the resulting media through an *instrument body* (e.g. signal processing in the digital domain). The media signal then *radiates* through space (real or virtual), reflecting in the architecture until it reaches the audience, who *sense* and *interpret* the stimuli for form and content. The performer is in this way also an active member of the audience and becomes part of a feedback loop; as they evaluate and adjust their performance by instinct or intention, in an embodied *response*—an interaction with the affordances and constraints of the physical interfaces, aesthetic and social contexts and design of the computational system as a whole (Chadabe 1984; Di Scipio 2003; Wessel 2006).

Composed instruments and instruments of composition

For the Situated Instrument Design class, I made a variation on the diagrams used by Chadabe, Wessel and Di Scipio, illustrating the flow of the data within the computational blocks of the digital instrument system (Fig. 2) and introduced the human action of *composition* into the model, a practice-specific expression of Wessel's term *intending*. The diagram presents a programming-oriented view of the computational logic of the instrument system, focusing on the points of artistic intention that shape the behaviour of the system.

This is an example of a *composed instrument* (Schnell & Battier 2002), where compositional logic is embedded into the instrument—becoming an *epistemic tool* (Magnusson 2009) that embodies the aesthetics, knowledge and biases of the composer-engineer, who makes plans, assumptions and predictions about the use of the system. In this way, composition can be seen as a kind of performative action; an action of creating later actions.

Since high-performance personal computers have become widely available, artists have gradually gained a higher degree of programming fluency, and more and more are able to implement the designs of instrument programs themselves,

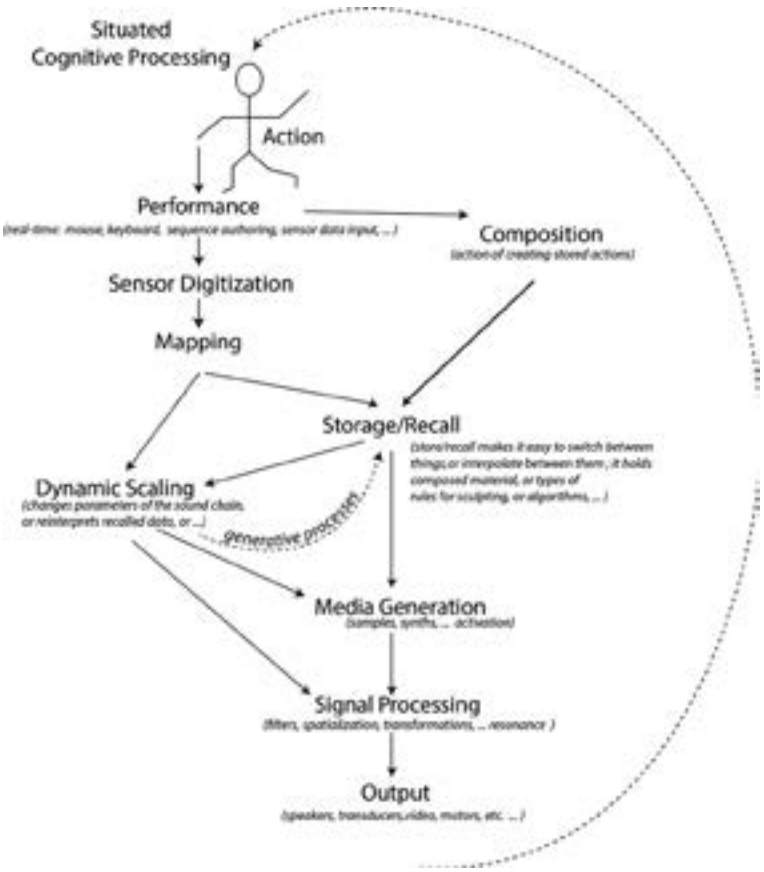


Fig. 2. Data flow diagram created for the Situated Instrument Design course at the Center for New Music and Audio Technologies (CNMAT)

which previously required a specialist engineer who would mediate the ideas of the artist. In the best cases, artist-created tools and instruments work to synthesise a bottom-up embodied understanding of media and performance interaction with a top-down view of planning (*intending*) which is used to shape the possible outcomes of the system.

We can think of the use of digitally mediated instruments as *computer assisted performance*, where the instrument algorithmically creates or manipulates media in response to the performer's actions. Joel Chadabe referred to performance with intelligent instrument systems as *interactive composing* (Chadabe 1984). A digital instrument can also be a tool to produce compositions, presets or customised mappings. In this case the system might be considered a tool for *computer assisted composition*, for example a software interface that provides the user with tools that produce new musical sequences based on the values set by a graphic user interface,

or using generative processes that produce compositional material. In this way, computer assisted composition systems (e.g. OpenMusic[7], bach[8], MaxScore[9]) are themselves instruments that the composer performs with to produce score-like media. And as before, there is a strong influence of the design of the system in the possible outcomes that the user is able to produce: the *affordances* and *constraints* of the system, for instance a music notation program that requires the user to specify a rhythmic meter forces the user to think in terms of rhythmic subdivisions.

Importance of context, distributed agency, computational agents

As we have been exploring, instruments function through varying degrees of mediation and delegated agency. We might also study instrument systems which function in frameworks of social interaction, where the 'medium' is the interaction of the participants, as in the case of participatory art, or *relational aesthetics* (Bourriaud 2002). For example, the acoustics of a room will have a strong effect on the way people talk to each other, as they adapt their voices to be heard or less heard, depending on the room's reverberation and level of speech intelligibility. An artist might 'instrumentalise' the acoustics of the space (e.g. using an active acoustics system) in order to shape the experience of the visitors who are engaged in conversation.

The incorporation of other agencies into artwork can also clearly be seen in works involving animals and artificial intelligence (AI), as in Joseph Beuys' famous piece where he locked himself in a room with a wild coyote.[10] The work of Robin Meier is another fascinating example, often incorporating a variety of animals and insects, for instance his work with Ali Momeni, where they glued mosquitoes to microphones (in a non-harmful way) and broadcast vocal music in the gallery space, which the mosquitoes interpreted as a potential mate, tuning their buzzing to match the pitch.[11] Or the potentially more harmful 'cat piano,' a (we hope purely speculative) instrument described by Athanasius Kircher in Book VI of the *Musurgia Universalis* (1650), which consisted of cats' tails 'inserted into narrow sheaths, beneath which there went up and down the hammers corresponding to keys' (Loughridge and Patteson 2013). In some of these examples the definition of 'instrument' can become problematic. Is an animal a form of media? Rather, I think of these pieces as relational works that combine the agency of humans and nonhumans.

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7 https://openmusic-project.github.io/
8 https://www.bachproject.net/
9 http://www.computermusicnotation.com/
10 Joseph Beuys, *I Like America and America Likes Me*, aka *Coyote* (1974).
11 Robin Meier and Ali Momeni, *Truce: Strategies for Post-Apocalyptic Computation* (2009).

Similarly, through the programming of complex, multilayered and non-linear interactions, computational systems can sometimes be understood as acting on their own. Rather than functioning as an extension of the human performer, the relationship between the human and media-producing system is a meeting of individual entities. The aesthetic and behavioural knowledge has been composed into the system, but then acts as a separate personality, with its own character and agency.

George Lewis describes his work with AI improvisation systems in this way:

> In *Voyager*, the computer system is not an instrument, and therefore cannot be controlled by a performer. Rather, the system is a multi-instrumental player with its own instruments. […] In this sense it is useful to consider Robert Rowe's taxonomy of 'player' and 'instrument' paradigms […], although I regard the two models of interactive role construction, not as a fixed binary opposition, but as a continuum along which a particular system's computer-human interaction can be located. (Lewis 1999: 103)

Puppetry in expanded/post-instrumental performance practice

This idea of composing an instrumental system as a character who performs a role also has a connection with automata, and 'strong AI' (Searle 1980).[12] From the perspective of the human-object relationship, we can still view the creation of an autonomous performance system as an extension of the composer who imagines how this character might act and interact with others and its environment. In a complex instrument the performer works in collaboration with the system, which additionally extends the performer's sense of self through participation in a larger team or *ensemble* social configuration. As they learn to perform together, it becomes second nature through the development of the group aesthetic and *entrainment* (Clayton et al. 2020), as they coordinate their gestures towards a collective sense of expressivity.

The practice of creating a sense of character or persona in a constructed system is closely related to the practice of puppetry, where there is a rich tradition of human/nonhuman symbiosis. Particularly in the contemporary field of expanded/

12 'What psychological and philosophical significance should we attach to recent efforts at computer simulations of human cognitive capacities? In answering this question, I find it useful to distinguish what I will call "strong" AI from "weak" or "cautious" AI (Artificial Intelligence). According to weak AI, the principal value of the computer in the study of the mind is that it gives US a very powerful tool. For example, it enables us to formulate and test hypotheses in a more rigorous and precise fashion. But according to strong AI, the computer is not merely a tool in the study of the mind; rather, the appropriately programmed computer really is a mind, in the sense that computers given the right programs can be literally said to *understand* and have other cognitive states. In strong AI, because the programmed computer has cognitive states, the programs are not mere tools that enable us to test psychological explanations; rather, the programs are themselves the explanations.' (Searle 1980: 417)

post-instrumental performance practice, I think of puppetry as the basic principle of mechanical and computational systems that produce media through collaborative interaction with a performer. This could take the form of mediated digital interaction or kinetic art performances, for example in the works of Jean Tinguely and László Moholy-Nagy, and the scenographic, nonhuman performances of the Futurists, Nijinsky, and DADA, theorised in Gordon Craig's *Über-Marionette* (1907) and Antonin Artaud's *Theatre of Cruelty* (1932).

Mapping, audio-visual actions

> No sound is innocent. Every utterance, rustle and nuance is pregnant with meaning.
>
> (Prévost 1995: 33)

While in an acoustic musical instrument there is generally a direct connection between the actions of the performer and the physical vibrations of the instrument, in a computational instrument the performer interacts with a system of mediated actions. As in puppetry, the compositional process of instrument design focuses largely on the *mapping* of actions from control interface to performed media.

What kinds of media performance should result from a given digital input? How do the perceptual qualities of the sensing interface relate to the perceptual qualities of the output media? How should the audience read the relationship between the visual gesture and sound performance? What kind of experience does the performer have with their instrument? What types of expression are possible?

By composing the mediation between action and result, we define the affordances and constraints of the system as well as possible relationships the performer might develop with the instrument. From the audience's perspective, we can consider the composition of an instrument as a communication of this mediation through the performance as a dramaturgical scenario.

Since audio and visual cues are the most prominent modalities in performance (Tsay 2013), the relationship between sound and image is one of the key inflection points of expression and dramaturgy in an instrumental system.

In the early 20th century, filmmakers like Sergei Eisenstein began to think critically about how sound influences the tools of visual storytelling, editing and linear narrative (Eisenstein 1949). Pudovkin described the *synchronism* of sound in cinema as a problem of perceived 'inner speech' of a character on screen as silently intuited by the audience, versus the 'outer speech' of synchronised sound, which creates a sense of realistic speaking of the characters but requires a different, and less active engagement of the audience (Pudovkin 1985).

As synchronised sound playback technology gained traction in cinema, film soundtracks began to incorporate the work of Foley artists to artificially create

sound effects (e.g. doors closing, footsteps and fabric moving) to be played in sync with the movement of characters and objects on screen. By connecting the visual actions with sound, the Foley artist creates a sense of *embodiment* through the use of *concrete*,[13] *representational* sound-image relationships.

In contrast, one of the most despised approaches to sound in early cinema was 'Micky Mousing,' where a *musical* accompaniment is composed to directly correlate with the movements on screen.[14] This direct musical correlation creates an audible obviousness to the relationship between sound and image, which, due to its highly literal orientation, has an effect of hyper-emphasising the flow of the immediate movement at the expense of the more dramaturgical, visually expressed *inner speech*. 'Mickey Mousing' depicts motions on screen translated into *musical gestures* (e.g. xylophone going up in pitch as someone races up the stairs), which functions within a framework of *abstract* musical structure (e.g. pitch-height, rhythm). The process of abstraction in 'gluing' actions in physical space into musical space often results in a simplification of the meaning of the image for slapstick comic effect.

In the field of instrument design, synchronism is not an issue: sounds in the real world are produced by the multimodal interaction of physical objects and spaces. To interact and express through an instrument is (in most cases) a synchronous experience. Moving a finger along the fingerboard of a violin changes the pitch—a correspondence of movement and pitch as seen in 'Mickey Mousing.' However, the dramaturgical choices defined by the relationships between sound and image are important in the creation of the contextual meanings and implications. What agencies and *inner speech* do the performer and instrument communicate? What types of meanings do specifically *digital* instruments embody?

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13 Pierre Schaeffer's development of *musique concrete* likewise explored the tension between the representational and abstracted processes in the sound domain. Similar to some principles of Montage theory, Schaeffer studied the importance of the *attack transient* on our ability to recognise the source of a given sound, produced acoustically by its characteristic relationship between physical objects. By removing the initial moments of a sound and fading into the resonant, continuation period, Schaeffer was able to abstract the sound from its source, and through recombination could *mask* the identity of one sound, using the transient of another source. In other examples, concrete, representational sounds were re-pitched and re-contextualised into abstracted musical space (Schaeffer, 1966).

14 As Jean Cocteau famously remarked: 'Nothing, it seems to me, can be more vulgar than musical synchronism in films. It is, again, a pleonasm. A kind of glue where everything gets stuck rigid, and where no play (in the sense of "play" in wood) is possible' (Cocteau 1954: 72).

> Worlds are perforated and permeable, which is a way we can share them. Entities don't behave exactly as their accessor wants them to behave, since no access mode will completely shrink-wrap them. So, worlds must be full of holes. Worlds malfunction intrinsically.
>
> (Morton 2019: 14)

As digital technologies were becoming dominant in the 1980s and 90s, an aesthetic of 'glitch music' emerged through the work of experimental musicians like Yasunao Tone, Nicolas Collins and the band Oval, who used skipping CDs as sound material. In the work of these artists, system malfunction becomes the voice of the instrument. In a similar vein as artists like Christian Marclay, who created loops with skipping and sliced vinyl records, the sounds used by Tone and Oval's skipping CD players is a *distinctly digital* flavour of malfunction, foregrounding the material-body of the system itself.

A typical commercially produced technology is designed as a top-down process to produce a target result, while the inner logic of the system is hidden (and usually patented). When the functioning of a system is purposefully inaccessible or unreadable we call it a *black box*[15] (Latour 1999; Schwoon 2024).

A CD player is designed to spin a compact disc at a certain speed and uses a laser data sensor to read the bits of sample data encoded on the surface of the CD. The sample values are stored in a digital buffer and then an internal clock is used to perform the sample data at a given sample rate, sending the sample values through a digital-to-analogue converter which converts the data to voltage fluctuations—eventually becoming sound as the voltage fluctuations are converted to sound waves by the speaker transducers. Normally we are not aware of this sequence of actions when listening to a CD: we're listening to the sounds, like turning on the radio or playing a vinyl LP on a record player. But by causing the read head of the CD player to skip, these artists intervened in the physical action of the system. No longer do we hear the sample data in sequence, producing the sounds as intended by the makers of the CD, but rather, like the 'undefined behaviour' of interpreting binary data with the wrong data type, the disruption causes the system to reassemble the information on the disc into an unintended new sequence as an artifact of a *system failure* (Cascone 2000). This 'undefined behaviour' suddenly shifts our listening away from the intended content of the CD and instead focuses our attention on the process of the CD player's buffering algorithm—a uniquely *digital* aesthetic gesture.

15 Not unlike the content of a shipping container, our understanding of a black box is purely external.

In this way, glitch can be thought of as a technique for producing *realistic* sounds that are emblematic of the material system. The technical object is brought to represent itself (Simondon 1980). This disruptive action of glitch is a kind of Luddite action that breaks the simulacra (Baudrillard 1994) of the system of reproduction and exposes the data management system that produces it. Through this malfunction, the real, concrete *aura* (Benjamin 1935) of the digital/mechanical CD player system is brought to the fore.

These techniques connect with earlier works like John Cage's prepared piano pieces and unorthodox use of record players in *Imaginary Landscape No. 1* (1939), and most directly with hip-hop turntablism (Fisher 2013). In the visual domain, we see similar approaches in Duchamp's 'ready-mades,' Nam June Paik's *Magnet TV* (1965), where he used a magnet to disrupt the functioning of a television, and Joan Jonas' *Vertical Roll* (1972), where she used the rhythmic shifting created by a usually incorrect setting of the television's vertical-hold circuit as part of the framework for her piece. Jimi Hendrix's use of feedback, and the experimental electronics of David Tudor and Don Buchla are other classic examples.

Glitch is a type of digital aesthetic which seems to take two main approaches: disrupting part of a functional black-box system (like skipping CDs, and Paik's *Magnet TV*) or working from more of a bottom-up, structural approach, through directly composing the workings of the low-level elements of the system. We see this structural approach in works like Tony Conrad's *The Flicker* (1966) which used the alternating black and white frames of film projection technology as an instrument for a kind of retinal music, and Iannis Xenakis' *S.709* (1994), where he uses dynamic stochastic synthesis techniques to directly generate sample data. Sachiko M's work with sampler test tones and extreme frequency ranges is another good example of shifting the focus of listening and experience from a virtual space of artificial narrative, towards a realist, material experience of digitality and boundaries of physical perception.

Each instrument system has its own unique forms of malfunction due to its construction, and through studying the artifacts of malfunction we can learn how the system represents itself. For example, a digital system will tend to represent itself with precise rhythms, exact repetitions, extremely short notes, perfectly tuned frequencies, aliasing due to the Nyquist sampling frequency and the ubiquitous frequency-domain compression garbling noise.

While glitch is often associated with digital technology, the work of improvisors like Milford Graves and Keith Rowe, and the work of *musique concrète instrumentale* composers like Helmut Lachenmann and Salvatore Sciarrino similarly deconstruct instrument systems and use the resulting glitch-like artifacts as material. And likewise, we can understand the glitch aesthetics as a kind of 'extended technique' of digital instrument systems.

Aesthetic approaches to tactile listening, texture and timbre space

In the process of composing with digital instrument systems, I am often thinking about the implications of sound in connection with gesture and spatial embodiment. How does the sound produced relate to the performance practice?

Self-representational techniques like glitches, mistakes, artifacts and non-standard methods of performing on instruments tend to produce noisy and complex sounds with a high degree of contrapuntal subcomponents. Working in this context, I find that I am almost always firstly focused on the timbre and texture of a sound that I am working with and drawing the motivic phrasing oriented from a perspective of *tactile listening.* Is the sound smooth, or rough? Spiky, with sudden, rhythmic variations of density? or more consistent, flowing in texture? Are there clearly defined layers to the sound? Is it a slow moving, low rumbling with higher sporadically moving frequencies above? A dry or liquid sound? Hot or cold? I approach tactile listening as a kind of synaesthesia focusing on the *feeling* of the sound texture, and finding the rhythmic and motivic possibilities that are there in the sound, in a very enactive, embodied, bottom-up way. After experimenting with the feeling of the material, I begin exploring possible formal organisations, which eventually are used in a (intending, top-down) compositional process that links different modalities of texture.

I started consciously reflecting on this approach in 2012, when I was in residence at Ircam, studying the usage of Wave Field Synthesis (WFS) and Higher Order Ambisonics (HOA) as instrumental systems. One of the key realisations I had while working with these systems was that I would often spend a long time making beautiful visual distributions of virtual sound sources moving through the space in different groupings and dynamic transformations, but then at some point I would have to stop and ask myself: *what sound should play through this spatial distribution?* In attempting to answer this question, I discovered the importance of the seemingly obvious fact that the texture and psychoacoustic properties of the sound has a huge effect on the perceptual experience of a spatial audio rendering. Based on these experiences, I worked to identify perceptual connections between sonic and *spatial textures* rendered by the WFS and HOA.

What I found very useful was to relate my experience of tactile listening and spatial texture with David Wessel's *timbre-space* (Wessel 1979), and David Huron's *texture-space* (Huron 1989). In his discussion of *timbre-space,* Wessel develops a spatial representation of sound plotted according to key psychoacoustic features, as a framework for composing perceptually-based sound transformations through *spatial gesture.* In a way, Wessel's 'timbre space as a musical control structure' can be seen as an instrumental approach to orchestration. David Huron's *texture-space* similarly plots musical features into a spatial representation, comparing contrapuntal textural aspects of *onset-synchrony* with *semblant motion.* In both Wessel's

and Huron's examples, spatial representation is used as a tool to understand the musical impact of *auditory stream segregation* (Bregman & Campbell 1971), the cognitive process by which we determine how many independent voices are in a signal—how the elements in a system bind together or break apart.

In the process of composing for the WFS/HOA system at Ircam, I found there was an increased sense of embodiment of the spatial rendering patterns when I linked the contrapuntal-textural aspects of sounds with similar textures of spatial articulation in the virtual acoustic space. The inherent textural qualities in timbre and auditory stream groupings seemed to highlight similar forms and spatial textures in the spatialisation and vice versa (Carpentier, Barrett, Gottfried & Noisternig 2016).

Since this time, I have continued to explore this tactile listening approach, using the connection between different types of texture as a method of solidifying the relationship between spatial and sonic elements in an effort to create cohesive bodies and holistic atmospheres. This approach connects back to puppetry, where the puppeteer/instrumentalist works to create a sense of living entity by relating the voice of the character with the movements of a sculptural form. Unlike natural sounding bodies, the puppet's voice is usually physically separated from its body—i.e. performed by puppeteers who are normally hidden and synchronise their voices to speak at the same time as the puppet moves its mouth. As in theatre, the voice of the character gives us information about who they are. Similarly, the audience reads the feelings and thoughts of the character through the puppeteer's performance mediated by the puppet mechanics. In this way, puppetry is one of the oldest forms of multimedia instrument design, and when done well creates a strong sense of human-object symbiosis.

In practice: video puppet instrument systems as embodied, scenographic compositions

In a series of recent works, *Apophänie* (2016), *Scenes from the Plastisphere* (2018), *Animism* (2021), and others, I have been working with camera-based 'video-puppet-instruments,' which fuse digital and organic bodies as a way of attempting to create new connections between human and nonhuman experience. In the situation constructed by the system, the performers use their hands (usually hidden from view) to manipulate objects, and organic textures, viewed through a high-magnification macro-lens and live video-camera capture. When projected to large scale, the miniature details of the organic textures seem to become all different kinds of strange animals, plants or more abstract creatures and their environments (Fig. 3). The video-image stream is then analysed by computer vision algorithms, which output various information about the image such as morphological character, size, orientation of an object and the quality of its contour, colour,

speed of motion, and so on—and then the analysis data is used to control digital sound processes.

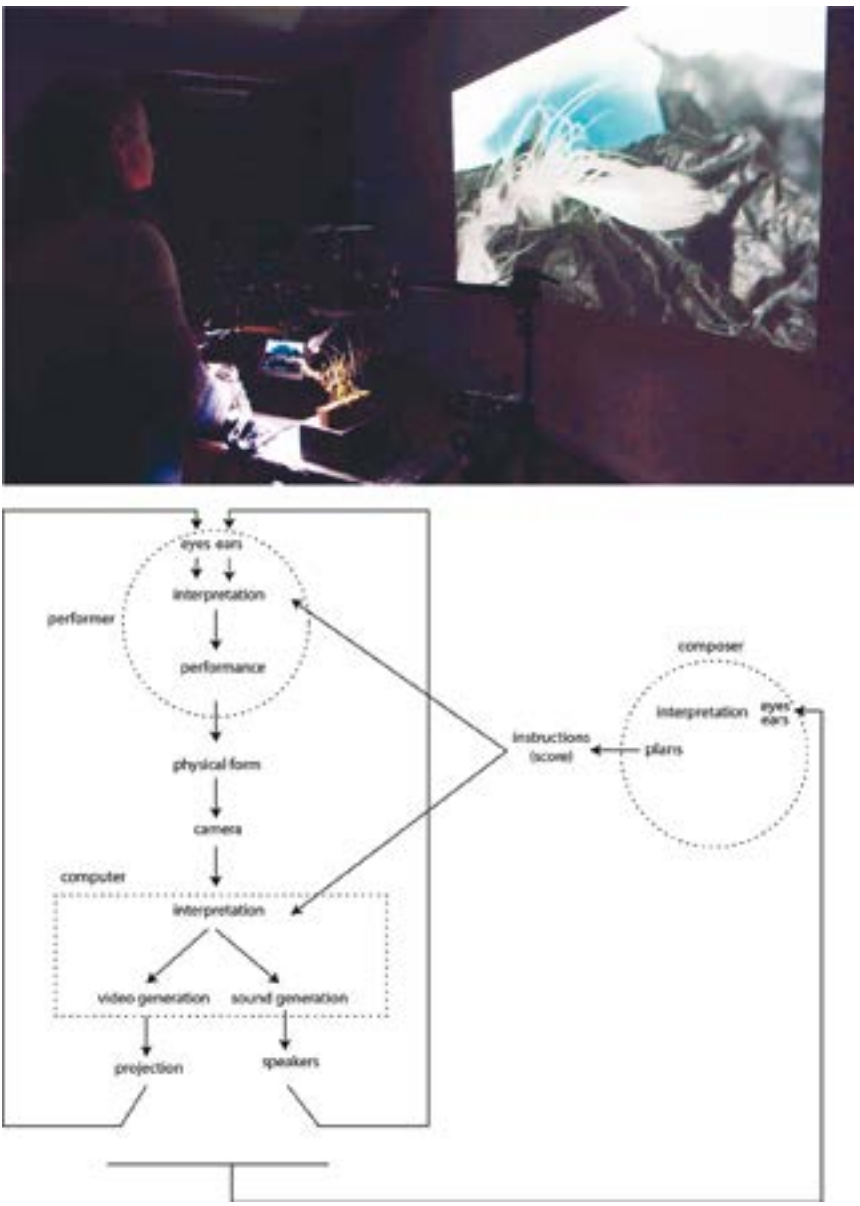


Fig. 3. Above: Image from rehearsal with the video-puppet-instrument used in *Scenes from the Plastisphere* (2018). Below: A diagram of the video-puppet-instrument system. The circles represent people, and the rectangle is the computer. To the left side, the performer is engaged in a feedback loop of action and interpretation. The composer (right side) directs, and influences the interpretations of the performer, computer vision analysis, and its mapping to sound and image media generation.

While composing for this context, I generally first experiment with various objects and physical materials, studying how different types of movement and texture work on the screen, similar to Wessel's discussion of exploratory babbling in enactive learning: testing different angles of light, camera framings, and improvising movements with the material, feeling which modes of action have the most control or expressivity in a given environment, and searching the results for traces of characters that might emerge.

I should add that I mean 'character' here in the most open way possible. The 'character' of the scene might be a landscape, or a crumpled-up piece of fibrous paper sitting in a shallow pool, slowly absorbing the water, which changes the paper's shape like a time-lapse film. Or perhaps the 'character' of a scene is the physical presence of the screen itself, or the movement of the camera, or the lighting. After discovering and developing a character in this way (physically/optically), I will usually work out what kinds of actions will happen on the screen, potentially bringing in plot narratives, or symbolic transformation based on the possibilities of the physical materials, camera and lighting.

I am often working with very organic, hard to control materials, and so the composition of the actions tends towards a kind of aleatoric time-window approach, where some details of the action are unspecified, and others indicated by dramaturgical performative descriptions. For instance, a twisted mass of wire reaching out towards the camera creates a kind of crab or spider-like gesture, however I leave the exact actions for the performers to figure out since the exact positions of the wires will be a bit different each time.

Once I have the sequence of actions figured out, I will generally break the sequence into scenes, and try to find effective computer-vision analysis approaches that would make sense for textures and scenic context for each scene. For example, in scenes with a solid white or black background, it is easy to isolate the shapes in the image from the background through contrast, whereas a scene in a highly detailed environment requires either some kind of background-subtraction or another approach, like optical flow, to separate the performed object from the background.

After finding a computer-vision analysis approach that connects with the motion and scenic material, I then develop the 'voice' of the characters by mapping the computer vision analysis to various digitally controlled sound processes. Since by nature the camera instrument is a highly mediated system, the relationship between sound and image becomes very important. Loosely drawing on the ideas of Foley, I will often study my perceptual experience of following tactile qualities of the objects on the screen and try to identify what expectations I might have of the kinds of sound an object might make in the real world. Often, I will make use of glitch type approaches to create sounds that reinforce these intuitive experiences of haptic texture in connection with a feeling of digital embodiment within the objects. Through this tactile listening approach I try to create a sense of realism

between the visual (and tactile) experience of the object and its sound produced by the digital system.

On stage, human performers work to form close relationships with the objects, their actions as captured by the cameras and the resulting audio from the computer-vision system. Part of the performance practice in the pieces is that the instrumentalist-puppeteers have to look deeply at the action on the screen and continuously adjust their movement to emphasise the characters they see in the video projection; as they attune to the movement of the character through their actions, the object seems to learn to speak through the computer.

Figure 3 illustrates the flow of interpretation and data flow in the video-puppet-instrument as an example of a composed instrument system. As shown in figures 1 and 2, the performer is part of an enactive feedback loop: their actions affect the sound and image through the mediation of the system, which they then sense, interpret and respond to by altering their subsequent actions. On a secondary level, the composer experiences and analyses the performance and makes plans, which influence the human and computer interpretations. The digital interpretation is composed (programmed) in software, which encodes the intentions, aesthetics and biases of the author into the system.

In connecting their physical movements with the sounds and image on screen, there is a kind of animistic projection of perception from the puppeteer into the object's body, producing a multilayered experience: the performer feels themself acting through the objects, but at the same time tries to feel from the perspective of the object, creating an extended body between them.

The example of these video-puppetry pieces is given to show just one out of many ways to think about the relationship between objects and humans, and how this might be used as material in performance and composition. The ecological-oriented approaches we have been discussing attempt to de-centre the human as the primary subject of performance, and instead tilts the focus towards the object and the larger context of human-nonhuman interaction and symbiosis. One of the goals in the development of these performance practices, which is potentially unattainable, is that somehow, by bringing the attention towards the nonhuman actors, the audience will have a greater sense of connection and empathy with the Other—human and nonhuman entities that are all around us, everywhere—in an effort to counter the subconscious biases of human exceptionalism, cultural supremacy, and tribalism, which have caused so much damage to our lives and biosphere.

In conclusion, I would like to read a quote from Antonin Artaud, who was thinking deeply about the human-object relationship:

> Once aware of this language in space, language of sounds, cries, lights, onomatopoeia, the theatre must organise it into veritable hieroglyphs, with the help of characters and

objects, and make use of their symbolism and interconnections in relation to all organs and on all levels.

The question, then, for the theatre, is to create a metaphysics of speech, gesture, and expression, in order to rescue it from its servitude to psychology and 'human interest.' But all this can be of no use unless behind such an effort there is some kind of real metaphysical inclination, an appeal to certain unhabitual ideas, which by their very nature cannot be limited or even formally depicted. These ideas which touch on Creation, Becoming, and Chaos, are all of a cosmic order and furnish a primary notion of a domain from which the theatre is now entirely alien. They are able to create a kind of passionate equation between Man, Society, Nature, and Objects (Artaud 1958: 91).

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II. Composing Instruments, Notation, Reconstruction and Collaboration

Composing Music Inside Out
Concepts between Instrument and Composition

Miriam Akkermann

Throughout the 20th century composers have been interested and involved in building musical instruments for specific compositions, developing environments using a composer-performer approach, and building (digital) musical instruments intended for broader use. According to composer and instrument builder Bill Vine, one central aspect in this is the assumption that new instruments will allow to overcome prevailing cultural and musical notions inevitably associated with traditional instruments. New instruments thus promise to provide an opportunity to change the relationship between composer, instrument, music, and audience—an aspect that Vine describes as the possibility to 'escape the entrenched bonds and histories native to traditional instruments' (Vine 2020). The expectations placed on new instruments are, however, again according to Vine, closely related to experiences gained from traditional ones; while new approaches to operability and emerging sounds may broaden the concepts of musical instruments, these developments are at the same time measured against, or in comparison to, established concepts. One reason for this often seemingly unsatisfying situation is, as Vine puts it, the strong and haunting line of music tradition. Besides concepts of form, sound structures (e.g. tonal systems), and the idea that a musical performance entails listening to musicians who have comprehensible skills with which they reproduce prescribed sounds on traditional instruments, this tradition also relates to the fact that traditional musical instruments are mostly designed according to basic physical principles that are more or less simple to follow. In contrast, Vine's selection of composer-built instruments belonging to the British Music Collection largely consists of instruments incorporating electronic and digital elements and excludes electronic instruments that are based on traditional musical concepts, as well as technologically augmented traditional instruments. This is especially interesting as it is precisely the stereotype of a 'musical instrument' that offers potential for discussion in the context of musical works incorporating electronic and digital technologies; in fact, the use of technology can help to consolidate defining features of musical instruments as well as blur the boundaries between compositional ideas, performative attempts and instrument design. On the one hand, the possibilities offered by new technologies can stimulate the creation of musical works. On the other hand, embedding technology in performance situations always goes hand in hand with decisions regarding usability, functionality and sonic possibilities, features usually related to to the design of musical instruments. This

opens up a wide range of possibilities for the creation of musical works featuring interwoven and interactive performance settings of varying technical complexity, and situated at the intersection between musical instruments and composition. According to music researcher and developer Norbert Schnell and composer and musicologist Marc Battier this development led to the emergence of the concept of 'composed instruments' in the 20th century, 'when musical instruments became dematerialized […] with [the use of] electronic technology' (Schnell & Battier 2002: 1).

Observing technologies embedded in compositions with complex performance environments against the background of traditional musical instruments thus provides a starting point for describing the (live or performative) operability of setups as well as their sonic features, and for framing the compositional idea behind technology-enhanced performance settings. This leads us to three central questions: What is the significance of a particular composition? How is technology embedded within it, and how can the technical layers be described? How do the concepts of (technology-based) 'musical instruments' and 'compositions' relate to one another within the musical work?

Starting with reflections on structures of compositions embedding technology and assumptions concerning the functionality of musical instruments, a schematic framework will first be outlined. This will serve as a basis for the discussion of two compositions created at the end of the 20th/beginning of the 21st century: Thomas Kessler's *Flute Control* and Iris Ter Shiphorst's *Dead Wire*. Both works highlight a soloist in charge of both a (traditional) acoustic musical instrument and a hybrid electronic system, thus oscillating between the concepts of mixed music composition, interactive performance environment, and composed instrument.

Between expectations and definitions

Towards the end of the 20th century, the concepts of 'musical composition' have evolved in various ways. While on the one hand the idea of single authorship has been questioned, taking into account collaborations of several protagonists contributing (simultaneously or at different stages) to a work's genesis, constantly evolving technologies opened up new possibilities of extending the range of artistic actions as well as enabling individuals to enhance the setting they are able to control. The rise of digital technologies was one of the driving factors in meeting one condition that according to Schnell and Battier is central in establishing a composed instrument, namely that 'the two main components of a musical instrument, the sound producing part and the gestural performance part, are decoupled, or isolated one from another.' (Schnell & Battier 2002: 1) This idea implicitly also resonates in the structure which music researchers Eduardo Miranda and Marcello Wanderley propose for digital musical instruments. In their scheme, musical in-

struments consist of three parts, a gestural interface, a sound production unit, and the mapping from interface to sound unit. They further outline two types of feedback that help to control the handling of the instrument, a primary (haptic) one from the interface, and a secondary (audio) from the whole instrument (Miranda & Wanderley 2006: 3). Miranda and Wanderley do not specify the kind of input gesture or sound production method. However, they assume that the interface provides an appropriate sound assignment and a predictable control mechanism allowing for a (more or less) intuitive, or at least comprehensible, direct control of the sound. A musical instrument according to their scheme would provide a sound production that can be intentionally controlled by use of a predefined interface. This suggests that performers can learn how to play the instrument and train their skills, allowing them to intentionally (re-)produce specific sounds in a (live) performance as well as to achieve (some kind of) virtuosity. Conversely, this means that such a musical instrument is usually controlled by, and designed for, one human musician.

Even though Schnell and Battier mention electronic instruments that meet the described criteria such as synthesisers which appeared from the 1950s onwards, they particularly emphasise the idea of electronic music studios as 'instruments'—a term also used in this context by Luciano Berio, among others—paving the way towards the concept of composed instruments: in the second half of the 20th century, electronic music studios provided invited composers with a technical environment they had to 'learn [how to] play' with the help of technicians (Schnell & Battier 2002: 2). In parallel to the electronic music studios being established as major production centres for compositions incorporating some of the most recent technologies, digital processors became smaller, faster, and affordable. Roughly around the same time, in the mid-1980s, established electronic music studios began to struggle,[1] complex performance environments using digital processors in real-time became the focus of interest as reflected, for example, by the relatively high number of papers published in the proceedings of the International Computer Music Conference 1986 in The Hague discussing real-time performance environments (see, e.g., Anderson and Kuivila 1986; Friberg and Sundberg 1986; Puckette 1986; Baisnee et al. 1986; Greenhough 1986). Many of these technical developments were closely related to artistic ideas, needs, or example applications. This connection between technology and artistic works—the framework and aims guiding the development of a technology—is not always easy to make out. For example, composer, developer, and music researcher David Wessel in 1986 presents an extension for embedding MIDI in a Lisp-based environment, showcasing a setup corresponding to his composition *Contact Turbulents* premiered the same

1 The RAI Studio of Musical Phonology in Milan, for example, went out of service by the end of February of 1983. According to Joanna Helms 'its instruments (and the techniques they necessitated) were widely considered obsolete.' (Helms 2020)

year, however without naming it in the paper (Boynton et al. 1986; Wessel 1986). Technical setups as well as technological developments thus cannot be regarded as completely independent from the music they are employed in, and the cultural and artistic context their genesis is related to.

Musical compositions likewise emerge within specific historic, cultural, and artistic contexts. In the context of western music, the term 'composition' stands for a concept describing an artistic idea containing specific and significant sound combinations which are according to musicologist Klaus-Jürgen Sachs prepared and elaborated before their performance, existing in a peculiar co-existence of notation and performance (Sachs 2016). Sachs here implicitly refers to a rather traditional understanding of western music and its framework. The creation of musical instruments is thus missing from his definition. In parallel, musicologist Helmut Rösing points out that from a systemic point of view, composing always takes place within a referential system consisting of social factors (as, for example, framed by traditional western music). In terms of a communication model, composing entails creating a reasonable and accepted connection between music and its socio-cultural environment. When understanding composing as acting within a social system, a musical work is created by a composer in dependency on the production situation and the production methods, as well as based on individual skills and the overall (socio-cultural, political and economic) working conditions; the emerging music becomes subject to perception and evaluation through performance or technical transmission (Rösing 2016). This approach assumes on the one hand that music—or at least the artistic idea in terms of the content to be communicated—derives from humans (which does not exclude non-human generated content which may in various ways be integrated), and broadens on the other hand the definition of what 'composing' means, also providing points of reference with respect to the idea of composed instruments, as compositional decisions can already take place when reacting to the production conditions. This can include defining the technological framework, designing the signal flow and integrating signal processing.

Many of the procedures assumed to be part of the compositional process can thus be seen as equivalent to the processes of designing the technical outline of a musical work and particularly of integrating live-electronic setups and interactive performance environments. The latter entails elaborating the emerging sound, which is expected to be repeatable but can differ between performances, and prescribing interaction—via the provided interface, and between musicians and sounds as well as between musicians and the audience, between all actors and the technical setup, as well as between sound and the architectural space.

There remain, however, some aspects that are not easily transferable between the concepts of musical instruments and composition. For example, musical compositions are assumed to manifest themselves at and within a certain time while musical instruments are considered to exist independently from a specific time

frame. For technology-based instruments, having an independent control and sound production unit, which Schnell and Battier consider a central feature of composed instruments, goes along with the option of changing the mapping. This raises the question which constellation can—if applicable—be considered 'the' instrument. A specific instrument can (primarily) be defined by its (hard- or software) interface-to-sound combination or by a specific preset and sample set which can be loaded into the setup. At the same time, samples and presets can be part of the compositional idea and not of the instrument design, for example when specific presets and samples are created and implemented for specific compositions. The outline of a technical setup does not necessarily imply how a sound is produced, meaning that Miranda's and Wanderley's 'sound production' applies to pre-recorded and pre-designed sounds as well as live generated sound, live sampling or real-time sound processing. In addition, the distinction between technical gear belonging to a composition-specific setup and devices used to adjust the overall audio of a performance according to the architectural space is not always clear. This applies particularly to devices such as microphones and loudspeakers which can serve, and are specifically used, for both purposes. Therefore, an important question to ask here is what parts of the technical equipment belong to a composition-specific setup. Does a certain setup provide a shell that can be adjusted for different compositions, or is the whole technical setup a complex instrument invariably linked to a specific composition? The same applies to form: does the interaction inherent to a setup account for the form of a musical piece, or do other elements constitute a formal structure? How does this relate to the possibility of using a setup developed for a specific composition to perform other musical works or improvisations? Who is considered composer and/or musician, or author of the (performance) setup?

Controlling composed sounds

Compositional ideas can manifest themselves in various elements of a musical piece including its setup. The implementation of technology can hence be done along two paths: firstly, following primarily (conceptual and aesthetic) compositional ideas, and secondly, meeting performance requirements, treating technology like musical instruments. Reading technology against the background of assumptions transmitted with traditional western musical instruments can thus help to pinpoint specificities of setups and reveal underlying expectations concerning musical structures, compositional approaches, and musical performances. This allows to discuss the question to what extent the artistic idea of a composition is inscribed in the embedded technology—or more precisely, to what extent the technical setup is designed based on compositional decisions. Miranda's and Wanderley's suggested scheme for digital musical instruments (Miranda & Wanderley

2006: 3) can serve as a point of departure for a more detailed look at possible structures of technical setups.

The starting point for the observation and a central feature of every musical instrument is the sound it produces. With technology in use, four basic processes for (technical) sound (re-)production can be distinguished: playback of pre-recorded or pre-designed sounds, (technical) sound synthesis in real-time, sound processing in real-time (modifying existing sound samples, live-sampled sounds or live sounds), as well as (pure) amplification of pre-recorded or live sounds without further processing. Mapping here is closely linked to the interface in use, especially as control interfaces may include gestural as well as more complex and indirect interactions. Besides the three elements mentioned by Miranda and Wanderley and depending on the range of interactivity within a setting, specifically created acoustic sounds (e.g. by acoustic musical instruments) as well as environmental (architectural) acoustic features can hence also be considered constitutive elements of a setup.

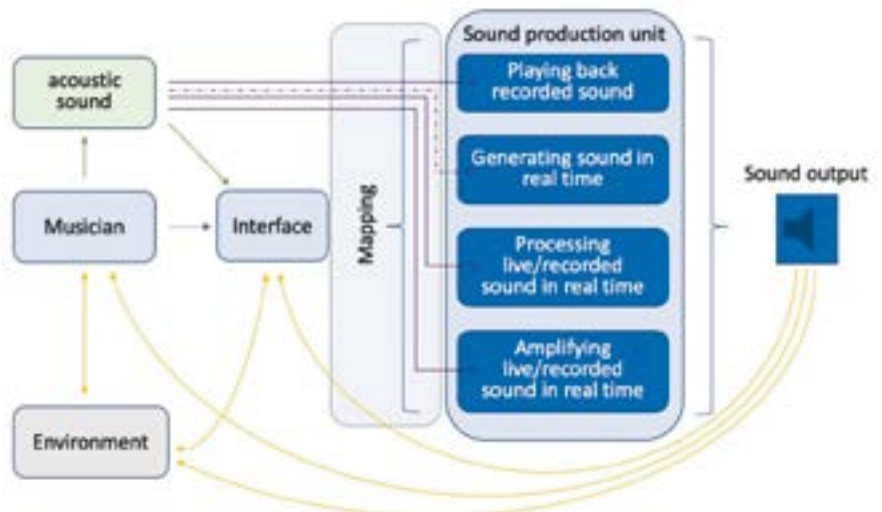


Fig. 1. Starting from a schematic outline of a musical instrument, this graphic shows different levels of interaction that can result in composed performance environments. The colours of the arrows stand for different levels of interaction: the direct influence of the musician via gesture (blue) and live sound (green), possible indirect influence of the acoustic sound on the sound processing (purple), and the possible lines of interaction between resulting sounds and agents in the performance space (yellow).

The resulting scheme, which centres around the 'sound producing unit', allows to point out compositional decisions taken with regard to the emerging sound as well as the sound control offered by technology that can be considered a composed instrument designed along a specific compositional idea. It becomes apparent here

that neither a generic structure for embedding technology nor a general way of implementing technology along compositional decisions exist. However, despite Vine's diagnosis that setups situated between instrument and composition 'frequently eschew the norms associated with traditional instruments' (Vine 2020), there remains a shared structure concerning sound production and control which seems fundamental to the idea of musical instruments.

Composed (with) technology

The complexity of the mutual relationship between compositional ideas, artistic processes and the technology involved becomes especially apparent in music-related performance settings. In contrast to traditional musical instruments, the handling of technologies cannot rely on (musical) norms, which in turn are to be expanded beyond extended playing techniques. Hence, for both kinds of instruments, the musician's role and actions are at the same time questioned and re-established. Musical and technical ideas influence both the structure of the performance setting and the role assigned to the musician(s). This includes the range of control regarding the instruments involved as well as the expected range of interaction, and therefore also shapes the way in which a composition and its performance setup are perceived. The compositions *Flute Control* by Thomas Kessler and *Dead Wire* by Iris ter Schiphorst present constellations in which one performer is responsible for an acoustic instrument and at the same time acts as a multivalent actor and mediator between sound, technology, and compositional idea. This rather narrow setting in its limited nature allows to focus on the role of the musician in outlining the variety of actions and interactions used to control acoustic and technology-based instruments and to discuss to what extent the resulting performance environment can be considered a composed instrument.

Thomas Kessler, Flute Control (1984/1988)

In *Flute Control*[2] for flute and electronics, Swiss composer Thomas Kessler focuses on the idea of creating a close musical interaction between the acoustic instrument and the electronic system. The original setup included a *Fairlight CMI IIX* synthesiser and a *Fairlight VT-5* voice tracker.[3] Created for the International Computer

2 For a detailed analysis of the composition see Toro Pérez & Bennett 2024, pp. 165–172 in this book.

3 In later performances, Max patches substituted the Fairlight devices. Kessler, who is named as author of the Max patches in 2017, in the program note thanks Beat Gloor (already mentioned in 1984 and 1986) and Dominic Kessler for helping with the programming; Eric Daubresse and Wolfgang Heiniger are named as IRCAM computer music designers (Isnard, n.d.).

Music Conference ICMC 1984 in Paris, the piece was the fourth of Kessler's eleven 'control-pieces', a series of compositions for solo instruments and live electronics composed between 1974 and 2005. *Flute Control* is dedicated to flutist Aurel Nicolet, who collaborated with Kessler during the genesis of the piece and played the premiere (Haus et al. 1985: 39).[4]

The composition centres around the actions of the soloist who controls all audible events: the live flute sounds including sounds created using extended playing techniques on the flute as well as sounds produced by the performer's voice (e.g. whispering), the playback of pre-recorded samples, and additional sound processing. Sample playback and processing are directly triggered by the flute sounds, as well as via a foot pedal. The live flute sound, originally tracked by the *Fairlight VT-5*,[5] is analysed taking into account sound parameters such as pitch, dynamics and timbre (Haus et al. 1985: 39). The analysis results, fed to the *Fairlight CMI*[6] as analogue control voltages, are used to control the playback of the prepared samples and the real-time sound processing. The programming of the *Fairlight CMI* is structured along so-called 'pages', control units in which processes, samples and presets can be arranged and stored (Grant 1985; 1984c). In order to expand the synthesiser's capacity, 'cards' (which appeared as additional 'pages') could be purchased. Kessler used 'Page R,' which offered both an eight-track sequencer and real-time processing, as well as graphic notation via the display (Dent 2019). This allowed Kessler to use eight parallel tracks for playing back prepared samples—eight voices which can be played and sonically altered at the same time—synchronised with the flute, and to embed the *Fairlight CMI* as a real-time sound processor. In the mid-1980s, the use of a *Fairlight CMI* was not a common solution for sound processing in the field of contemporary music (in contrast, the sampler is well-known for its use in Pop and Rock music), which is evidenced by the presentations of other projects entailing experimentation on sound synthesis given at the 1984 ICMC, emphasising in particular IRCAM's *4X* sound processor and the *Yamaha DX7* and *CX5M* synthesisers. Furthermore, the concert critique for *Flute*

4 The composition was revised in 1986 and presented at the Centre Pompidou in Paris by flutist Philippe Racine (IRCAM, n.d.).

5 The *Fairlight VT-5* integrates an 8MHz 68008 CPU for processing monophonic input signals. It is able to analyse the sound's pitch and harmonic content and send out analogue control voltages (later MIDI note values). Though its commercial sale start is dated to 1985, it is possible that Kessler used it—as mentioned in the concert critique—already for the premiere in 1984, as Greg Holmes states that the patent was already granted in February 1984 (Holmes 2006).

6 The basic hardware of the *Fairlight CMI*, a digital audio sampler built in Australia, includes a monochrome screen with a light pen for entering data and drawing waveforms, a calculator with voice cards and two 8″ disc drives, and a six-octave velocity-sensitive keyboard with a separate alphanumeric input device. The digital processing unit consists of a *Motorola 68000* processor which allows storing, playing back and changing up to eight voices with 16KB RAM each, and up to 8-Bit sampling depth depending on the pitch, as well as a maximum sampling rate of 24kHz. Memory capacity is 128 kilobytes, which limits the sampling time to four seconds (Grant 1984a; 1984b; 1984c).

Control published in the *Computer Music Journal* in 1985 explicitly points out the experimental setting of this piece as also resulting from the 'obvious limitations of a single Fairlight used as a real-time processor' (Haus et al. 1985: 39).

Central to the composition's conception, as indicated by the title, is the aspect of 'control,' which is present on three levels: the flute controlling the electronics, the soloist controlling the flute and the electronics, and the composer controlling the emerging music. Kessler carefully transfers the music he envisions into a detailed handwritten score, writing the live flute part in traditional western music notation, and adding graphical indications for playing the electronic part—volumes and fades effected at the Fairlight—structured along the sample track numbers (each track gets its line), bar numbers, sample lengths, and indications such as audible pitches and spoken word fragments. In addition, he prepares pre-composed material, which, according to Lev Koblyakov, happens only in a few 'control'-pieces (Koblyakov 1990: pp. 20). The flute player is required to control the live sounds as well as the pre-programmed sound sequences according to the score. Implemented to directly depend on the flute's actions, the *Fairlight CMI* no longer appears as a (stand-alone) digital musical instrument but blends in with the performance setup—the whole interdependent setup merges into an instrument-like setup played directly and indirectly by the flute player. At the same time, there is an invisible electronic musician, a person controlling and adjusting the audio volumes and overseeing the electronics; according to Lucas Bennett and Germán Toro Pérez, Kessler took on this role in most performances up to 2021.[7] While the composition's setup as well as the basic artistic outline suggest that full control is handed over to the soloist, a closer look reveals that the composition comprises a strict interaction plan bound to the functions of the setup. The soloist must closely follow the instructions to control the electronics and to be able to produce the intended combination of acoustic and electronic sounds. Implicitly, the flute player is thus also controlled 'by the electronics', more precisely by the way in which the interactivity between performer and electronics is designed within the composition. The requested interaction is directly embedded within both the structure of the technical system and the musical content. The sounds used for control are not clearly distinguishable from the overall soundscape, as the live sounds produced by the soloist overlap with the recorded samples, resulting in pure flute sounds as well as sounds from the flute's keys, wind sounds, fragments of spoken words, and extended playing techniques—live sounds and samples, and control sounds fuse into one interpretation. The flute implicitly becomes an interface controlling the electronics, whereas the electronically presented sounds appear as an extension to the flute. Quite unusual in this is the soloist's dual role as flute player and computer

7 The piece was performed in Zurich in 2021 with soloist Matthias Ziegler, flute, and Leandro Gianini, sound direction. [Editor's note: The current version allows the soloist to perform the piece without an additional musician in charge of the sound projection, thus achieving a fundamental goal of the 'control' pieces.]

musician controlling a complex composed instrument which in this constellation is solely dedicated to performing *Flute Control*.

Iris ter Shiphorst, Dead Wire (2011)

Dead Wire is a composition for solo piano, sampler, and live electronics by German-Dutch composer Iris ter Schiphorst, who developed the piece in collaboration with pianist Christoph Grund and the SWR Experimentalstudio (Musik der Jahrhunderte e.V., n.d.). Premiered in 2012 at Festival *eclat* in Stuttgart by Grund (IRCAM, n.d.), ter Schiphorst creates a performance setting centred around one musician, a piano player, who is assigned to control the acoustic instrument and the electronics, thus becoming soloist both at the piano and at the electronics. The performance setup consists of a live (acoustic) piano, two MIDI keyboards, two foot pedals, a computer running a Max patch, and a second computer running a Helion sampler software. One MIDI keyboard controls the real-time processing of the acoustic piano, the playback and spatial distribution of the prepared samples and the live-sampled fragments recorded using a foot pedal including a section for controlling the sound processing. The second is used to trigger the Helion sampler. In addition, a second foot pedal allows to control the output level. The setup also comprises a set of loudspeakers positioned in the performance space for evoking feedback sounds. (SWR Experimentalstudio 18/19, 2018; ter Schiphorst, n.d., ter Schiphorst & Grund 2023).

According to ter Schiphorst the piece is based on to two ideas: her interest in the phenomenon of clavichord-typical 'quivering'—a feature a common piano does not offer—and the overload of tasks facing the soloist, deriving from a plenitude of playing possibilities and control demands embedded within the compositional structure and the performance setting. While the first idea is reflected in the composition's title—the 'quivering,' as well as microtonal up- and down-movements are produced digitally using devices with non-vibrating 'dead' wires—the second is present in the subtitle of the piece: 'Psychotechnics of Keyboards/a Dissociative Fugue'. Both approaches are rooted in the solo instrument, the piano, and are fused in the sound material: live piano played at the keys, live sounds produced by extended playing techniques inside the piano, such as plucking and hitting the strings, singing and screaming (amplified and into the piano's resonant body), and piano samples which are either recorded in real-time or pre-recorded sounds deriving from another composition of hers.[8]

8 Retraceable due to the mentioned time of creation and framing, as well as confirmed by the programme note printed in the composition's score, the excerpts are taken from *Dislokationen* (2008–2009) for orchestra, solo piano and sampler, which was dedicated to, and premiered by, Christoph Grund (ter Schiphorst, n.d., Pöllmann 2011).

Similar to *Flute Control*, the whole piece centres around the soloist's actions. However, in *Dead Wire* complete control of all appearing sounds and involved parameters is denied. Besides following the playing instructions in the printed score, the soloist has to control three layers related to piano sound (live piano/extended sounds, pre-recorded piano samples, live sampling), one layer with processed and pre-recorded, non-piano sounds, the output level (to produce acoustic feedback in the performance space) and sound spatialisation. In handing over complete control to the soloist, the setup eschews controllability while implicitly offering a wider range of engagement, providing both contrast and support for sounds and actions. Live electronic processes and samples blur into an indirect but interrelated extension to the live piano. This impression also derives from the exposed role of the musician who audibly and visibly acts and interacts with the piano, the keyboards and the sounds. But while the soloist is formally intended as both piano player and multi-level electronic musician, he appears at the same time engaged in a mutual and interdependent relationship with the setup—a combination of acoustic instrument and technology. In this role, the musician is at the same time controlling and being driven by the composed multi-layered instrument-like setting—a constellation that reminds us of the interdependencies in *Flute Control*. While Kessler's soloist's playing appears to be responsively interlaced with the prepared samples fusing into a sound that appears to be completely controlled by the flutist, ter Schiphorst sees the samples from the orchestral concert as a 'resonant space' which can be comforting but also disturbing, and the soloist is (most of the time) not assumed to (completely) chime in with the emerging audio. Despite this, he is challenged to keep the complex setup under control and to eventually interact with the acoustic features of the performance space. Here, the performance space, which in Kessler's setup exists, too, but is not mentioned as a characteristic factor for the composition, becomes part of the overall setting and therefore part of the composed instrument, adding a hardly controllable layer that changes with each performance location.

Composing inside out

The relationship between acoustic and synthesised sound, traditional musical instrument and electronics, musician and sound output, as well as between audible sounds and environment—the (physical) space in which the sound emerges—appears as a central aspect discussed in the context of compositions incorporating live-electronic systems. Technology can serve as a catalyst for new tools of artistic expression and seems to invite artists to question traditional settings and assumptions about the created music, the musical performance, and, as Vine proposes, the concept(s) of musical instruments. Both examined works create on the one hand complex composed instrument-like performance settings, and on the other

hand put the relationship between acoustic instrument, technology, and performance space up for discussion. While in *Flute Control*, the electronics become an extension of the flute and at the same time the flute becomes the interface for the electronics, in *Dead Wire*, the three keyboards merge into one interface controlling a variety of piano sounds—however, they are only one part of the whole setting. The perception of the 'instruments' employed does not necessarily match the real technical setup, but is bound to the compositional, musical, and performative structure of the piece. In addition, the impression of a setting being interactive or instrument-like can be strongly influenced by the quality of the performer's (physical) actions: as composer and music researcher Cathy Cox emphasises, the range of physical gestures and the performing qualities of the musician can play an important role in the range of interaction in a performance setup as perceived by the audience (Cox 2004). In the examples examined, the role of the musician differs slightly, oscillating between a soloist in control of an interdependent system of acoustic and electronic sounds (Kessler), and a soloist technically in control of the setup but overwhelmed by the control responsibilities and required interactions (ter Schiphorst). However, both compositions foster the role of an exposed and physically present soloist, which contributes substantially to recognising the setup as a complex instrument capable of producing a conglomerate of prepared and live sounds related to the soloist's acoustic instrument.

Looking at the complex settings of the selected examples and taking into account the structure of musical instruments helps us to reveal details of inherent interactions and dependencies and offers one perspective for tracing the ideas envisioned by the composers. The concept of composed instruments helps us to ask questions about decisions concerning technical aspects that have both practical and artistic motivations and consequences. At the same time, this approach shows that complex setups cannot be fully grasped by applying the concepts of 'composition' and 'instrument'. The technology embedded in the setups is not an end in itself, but a substantial element that can foster (new) empowering ideas and interrelated performance settings.

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Transparent and Black Boxes
Potentials of Notation in Live Electronic Music

Kilian Schwoon

Since prehistoric times, making music has been part of human activity all over the world. By contrast, writing music has been a phenomenon limited to few cultures, and only in Western art music have scores become so dominant in musical practice and theory.

The belief in notation as a precise means of communication was particularly strong during the first decades after World War II. In the era of information theory, music was often seen as a 'message' sent from a composer to a listener by using notation, with performers acting as 'receivers' of such an encoded message and having the task of decoding it correctly. Standardising the notation of all kinds of music became an ultimate goal, as evidenced for example by the International Conference on New Music Notation in 1974 (Accornero 2022: 14–15, 20–22).

Even within the boundaries of Western art music, achieving this goal was undermined by various tendencies such as graphical notation or (semi-)improvisational practices. Live electronic music was another challenge to such a view of notation. For Luigi Nono, one of the early pioneers in this field, the whole concept of a 'score' had become questionable after several years of live electronic experiments and performances:

> I can no longer write a score. It is not by chance that *Prometeo* is in its fourth version. I am unable to set the material down definitively. Perhaps it is no longer possible to define. We can only project, suggest, attempt, discuss (Nono 2018: 360–61) [1987].

In his live electronic music, complex interactions between performers, machines and listening spaces produce ever changing results, the 'message' itself has become unstable and mobile. This blurriness may seem like a shortcoming, but Nono emphasised the 'enormous fascination' of the newly discovered musical practice (Nono 2018: 362).

Musicology has long relied on notation as a thorough means of encoding music. In line with Nono's remarks on notation as 'suggestions' and 'attempts', some researchers have recently begun to reconsider this paradigm. Floris Schuiling, in particular, has outlined an 'ethnomusicology of notation' with a 'broadly anthropological perspective on the social, epistemic and creative processes involved in practices of writing and reading music' (Schuiling 2019: 430). Drawing on

Bruno Latour's terminology (Latour 1986), he has noted how inscriptions can at the same time have a stabilising and a mobilising effect (Schuiling 2019: 434–35). For instance, by focusing on a score without studying other interpretations, one can freely imagine a sonic result and develop a new, even surprising interpretation. The performer can thus be seen as an autonomous agent in a network of relationships, as part of a 'notation culture' (Schuiling 2019: 431), and not merely as a decoder. Fragmentary, ephemeral notations are perfectly compatible with such an approach.

Notations of Fixed Media Music

In the past, live electronic music and music for tape (or other fixed media) have largely developed separately. Since the turn of the millennium, more and more composers have integrated fixed sounds into interactive performance environments, surely encouraged by the new technical possibilities of easy and precise sample control. Therefore, a brief discussion of the notation culture of fixed media music with a focus on agency will be relevant also for live electronic music.

The most common type of scores involving fixed sounds are 'performance scores', where precise synchronisation with live performers often requires some information about these sounds. Rather vague visual and textual cues are also characteristic for 'diffusion scores'; the development of fixed media music has given rise to the 'art of sound diffusion' (Smalley 1986: 92), that is the musical task of adapting and interpreting fixed sounds on a loudspeaker system in a given space. Some performers rely on such scores as mnemonic devices.

The art of sound diffusion is a typical effect of mobilisation through inscription, in this case on a recording medium. This is also true for another type of score that is not bound to the requirements of performances, namely 'listening scores'. These often quite elaborate transcriptions of fixed media music lead to a new practice of 'listening–reading' (Bayle 2007: 245) and thus a deeper understanding of this music. They are particularly useful for musicologists and educators, but of course also for anyone else involved in the creation, performance, and appreciation of fixed media music.

In the creation process, experts in music technology often play a crucial role. Their tasks may be written down in 'realisation scores', usually as a retrospective documentation of the technical devices and procedures employed during the production. New realisations based on such scores are rare, but besides being interesting for study purposes, they also enable rewritings, such as new digital versions of works produced with analogue technology.

The different roles described above are not necessarily carried out by different persons. For instance, it is very common in the field today for composers to also be experts in music technology and sound diffusion.

Agency and Blackboxing in Live Electronic Music

In live electronic music, the agency of performers of electroacoustic devices and of experts in music technology is quite different from what it is in fixed media music. Such performances entail not only sound diffusion, but also playing and controlling all sorts of electronic instruments, interfaces and processors. Expertise in music technology is again required during composition and when setting up a loudspeaker system, but also in other preparations for each performance and in monitoring a complex performance environment. Hybrid roles such as programmer and performer of electronics are common as well. Performers of mechanical instruments or singers may integrate some electroacoustic devices so deeply into their actions that even the distinction between them and performers of electronics becomes blurred.

In the sound diffusion practice of fixed media music, the mixing console and the loudspeakers can be regarded as rather passive tools, similar to mechanical instruments. At the same time, just as in instrumental music, there are complex interactions with the material properties of these tools, with the performance space, as well as with the audience. In live electronic music, these interactions are often further expanded through technology. A 'gradual model of agency' (Rammert 2008: 74–77) could be useful to describe a range of possibilities: from the causality of an instrument or a simple sound processing device to complex and hard-to-predict feedback systems to autonomous robot performances as an extreme example. At a time when 'conversational AI' is pervading everyday life, it seems appropriate to include non-human agency in these considerations.

Whether playing an instrument or interacting with a robot, performers will concentrate on their musical tasks and not on the inner workings of technology. Bruno Latour emphasised the importance of 'blackboxing', namely the process of hiding scientific and technical complexity that allows one to focus only on the inputs and outputs of a device such as an electronic musical instrument (Latour 1999: 304). But this process is also reversible: it is possible to disassemble black boxes and examine their components. These components can in turn be disassembled into smaller units or integrated into other black boxes (Latour 1999: 184–85).

When working with modular analogue synthesisers or audio programming languages, such processes of boxing and unboxing take place all the time. In visual audio programming, there are often even literally boxes that contain other boxes at various levels. 'Encapsulation' and 'decapsulation' are important principles of structuring signal flows and interfaces. The roots of such technical and creative processes go back to research around 1960, when Harald Bode developed a system with analogue units that could be freely interconnected. He was convinced that only an empirical approach of combining such modules would make 'novel performances' possible (Bode 1961: 264). Similarly, Max Mathews introduced the concept of 'unit generators' as building blocks in his programming language

MUSIC III (Roads 1980: 16). Their combinations were meant to 'produce sounds of almost any desired complexity or simplicity' (Mathews 1961: 679).

Modular aspects are also characteristic for live electronic performance environments. Notably, Harald Bode developed his concepts under the influence of a very special performer of live electronics: he credited the electric guitar pioneer Les Paul and his 'sound modification devices and methods' as the main source of inspiration (Bode 1984: 733).

The metaphor of blackboxing might help to discuss the problems of preservation, documentation and reperformance of live electronic music. Preservation of fixed media music is mainly concerned with the physical or chemical deterioration of the chosen media. Hardware and software for playback are relatively standardised and stable, but they must also be taken into account. The risk of hardware and software becoming obsolete is so much greater in the case of live electronics that such performances have an inherently 'transitory nature' (Schedel & Bressan 2019: 96). Theoretically, reperformances with 'period software/hardware' like in early music might be a solution (Schedel & Bressan 2019: 101), but with today's speed of technological innovation this is hardly a serious option. Of course, machines and codes should be preserved, but as a strategy for notation, in most cases it makes sense to avoid dependencies from specific computing platforms or software (Bernardini & Vidolin 2005: 7).

Such a strategy requires decisions about the elements of a performance environment that can be treated as black boxes because they are either standardised or easily described by their inputs and outputs. Modules using standard synthesis or signal processing techniques are candidates for such black boxes. For other modules that are used as black boxes during performance, it might be necessary to make them transparent and describe their components and internal interactions. In still other cases, semi-transparency may imply that some aspects of a module's inner workings are revealed, while others are left to interpretation. New ways of describing black boxes in natural language are on the horizon.

Current Practices of Notation

The repertoire studied and performed during the project *Performing Live Electronic Music* (ICST, Zurich University of the Arts, 2019–23) provides an excellent overview of typical strategies of notation since the turn of the millennium.

Some pieces actually require a surprisingly low degree of blackboxing. For instance, Ash Fure's *Shiver Lung* for septet and electronics (2016) focuses on basic electroacoustic devices, namely bullhorns and subwoofers (without cases).

The score includes pictures and hyperlinks to reference models, but they could easily be replaced by others. There is no need to explain the inner workings of these black boxes, just as there is no need to explain the mechanics of a cello.

The piece involves low frequency oscillations (constant at 10.67 Hz) sent to the various subwoofers and a few fixed sounds. These elements are briefly described in the score, like in fixed media performance scores. They are controlled by particular software (written in the programming environment *Max*), but as long as the sound files are preserved, the information in the score would be enough to reconstruct the control system, everything is very transparent.[1]

A spatial diagram of the overall setup in the performance space is included in the score, as well as precise instructions on the playing techniques and their notation. Especially the use of the bullhorns and the subwoofers is explained in detail. For instance, the subwoofer membranes are set into motion by the low frequency oscillations and the players then interact with their hands and various objects on the membranes (a prime example of using 'loudspeakers as instruments' (van Eck 2017)). The symbols resemble extended drum notation (cf. Fig. 1), and this is also the impression given by the overall score: it is basically comparable to other contemporary scores using extended playing techniques and unconventional instruments. When such a score is written as clearly as in this case, it is highly reperformable.

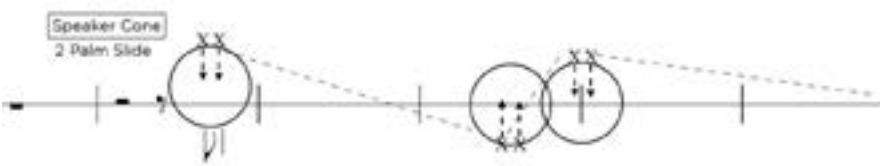


Fig. 1. Ash Fure, *Shiver Lung*, p. 6, © 2019 Henmar Press, Inc. New York. Reproduced by permission of Faber Music Limited. All Rights Reserved. [EP68702]

The score of Mark Andre's *üg* for ensemble and electronics (2007/08) looks very similar to his scores without electronics. Electronic cues, written much like rehearsal letters, correspond to certain preset configurations. There is an additional staff line for the electronics with very short descriptions of signal processing techniques (e.g. 'Faltung' for convolution), loudspeaker assignments ('LS') and dynamic indications for sound diffusion. Furthermore, the pianist also plays a sampler. The piano staff includes descriptions of the samples ('Koran Sure 2', for example) and again the speaker outputs (see Fig. 2).

These elements give some basic orientation to the keyboard player and the conductor, so that they have a vague idea of the result. But as the main score contains no further explanations, the degree of blackboxing is actually very high. It impedes a deeper understanding by a musicologist or anybody else who is studying the score. But there is a way to open the black box: the performance material

1 The only aspect not mentioned in the score is a very small amount of random amplitude modulation of the low frequency oscillations from bar 143 to 177.
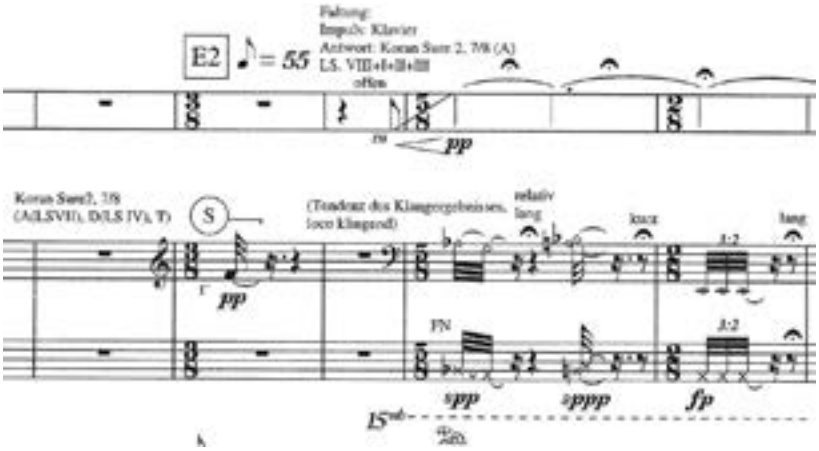


Fig. 2. Mark Andre, *üg*, p. 4. © 2007 Henry Litolff's Verlag Limited & Co., Kg. Reproduced by permission of Faber Music Limited. All Rights Reserved. [EP12489-R]

includes detailed information compiled by the team of the SWR Experimentalstudio that had developed and realised the piece together with the composer.[2] Live performance software (again written in *Max*) is provided, but there are also signal flow diagrams, tables with mixer configurations and other documents that would permit reconstruction with different tools.

All these documents are aimed primarily at experts in music technology, and the indications on the electronics staff are certainly primarily intended for the sound director (to use Karlheinz Stockhausen's preferred term for the person responsible for the sound diffusion and coordination of the live electronics team during rehearsals). These indications are minimal, but the sound director will usually add setup-specific information in the personal copy of the score, such as the channel numbers on the mixing console (García Karman 2013: 148–51). A sound director is aware of all the hidden technology, but in this case she or he even takes certain elements out of the black box and makes them visible for personal use.

Some similar principles of notation can be found in a smaller-scale piece like Hans Tutschku's *pressure – divided* for violoncello and 8-channel live-electronics (2015). There is a relatively 'normal' score with a staff for the violoncello and another one for the electronics. The electronics staff provides cues for electronic events, with brief descriptions of the signal processing methods and labels of sound files.

More like in *Shiver Lung*, a detailed description of the electronics is included in the score, open to everyone. It features photos of the equipment, a spatial diagram, and snapshots of the interface of the live performance software written in *Max*. There is even an entire section titled 'operating the Max/MSP patch' that

2 The score credits Joachim Haas and Michael Acker.

resembles a software manual in the sense that only the interface is explained, not the hidden parts of the patch (Fig. 3).

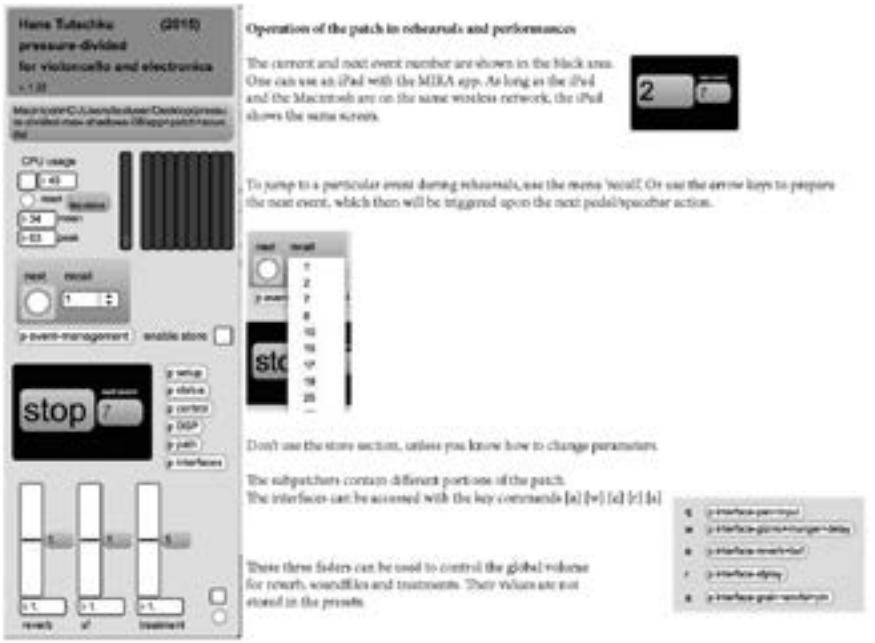


Fig. 3. Hans Tutschku: *pressure – divided*, introduction, p. 7. © Hans Tutschku

The documentation is so precise that no additional communication should be required, making the piece highly reperformable. The only crux is the *Max* patch which Tutschku relies on heavily. As a composer, performer and programmer in one person, creating complex *Max* patches is an integral part of his composition process. Hiding this complexity is important for performance, and much effort went into designing a practical musical interface and providing the 'manual' included in the score. However, documenting the patch in a way not depending on this software would be difficult and doesn't seem necessary to Tutschku, given the ubiquitous use of this programming environment (Tutschku 2020). This means that there is a high degree of blackboxing in this respect, also because the focus on the interface makes the low-level programming in *Max* difficult to read. Many aspects are thus rather opaque to the performer of the electronics and to the cellist.

In addition to many scores based on established notation techniques in contemporary music, the project *Performing Live Electronic Music* also saw some more experimental approaches. Clara Iannotta's *Outer Space* for four performers, lights and electronics (2018) incorporates the screening of the film by Peter Tscherkassky with the same title (1999), however, she wants to avoid an opera-like silent movie

setup. Instead, the musicians should play in the dark and their presence should be barely perceptible. Music stands with lights were not an option (Iannotta 2022).

Iannotta therefore developed the idea of 'vocal click tracks'. The performers, some with electroacoustic devices, are guided by fixed audio tracks containing clicks, but also spoken instructions like 'start to play the lowest note in 10″' or 'take the piece of wood to put on transducer 1'. There is a score with all these clicks and instructions, as well as hints at other prerecorded elements and notations of semi-improvisational structures that are relatively easy to memorise. After a rehearsal period using this score, the vocal click tracks provide enough guidance to the performers. The score can be put away and everything can indeed be played in the dark.

Media technology is fundamental here for a different kind of performance practice, with an extreme focus on listening. Despite the darkness, there is not much hidden technology, everything is rather transparent. But there is an interesting kind of blackboxing, as Iannotta uses video documentation of specific devices like a 'piano machine'. This may help to find alternative devices with similar qualities without worrying too much about the details of implementation.

Agostino Di Scipio's *Modes of Interference / 2* for audio feedback system with sax and live electronics (2005/06) also reveals a deep interest in new ways of listening and playing. More specifically, he speaks of a 'performance ecosystem' consisting of a performer, equipment and a room (Di Scipio 2018: 19–20; 2021: 185–86). The score in the narrow sense of the word is very short, comprising only two pages with a precise timeline and mostly verbal descriptions of actions as well as listening instructions such as 'wait for the sound texture to get thicker and stable' (cf. Fig. 4).

But of course, composing such a piece also means inventing and developing a system. Here, everything is documented in great detail, starting with an overview of the feedback loop, which is followed by a description of the technical setup in its sound engineering aspects. Then comes a long guide to saxophone performance and, like in Tutschku's piece, a manual of sorts for the live performance software. Di Scipio uses the open-source programming environment *Pure Data*, but he regards this only as a reference implementation. In fact, the score also contains detailed descriptions of the signal processing methods, with a block diagram of the full process (cf. Fig. 5) and explanations of all the modules involved. Some graphical elements of the *Pure Data* interface are used, but for non-obvious names of object boxes there are always further explanations. The degree of transparency is extraordinary, whereas the level of expertise required to implement a new live performance software is obviously quite high.

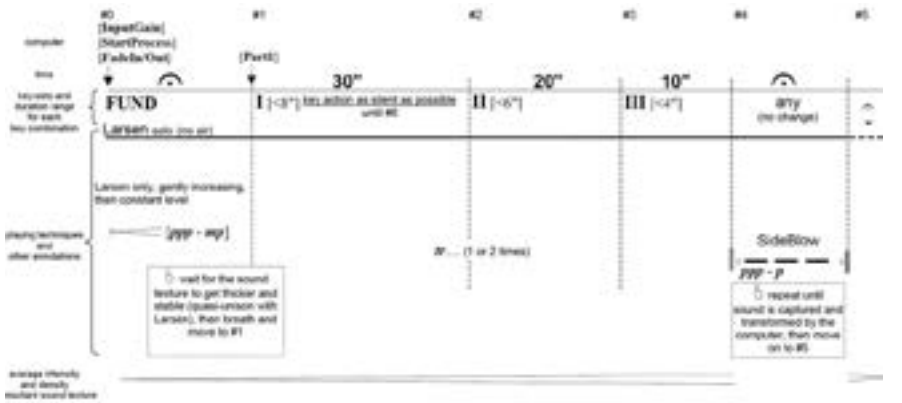


Fig. 4. Agostino Di Scipio, *Modes of Interference / 2*, p. 11. © Agostino Di Scipio

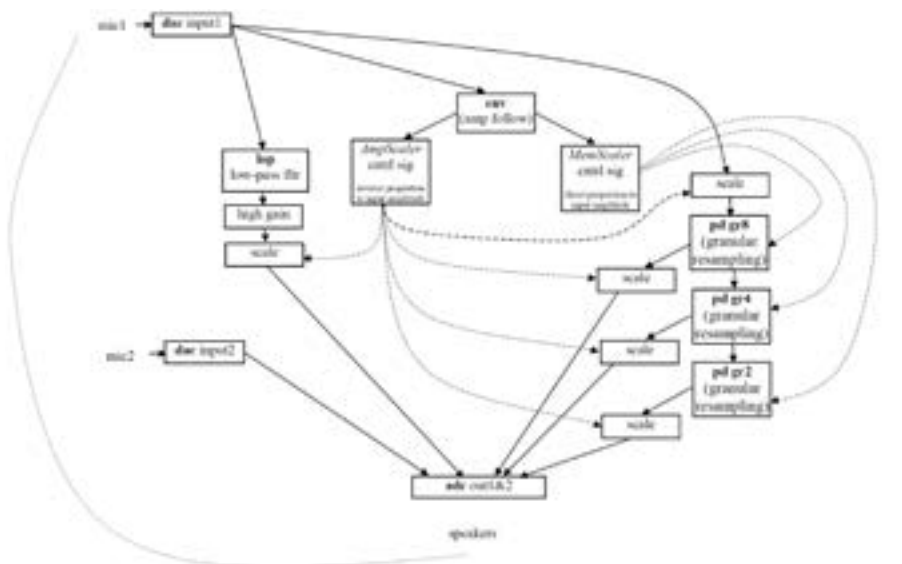


Fig. 5. Agostino Di Scipio, *Modes of Interference / 2*, p. 13. © Agostino Di Scipio

The Power of (Human-Readable) Text

The scores discussed above exhibit various types of blackboxing characteristic of live electronic music. Composers tend to focus on the actions and interactions strictly necessary for the practical realisation of the pieces. Even fixed sounds are usually only represented by short descriptions, as they are often just triggered without a need for performers to interact with them. With so much hidden information, it is rarely possible to 'read' the electronics along with a performance in a meaningful way.

On the other hand, the instructions concerning electroacoustic and computing devices differ significantly in these scores. The amount of blackboxing greatly influences how reperformable a piece will be. But it is not only a question of futureproof documentation: In Agostino Di Scipio's *Modes of Interference / 2*, the sax player must be very much aware of what is happening technically and acoustically in such an audio feedback system. The way the entire score is structured allows the performer to study it in varying depth depending on his or her individual knowledge. Performance practice aside, these aspects are also simply very important for understanding the piece (and thus to musicology and education, for example).

Nevertheless, it is not always the best idea to describe every detail in a score. Some further concepts from Floris Schuiling's theory of notation cultures may be helpful here, especially the notion of 'entextualisation'. With this term, he refers 'to the social processes by which people determine what is "part of" or "inside" a musical text' (Schuiling 2019: 443).

If Luigi Nono felt unable to define such a text, it was perhaps also because he was part of a notation culture that expected him to produce a 'complete' text. In live electronic music, there are certainly more and different agencies involved in entextualisation than in other music. Negotiations take place not only between composers and performers of mechanical instruments, but they also involve experts in music technology and performers of electronic instruments.

It is often not easy to deliberately leave gaps and use blackboxing in a musically meaningful way. But it can offer new perspectives: 'the "incompleteness" of notation […] should not be understood negatively, but as an opportunity affording creative engagement by the performer.' (Schuiling 2019: 445) This creativity extends to future developments in music technology, to the possibility of adapting or even 'reinventing' a piece technologically while remaining true to the essence of the original text.

Human-readable texts of live electronic music may encompass five-line notation, verbal instructions, diagrams and so on. Digital means offer the possibility to go beyond sheet music towards multimedia and interactive scores, and there is an active research community investigating new technologies for music notation.[3]

A practice of 'listening–reading', as it has emerged in fixed media music, would also be desirable for live electronic music. Reading this music, one should be able to understand the core musical text, including fixed sounds, live synthesis and signal processing aspects. Automated transcription techniques of fixed sounds and control data may improve in the near future. This would allow to more efficiently create 'study scores' providing substantial information about the live electronics. For conductors and sound directors, this might be too much information

3 The proceedings of the International Conference on Technologies for Music Notation and Representation (TENOR, since 2015) provide an overview.

for a practical performance situation. In this case, they could use the study score for their personal preparation and a reduced one for rehearsing and performing.

AI-driven code generation will drastically change the way we assign tasks to machines (Welsh 2022). It is not far-fetched to predict that the inputs and outputs of many black boxes in live electronic music could soon be described in natural language, with AI turning these prompts into specific software. This new form of entextualisation would not only drastically simplify reperformances in different technological contexts, but would also make these black boxes much more transparent to non-experts, especially musicians and musicologists.

From a broader perspective, there is an abundance of music today that is not based on notation cultures at all, or in which notation only plays a minor role. This is true for aural music traditions, but also for many current popular as well as experimental performance and recording practices. Moreover, non-human agents such as robots or avatars surely don't need to read music.

The composers of the pieces discussed in the previous section all grew up in the notation culture of Western art music and continue to rely on its basic principles. Even if writing music with live electronics creates new challenges, they believe, consciously or not, in the power of entextualisation. They are active in complex networks of people and technologies differing substantially from those in both instrumental and fixed media music. Notation is deeply embedded in all these relationships, but the focus on practical issues often results in opaque commands and labels for electronics, detached from the listening experience.

An inner listening while reading a score can actually be a very fulfilling musical activity. Maybe there should be more 'pleasure of the text' in live electronic music, to borrow Roland Barthes' term (Barthes 1973). This could help to create a vibrant culture of notation and performance of this music in continuous transformation.

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Fragility & Ephemerality
Re-staging Live Electronic Performance Environments

Lucas Bennett & Germán Toro Pérez

Over the course of the four-and-a-half-year project *Performing Live Electronic Music. Technical and Aesthetical Challenges in the Digital Age* (2018-23), the selected repertoire of pieces was studied according to a consistently applied methodology, assuming in principle that for all of them documentation and preservation as the groundwork for successful future re-performances was of the same urgency and relevance. Looking back at the 27 individual pieces, it becomes clear that the perspectives for successful re-staging in the future vary greatly throughout the repertoire list and in some cases even seem quite doubtful.

The following remarks on fragility and ephemerality and the re-staging of live electronic instrumental environments want to offer some possible explanations for this. They are necessarily incomplete and are above all meant to invite discussion.

Why is the question of preservation, updating and re-performance of live electronic music often so challenging? There are of course well-known technical reasons related to the diversity, complexity, variability and relatively short availability of technology; there are also organisational and logistical ones, given the increasing number of works in relation to the limited resources of institutions such as archives, studios and publishers, etc. Limited access to materials, many of which are held in private archives, also plays a role.

These issues have been broadly discussed and given rise to different approaches to their solution, the emphasis generally lying on the preservation of the material basis and on updating systems to accommodate current hardware and software environments.

However, relating to the problematic at hand, relatively little attention has in our opinion been given to questions of historic context and aesthetics. We feel that the problem goes beyond questions of technical obsolescence and is in fact deeply connected with the very essence of this art form.

Accordingly, we want to take another look at these issues. In the following, we will discuss three examples studied in the course of the project, one with relatively straight-forward, the other two with somewhat more ambiguous implications, with a view to questioning—to some extent—the sense of urgency of preservation 'per se' that had to inform the methodology of the project and to enquiring what they can tell us about the constitution of this art form.

Case number one: Thomas Kessler's Flute Control

Around 1984 Swiss composer Thomas Kessler was approached by flutist Aurèle Nicolet to compose a piece for solo flute incorporating the then recent *Fairlight CMI II*, CMI of course standing for 'Computer Musical Instrument', a groundbreaking digital synthesiser, sampler and audio workstation, which the composer had at his disposal (Kessler 2021a; 2021b).

The resulting piece was to be the fourth of Kessler's 'control' pieces, a series he began in 1974 with *Piano Control* for piano and live electronics and which has gone on to the twelfth piece *Accordeon Control* from 2017. In these pieces, Kessler, who had since the nineteen-sixties worked extensively on performances incorporating (analogue) synthesisers, aims to give the soloist a high degree of *control* over the live electronic system and the overall sound, a goal which he puts into contrast with a sound diffusion centring around the mixing console and largely beyond the musician's control (Meyer 2008: 17; Kessler 2021a: 18'10''–19'00'').

Back to *Flute Control* and the *Fairlight CMI*: This device offered a most impressive range of functionalities, most spectacular of which was an analysis module capable of detecting the four parameters pitch, amplitude, timbre and attack, and a programmable composition environment using LISP-like commands. The piece's realisation reflected the machine's capabilities, such as being able to incorporate eight independent voices, as well as its limitations, such as 8-bit resolution and a mere 128KB memory, the latter leading Kessler to work on a 'micro level' in the realisation of the electronic part, using short samples of text snippets taken from Baudelaire's poem *Invitation au voyage*, among others (Kessler 2021a; 2021b). A first version of the piece was soon commissioned by IRCAM and developed together with Aurèle Nicolet, both experimenting with playing modes to trigger and manipulate events in the electronic part. It was also Nicolet who spoke the text snippets that Kessler took as point of departure for developing the electronic part. However, the piece that was eventually premiered in 1986 was a further developed and expanded version realised in close collaboration with flutist Philippe Racine (Kessler 2021a; 2021b).

While *Flute Control* had seen many performances using the Fairlight System (see Fig. 1), to the best of our knowledge up until the early 2000's, the electronic system was eventually ported to Max for practical reasons. It was this version that was the basis for Matthias Ziegler's performance and recording (Toro Pérez 2023) within this project in May of 2021.

How do the Fairlight and Max 'versions' compare to one another? First, on a technical level, it should be noted that with the Fairlight, the content of the eight voices would essentially be re-computed during each performance according to the code in the programming module. In the Max version, the corresponding segments are simply sound files (which would not have been possible on the Fairlight). However, the Max version uses the original material and accordingly,

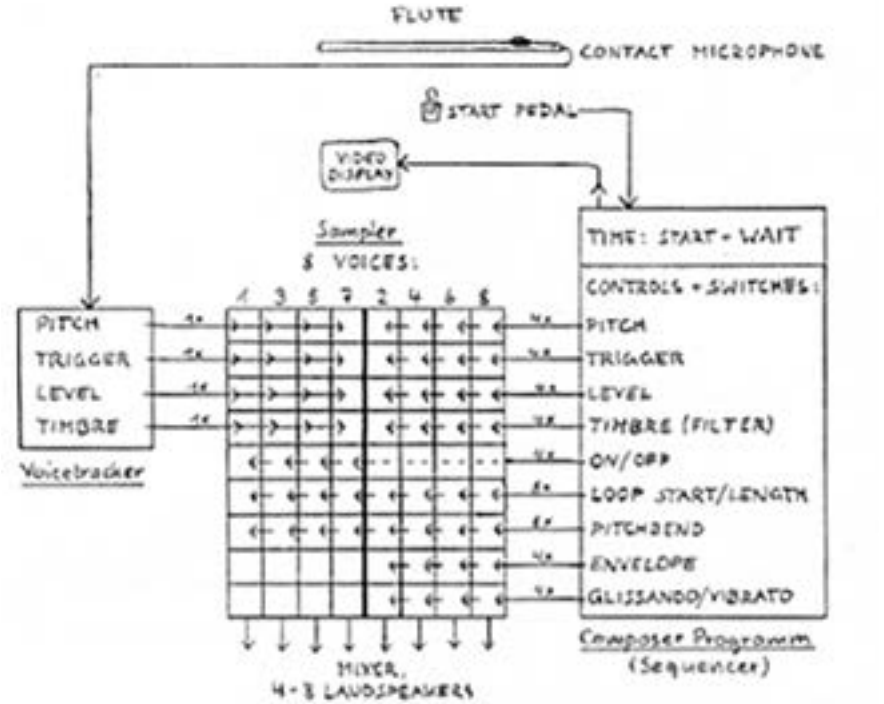


Fig. 1. System schematic for *Flute Control*. Whereas the first version had included a pedal and a keyboard for the flutist to operate during performance, the latter was discarded for the second version © Thomas Kessler

although some performers are said to have commented on subtle differences in certain sound events, the overall sonic character of the piece remains much the same, which the composer thus confirms: 'It does not sound better than back then.' (Kessler 2021a: 26'40''–28'18'')

The really *important* difference between the versions lies in the shift of control towards the performer, which the Max version affords. With the Fairlight version, the soloist would control the electronic part through his playing with the system behaving for example according to the threshold settings that had been programmed. The performer was, however, not able to control these settings himself, let alone in performance, but Kessler would take care of this. With the Max version, settings for all cues can be adapted to an individual performance by the performer on his or her own computer. While this in no way means that working with a sound engineer in preparing these settings and judging the acoustics in a performance space becomes unnecessary, it does give the performer the opportunity to get to know the system very intimately and develop an 'ideal' interpretation, a process that using the Fairlight would face constraints in terms of flexibility, availability, and time. With the Max version, the performer can do this

independently at home (Kessler 2021a: 33'04''–57'00''). Ideally, Kessler pointed out in a conversation during the project, the sound engineer would not even have to intervene in any way once the initial settings are found in a given venue. In smaller venues, musicians might even attempt to perform the piece alone, e.g. with four speakers instead of six (cf. Kessler 2021a: 37'25'').

Kessler, however, stated that this particularly successful example of a piece's digital update could not be applied to all of his control pieces due to the aesthetics of some of them, e.g. *Piano Control* (1974) where the soloist plays the piano and operates a synthesiser at the same time—an essential dramaturgical and performative aspect shaping the musical and sonic development (Kessler 2021a: 31'05''–32'15'').

However, notwithstanding subtle differences, it would clearly seem that for *Flute Control* the updated, ported version comes closer to the goal of 'giving back everything to the performer' which was envisioned in the original concept. Said Kessler in a conversation with musicologist Thomas Meyer:

> My style of working with live electronics is somewhat different from that of Stockhausen or Boulez, whom I admire very much and whose works I have performed with students. There, everything is mixed together, no matter how many musicians are involved: The sounds enter through the microphones into a big sound factory, into a mixing console and are distributed back into the room. In my solo pieces, on the other hand, the soloist controls the electronics - the synthesiser, later the computer - himself with a pedal, even if it's a bit tedious for him. Nobody sits in the hall and manipulates a bit, but the musician knows exactly: this is my sound. He can set it up at home, rehearse it and listen to it. (Meyer 2008: 17)

Case No. 2: Gerhard E. Winkler's KOMA[1]

The development of increasingly powerful computer and software systems in the 1990s made it possible to use computationally intensive processes in real time and thus also to apply complex formalised concepts in live electronic systems. Interaction became a central concern of the new digital real-time culture. Real-time systems were to enable a direct interaction between man and machine and a liveliness in dealing with electroacoustic instruments that was to be on a par with instrumental music.

The young digital technologies also allowed building network structures and the application of new forms of visualisation. Similar to the context of open forms, especially in the 1960s, questions of notation also came to the fore in connection with live electronic interaction systems.

In the work of the Austrian composer Gerhard E. Winkler, complex dynamic systems have played an important role since the early nineties. In various ways,

1 This presentation of *KOMA* is based on (Toro Pérez, G, Bennett, L, Färber, P, Gianini, L & Hidalgo C 2021), which first appeared in ICST's *Electroacoustic Performance Practice Database*.

Winkler has installed a mathematical model as the core of a reference network within a live electronic feedback system, in which the piece will then emerge as the result of interaction between musician and software. Winkler intends to create

> […] a communication situation between human (musician) and machine (computer) in which both 'partners' interact in a complex, nonlinear way […]; the musicians emit signals to which the computer responds in a nonlinear way and in turn emits other signals that cause changes in the parameters of the score and the live electronic sound transformation. (Winkler 2004: 1)

On a symbolic level, such systems take on the function of nature-like world models for Winkler, through which a process of cognition can be initiated. Winkler:

> I use complex dynamical systems [...] not only to create a unique and challenging creative experience, but also because I have a deep interest in understanding the behaviour of these systems and their commonalities with nature. We must carefully examine the interdependencies between the smallest ecological network and global interconnections in order to survive in a world that is more complex than we can imagine. (Winkler 2010: 100)

In his piece *Emergent* for 13 players, computer-controlled synthesiser and live electronic sound transformation from 1993, Winkler had developed a corresponding system for the first time. In doing so, he transferred a possible run-through of the system into a score after its interactive realisation. The resulting 'work' thus remained fixed in writing and separated from the multiple possibilities of the system.

Doubts about this concept of permanently fixing a variant led Winkler from 1994 onwards to an expanded, one might say 'permanently open-ended' approach (Winkler 2010: 89). In his 1995-96 piece *KOMA* for string quartet, real-time scores, light-colour control, and interactive live electronics, realised at IRCAM in Paris, no run-through variant is fixed; rather, each realised interaction with the system represents a unique version. In a feedback loop, the four musicians play from the system-generated notation, what is played, is fed into the system, the system analyses the signals and controls sound transformations, changes in the state of the system, and in turn the output notation for the strings.

The core of the programming is based on the 'Butterfly' model, which is part of the catastrophe theory of French mathematician René Thom, among others, and which, put simply, depicts the change between extreme states of a system. The title of the piece *KOMA* is on the one hand an acronym for 'Catastrophe Theory Organised Musical Architecture', but at the same time refers to a poetic concept: Koma is the luminous shell around comet nuclei that is excited by the solar wind. Winkler compares the musicians in the middle of the hall with the comet nucleus and the sound transformations in the room with the luminous shell. Finally, the Greek word 'coma' means deep sleep and is meant to refer metaphorically to the

only apparent freedom of those acting in the network (Winkler, *KOMA* (score), introduction).

In *KOMA*, the notation of the piece shifts from the score to the system. Therefore, when Winkler describes authorship in this context as the mere creation of a set of possibilities (Winkler 2004: 5) it becomes clear that the system itself, and not one of its realisation variants, now basically represents the work.

Twenty-six years after its premiere, *KOMA's* electronic system does not run on current hardware and software configurations. In our project, we set out to reconstruct the system with subsequent rehearsal and performance of *KOMA* in the summer of 2019. This was made possible not least thanks to the generous support of Gerhard Winkler and Serge Lemouton of IRCAM, who had programmed and set up the system for the first performance.

While it was first intended to reconstruct the system so as to allow for it to run on today's hardware, this plan eventually had to be abandoned. In view of time constraints and of the complexity of the system, it seemed more feasible to set up a system resembling the original as closely as possible, using, among other equipment, Power Macintoshes from the 1990s. This would make possible a thorough exploration of the system in rehearsals, and, in a next step, porting it to current environments.

After the rehearsal process, workshop sessions with the composer and a concert performance, this last step was not undertaken. While re-programming *KOMA* would essentially seem feasible, the fact that this is a complex, highly individual, singular system would make this a challenging and time-intensive task. Also, the rehearsal phase had shown the necessity for the live electronics performers to intervene in the system's workings on several levels, raising questions about the prospect of staying true to the original concept of an autonomous system.

However, it seems that there is yet another obstacle intrinsic to the work, having to do with the fact that in *KOMA*, the composition essentially resides in the system itself. We gradually came to feel that if the system were to be transferred to currently available hardware and software, such an update would really amount to a *new version of the work*, different from that of 1996, questionable conceptually and performance-wise. How so? We believe that since in *KOMA*, the electronic system and the work are in fact congruent to such a degree that the technological context of the time would have been an essential factor in appreciating the work in full. It seems to us that the system and its possibilities commanded a fascination very much connected to that particular moment in time when it became possible to realise and to run a spectacular, really speculative experiment of sorts and presenting this to the public. While the concept behind *KOMA* has certainly not lost any of its appeal and is an important historical landmark of live electronic music—consider the composer's remark that our undertaking was essentially an 'archaeological' one (Winkler 2019: 2'08''), we would dare say that the mere sense

of excitement connected to a then avant-garde technology allowing to stage and demonstrate such a concept cannot actually be recreated.

Case No. 3: Maura Lanza's & Andrea Valle's Regnum Animale

Regnum Animale was the first piece of Lanza's and Valle's cycle *Systema Naturae*. Commissioned by the Milano Music Festival, it was first performed by Repertorio-Zero in 2013. Its core musical concept is the interaction of acoustic instruments, here a string trio, with what the composers refer to as a 'residual orchestra' (cf. Valle 2015) consisting of discarded, re-used electromechanical objects controlled by computer and synchronised with the instrumentalists by a click-track, both reproducing a fixed score.

The cycle draws inspiration (and its title) from Carl Linnaeus' (1707-1778) *Systema Naturae* from 1735, which presented a classification of animals, plants and minerals (Lanza & Valle 2017: 1). Accordingly, the pieces following *Regnum Animale* were *Regnum Vegetabile* for sextet and 30 hacked hairdryers from 2014 and *Regnum Lapideum* for septet and 25 objects from 2016. The concluding piece *Fossilia* from 2017 combines all the preceding instruments and objects. Another source of inspiration were medieval catalogues of living things such as Bestiaria and Herbaria, the whole piece thus forming a 'catalogue' (Valle & Lanze 2017: 1). *Regnum Animale* consists of 28 pieces, each lasting 45 seconds.

The minute study of the specific objects, among them electric knives, turntables, electric shavers and many more, and their sonic properties and possibilities, spectrum, dynamics and rhythm, led Lanza and Valle to integrate them into a classification system much like that for music instruments by Hornbostel and Sachs (Valle & Lanze 2017: 2). For example, under the category of Idiophones, we find among the objects a 'Rasoio' (an electric shaver buzzing in a metal box with buttons) or a 'Meshugghello', an AC doorbell, to name just two. While there is a distinctly ironic touch to some of these names, the systematic of sound bodies making up the 'residual orchestra' makes in fact perfect sense and is highly consequential.

Initial work on *Regnum Animale* entailed the close analysis of the sonic properties of the acoustic instruments and the objects, the goal being, put simply, to find common ground between the two, leading Lanza and Valle to explore and use the basic musical potential of the mechanical objects, while the instruments would be treated 'in a more object-like fashion', using non-classical playing and preparation techniques (Valle & Lanza 2017: 2–5).

The compositional process entailed a particular workflow with a shared working environment between the two artists covering the design of the electromechanical instruments, algorithmic composition, automated notation generation,

real-time control of the objects and the synchronisation with the instrumental ensemble (Valle & Lanza 2017: 5–7).

While preparing our workshop and the concluding performance of *Regnum Animale* in May of 2021, close collaboration with Mauro Lanza and Andrea Valle proved essential from the beginning, for example in correctly applying the preparations for the strings, which demands a great deal of precision. And although it is possible for the instrumentalists to practice without the objects using a particular patch and audio file simulations, the setup of the residual orchestra was done, in fact had to be done, by Andrea Valle and Mauro Lanza themselves. The intricacies of the devices themselves, judging problems such as unwanted resonances on the podium and the overall behaviour of the objects requires great experience in handling an array of non-standard devices. In the performance, it was Andrea Valle who would operate the control computer and initiate each section, while our sound engineer was in charge of the amplification of the instruments and the objects.

All this raises questions concerning the long-term sustainability of a piece such as *Regnum Animale*. This hinges above all on the availability and operational state of the electromechanical devices. At first glance, the use of ultra low-cost objects might help to ensure that these remain in supply for a long time to come, however, one has to bear in mind that these are really individually adapted, singular objects. They are quite fragile and will fail at some point. As has been mentioned, the core concept of the piece requires the instrumental and mechanical parts and respective sonics to approach each other and to enter into a real dialogue, requiring the devices to operate precisely.

Such questions were discussed with Lanza and Valle during the workshop. While they agreed that it might become difficult in the long run to obtain the same objects in order to reconstruct one of the residual orchestras, they pointed out that starting out from the existing documentation, a re-creation of the work might eventually lead to similar results (Lanza & Valle 2021a: 39'50''–40'35''). However, as it stands today, we would maintain that we find it difficult to imagine that the experience of *Regnum Animale*—so closely linked to the performance practice of Lanza and Valle—could be successfully recreated in the long term in their absence, once the original residual instruments with their specific aura and sonic profile start to deteriorate.

In fact, this specific aura will at some point be lost, because even if the objects' maintenance could be ensured, and even if the knowledge about the 'authentic', intended sound could be preserved, the context that makes the objects special and meaningful to us—many of them being still well-remembered daily-use appliances that carry all sorts of associations—will fade away and thus, the lively, emotional 'resonance' they produce in us will eventually be replaced by a historical understanding of them.

Conclusions

In summing up, while a piece like Thomas Kessler's *Flute Control* can be taken as one of several successful instances of live-electronic re-staging studied in this project, in fact even enhancing the original concept of control intimacy, this work, too, is still not guaranteed a long-term existence. However, it proves less dependent on a specific material-technical constellation at a specific point in time, which is essential for *KOMA* and *Regnum Animale*.

We would observe that live electronic music, with its multiple connections to technology, is generally materially entangled with the world, with constellations and situations existing at a certain point in time conditioning the music's questions, interests, and impact. Where, as in *KOMA* and *Regnum Animale*, its instruments are not merely objects but complex singular systems—thus forming an essential part of the work itself—the work depends on the specific, singular setup and, in many cases, the materiality and the contextual references of these instrumental constellations. We would argue that because of this, the time window for impact and full appreciation of such works may be limited. On the other hand, while they are in this way ephemeral and fragile, their 'entanglement with their world' allows them to unfold a particular aesthetic and epistemic impact in their time.

Obviously, art is not as robust and timelessly expressive as we would sometimes like to think, but a fragile cultural phenomenon conditioned by its historical context. In principle, the question of time and context windows in which works exist arises for all music. Think of liturgical music performed within a concert context or baroque works performed in the concert hall. There are however gradual differences. Live electronic music seems to exhibit this dependence on the world to a particularly high degree, which is both its strength and limitation. We must take note of this and ask ourselves whether it is necessary or even possible to extend its lifespan in all cases and at all costs. This does not mean that we should not care about its preservation. We must however also accept its inevitable eventual disappearance and understand this as a call to sharpen our awareness of this art form and experience it in the here and now.

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Combined Methods to Study Collaboration, Co-Creation and Collaborative Performance in the Digital Music Era. Three Case Studies between Oral History and Source Criticism

Laura Zattra

1. Introduction

One of the most interesting aspects of the almost seven decades of development of digital music is not so much the fact that new instruments have continuously been created, but the fact that there is a machine which is capable of defining its own instruments. The computer is an instrument for composition as well as a medium; it is used for creation, production, reproduction, and storage. Being a 'limitless' instrument, the computer and its software enable several (infinite?) possible attitudes. Someone can be attracted by the palette of sounds tools to combine and transform them, or by the possibility of considering them an alternative to human musicians, or by the computer's ability to formalise compositional processes, etc. This unlimitedness, combined with the complete freedom involved in artistic creation, has been channelled into equally unlimited approaches to digital creativity. As a consequence, every creative process inevitably produces a considerable number of sources depending on the machines and instruments (each with its own 'languages' and technical functioning), the performers (musical assistants, computer music designers, musicians) and, of course, the creators who can be composers, sound artists, or other, who 'direct' this complex process.

This chapter considers my experience conducting research around three case studies that provide excellent examples of different approaches in the use of computers and digital instruments. I chose these works not only because they belong to the repertoire studied within the project *Performing Live Electronic Music* developed at the Institute for Computer Music and Sound Technology (ICST) of the Zurich University of the Arts (ZHdK), but because they represent three distinct examples of collaboration and co-creation that have produced diverse sources and different modes of teamwork and involvement of the actors (human and non-human, with different roles and positions within these networks). The three examples provide an opportunity for comparative study and analysis, and lead to an attempt at mapping a (albeit incomplete) scenario of different strategies of composition, co-operation, self-acknowledgment, and self-archiving. Occasional discussion of other computer music works will help to broaden my line of reasoning.

The works considered here are Fausto Romitelli's *Professor Bad Trip: Lesson I* for eight players and electronics (1998); *Regnum animale* for amplified string

trio and electro-mechanical devices by Mauro Lanza and Andrea Valle (2013); and Clara Iannotta's multimedia project *Outer Space* for baryton sax, percussion, electric guitar, one objects performer, amplified grand piano, midi-keyboard, live video and live electronics (2018).

The first work is characterised by a spectral music aesthetic, in which the building and fusion of sounds mixtures hybridise techniques typical of avant-garde electroacoustic music with cross-gendered electronic music, incorporating loops, riffs, citations from rock, pop, etc., and the use of instruments such as the electric guitar, rarely used in avant-garde music (Michel 2005; Kaltenecker 2014; Decroupet 2018; Moroz 2020). In this chapter, I base my discussion particularly on the crucial role of computer music designer Laurent Pottier, who assisted Romitelli during the creative process and has been in charge of performing the live electronic parts in concerts from the first performance onwards. Pottier was not involved in the study/performance at ZHdK but is a fundamental witness to this creative process. The second work, *Regnum animale*, is the first part of a cycle of four 20-minutes compositions entitled *Systema Naturae* written by Lanza and Valle for various instrumental ensembles and electromechanical setups (Valle & Lanza 2017; Guidarini 2021). Commissioned by Milano Musica Festival and first created in Milan in 2013 by the ensemble RepertorioZero, *Regnum animale* features a string trio and 25 mechanised objects controlled in such a way as to create events, explore their spectra, and organise their dynamics; the musical instruments are also treated more like 'objects' to be explored than as traditional musical instruments, thanks to the use of numerous extended techniques. Like the other parts, the piece is organized as a 'catalogue' (in the Medieval meaning) of short pieces with invented Latin names (for the cycle the catalogues that inspired the two authors are *bestiaria*, *herbaria* and *lapidaria*). The musical cycle offers the audience a strong visual component thanks to the objects placed on the floor. Finally, *Outer Space* by Clara Iannotta, commissioned by the Darmstadt Summer Course, also develops around the visual component, in this case a short film with the same title by Peter Tscherkassky, which has become a source of inspiration for Iannotta on visual music (on her personal website, she includes this piece among her interdisciplinary works) (Iannotta 2018; Accornero 2021; Ballard 2021). The work integrates the ensemble's musicians into the film in the sense of a musical painting of sorts, composed by her through playing with rhythm, noise, dynamic of the visual, synchronisation and desynchronisation. Although the piece is not strictly a mixed computer music piece, nor a computer-assisted composition, Iannotta's music is characterised by 'an electronic-sounding terrain' (Ballard 2021: 2), in which instruments are electrified (e.g. by transducers activated via laptop computers) and played by the musicians with a profound timbrical research for mixtures that can easily make the audience think that there are in fact electronic components and computer-based components involved (live electronics are also present).

The three pieces cover a period of twenty years (1998, 2013, 2018) and exemplify three distinct compositional, performing and collaborative practices which will be analysed here. In this chapter, a combined methodology is proposed, allowing to investigate the three creative processes, each one determined by compositional choices, the work environment, the choice of computer programs, the study of possibilities and the compilation of instructions, patches, algorithms etc., and collaborative choices, etc. In fact, as Marc Battier explains,

> the environment of a work is [. . .] not just a subsection of a network of tools, gathered together for a unique occasion: it cannot be reduced to the juxtaposition or the assembly of tools. It's born of a voluntary and active action that groups, re-cuts and condenses various poles, concepts, materials or software; the environment is a condensation of these poles in one network (Battier 1992: 217).

Such an environment is technological, but it is also a social environment.

The methodology considers, for each of the three pieces, four areas of study that correspond to my lines of research: reconstruction of the creative process before and after the composition of a work, study of collaboration, archiving (sources, documentation, self-documentation, and sensitivity to these preservation issues), and finally oral history. In contrast to my past research projects, in which I used sources in view of a single purpose (this could be analysing a musical work, reconstructing the creative process, reconstructing a biography or the history of an electronic music centre, studying the interaction between agents and operations within the creative process, reconstructing lost sources, discovering hidden figures who were indispensable to the creative process, e.g., computer music designers and sound designers), in this article I combine the above-mentioned four research paths in a coherent manner.

The following chapters present an overview of the status of the academic research for each of the directions outlined (section 2), and the method of my present investigation (section 3). The outcomes of the three case studies (presented in sections 4-8) are obtained through a questionnaire submitted to the agents involved in the three different productions. The aim was to examine the creative process (single or collaborative) and to understand the collaboration process (section 4), to investigate how aware the actors are of the importance of documentation (section 5), and to examine their practices of notation, transmission, and preservation of the know-how including what is not precisely written in the score, and to investigate the meta-cognition in this process—the awareness of their thought processes and the understanding of the patterns behind them (section 6). Finally, in a comparative perspective, the purpose was to analyse the workflow that took place in each of the three productions (section 7) and to present final remarks also on the level of authoriality (section 8).

2. State of research

2.1 Tracking the creative process

The number of studies of the creative process in music, particularly in electroacoustic music, has been markedly increasing in the last years. In 2011 a conference specifically dedicated to this theme and entitled *Tracking the Creative Process in Music* was conceived by Nicolas Donin from Ircam with whom I've been collaborating since 2007 (see the entire special issue *Musicae Scientiae*, Vol. 20, Issue 3, September 2016 entitled *Tracking the creative process in music*; Donin & Traube 2016).[1] The conference has brought together researchers from different disciplines (history, music analysis, psychology, philosophy, cognitive science, sociology, ethnomusicology, anthropology, etc.), reflecting on the 'epistemological paradigm shifts that musicology underwent' at the end of the twentieth century (text cited from the conference presentation), adapting to new creative processes typical of musical creativity that can go beyond traditional notation, include improvisation and gesture, technological and collaborative dimensions, the redefinition of the roles of the composer and the performer, and new strategies of documentation. In addition to these conferences, various contributions have been published in the last decade examining issues such as source criticism, genetic criticism, the deconstruction, reconstruction and re-synthesis of the creative process in eletroacoustic music (Zattra 2015; Clarke, Dufeu & Manning 2020; Hagan & Puckette 2020). Nicolas Donin has proposed to 'cross-fertilise' empirical and historical musicology based on his work on contemporary compositional processes (Donin 2012). Such studies give special consideration to the subject of performance and re-performance. The study of the creative process in works from the past can be undertaken in view of obsolete electronic technology, allowing the same pieces to be re-performed and thus saved from oblivion and technological obsolescence. Examples of my reconstructions of the creative process based on material and heterogeneous sources are published in (Zattra 2007; 2016; 2020).

Regardless of the terminology we use to describe the different moments of creativity—computer music designer Alvise Vidolin calls them 'the before' and 'the after' (Vidolin 1997), while Jean-Jacques Nattiez and other semioticians call them the poietic and the aesthesic level—it is certainly useful for my study of the pieces by Romitelli, Lanza/Valle and Iannotta to separate the beginning of the creation, the preparation (sections 4, 5), the performance, and the after (section 6). Nevertheless, we must not forget the hybrid cases in which we find an activity of improvisation and spontaneous creation in music that includes electroacoustic technology: the so-called Experimental Music, if we adopt the terminology of Michael Nyman, since the early improvised works with electronics by John Cage,

1 Conference venues in 2011: Lille; 2013: Montreal; 2015: Paris; 2017: Huddersfield; 2019: Lisbon.

Morton Feldman, Christian Wolf, Musica Elettronica Viva and the Gruppo di Improvvisazione Nuova Consonanza, the AMM ensemble, to name a few (Nyman 1974; Solis & Nettl 2009). Improvisation lies somewhere inbetween in the musical works I am considering in this chapter. Collaboration and co-creation are common qualities in all three examples, leading to difficulties in tracing the traditional chronological development of musical creativity.

As a side note, it is worth mentioning that studies of the creative process in music have proliferated from previous musicological approaches: the tradition of philology applied to instrumental music of the past, the tradition of sketch studies that began with Richard Kramer in the 1990s (e.g. Kramer 2012), and genetic criticism (e.g. Kinderman 2017), that expanded to electronic music from the early years of our 21st century (De Benedictis 2009; 2011; Zattra 2007; 2015).

2.2. Collaboration

Studies on collaboration in music are also becoming more numerous, although they are mainly dedicated to instrumental music, and not specifically dedicated to electroacoustic music. Eric F. Clarke & Mark Doffman's (2017), Sawyer's (2006) and John-Steiner's (2000) contributions examine artistic collaboration and distribute creativity, while the socio-cultural study by Miell and Littleton (2004) is only partially devoted to music. Specific studies investigating the composer-performer relationship exist, e.g. on Brahms and Joachim (Main 2016; Uhde 2022), Stockhausen and Stephens (Whittall 2017), and John Cage and David Tudor (Nakai 2021). This literature, however, tends to highlight the outcomes rather than the processes, strategies and collaboration workflow (as pointed out by Roe 2007).

Within this still little developed area, electroacoustic music is a tiny niche. If, as Carl Faia (2014, 15) emphasises, 'music, broadly defined, is a collaborative art form. Perhaps, even, the ultimate collaborative art form. The interdependence of the various actors within the field is manifestly clear', then the art of organised sound with analogue or digital technology is collaboration at its best. Paul Roe's PhD thesis (2007) takes this persepctive, and computer music designers Carl Faia (2014) and Mathiew Lacroix (2022) have studied their own collaborations with different composers, both during the creation and performance phases. Clément Canonne studies on collective free improvisation, incorporating perspectives from ethnography and experimental psychology, are also worth mentioning (Canonne 2016, 2021). Jennifer Iverson's book *Electronic Inspirations* reconstructs the history of the Westdeutscher Rundfunk (West German Radio) in Cologne (WDR studio), the Darmstadt Summer Courses, and the role of Karlheinz Stockhausen, opting for a methodology devoting significantly more attention to hidden and semi-hidden dynamics, actors, and networks of institution, in short, collaborations. The

topic of the 'invisible collaborator' is a recurrent theme throughout the book.[2] Giulia Sarno's recent book on the Italian centre for electronic music research and production 'Tempo Reale', like Iverson's, depicts the typical network of persons necessary in the creation process and other activities (Sarno 2023). Other notable contributions investigate the creative process of Luigi Nono, who habitually collaborated with his performers. It is worth mentioning Veniero Rizzardi's essay in which he reconstructs the evolution of Nono's *A floresta* é *jovem e cheja de vida*, originally intended for live performance, but only after Nono's passing transformed from an 'oral score' as established between Nono and his collaborators, to a partial prescriptive score (Rizzardi 2018); and Nono's *A Pierre. Dell'azzurro silenzio, inquietum,* another typical collaborative work (Zattra, Burleugh, Sallis 2011).

Practice-led-research projects are well exemplified by two projects, both realised at the Zurich University of the Arts (ZHdK): the projects 'Performance Practice of Electroacoustic Music—The Studio di Fonologia Years' and 'Performance Practice of Electroacoustic Music—Towards a Practice-Based Exchange between Musicology and Performance' (Toro Pérez & Bennett 2018). Both projects have elaborated research around the theme of the composer-performer collaboration.

In my recent research projects, I have considered the topic of collaboration focusing particularly on the role of computer music designers (Zattra & Donin 2016), their interaction with composers (Zattra 2018; 2022) and the co-creation strategies between Luigi Nono and his computer music designers during the last decade of his production (Zattra 2020).

2.3 Archiving

Archival studies in the field of electroacoustic music have been evolving very quickly in the last years. There clearly is an increasing awareness developing rapidly both on an epistemological and a technological level since the remote first attempts to safeguard electronic music undertaken in the 1990s (e.g. the first digital transfer of Luigi Nono's works effected by Alvise Vidolin; or the digitisation of the tapes of the Studio di Fonologia della Rai in Milan, to just consider the Italian electronic music scene). Scholars are theorising on the importance of this discipline and setting up research, archival, and technological protocols. This results in a series of projects dedicated to technology transfer and the creation of databases (with scores, digital patches, technical reports, audio and video documentation, etc.), not only intended as sorts of museums of works, but also and especially as 'living' museums for electroacoustic music where performers, computer music designers, musicians and composers find material for their performances and re-performances. Important to mention in this regard are the works and projects by

2 This of course echoes Steven Shapin's fundamental study, 'The Invisible Technician', *American Scientist* 77, no. 6 (November–December 1989): 554–63.

Alain Bonardi (2008; 2018); Serge Lemouton, Bonardi and Laurent Pottier (et al. 2018); and their project *Antony* 'Collaborative archiving and creative preservation of digital music works'.[3] Another noteworthy project is the *Electroacoustic Performance Practice Database* developed at ZHdK.

I myself have lately been reflecting on the concept of archiving and self-archiving. The very organisation of the archives (physical or virtual) has led me to think about what the sources inside an archive can tell us about the musicians' way of approaching their work, about their 'workshop', and the very close relationship between the process of accumulating documents and the person who carries out this operation. Since I have encountered various types of archiving practiced both by composers and institutions, and I have had the opportunity to come into contact with very well-organised settings but also with archives where I literally had to get my hands dirty with dust in order to look for what I needed (sometimes without finding it), I have started reflecting on these concepts. I have recently worked on the Fausto Romitelli, Giacomo Manzoni and Camillo Togni collections held at the Fondazione Cini in Venice (Zattra 2021), and on John Chowning's archive. In a forthcoming article, I have tried to demonstrate that there is a close connection between the importance of the study of sources in electroacoustic music (source criticism, philology and analysis) and considering the corpus of sources in their entirety (the archive): what can we deduce from the composers' personal archives and what do archives tell us about the person who has collected and organised (or disorganised) them (Zattra, forthcoming a). From the chemical reaction arising from the two dimensions, I was able to point out the analogies and differences between the worlds of Teresa Rampazzi, John Chowning, the NoMus archive in Milan and the Studio di Fonologia, as well as Camillo Togni and Romitelli (Zattra, forthcoming b). Self-archiving can actually be considered a mirror, a way for composers and musicians to show part of themselves through the distinction between 'person' and 'character', between what is the reality of a person and their emanation to the outside world (passim by Zattra in the roundtable published in (Santacesaria & Sarno 2022)).

2.4 Oral history

For several authors, the definition of electroacoustic music is only associated with aural practice. François Delalande pointed out in the 1980s—and coming from a GRM member this is completely coherent—that it is 'made for listening and by listening' (Delalande 1986: 158). This statement applies not only to the non- or partial existence of an idea of 'writing' and/or of score and notation, but to the fact that for many, this music is more about orality, both ontologically and in its creative and performance processes. This is reflected in the more general words of

3 Website of the Antony project: https://musinf.univ-st-etienne.fr/recherches/antony_en.html

Gerald Bennett when he asserts that electroacoustic music (he was talking about computer music) is 'an almost exclusively oral culture. There is very little written documentation of compositional practice' (Bennett 1995). I prefer to think, like other scholars, that this music is characterized *both* by the idea of 'writing' (it is therefore possible to reconstruct its compositional processes, and to reproduce and re-perform it, since there exist forms of notation, like computer scores (albeit heterogeneous ones) *and* the idea of orality. The almost 100-year history of electroacoustic music shows that oblivion or inaccurate preservation occur because of scientists' and musicians' continued acquisition of knowledge and the urge for experimentation which have led them to postpone, and often to forget, the organisation and preservation of their musical materials. For that reason, the protagonists are the only existing vessels of this knowledge and must be interviewed.

As archiving studies have been evolving in the last years, the same has been happening with oral history, unfortunately sometimes considered by traditional historians as problematic. Can an interview be trusted to construct the history of electronic music? My (and many scholars') answer is 'yes', because such a tool is the only way to illuminate those obscure points that do not emerge from material sources. The transmission of composition techniques, compositional and technological choices, technological practices, shortcuts and tricks, the collaboration between the numerous contributors to the creation process, all this information can only be investigated using the tool of the interview. The collective memory of the protagonists conveys knowledge that other media cannot reveal. Naturally, compared to the material fixity of other sources, interviews have a high degree of intrinsic instability and resolute methodology is mandatory. Any interview (audio or video recording or transcription) has to be evaluated with the awareness that both interviewee and interviewer may condition, sometimes contaminate, the content (illuminating in this regard is chapter seven of Paul Thompson and Joanna Bornat's volume *The voice of the past: Oral History* 2017). Nonetheless, we must not forget that even material sources may be the result of falsification, of a process of filtering information, may be unavailable or have been discarded due to obscure human necessities that have altered the presumed objective 'scientificity'.[4]

Within the study of electronic music, audio and video interviews are indispensable sources for many reasons. They allow digging into the far corners of historical facts. They give a voice to those who usually do not have a crucial position in an artistic production. They document viewpoints that are often unpublished, little known, in part due to their nature as sources not 'cleaned up' by the criteria of official history (emotional prosody, body language, facial expressions reveal information beyond informational content). The US-based IEEE (Institute of Elec-

4 One of the internationally renowned founding theoriser of oral history is the Italian Alessandro Portelli, who has also written extensively on music, has worked with the Institute Ernesto De Martino (an Italian anthropologist and historian of religions) and is known for his the seminal Appalachia oral history project developed during the 1970s (Portelli 1984; 2010).

trical and Electronics Engineers) has for some years been creating an important platform for the preservation of the history of engineering and technology.[5] Based on the oral history method, the platform collects the testimonies of the most important engineers active in the world, published not in audio form but completely transcribed (650 so far). Prominent among them—and relevant for our discussion—is John Pierce's (interview from 1992),[6] and the part of the project dedicated to women and computing (not only related to music).[7] Also notable is the work of the California-based Computer History Museum which aims to preserve stories and artefacts of the information age and computer technology in order to understand their impact on society. Their YouTube channel publishes new oral histories almost daily, either recorded by researchers in the laboratory (or in private places), or in the form of lectures or symposia (e.g. the 2004 lecture featuring Curtis Roads in conversation with Max Mathews and John Chowning; Max Mathews' demonstration of his Radio Baton in 2010, and the extensive autobiographical talk by Tod Machover, Professor of Music and Media and Academic Head at the MIT Massachusetts Institute of Technology in Boston (2012)).[8]

Personally, I am conducting a series of interviews with my colleagues at Ircam as part of the RAMHO project (*Recherche et Acoustique Musicales en France: une Histoire Orale*).[9] Among the persons I interviewed with François-Xavier Féron there is John Chowning (nine interviews between April and July 2021 adding up to a total of 21 hours of recordings), the aim being to reconstruct Chowning's relationship with Ircam, but also more generally to reconstruct his life month by month (Féron & Zattra 2023). The interviews were stored, transcribed and compared with material sources.

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5 Link to the website: https://ethw.org/Oral-History:List_of_all_Oral_Histories.

6 Link to John Pierce's transcribed interviews: https://ethw.org/Oral-History:John_Pierce.

7 Link to the IEEE peroject on women and computers: https://ethw.org/Oral-History:Women_in_Computing.

8 2 Curtis Roads in conversation with Max Mathews and John Chowning 2004 (https://www.youtube.com/embed/Hloic1oBfug); Max Mathews' demonstration of his Radio Baton in 2010 (https://www.youtube.com/embed/3ZOzUVD4oLg), and an autobiographical talk by Tod Machover in 2012 (https://www.youtube.com/embed/EFKzBvInaCY).

9 The RAMHO project (*Recherche et Acoustique Musicales en France: une Histoire Orale*) is coordinated by François-Xavier Féron at the STMS-Ircam laboratory in Paris and brings together researchers from different scientific disciplines. This long-term project connects oral history and archival research in an effort to trace the development of musical acoustics in France and more broadly the concept of musical research during the second half of the 20th century. The project and methodology are presented in (Féron & Zattra 2023: 123-124).

3. The questionnaire: content and rationale in the study of Romitelli/Pottier, Valle/Lanza and Clara Iannotta

Methodologies and lines of research presented in Section 2 of this contribution were investigated by means of a questionnaire submitted to the main persons involved in the different productions. What follows then are not specific analyses of the three works, but rather results of what emerged from these actors' answers, their perception, their workflow, enhanced by my analysis of material sources (scores, sketches, diaries) and my analysis of sources stored in the online platform of the project *Performing Live Electronic Music.*[10] These are mostly oral sources: conference talks, videos of rehearsals of the different works, etc.

The questionnaire (given in full in the Appendix) is inspired by the work of Paul Roe's a PhD thesis entitled *A Phenomenology of Collaboration in Contemporary Composition and Performance* (2007), in which he presents his results after commissioning five Irish composers to write solo bass clarinet pieces for him to perform. He examines collaboration in a practical framework via a questionnaire, and through the careful documentation of the creative processes of interactive practice. The questionnaire is divided into five distinct blocks, and for each part up to five questions were proposed. The five blocks are:

1. Pre-compositional phase: Sketching
2. Compositional process
3. Transmission process and performance
4. Communication
5. Recognition and authorial ownership.

The questionnaire was sent in September 2022 to Laurent Pottier (computer music designer of Fausto Romitelli), Mauro Lanza and Andrea Valle, and Clara Iannotta (only partially present during the ensemble's study and rehearsals of the piece at ZHdK). I gave the participants the possibility to answer according to their preferences: writing or sending an audio or video recording, and using the language in which they preferred to express themselves. I also left it up to them to answer all or just part of the questionnaire, choosing some questions. I preferred to leave them free to choose to how much, to which and how to answer to the questions, as the purpose of the project was not strictly quantitative. The goal was to stimulate reflections on the various topics covered. I got replies from everyone except Mauro Lanza: a video from Andrea Valle (in Italian), four audio files from Clara Iannotta (in English), and written answers from Laurent Pottier (in French).

The questionnaire was used to investigate those aspects that do not emerge from the sources that I was able to consult: the Fausto Romitelli collection at the Cini Foundation in Venice, and all the primary and secondary sources by and on Laurent Pottier, Valle, Lanza and Iannotta. The purpose of the questionnaire was

10 Toro Pérez G (ed), *Electroacoustic Performance Practice Database, ,* http://ppeam.zhdk.ch/

to investigate the hidden aspects, in particular how the actors organise their work, how they collaborate, their communication strategies, the attention they devote to communicating with each other and with the performers, the phase 'before' and 'after' the first performance of a piece.

4. Sketching and Compositional processes

4.1. Romitelli through the lens of Pottier

Laurent Pottier's collaboration with Fausto Romitelli started with the work *Entrance* (1995). In *En-Trance*, the electronic part was done mainly with *Csound* software controlled by the programme *PatchWork*. Among the sources in the Fausto Romitelli collection held at the Fondazione Cini, I was able to see the complete list of computer files printed in screenshots and on paper, and pertaining to the computer that Fausto Romitelli used the 1990s, a *Macintosh Classic* personal computer from 1991. This was very likely the computer he bought when he began to study new technologies within the 'Cursus d'Informatique Musicale' at IRCAM in Paris, and which he then used up until his death. The files stored on the computer are the results of Romitelli's collaboration with Pottier. My research (Zattra 2021; and sections 4, 5, 6 of this contribution) has established that patches and programming data were 'exchanged' between Romitelli, who was based in Italy, and Pottier, who worked at Ircam in Paris as a computer music designer and who assisted him in the realisation of several compositions in the 1990s. The 'exchange' at the time was based on backups of data and patches stored on computer memory, audio CDs, CD-ROMs, notes on paper, and faxes; the data and patches were then used individually, each using their own computers (home and studio) and again exchanged and reused in joint work sessions at Ircam. The first aspect which deserves our attention, and which is by far the most evident, is the dating of the files. Dates range from 6 April 1993 to May 1996; with five files dated 13 July 13 2001.[11]

When asked in the questionnaire whether they used to sketch out ideas or rough plans before starting the actual composition phase—for example in order to try effects and test solutions—Pottier replies by confirming my initial hypotheses stated in (Zattra 2021; Decroupet 2018; Guidarini 2021; Moroz 2020; Olto 2017a; 2017b; Pustijanac 2018). The computer music designer states that these sketches consisted of 'calculation of harmonic structures in Patchwork, but also pencil +

11 Some files are dated 27 August 27 1956. This obviously is surprising but can be explained by a dating error caused by a problem with the lithium battery of the computer (when the battery fails, most *MacIntosh* computers reset to the birth date of one of the designers: 27 August 1956). An overview of the Fausto Romitelli collection (computer and patches) held at the Cini Foundation in Venice, Italy—donated to the Foundation by his family in 2016—is presented in (Zattra 2021).

paper sketches, Excel files sketches, and Patches and music sheet made in Patchwork' and that many of these sketches are held at the Cini Foundation. My analyses of the sketches show indeed that some computer materials previously created for *Natura morta,* then *EnTrance* in 1995 and so on were reused (partial data has been studied by Eric Maestri and Alessandro Olto; (Olto 2017)).

Laurent Pottier reveals that over the years he had developed a connection with Romitelli: 'we had common musical sensitivities. Exchanges had already taken place during my DEA (EHESS 1992) [the bachelor thesis] where I had analysed his work on *Natura morta con fiamme* (1992)'. Both the interview (the written answers to my questionnaire) and the material sources prove a long collaboration, starting at the beginning of the 1990s. In fact, at the Cini Foundation we find patches evidently corresponding to specific pieces such as Blood, Cupio1, Cupio2 or Domeniche, clearly related to the works *Blood on the Floor, Painting 1986* (2000), *Cupio Dissolvi* (1996), and *Domeniche alla periferia dell'impero* (1996–2000) respectively. But among the patches we also find tools that correspond to sound effects or transformations used across different pieces: Deform, Densifier, Destroy, Distcordfond. This corroborates the fact that the computer music designer created an 'orchestra' of sorts, meta-tools for the composer to play with, use and re-use across different works. This is a *modus operandi* that is typical of computer music designers at Ircam and elsewhere, particularly those who worked with composers for a long period of time (another example is Carl Faia and his work with Jonathan Harvey (Zattra 2022)).

Let's consider for example the patch 'Cupio2' pertaining to *Cupio Dissolvi* (the patch is shown in (Zattra 2021: 93)). The patch Cupio2 uses several modules, among them Findmultidist connected with another module Esempio 1 that 'finds the coefficients of distortion of a list of chords spectra […] for a fundamental […]' which in turn refers to Esempio 1 among the patches and Lisp codes in another folder of the computer; the module HHratio of the patch Cupio2[12] is connected to 'esempio 2bis' and so on. Every patch and every module is described in plain text (as one can see in footnote 12); these explanations were written by Pottier for the benefit of Romitelli and for himself for later reference. 'Esempio 1' is dated 8 July 8 1994; Esempio 2bis is dated 19 March 1994, and these dates place the creation of the modules at a specific time within the creative process of not just one work (after March 1994) but of later works in which it was used again. If we consider the dates indicated on the computer screenshots made at the Cini Foundation to be plausible and correct (everybody knows the problems related to the creation

12 The module HHratio 'creates a list of FM spectra whose partials correspond to the frequencies [LISTI]. The module calculates all the FM spectra of index [INDEX] for the carrying [PORT], modulated by a ratio that, starting from a ratio [RATIO], is lowered of 0.5 until [ratio < .1], but a FM spectrum is edited only if the given frequencies [LISTI] belong to the FM spectrum itself. The tolerated approximation between given frequencies and partials is half-tone' (*Fondazione Cini / Fondo Fausto Romitelli – Patchwork Files + Codice Lisp*, p. 4/14).

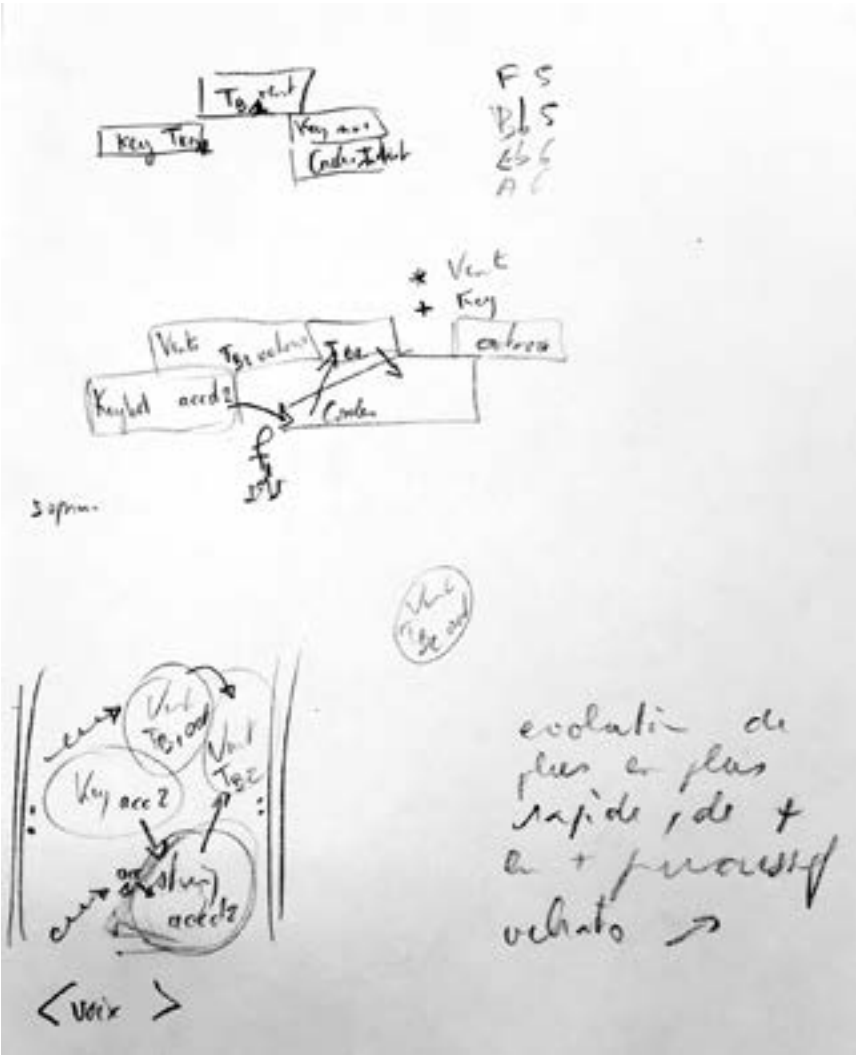


Fig. 1. Example of handwritten sketch for *EnTrance*, with the handwriting of Laurent Pottier (courtesy Laurent Pottier's personal archive)

date or modification date of a file, which can change across the digital storage procedures), this would lead us to assume that it took several years to create a work, *Cupio Dissolvi*, which was first performed with the ensemble L'Itinéraire on 14 February 1997 in Paris.

When Pottier was asked in the questionnaire whether they had 'develop[ed] a specific way to communicate? New terms? Specific tools in order to make the compositional process advance?', he actually confirmed that 'yes, we have developed specific instruments for the CAO (computer assisted composition) in Patchwork

and for the synthesis (with CSound)'. Pottier also sent to me some sketches held in his personal archive concerning *EnTrance*. These sources are not reproduced in the Romitelli collection at the Cini Foundation. They are only preserved in Pottier's private archive, such that new future research would be necessary to investigate the assistant's role and the collaboration with the Italian composer, and his personal contribution (see one example of handwritten sketch in Figure 1, with the calligraphy of Laurent Pottier). Partial research has already been done by Alessandro Olto and Laurent Pottier and published on Ircam's website (https://brahms.ircam.fr/fr/analyses/EnTrance/). Other documentation of Pottier's work is presented in his PhD thesis (Pottier 2001); documentation for the re-performance (including the technology porting) of *EnTrance* is published on the Ircam website (Lemouton 2022).

4.2 Lanza/Valle

As mentioned in Section 3, my investigation of the co-created work by Mauro Lanza and Andrea Valle reflects the answers to the questionnaire of Andrea Valle, recorded in the form of a video interview (via Zoom). Recalling the pre-compositional phase of *Regnum animale*, Valle emphasises that it is important not to forget that we must consider an entire cycle of works entitled *Systema Naturae*. In fact, *Regnum animale*—performed in Zurich within the project *Performing Live Electronic Music*—is the first part of a four-part cycle: *Regnum animale* (2013), *Regnum Vegetabile* (2014), *Regnum Lapideum* (2016) and *Fossilia* (2017). The composition of the entire cycle was completed in 2017. His thoughts are therefore not only related to the first composition.

During the pre-compositional phase, Andrea Valle took notes in two forms (the following is the *verbatim* transcription of the interview, translated from Italian to English by me):

> the first on paper, a little, but this is an interesting initial phase because sometimes it is necessary to clarify the organisation, the piece, or the process of generating the sound, or symbolic, or organisation of software or physical elements, the circuitry. This is useful in general [in composition] but certainly also in *Systema Natura*. I usually put down the date and time. I write them by hand because this is a faster way of taking notes. The hand and the ink follow my thoughts more quickly. In this sketch of *Fossilia* [Fig. 2], not even I understand what I meant. I myself find it hard to read. This notebook [the one that I am showing you] starts in February 2014 and now [September 2023] I have almost finished it. This to say that the rate of these things is limited but fundamental. That's why [this notebook] lasted so long.

Fig. 2 show the handwritten pre-compositional sketch for *Fossilia.* Although I could have asked Andrea Valle to send a scanned version of the original page, I prefer to use a screenshot taken during the interview, in order to evoke the oral source.

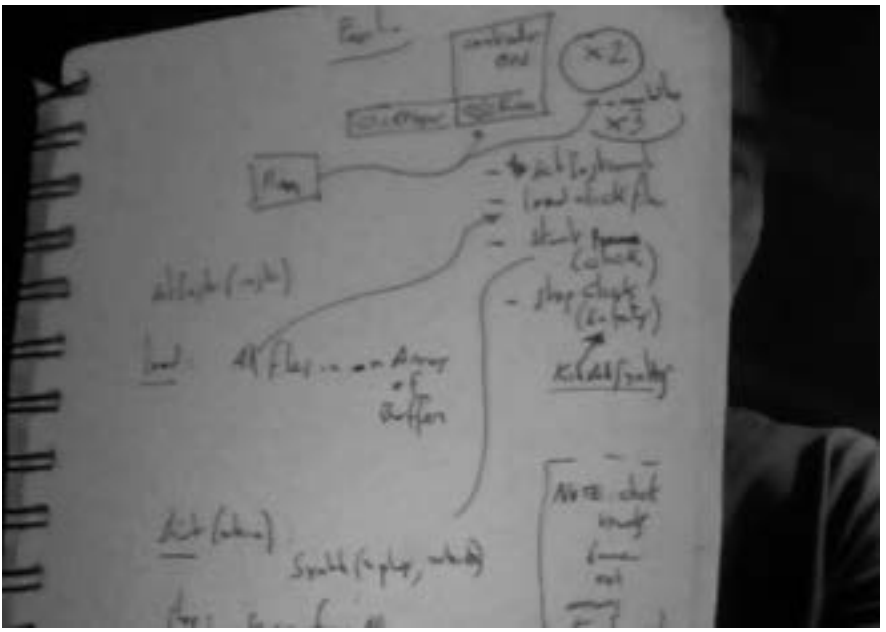


Fig. 2. Example of a handwritten sketch by Andrea Valle for *Fossilia* (screenshot taken during the interview), with the handwriting of Andrea Valle (Andrea Valle's personal archive)

Andrea Valle practices yet another manner of taking notes and sketching for programming and writing on computer. He uses Supercollider, 'therefore it is pure code'. As regards audio sketches or recordings, he says:

> I don't take notes in the form of sound material. There are audio sources here (in *Systema Naturae*) but they are not "sketches". There are lots of quotations, from op. 21 by Anton Webern, we transcribed parts from Gesualdo [da Venosa], parts elaborated from the graphic scores of Cage, but taking a piece of notation and converting it, never. Here [in this work] we have electromechanics, so it's not even obvious to do this [meaning: sketching]. At first I cannibalised my previous setups, but in reality it's all idiosyncratic. I never use the piano for sketching, I sometimes use my electric bass, but I don't use it for symbolic input, only for audio.

4.3 Clara Iannotta

Clara Iannotta's reflections on her pre-compositional process are very different from the previous two case studies and reveal her compositional approach. Literary influences from reading poems and books shape her aesthetics. Moreover (we remind the reader that her answers were sent in the form of pre-recorded audio files in English), her creative process is far from linear. In fact, she answered question 1.e ('Did you obtain every goal you had set during the preparatory period?')

declaring that she 'has no goal' (meaning that she starts with no predetermined purposes), 'so probably yes', and the reason is that she is 'an "intuitive composer"'. This answer by Iannotta illustrates not only her pre-compositional phase but also her entire compositional process based on one initial idea: she writes the first three minutes, then rewrites them, then goes on, minute after minute.

Iannotta sent me a scan of her diary, her sketchbook for the piece *Moult* (2018-19, for orchestra), to show me how she works (Fig. 3 shows the very first page; note the date '15 January 2019, Rome').

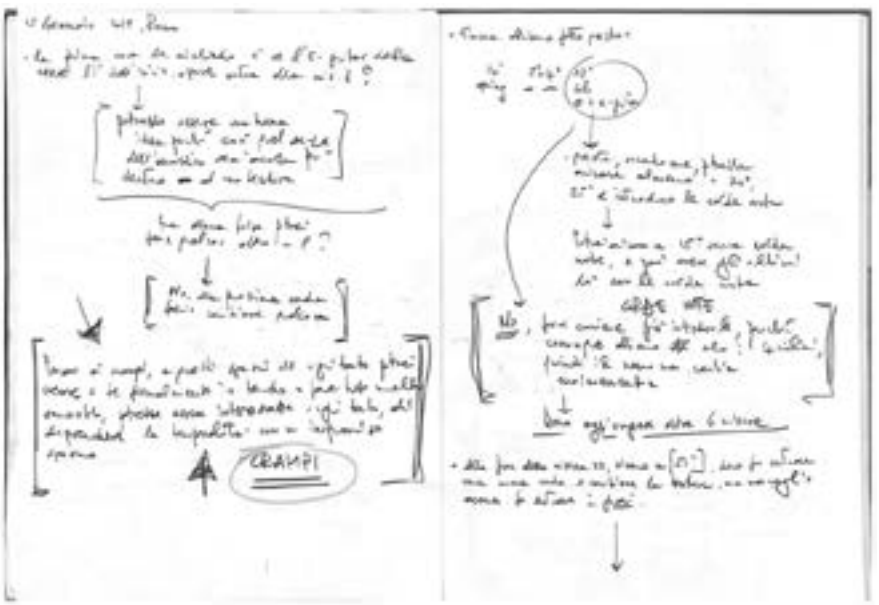


Fig. 3. Handwritten diary (first page) for Clara Iannotta's orchestra piece *Moult* (2018-19), with her handwriting (Courtesy Clara Iannotta's personal archive)

With regard to this diary, she declared that 'this is the third re-writing of the piece, but I'm not so sure', she says, 'it seems the third because of the dates (15 January 2019 in Rome)'. The diary is full of annotations, comments, inspirational remarks, and written in the conditional mode: I could, I should, etc. Reading her diary, we learn that on 16 January 2019 (one day after the first annotations) she is already writing some lines of music, specific passages, chords. On 29 January (in Rome) and on 30 January (in Berlin—we know from this annotation that at that time she had the flu!) she has already written two minutes. On 18 February she is back in Rome. Anticipating the topic analysed in Section 5.3, we can easily see that Iannotta's diary also leads us to discuss a further aspect: the preservation and archiving of her own compositional process.

5. Archiving

I regard the issue of archiving not only, or not so much, as an instrumental or practical activity constructed by the persons I have interviewed in relation to the materials they produce. I see this matter also as a general theme that allows us to understand what vision the interviewees have of themselves (how they organise their materials), if, how much, and how they reflect on their activities (archiving as a possible part of the workflow), how they present themselves to the outside world (the archive and its organisation reflect the person) and, finally, if they are aware of their thought processes and understand the patterns behind them (archiving as a way of rationalising a creative process) (Zattra, forthcoming a).

5.1 Pottier (Romitelli)

For Pottier, archiving and the process of archiving are important chapters in his activity. Not only has he published, theorised and worked in research projects dedicated to these questions (he specifies in his biographies that among his research domains are collaborative archiving and creative preservation of computer music works (e.g. Pottier 2001; 2013; Lemouton, Bonardi, Pottier, Warnier 2018a; 2018b; 2019; Mihalic & Pottier 2011). He also maintains his own personal archive, conisting of paper documents and digital formats. Alongside the answers to my questionnaire, he sent me some unpublished documents relating to his collaboration with Romitelli, some handwritten by him, others by Romitelli (e.g. Fig. 1). Aside from digital files stored on computers, these are paper documents, reflecting the pre-internet decade when their collaboration took place. (Future research will be necessary in order to analyse these unpublished documents).

Pottier is founder or member of several projects aiming to preserve electronic music through technical porting to updated software in order to solve the problem of obsolescence (for instance the aforementioned Antony project 'Collaborative archiving and creative preservation of digital music works' conceived at Ircam and the University Saint Denis in Paris). He is a member of the committee for projects and conferences dedicated to archiving and preservation, the most recent event was the November 2023 conference *Réféctions sur la numérisation des fonds en musique contemporaine* (Saint Etienne, France: https://www.iremus.cnrs.fr/en/appel-communication/international-conference-commission-creative-process-reflections-digitization).

5.2 Lanza/Valle

Andrea Valle has articulately expressed views on what he and Mauro Lanza were doing in this regard and described a series of personal perceptions ranging from practical aspects of organising material (archiving to backup materials or for ready

usefulness in order to exchange documents, patches, etc. between themselves), to a certain automaticity of the process of archiving inherent digital technology which they did not foresee or not deem in itself fundamental, which, however, could prove useful at a later time. He argues that 'WhatsApp archives its own chats, so does Messenger, which we used. We did not use Dropbox, but used Github instead. The two of us save materials and files on our own, we do backups. But this backup is not aimed at preserving our creative process. That is another thing'. Another, different way of 'archiving', or rather transmitting knowledge or a process to the musical/scientific community through the filter of *post facto* reflections is by way of academic papers published by Valle in the context of his position as an associate professor at the University of Turin.

> I am also an academic and I write papers, articles. For example, for the SMC Sound and Music Computing conference I wrote about our piece *Systema Naturae*. Academic writing is my field, but of course I've asked Mauro [Lanza] [if he would give me] his texts and inputs [in order to theorise on our work]. As for scores, we never published them, they are of course submitted for copyright reasons, but never published. On the other hand, for research purposes, we are keen to disseminate all these materials.

Academic publication takes place some or a long time after the process of composition/creation, in the case of *Systema Naturae* it happened repeatedly long after the cycle's completion. Therefore, this type of archiving is sedimented by the filter of time passed between the collaboration and the writing (Valle & Lanza 2017).

5.3 Clara Iannotta

For Clara Iannotta, her constant writing during the compositional process reflects her vision of creating music, which is almost 'a therapeutic activity' (Iannotta in her interview with me). She sees sketching and taking notes throughout the entire compositional process as an activity through which to investigate herself or the world. Writing becomes archiving, and archiving becomes her way of clarifying her thoughts.

> Everything is stored, organised, the day where I am [sic]. The relation I have with music is almost therapeutic, it allows to process how I see the world… It's an intimate discovery of myself, it's very selfish, but it's what my relation with my music is, which means that my notebooks are a diary. I don't throw anything away at my house. Everything, every sketch is inside. Anyway, I don't look back, I don't care.

6. Transmission Process and Performance / Communication

The answers I received to item No. 3 (Transmission Process and Performance, itself divided into three questions), were very different between the three case studies. The questions were meant to investigate whether notation or forms of communications occurred with the performers ('a. What type of notation, if any, did you use?'), to explore if the communication with the performers was efficient ('b. Do you find that what is produced in performances of this work is what was anticipated? And does this matter?') and if, in case that there was a strict collaboration with a specific performer, the work is ready to be performed by different performers ('c. In creating a piece that is written with a particular performer's ability in mind, does this present difficulties for subsequent performances by other performers?'). As I had expected, because the questions were very diverse and because I gave the option to answer one or more questions or to discard others, the following reveals very diverse approaches to this topic.

6.1 Pottier about Romitelli

Pottier decided to answer (in writing) question b, and his answer concerns his role as computer music designer. He states that 'during the creation, in the presence of the composer, the results were what was intended. On the other hand, during the various re-performances of the piece, certain parts were strongly modified (question of mixing), mainly the parts of the sampler. The tape is often undermixed'. This is a difficulty, according to Pottier—and this is also true for Iannotta's piece—because the live electronic part is sometimes difficult or impossible to define in the score, and therefore subject to different interpretations.

6.2 Valle (and Lanza)

According to Valle (Question a)

> the cycle [*Systema Naturae*] is made for traditional instruments and […] the notation is traditional, contemporary but traditional: three quarters, one eighth, metronomic time, etc., also because we arrange the machines through click tracks. Our pieces can be defined as "advanced", but not in terms of the aesthetics of the construction of the object, because they are pieces of music! There is the visual component, but we don't work on that in the execution; when we work, we treat them as tools. They are finished pieces, closed, so we use traditional notation, also because the preparation of the instruments has its own finite deterministic preparation. All the machines always sound [the same] way [they were meant to].

As for question b (asking whether what is produced in performances of this work is what was anticipated or not), Valle's answer reveals interesting aspects also related to their collaborative workflow. He says:

> Yes, because we have two ways of anticipating the results: all the pieces are tested with the machines. If Mauro has to hear them, I'll make a recording, throw a microphone and pass them to him. Mauro has a simulator of the acoustic instruments done in Csound and controlled in Lisp, with all the samples, all the dynamics. When I or he has to rehearse a part, I give him the data, and this brings out the musical part. We never got any surprises when we went to the first tests because our anticipation came very close. We use it as a guide for the musicians, even if this could actually be superfluous, because they rehearse so much with the click track. When they perform, they concentrate on the click track and the machines do not move them to performative concepts. We have never had any particular surprises.

Reflecting on the role of acoustic instrumentalists and the communication established with them, Valle (of course reflecting Lanza's view) informed me that 'it's not as if we took a musician and asked him what "only you" can do'. Here, Valle refers to the typical practice of the post World War II musical avant-garde, in which solo performers made a reputation for their highly original techniques that inspired many composers to compose works (among them David Tudor, Cathy Berberian, Severino Gazzelloni, Aloys and Alfons Kontarsky, Frederic Rzewski, Heinz Holliger, Vinko Globokar and others (Pace 2022)). Valle continues and explains that contrary to these practices, for them in *Systema Naturae* this condition had not been set because

> we always worked with musicians who were very good. The trio we worked with for *Regnum animale* is excellent, and the piece was constructed that way because we knew they were very good. The other pieces are not as difficult as the string trio. We make use of the established playing techniques; for strings, you have to make sure they are positioned in the right way, and most of the times everything went well immediately.

6.3 Clara Iannotta

Clara Iannotta states that she writes traditional scores and in a traditional way, so scores 'look like scores'. However, her scores feature additional words, explanations, comments. Moreover, and interestingly, she uses novel ways of expressing what scores cannot tell, since she uses a lot of video tutorials—as she observes—that she sends to her musicians. Traditional score, verbal explanations and video tutorials are a complex and interrelated system to communicate. These video tutorials were also greatly appreciated by the musicians in the project *Performing Live Electronic Music*, as evidenced by the discussion recorded on 22 January 2022.

However, after reassuring us of the effectiveness of the interrelation of scores, written and audio/video materials, she adds, almost as if asking herself: 'Does it

work? More or less, it works technically, if the musicians look at the videos! And it does not work in the moment in which my sounds are not individual'. By this she means that this stratified manner of notating music works when writing for a single instrument or for a few. When composing for several instruments and thus writing for complex, layered textures, this system does not yet work or has not yet been fully tested by her. 'Up to now (now I am changing) I don't write chamber music (except for string quartet)'. She has only lately begun to write for bigger ensembles: *Moult* for example (2018–19) is a piece for chamber orchestra. Her frustration over the idea that the score does not succeed in showing the complexity of layered sounds is clearly perceivable in her words:

> I think about sound as a living organism, many organs, or that organs are made of many things: so, the musician that is learning is part of something bigger. The problem is that sometimes they think as individuals. I very rarely meet musicians that understand how they have to listen to each other. My scores don't deliver that idea, not even to the conductor. I seldom work with conductors that understand my score. It's my fault. I have to find the way. In the latest pieces, however, I'm writing scores different from my previous works. I am still really trying to find my way of communicating in the score exactly what I want.

It goes without saying that even when the composer supplements scores with tutorials, extra explanations and so on, there is always the possibility that a) the musicians don't look at the tutorials and videos, and b) more importantly, that scores do not allow to show the richness of sounding results. This fully reflects the never-ending discussion on the notation of avant-garde and electronic music that is not yet settled, and probably never will be.[13] Luciano Berio never completed the score of *Différences* (for flute, clarinet, harp, viola and cello in dialogue with a tape part), not only for lack of time, but above all because 'to write down the score of a work that is inherently complete as a sound artefact probably seemed like a pointless task, or something that would have had a different function than a conventional score' (Rizzardi 2018: 45). Luigi Nono had the same difficulties.

However, in Iannotta's case it is interesting to notice how her frustration might stem from the inability of musicians to understand to what degree their role is to be part of a *living sound* organism. This is the reason why in her music it is necessary for musicians to repeatedly listen to each other. On 22 January 2023 (recorded workshop archived in the *Performing Live Electronic Music* project documentation) Iannotta declares that she definitely recognises her piece performed here in Zurich (she was not present during the rehearsals) although she also states

13 To mention only the latest writings on this topic: *Sound and Score: Essays on Sound, Score, and Notation* (de Assis et al. 2014), the *eContact!* issue entitled *Notation for Electroacoustic and Digital Media* edited by Jef (Chippewa 2018), Annette Vande Gorne's *Treatise on Writing Acousmatic Music on Fixed Media*8 (2018), and my co-authored issue *La notazione della musica elettroacustica. Scrutare il passato per contemplare il futuro* (Alessandretti & Zattra 2021).

that 'had I been there, there might have been other things that would have ended up being incorporated into my idea of sound'. She was very pleased, she continues, although there was a problem with the feedback of the piano sound: 'I forgot completely about the piano machine that we used [during the first performance]. We [had] used two contact mikes and put inside the ear a retour. There are things that I forgot because [normally] I'm always there [present during the rehearsals of my pieces]'. Another interesting aspect concerning the transmission process is that in *Outer Space*, before meeting Brian Archinal (the percussion player of Nikel ensemble, which had premiered the piece), the Zurich ensemble thought to be playing a delicate piece, but upon meeting with him learned that it was supposed to be louder. This means that dynamics are another difficult component to define, because they are not objective dimensions, but depend on the context (the case of Iannotta's *Outer space* evokes, among many other examples, the difficulties performers, after Luigi Nono's passing in 1990, had with the piece *A floresta* è *jovem e cheja de vida*, as Nono had always conducted the ensemble and supervised the sound projection (Rizzardi 2018).

7. Workflow

The methodology used in this study allows to shed light on the collaborative processes from various points of view: division of labour, workflow, expertise/specialisation, synchronicity or diachronicity, psychology, preservation, and authorship. According to Keith Sawyer, there exist two types of temporal patterns in music collaboration: (1) diachronic collaboration, when each participant's contribution happens at different moments, separated even by days or weeks, and/or in different places; (2) synchronic collaboration, when the actors occupy the same place at the same time, they constantly observe each other, and interact accordingly and immediately (Sawyer 2014: 274–75). In the three case studies there are both diachronic and synchronic dimensions. Actors meet and work together (or rehearse), but they also work on their own following the meetings. There are also semi-synchronic dimensions when internet-based communication is involved. The general workflow process in collaborative electroacoustic music I sketched in (Zattra 2022) shows repeated recursive actions that alternate with practical moments and more introspective stages that in design thinking (Cross 2006) range from context analysis to goals and solution criteria, from creative thinking, sketching, and prototyping to delivering and performing and reperforming in concerts (the same happens in collaborative sound design projects (Zattra, Misdariis, Pecquet & Donin 2021)). Let us look at the different situations in more detail.

7.1 Pottier (with Romitelli)

Laurent Pottier told me that 'the electronic part was produced by synthesis, computer processing during six months at the IRCAM studios done entirely by the computer music designer (myself), with only an almost weekly meeting to take stock of progress and make choices, give instructions for the evolution of work'. In this sentence, Pottier emphasises the significance of the computer music designer in the workflow. In this regard, he also asserts that 'it is clear that it was the computer music designer that created the sounds and developed the synthesis techniques used in the work'.

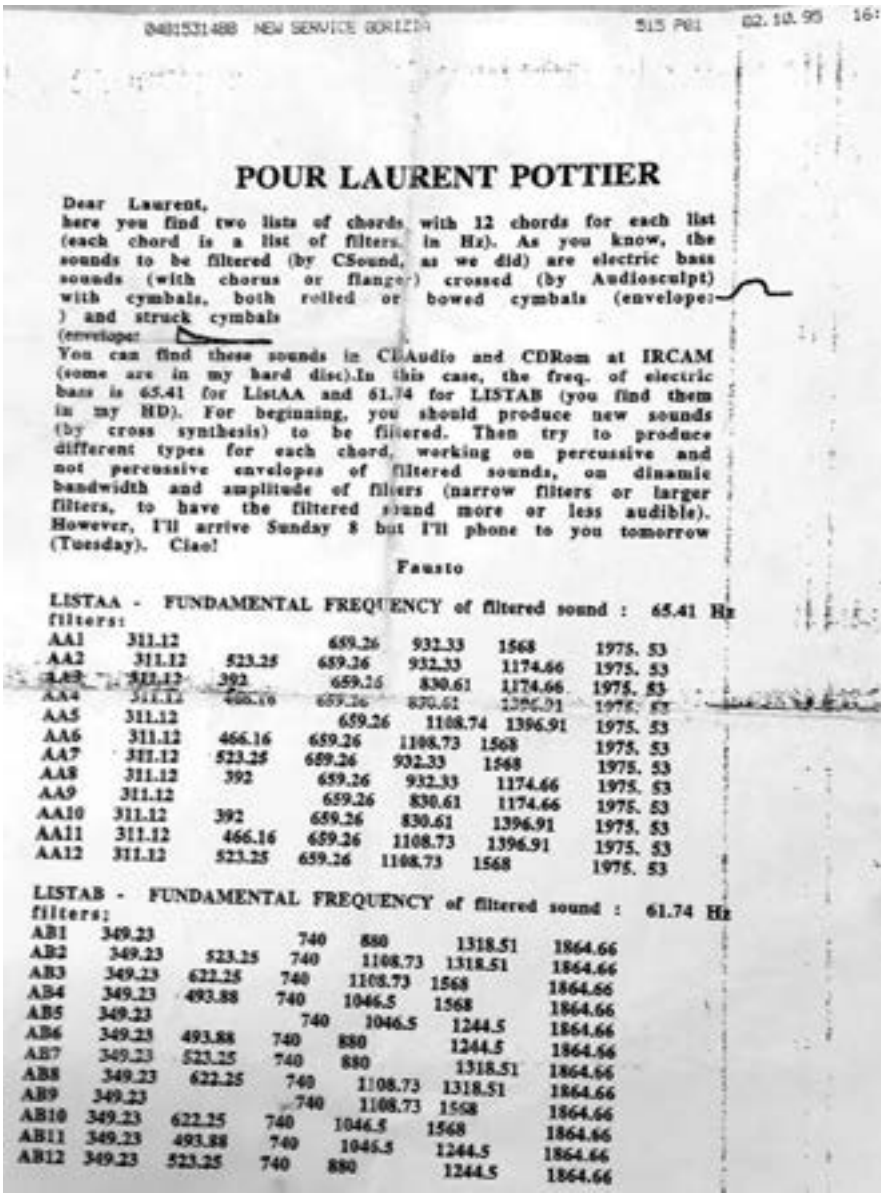
Pottier sent me a scanned fax (dated 2 October 1995), which typifies the dialogue between the two and the sequence of processes, tests and attempts through which their work was going from initiation to completion. The exchange happened in view of one of the meetings that would take place the following week (Romitelli writes 'I'll arrive Sunday 8' that would be Sunday 8 October (fig. 4). The page shows a text in which Romitelli explains to Pottier to start from some analyses of sounds they had previously completed (he mentions audio CDs, CD-ROMs and hard drives all located at Ircam, which contained these sounds, the data from the sound analyses, and thus the patches as discussed in section 4.1). Pottier, Romitelli suggests, would then have to produce new sounds in cross-synthesis and filters, and 'try out' (one can thus see the trust placed in the computer music designer's work) successive new sounds for each of the data attached to the fax page.

7.2. Lanza/Valle

In line with his academic activity of writing and publishing results, Andrea Valle has already considered the *Systema Naturae* project worthy of theorisation, as is particularly evidenced by a co-written paper examining the collaboration and workflow(Valle & Lanza 2017). The cycle 'is a shared effort with a minimum division of labour between the two authors'. As Valle has told in my interview, there is a

> non-quantifiable number of meetings, because we used the Internet, Skype, Facebook chat, WhatsApp, email, filesharing. For *Fossilia* [the concluding composition, realised in 2017] I had put up a repository in which we had archived everything. Even now we talk to each other a lot, we call it the Turin-Berlin axis. It is a constant interaction. It is almost as it would be in real time, because even if maybe sometimes he doesn't respond immediately to the chat, he does so within a few hours, so it is almost real time.

The workflow in *Systema Naturae* is described and schematised in the same paper and reproduced here in Fig. 5. They write that the progression can be described as a three-step process: architectural design, sound organisation, performance design. In Figure [5] the three steps are represented vertically (bold rectangles), ac-



0481531488 NEW SERVICE GORIZIA 515 P01 02.10.95 16:

POUR LAURENT POTTIER

Dear Laurent,
here you find two lists of chords with 12 chords for each list (each chord is a list of filters. in Hz). As you know, the sounds to be filtered (by CSound, as we did) are electric bass sounds (with chorus or flanger) crossed (by Audiosculpt) with cymbals, both rolled or bowed cymbals (envelope:) and struck cymbals
(envelope:
You can find these sounds in CDAudio and CDRom at IRCAM (some are in my hard disc).In this case, the freq. of electric bass is 65.41 for ListAA and 61.74 for LISTAB (you find them in my HD). For beginning, you should produce new sounds (by cross synthesis) to be filtered. Then try to produce different types for each chord, working on percussive and not percussive envelopes of filtered sounds, on dinamic bandwidth and amplitude of filters (narrow filters or larger filters, to have the filtered sound more or less audible). However, I'll arrive Sunday 8 but I'll phone to you tomorrow (Tuesday). Ciao!

Fausto

LISTAA - FUNDAMENTAL FREQUENCY of filtered sound : 65.41 Hz
filters:

AA1	311.12		659.26	932.33	1568	1975. 53
AA2	311.12	523.25	659.26	932.33	1174.66	1975. 53
AA3	311.12	392	659.26	830.61	1174.66	1975. 53
AA4	311.12	466.16	659.26	830.61	1396.91	1975. 53
AA5	311.12		659.26	1108.74	1396.91	1975. 53
AA6	311.12	466.16	659.26	1108.73	1568	1975. 53
AA7	311.12	523.25	659.26	932.33	1568	1975. 53
AA8	311.12	392	659.26	932.33	1174.66	1975. 53
AA9	311.12		659.26	830.61	1174.66	1975. 53
AA10	311.12	392	659.26	830.61	1396.91	1975. 53
AA11	311.12	466.16	659.26	1108.73	1396.91	1975. 53
AA12	311.12	523.25	659.26	1108.73	1568	1975. 53

LISTAB - FUNDAMENTAL FREQUENCY of filtered sound : 61.74 Hz
filters:

AB1	349.23		740	880	1318.51	1864.66
AB2	349.23	523.25	740	1108.73	1318.51	1864.66
AB3	349.23	622.25	740	1108.73	1568	1864.66
AB4	349.23	493.88	740	1046.5	1568	1864.66
AB5	349.23		740	1046.5	1244.5	1864.66
AB6	349.23	493.88	740	880	1244.5	1864.66
AB7	349.23	523.25	740	880	1318.51	1864.66
AB8	349.23	622.25	740	1108.73	1318.51	1864.66
AB9	349.23		740	1108.73	1568	1864.66
AB10	349.23	622.25	740	1046.5	1568	1864.66
AB11	349.23	493.88	740	1046.5	1244.5	1864.66
AB12	349.23	523.25	740	880	1244.5	1864.66

Fig. 4. Fax page sent by Romitelli to Pottier (courtesy Laurent Pottier's personal archive)

tivities by the two composers are placed on opposite sides (ML and AV), while the dotted area in the middle represents contents that are shared over internet (shared information), crossbreeding both sides. Rectangles inside step 2 represent, more than objects, activity modules that create data outputs. Grey rectangles indicate outputs that are passed to step 3 (Valle & Lanza 2017: 396).

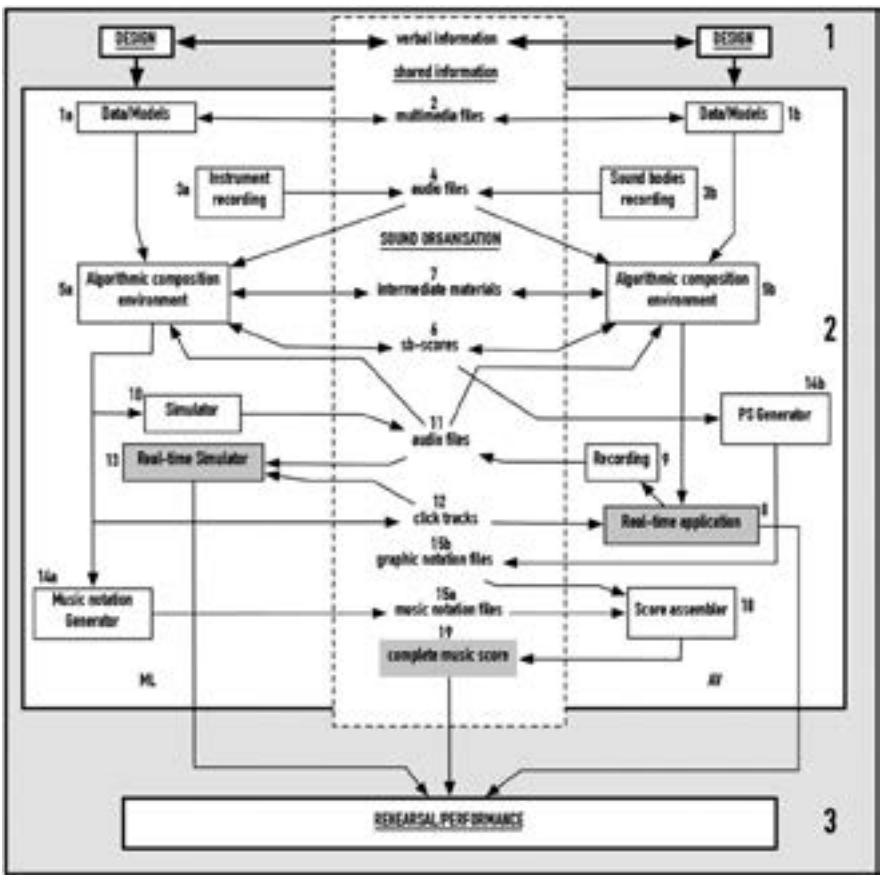


Fig. 5. Shared composition information flow in *Systema Naturae* (also reproduced in (Valle & Lanza 2017: 396) and (Guidarini 2021: 51)

Luca Guidarini takes some concepts from the cited article and develops them in a paper dedicated to the *instrumentarium* constructed in *Systema Naturae* and writes (my translation from Italian): 'the first phase consists of the definition of the preparatory materials: from the organisational and formal parameters to the construction and preparation of the tools. The second phase consists of the process beginning with the initial structuring of the algorithms up to the formalisation of the score. Valle and Lanza in this phase exchange information, algorithms, diagrams, graphs, recordings and audio simulations. In particular, the communication of

data and compositional information between the programming environments used by the two composers (OpenMusic for Mauro Lanza and SuperCollider for Andrea Valle) is possible thanks to the creation of a shared computer language called Sb-score and similar to a Csound score file (Guidarini 2021: 50–51).

During the third phase they elaborate the performative component, the entire architecture—software and hardware—required for live execution.
Prompted to elaborate on what had already been explained in the cited articles, Valle stressed that

> we have constructed a language each for ourselves, and at the same time this worked between composers because we are composers. We have protocols which are variable, we exchange files. Only at the very end do we get to the standard notation. We exchange live Csound 'scores' because the score functions as it is with the MIDI protocol, its attack-duration etc. That works fine for us. We usually use this kind of system because both of us, when we receive it, understand it and can personify it. We invent terms, we invent names for tools, and specific tools. Each one builds the software he needs: for me in this case it was SuperCollider (now I work with Python but not in *Systema Naturae*), Mauro [Lanza] in Lisp with the help, for some processes, of OpenMusic. And to communicate we typically use diagrams and textual information.

When asked if it was a strong working relationship that had developed over many years and if there had been awkward moments in their collaboration, Valle declared:

> We started in 2012 and we had a good time. We did four pieces, now the cycle is completed. We worked intensely for five years, we worked together very well, we had a common aesthetic, a common sense of humour, sometimes a bit macabre, between medieval and baroque, and there was our interest in technology. We developed an inclusive catalogue, as the moderns say. Managing a set of musical pieces focused on certain aspects has made our work easy. And working together was easy. Personally, I am fast, Mauro is more precise. Mauro paints, and we integrate each other. We sketch the work and then everyone does the *labor limae*. There were awkward moments, yes, and bizarre moments, but not in our reciprocal communication; we burned half of a setup once!

7.3. Clara Iannotta

Vera John-Steiner's study on music collaboration establishes that in distributed collaboration there are cases of integrative collaboration where the participants work so intensely that they modify each other's practice (John-Steiner 2000). This is the case in Clara Iannotta's piece *Outer Space*. Her work was realised in close collaboration with the Ensemble Nikel. In the score, instead of indicating the list of instruments, she uses the proper names of the instrumentalists (this is reminiscent of Luigi Nono's sketches, in which he wrote the initials of his close collaborators). The score also includes click-tracks as time stamps, but some oral indications

were used to complement the score in addition to the videos with the explanations of performance techniques on self-made instruments sent by her. As Iannotta declared on January 22, 2022 (discussion archived in the *Performing Live Electronic Music* project documentation), 'by watching the film […] we made adjustments, constant adjustments, until the very end. Nikel is a special ensemble in the sense that they are extremely fast in understanding what you want, in adapting, and they never complain. It was a dream come true'. From Iannotta's words, we can also deduce that this is a case of complementary collaboration, with 'clearly defined roles, distributed expertise, discipline-specific working methods' (Love & Barrett 2014: 52). She has met with the musicians, but they have also worked on their own after the meetings. There were also semi-synchronic dimensions when internet-based communication was involved. In this sense, I think it is also important to stress the fact that Brian Archinal (Nikel's percussion player) was present at rehearsals in Zurich (during which Iannotta was not always present) and explained some aspects of performing the piece, since the score has several improvised elements and had only been performed by the Nikel ensemble. We understand subsequently that some obscurities in Iannotta's work—as he told me in my interview, like the impossibility to represent certain things or sound effects or ideas in the score—was solved by the presence of the performer. In *Outer Space,* there were both diachronic and synchronic dimensions in collaboration.

8. Conclusions

In this last part of the article, I try to draw some general conclusions that appear to be common to the three case studies, and then I continue with some specific considerations for each of them. First of all, what emerges from the comparison seems to indicate that taking notes, sketching, and preserving the creative process, are important steps in all three productions. However, for Iannotta, her diary functions as a way for clarifying her creative process, yet it is not meant to be used later, once the piece is completed. Her notebook remains 'there', specifically related to one historical moment. Laurent Pottier and Andrea Valle / Mauro Lanza, on the other hand, also keep their material, but it seems that it serves to recall solutions and strategies they might re-use, and/or for future reperformances (Valle/Lanza and Pottier); in the case of Romitelli this process developed during the 1990s has proved crucial once the problem of technological obsolescence emerged and the technological porting was a necessity (for Pottier, this problem has already arisen, as Romitelli's works are older than Lanza/Valle's and Iannotta's).

Analysis of the questionnaire reveals differences between the roles and the implication of the persons interviewed, not only from the point of view of my perception, but also their own perception (meta-cognition). The Romitelli-Pottier collaboration clearly indicates one composer and one computer music designer

(as theorised in Zattra 2022; Zattra & Donin 2016). The Lanza/Valle collaboration shows two composers at work, one interested in code programming and the construction of the tools and mechanical instruments (Valle), the other interested in programming structures and sounds, and the musical writing (it is important to emphasise here that it would be necessary to elaborate on this point by trying to again submit the questionnaire to Lanza). Finally, Iannotta is a composer (in charge also of the electronics) who works with performers that can substantially participate in the compositional process with their own ideas.

The notational problem is another theme clearly concerning all interviewees. Although they all agree that the performances are always good, satisfying, that they recognise the piece, etc., it is also true that they think their presence could be important for the success of a concert. And finally, the theme of collaboration which emerged in all three productions raises other issues such as recognition and authorship. Generally speaking, definitions of collaboration stress that in addition to dialogue and an extended time of working together, collaboration is characterised by equality and shared ownership (John-Steiner 2000; Love and Barrett 2014: 52). Equality, according to the human rights' definition, is 'about ensuring that every individual has an equal opportunity to make the most of their lives and talents'. That said, it can be deduced that the three case studies I have analysed differ. All interviewees agree that collaboration is important, but this is a complicated and layered concept both inside the specific collaboration, and outside, meaning how the public perceives it where the audience cannot always recognize individual roles.

Vera John-Steiner (2000) proposes degrees of collaboration. At one end of the spectrum, in distributed collaboration, participants work on informal shared interests; at the other end, we find integrative collaboration where participants work in intense, committed partnership, so closely that they transform each other's practices. 'The most common form, complementary collaboration, sits between and is characterised by clearly defined roles, distributed expertise, discipline-specific working methods' (Love and Barrett 2014, 52). I would suggest that in the three cases everyone has shared a common goal and was engaging in a form of integrative or complementary collaboration, depending on the particular case. But not everyone feels completely at ease in this type of collaboration. With respect to the collaboration between Laurent Pottier and Fausto Romitelli it appears that, although the position of the computer music designer was crucial in the creation of *Professor Bad Trip: Lesson I* and other works by Romitelli of the 1990's, there still exist problems related to to the recognition of that role. If we take into account that Pottier was both the assistant during the creative process and the performer of the electronic parts in concert, his position seems even more critical. To that effect, his words sent to me in response to the questionnaire are careful (I remind the reader that Pottier was not involved in the study process and reperformance at ZHdK within the *Performing Live Electronic Music* project):

> with the passing of Romitelli [at the age of only 41], it is the computer music designer who remains the person who most knows the ways in which the work has to "sound", has to be played. But actually he [Pottier intends here to name the role of the computer music designer, but uses the masculine singular pronoun meaning himself] is never informed or solicited when re-performances of the pieces take place. He wants to suggest that during some reperformances, the spirit of the work is often ignored. The computer music designer is overlooked in this example (barely cited in the concert program notes).

The problems of recognition, some 35 years after Menger's writings (1989) about the ambiguities and paradoxes of the role of the 'tutor' (the term used at the time) and the fact that public recognition of the work's qualities was oriented exclusively towards the name of the composer (pp. 134–139), still exist (Zattra & Donin 2012: 446).

Pottier's words reverberate similar concepts evoked in Lanza's interview, and to the circumstances that lead the public to struggle to recognise situations of equal collaboration, of equal roles in a project. Valle, in his interview, proclaims that

> we [me and Mauro Lanza] always strongly insist on this point. But we also think that so far contemporary music is not ready for the concept of collaboration, for co-creation, not ready to understand that there could be more than one author. Simply, audience think that there is a composer and a technician! For an empirical reason, this is the main idea that still is present in most people's minds.

The words of Clara Iannotta—who in a few sentences summarises the advantages, disadvantages and dynamics at play in collaborative production, an overall creative dynamism that is increasingly necessary in works with digital technologies—are probably decisive in this respect. 'I am embracing collaboration more and more. Although you have to compromise! The important thing is that you like the people you work with, and if you do, it's great'.

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Appendix: The questionnaire

1. Pre-compositional phase: Sketching
   a. Did you sketch? And if so, how?
   b. Did you use previous material in your sketching?
   c. What method of sketching do you use (e. g. piano, software, patches, sound examples, recordings….)?
   d. Where did your ideas come from?
   e. Did you obtain every goal you had set during the preparatory period?

2. Compositional Process
   a. Discuss the timescale of your project (also explaining days, months, hours, number of meetings, manners of meeting: phone calls, online meeting, WhatsApp/ other chat services)…
   b. Did you preserve any trace of this process? If so, why did you preserve it or why did you choose not to safeguard it?
   c. Is it organised? And if so, how?
   d. Is it is stored somewhere and/or available for research purposes?

3. Transmission Process and Performance
   a. What type of notation, if any, did you use?
   b. Do you find that what is produced in performances of this work is what was anticipated? And does this matter?
   c. When creating a piece that is written with a particular performer's ability in mind, does this present difficulties for subsequent performances by other performers?

4. Communication
   a. Did you develop a specific way to communicate? New terms? Specific tools in order to make the compositional process advance?

b. Was there a strong working relationship developed over many years, or was it the first time?
c. Was there non-verbal communication? If so, what did it consist of?
d. Were there awkward moments?

5. Recognition and authorial ownership
   a. What are your thoughts on collaboration? (also regarding the concepts / relations / differences between composer / collaborator / performer / etc.)

III. Performer's View: Historical Development, Institutional Traditions, New Ensemble Practices and Performance Attitudes

Changes in Live Electronics Practice

Alvise Vidolin
Centro di Sonologia Computazionale (CSC)
University of Padua

Live electronics is a musical practice that has been evolving since the second half of the last century. It is above all characterised by live processing of voices and/or instruments. In the course of more than half a century of musical compositions with live electronics, there have been works with synthesised sounds or reproductions of recorded sound parts, but the term live electronics is mainly linked to the interaction of voices and/or players that are recorded via microphone, amplified, processed and spatialised live in the concert hall. The audience listens to the sound resulting from the sum of the direct sound of each performer, the sound transformed by the live electronics, and the sound field produced by the hall, excited by multiple speakers placed in various positions.

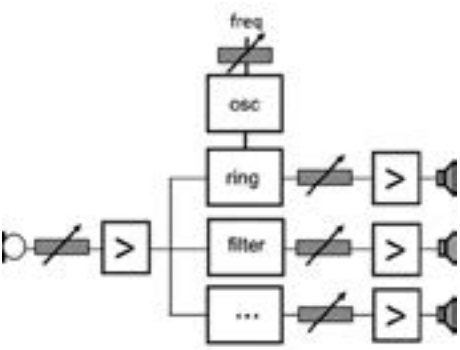


Fig. 1. Simple patch example. Microphone, amplifiers (4), loudspeakers (3), oscillator, processors (2) and manual controllers (5) linked together in the patch.

In this context, the sound director, overseeing and balancing the various processes plays a crucial role akin to that of a conductor regarding aspects of live electronics: musical interpretation, sound processing, balance of parts (acoustic and electronic), diffusion and spatialisation of sounds.

Sound direction in the analogue years

In the 1960s and 70s, live electronics systems were relatively simple and consisted of a few statically connected devices. In today's parlance, the system consisted of a single patch, few controllers and the electronic performer playing one or at most a few simple controllers (fig. 1). His actions were limited to changes in processing

parameters, for instance the carrier frequency in a ring modulator, or the level of individual processing devices and general stereo or quadraphonic amplification. In the first decades, the sound director was often the composer, possibly assisted by a technician in designing the electroacoustic system.

Significant examples of this early period are Karlheinz Stockhausen's works *Mixtur* and *Mikrophonie I,* both composed in 1964. Fig. 2 shows the patch for *Mixtur* and the first page of the score. The orchestra is divided into four groups: H corresponds to woodwinds; B to brass; P to plucked instruments; S to strings. It must have been surprising in those years that a composer would use four ring modulators to live transform a large orchestra. Each group is recorded with multiple microphones and transformed through a different type of processing. On the first page of the score, woodwinds are modulated with a sine waveform of rising and falling glissandi that move within three octaves, from 1248 Hz (D6#) to 152 Hz (D3#); brass instruments are modulated with a slow descending glissando from 636 Hz (D5#) to 172 Hz (F3); plucked instruments are modulated by a constant frequency of 368 Hz (F4#); string instruments are modulated with an ascending glissando of a sine wave signal in the sub audio range of 1 to 10 Hz. In the latter case we do not obtain a timbre transformation of the orchestral group, but a slow amplitude tremolo which evolves into an accelerando. Each performer controls the carrier frequency of the ring modulator, acting directly on the oscillator, following the times and graphs indicated in the score. The technical gesture immediately becomes a musical gesture (see Fig. 2).

In *Mikrophonie I*, while continuing to explore the timbre parameter with electronics, Stockhausen used a completely different technique. This piece is a composition for tam-tam, two microphones, two filters, and two controllers. The microphone is used actively as a musical instrument: the sound picked up by the microphone is processed by a bandpass filter which uses a dual-control slider to freely vary the bandwidth, assigning the lower and upper cut frequency of the filter. The processed sounds spread quadriphonically around the audience.

The performers are divided into two groups. In each group there is a percussionist, a microphone player, and an electronic performer. The microphone player has a very important role, being tasked with using the microphone as if it were an audio zooming device capable of picking up even soft sounds and/or resonances, quickly tracking the acoustic sources activated by the percussionist in different areas of the tam-tam.

In those years, the approach to live electronics was less formal in the United States than in Europe. While adopting the same technologies, the application context was freer and the electronics used were more closely related to domestic devices, often self-built, than to professional ones. A good example of this is David Behrman's *Players with Circuits* (1966), its title already indicating the direct relationship between the musician and the electric circuit (the patch).

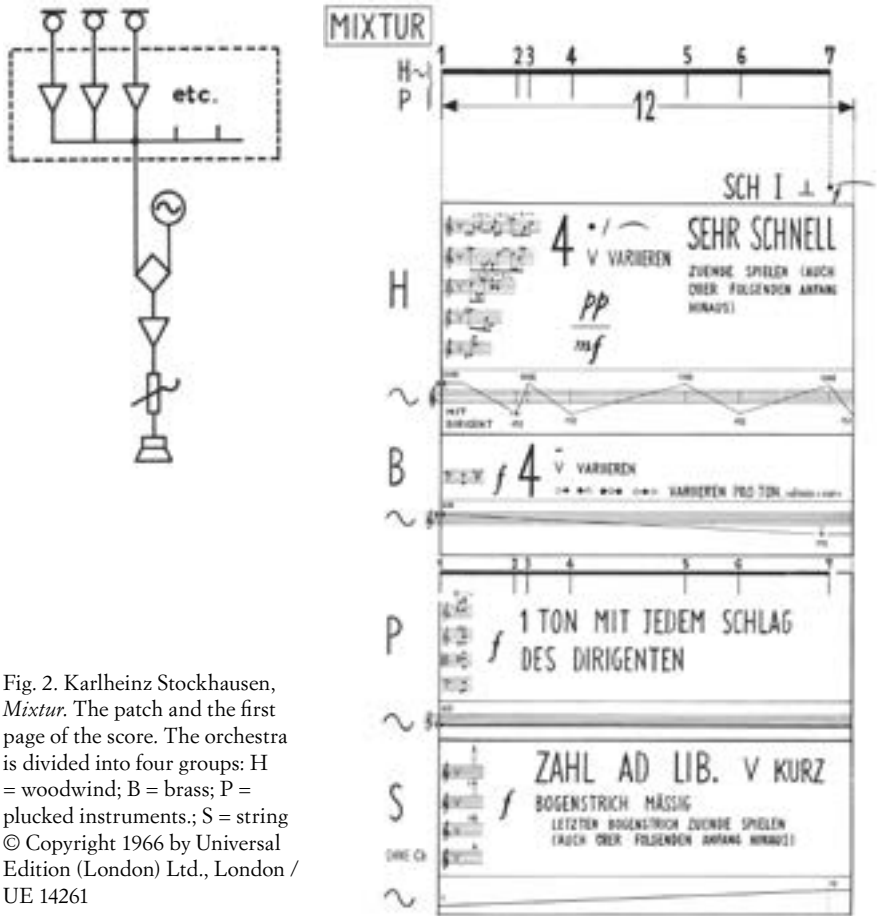


Fig. 2. Karlheinz Stockhausen, *Mixtur*. The patch and the first page of the score. The orchestra is divided into four groups: H = woodwind; B = brass; P = plucked instruments.; S = string © Copyright 1966 by Universal Edition (London) Ltd., London / UE 14261

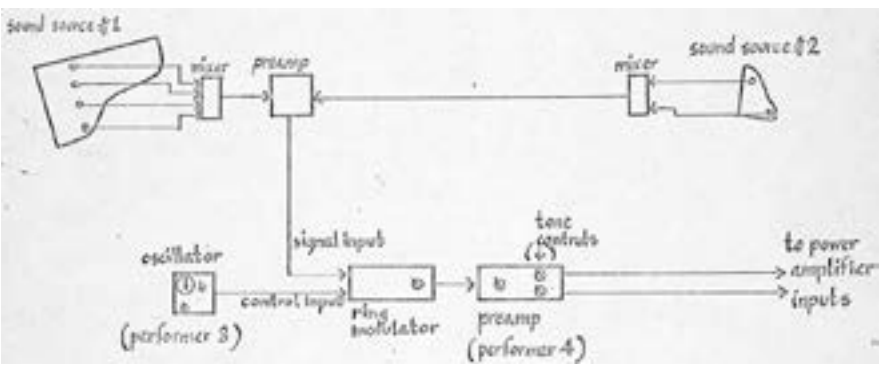


Fig. 3. David Behrman: *Players with Circuits* (1966). The patch. © David Behrman

In the score consisting of two typewritten sheets Behrman provides instructions for a version with four performers, explaining the patch in fig. 3. The first two performers play two instruments recorded with multiple microphones and mixed into a monophonic signal. This signal is processed with a ring modulator by performer three who acts on the frequency of the sine-square wave oscillator (with a frequency range of 2 Hz to 20,000 Hz), and the resulting sound is further manipulated by performer four who acts on the tone controls of the preamplifier with separate bass and treble tone control.

The performance is guided by the chronometric time, with each performer using a stop-watch. Fig. 4 shows the short model drawn in the instruction sheet for preamplifier adjustment by performer four at the beginning of the piece. Although composed in the same year, the level of detail provided is very different between Behrman's and Stockhausen's scores.

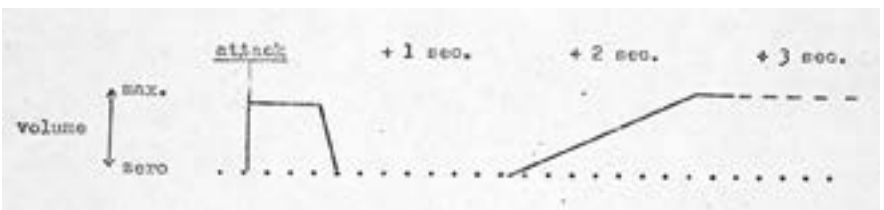


Fig. 4. David Behrman: *Players with Circuits* (1966). Excerpt from the score. © David Behrman

Another interesting work from the American music scene of the 60s is Steve Reich's *Pendulum Music* (1968) for microphones, amplifiers, speakers and performers. It is a sound action more suited to the world of artistic performances than to the classical ritual of the concert; a performative piece featuring an acoustic phenomenon, a paradigmatic example for early American experimental electronic music. The score is a text, handwritten by the author, with the performance instructions: the number of microphones, free to oscillate, that can be hung over the corresponding loudspeaker, driven by as many performers who initiate the oscillation process, releasing them together and activating the amplifiers so that a short feedback pulse is created as the microphone passes over the loudspeaker. The performance ends when all the microphones stop oscillating and a continuous sound is heard. *Pendulum Music* is an essential example of the electroacoustic nature of live electronics. In today's parlance, this piece can be considered as the sonification of pendulum motion through the Larsen effect. It is interesting to note that acoustic feedback and room resonance would play an important role in live electronics of later years.

The biggest perceived problem at the beginning of the 70s was how to vary the patching during performance, or rather to alternate freely between different patches. In the 60s, the connections between the various devices were made with cables and switches and it was very risky to de- and rewire a patch while playing live.

An example of a custom solution for the live electronic performance of a piece requiring different switching and level adjustments during performance is Stockhausen's *Solo* (1966) for a melody instrument with looping feedback system and four assistants operating the technical equipment. This piece uses a long strip of magnetic tape closed in a ring and made to slide between a writing head and six reading heads arranged in space as shown in figure 5. The performer's sound recorded with a microphone is stored on the tape and played back potentially six times at different time intervals depending on the position of the six reading heads along the loop. The four boxes that we see in the figure on the table are the execution tools of the four assistants: switches and potentiometers through which the six reading heads can be activated and the input, output and feedback levels adjusted.

The electroacoustic system Stockhausen had built for *Solo* was hardly usable for other compositions, and it was not sustainable to have to build a new electroacoustic system for each composition. The first problem to face was that of patching, for which synthesiser manufacturers had come up with various solutions. Figure 6 shows three synthesiser models; the *Moog* using cables, the *Harp* using bus routing, and the *EMS* using the matrix. Of the three, the matrix was the solution best suited for patching, which, as we will see, was to undergo increasingly interesting evolutions over the years.

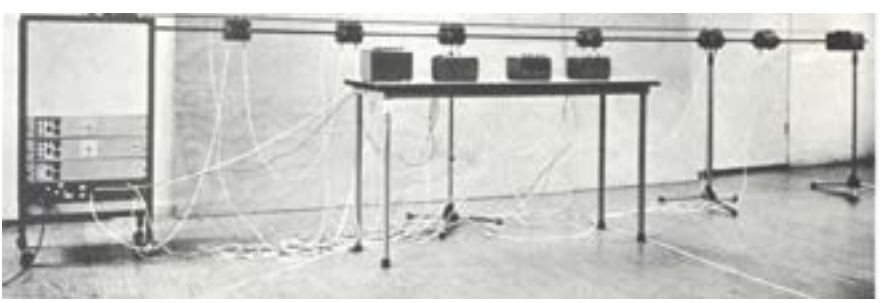


Fig. 5. Technical realisation of Stockhausen's *Solo* (1966). © Copyright 1969 by Universal Edition A.G., Wien / UE14789



Fig. 6. From top: Moog synthesiser wire connection, Harp synthesiser (bus c.), EMS synthesiser (matrix connection)

The matrix proposed by Peter Zinovieff in the synthesizers of the Electronic Music Studios in London made it easier to edit the patch while playing. The user sticks special conductive pins connecting an input (listed on the horizontal-axis of the matrix) to an output (on the vertical-axis).

Meanwhile, Hans Peter Haller at the SWR Experimentalstudio in Freiburg im Breisgau) faced the problem of switching multiple patches in sequence, which was especially challenging when the patches were very different from each other. A system consisting of four remotely switchable plug-board matrices was realised. By mounting the pins through a thin plexiglass holder, it was moreover possible to quickly replace already used patches. The system thus allowed to handle even long sequences of patches, paving the way for the cue-list technique.

In the 70s, the SWR Experimentalstudio, headed by Haller, in collaboration with the *Lawo* company, designed a mobile live electronics studio and developed innovative devices for patching, controlling (remote controls to connect the stage to the sound direction table in the centre of the hall) and sound spatialisation, which became a reference model for live electronics. In 1971, the first prototype of the *Halaphon* spatialiser was built and used in the premiere of *Planto por las Victimas de la Violencia* by Cristóbal Halffter at the Donaueschinger Musiktage.

At the end of the 70s a new fully voltage-controlled matrix was developed for both patching and switching. The patch sequences were controlled by a minicomputer allowing very frequent patch changes, as evidenced by the score of Luigi Nono's *Quando stanno morendo. Diario Polacco n. 2* (figure 7), which was
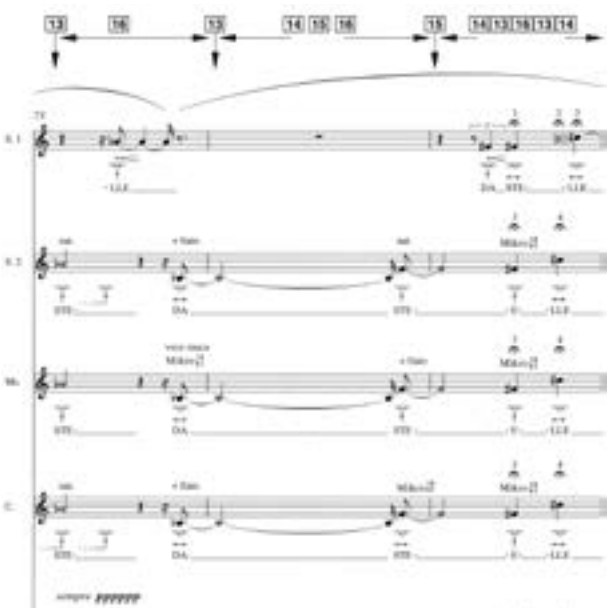


Fig. 7. Luigi Nono, *Quando stanno morendo. Diario Polacco n. 2* (1982). Extract from the score. Published by Casa Ricordi Srl, part of Universal Music Publishing Classics & Screen. International Copyright Secured. All Rights Reserved. Reprinted by Permission of HAL LEONARD EUROPE BV

premiered at the 1982 Venice Biennale. Each number inscribed in a square is a component of a *cue-list* that defines the sequence of patches. Up to seven patch changes can take place in a bar of about seven seconds, approximately equalling one change per second. These continuous and close patch changes are dictated by the aesthetics of "rupture" present in the musical works linked to Nono's opera *Prometeo, tragedia dell'ascolto* (1984–85).

Taking a cue from the works presented up to now and extending the analysis to the many other works with live electronics made in the analogue years, we can draw some conclusions. System design was and is very important in order to guarantee the musical functionality of electroacoustic devices in performance. As is well known, the instruments used in early electronic music were developed in scientific research or telecommunication laboratories for purposes that were anything but musical. It was thus necessary to start an electronic lutherie business of sorts to develop electronic instruments designed for musical purposes. For live electronics, the demands were even more exacting, as the technology had to satisfy the need for portability, remote control of the system, and the instantaneous commutation of the connections between the various devices. Work on the live electronics system design was therefore often divided among several people with different technical skills, involving musicians, electronics engineers and eventually specialised companies all coordinated by the sound director.

In the production of a musical work, it is necessary that the sound director assists the composer in translating the musical ideas into concrete actions, such as choosing the appropriate devices, designing the patches and manual controls in the performance environment, and managing the pre-production musical rehearsals. In concert, the sound director has to effect the 'tuning' of the system in the concert hall and realise the musical performance, if necessary with the help of other electronic performers.

Digital Technologies for Live Electronics

At the beginning of the 80s information technology was quickly evolving, and several technologies were developed that would greatly impact the future of live electronics.

In 1981, Pierre Boulez premiered his *Répons* at the Donaueschinger Musiktage, a piece for a large chamber orchestra with six percussion soloists and live electronics. The sounds of the six soloists were processed in real time by a digital system called *4X*, and this performance for the general public of contemporary music marked the beginning of a new phase of electronic music called real-time computer music. The *4X*, developed at IRCAM in Paris, was the most powerful real-time digital sound generation and processing machine of the 80s, and a great

deal of technological-scientific research as well as important musical productions were realised with this system, desired by many composers.

The paradigm shift brought about by computer technology and real-time digital systems led also to a cultural change in sound direction. The concept of the live electronics system likewise radically changed, as it was no longer composed of a set of devices each of them designed to perform a single specific task. Now there was a computer that could be programmed to perform those same functions even in multiple ways, depending on computing power. The same computer could be programmed to perform completely different functions (processing, patching, controlling, etc.) and could thus satisfy different musical needs both in terms of quantity and quality. In addition, physical controls could now make use of various software tools, such as mapping or calibrating a controller in the desired musical range, by programming the appropriate gesture-output conversion rule.

Curiously, among the first research undertaken in this early period of great enthusiasm was precisely the (partial) automation of the sound direction. Philippe Manoury's *Jupiter* for flute and live electronics realised at IRCAM and first presented in 1987 was one of the first pieces to use a program that would follow the score and allow the control of live electronic processing and synthesis through a stream of musical events from a live instrument. In those years it was assumed that computers would soon be able to perform many of the sound director's functions. This became true regarding some technical aspects. For specifically musical actions, however, this remains to this day a difficult problem to solve.

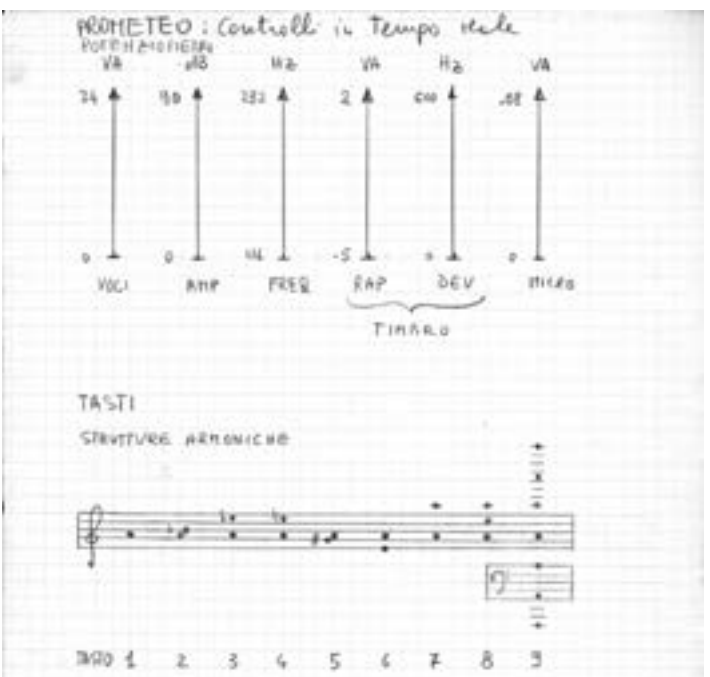


Fig. 8. 4i System. Performance environment in Nono's *Prometeo* © Alvise Vidolin

Nono's *Prometeo*, which was mentioned in the previous paragraph, also used a live electronics digital synthesis system that played a significant role in the opera. This was the *4i* System, developed in the early 80s at the Center for Computational Sonology (CSC) of the University of Padua. The *4i* was born from a 'rib' of the *4x* system, which was possible thanks to the collaboration between the Venice Biennale (LIMB), CSC and IRCAM and above all Giuseppe Di Giugno, the inventor of this technology. In the opera *Prometeo*, Nono developed a composition-performance technique called 'mobile sound'. This was applied to voices and various solo instruments, adapting it to individual peculiarities. The 'mobile sound' technique was also simulated in the *4i* system, creating a specific performance environment called Peata. This environment was able to generate a real time polyphony of 24 voices with frequency modulation synthesis technique. Live control of these voices was done with gestures using six potentiometers and nine keys, as illustrated in the original sketch reproduced in figure 8.

Each voice cyclically generates a short, randomly varied sound event lasting about one second. At the beginning of each cycle, the event is updated according to the values of the six potentiometers: number of voices, amplitude, frequency, timbre (two potentiometers: modulating carrier ratio and modulating deviation peak) and micro-intervals. These micro-intervals (small random variations of the voice's frequency) are the main features of the 'mobile sound', together with small variations of the carrier/modulating ratio and slow timbre variations created by the modulating deviation peak. The keys allow the performer to vary the intervals between the voices, including the unison, ascending and descending bicords of minor second, tritone, fifth, and again a fifth plus octave triad and an (not used) expansion to seven octaves. This evokes the beginning of Gustav Mahler's First Symphony which had inspired Nono in the first version of *Prometeo* from 1984.

Sound direction in the phase of digital transition

In the 80s, only a few research institutes could afford to use real-time audio computers. Most music productions continued to use analogue technology, progressively adopting digital devices offered on the market. In 1975, *Eventide* produced the first 'harmonizer' (*H910*), capable of processing mono sounds and transposing within the range of plus/minus one octave. In 1978 the *Publison DHM 89 B2* was introduced, offering dual pitch shifting within a range of +1/-2 octaves and a dual reverser effect. Some years later, *Publison* produced the *Infernal Machine 90*, adding, among other effects, good digital reverb. There were also complete digital systems such as the *Synclavier* (*New England Digital Corporation*) and the *Farlight CMI* (*Computer Musical Instrument*) which were, however, used more in studio productions than in live-electronic concerts, a notable exception being Joel Chadabe's performance *Solo* (1979). The antennas were modified theremins made

for Chadabe by Robert Moog, and Chadabe used them to 'conduct' the musical processes generated by the *Synclavier.*

Starting in the mid-1980s, the MIDI protocol had progressively replaced analogue voltage control, vastly expanding the possibilities of control and interaction between the devices. Thanks to personal computers, MIDI controls could be enhanced by computer programming tools. In 1988, Miller Puckette released the first version of Max (a graphical development environment at the time limited to live music control) which had been developed for the Philippe Manoury's composition *Pluton* for MIDI piano and real-time electronics.

In the late 80s, computing power of personal computers was still very limited compared to today (it would take some ten more years until personal computers were used in live sound processing), but sufficient for control operations, also facilitated by the intuition of some personal computer manufacturers (e.g. *Atari*) who equipped their models with the standard MIDI interface.

In those years, the electronic music instrument industry began to produce the first samplers, designed for studio use, but progressively followed by lighter models suitable for live performance. The combination 'personal computer—midi control—sampler' brought about the birth of what we could call 'pseudo live processing', meaning a live performance technique based on samples pre-composed in the studio. Live performer David Moss calls it 'studio electronics', but it is nowadays referred to by many other names, some of them not so kind, such as e.g. 'fake electronics' or 'dead electronics'; pointing to an issue relating to the nature of live electronics that has already been addressed by other writers and which would have to be developed in a broader debate.

In concert, the sound director will perform these samples live, usually following a cue list; the samples have to be well synchronised with the vocal or instrumental performers, so as to simulate live processing. This technique, developed in the 90s, can be considered an evolution of the mixed electronic music performance practice of the 60s and 70s based on magnetic tape. In those years it was the performer who followed the tape, here it is the sound director who follows the performer, or rather, they both play together.

An important example of this performance practice developed in the early 90s is Salvatore Sciarrino's piece *Perseo e Andromeda*, a one act opera lasting just over an hour for soprano, mezzo-soprano, baritone, bass and synthesis sounds with texts by Sciarrino after Jules Laforgues. The Electronic production was realised at CSC by Alvise Vidolin and Paolo Zavagna, the first performance took place at Staatstheater Stuttgart in 1991.[1] With the exception of the four singers (with the curious feature that Perseo's part is portrayed by the two male voices always singing as a duo), all sounds are synthetic. Sciarrino used a single generative principle to give unity to all sounds, based on subtractive synthesis transforming white

1 CD BMG-Ricordi CRMCD 1059 (2000)

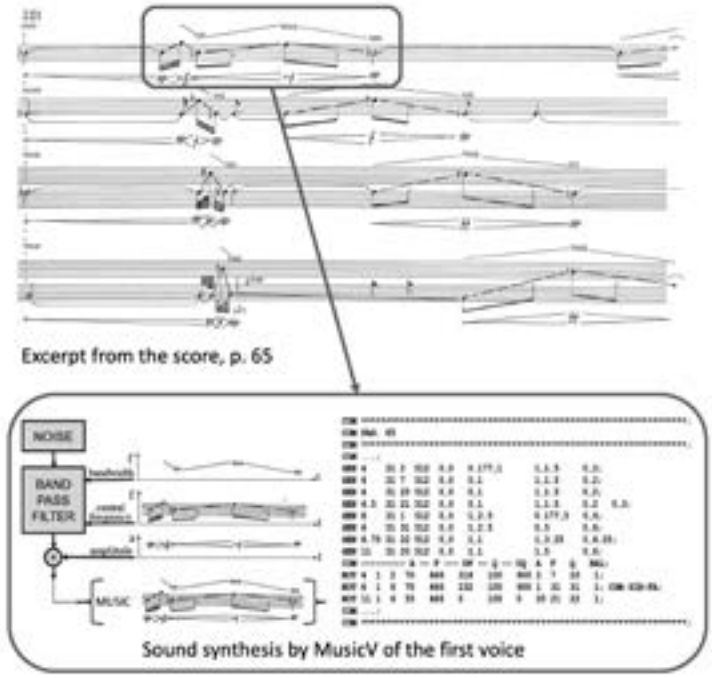


Fig. 9. Sciarrino's *Perseo e Andromeda.* From the score to the digital synthesis of sounds.
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noise into a vast palette of noises and melodic gestures through judicious use of dynamic filtering. The wide variety of sounds looked for by the composer ranges from evocative, but not imitative, sounds such as wind, sea, cobblestones, etc. to short melodic musical objects and abstract sounds as would be the sound of the horizon, anchor and obsession of those who live on a lonely island like Andromeda. The *Perseo and Andromeda* 'orchestra' was made up by four computers played by two performers. The *4i* system was used live for the musical parts in which the timing was freer, as it depended on the theatrical actions. Workstation 1 and 2 were played separately via a cue list to playback parts following the conductor; these audio files were generated by a *MusicV* program running batch synthesis on the workstations. Lastly, a fourth computer was used for sound spatialisation, controlling via MIDI a bank of eight amplitude controllers through which the levels of as many amplification channels were changed. It was played through a cue list to playback the sequence of sounds movements notated in the score.

The use of samplers and, subsequently, the playback of audio files from a computer became a widespread practice in these years, sometimes also creating ethical and copyright issues concerning the use of samples. Although the use of playback

contradicts the 'nature' of live electronics, it is nowadays widely used to make performances more reliable when rehearsal conditions are not optimal.

The 90s marked the beginning of a new phase of live electronics in which it became possible to build personal systems using the digital industry's products. The personal computer is at the centre of the system, complemented by digital audio interfaces, sound processors, MIDI controllers and digital mixers. Yamaha, which with its *DX7* had been a pioneer of musical keyboards using digital sound synthesis, also became a pioneer of digital mixers in the mid-90s with the *02R* model, which soon became a standard for live electronics thanks to the possibility of controlling most mixer parameters via MIDI. In these same years, systems were evolving rapidly thanks to faster computer CPUs and the possibility of creating with software what had previously required hardware devices.

Live electronics in the new millennium

From the 2000s onwards, personal computers have become powerful enough to serve as the main tools in live electronics, now realising their tasks, live audio patching, processing and controlling, exclusively via software. The main software used is *Max/MSP*, which by now with the extension *MSP* (Max Signal Processing) allows live processing of sounds, or alternatively *Pure Data* and *Super Collider*. These applications allow for the complete realisation of the performance environment required by most compositions. In addition, free software communities or digital audio companies produce a panoply of plug-ins satisfying a wide variety of processing needs, including simulations of historical analogue and digital audio devices.

Thanks to these innovations, the sound director can create a more stable working environment in which basic procedures can be reused, while specific elements of the individual compositions are programmed and inserted on a case-by-case basis. Although we are still far from the instrumental model that music history has handed down to us, the live electronics community is moving towards an open performance environment model in which to incorporate the different specificities of individual compositions, both in terms of processing and controls.

At this point it might seem that all technological problems have been overcome and that the sound director can devote himself completely to the musical aspects of a performance. Certainly, music evolves by treading new paths and following intuitions that never occurred before. Thanks to technology, many of these intuitions can be translated into sound, opening new avenues for musical composition. We must thank the Institute for Computer Music and Sound Technology (ICST) at the Zurich University of the Arts (Zürcher Hochschule der Künste/ ZHdK) and its staff for making possible the four-year project *Performing Live Electronic Music – Technical and Aesthetical Challenges in the Digital Age*, which has

given a broad overview of this alliance between music and technology by analysing and performing in beautiful concerts a wide selection of important musical works from this repertoire.

At the same time, however, the fragility of this music-technology relationship also became evident. The times and methods in music differ from those in technology, especially when it comes to refining electronic instruments (patches and controls) and learning to master them. Technology must be at the service of music, but the rapid obsolescence of devices and the unstoppable evolution of software have shown that a considerable collective effort is necessary to keep this musical repertoire alive. Music has survived through time thanks to scores and oral transmission. In the last century, sound recording has made it possible to preserve musical performances of considerable historical importance. On the other hand, *auteur* recordings have often constrained musicians, limiting their interpretative creativity. Different from traditional notation, notation for live electronic music must include a description of the electronic instrument and its performance technique. This description can be very complex, especially if the software contains compositional algorithms. As regards the performance technique, in many cases it may be useful to combine the technical description with a recording of the performance gestures. Another constraint is imposed by the use of patented processors because the industry does not want to make its secrets public. In any case, we must find the best way to notate live electronics music without turning a score into a technological essay, but ensuring the sustainability of the works. This must be done quickly because in this field time is a crucial factor.

Through the ages, performers have passed down the music by choosing the finest instruments available, interpreting the score and translating it into sound, teaching the necessary performance techniques and involving the audience in the performance. If we want to keep this virtuous circle of music alive, our community must know how to train new luthiers, performers and sound directors to ensure the sustainability of this repertoire.

As became clear during this project, the best way to ensure the sustainability of this music is to reperform it. As we have seen, a 'chamber' repertoire with live electronics is developing, which gives us hope that performers will incorporate these compositions into their repertoire. With each re-performance the technological apparatus is checked, updated and possibly renewed; at the same time, the audience and listening memory of the repertoire are expanded.

The documentation collected at http://ppeam.zhdk.ch/ is a formidable working tool for future performances of these repertoire. Therefore, the collective effort must aim to keep the documentation up to date with each new performance.

Conclusion

We have thus come to the end of the sound director's journey through the world of live electronics, a journey that we could call one of initiation, given that today this technology is no longer a novelty, but has become, albeit at different levels, a part of contemporary musical life and most productions.

As we have seen, this journey began by performing the first compositions with the few tools available: the electroacoustic chain 'microphone-amplifier-loudspeaker', instantaneous processing, and time-translation (delay). This was eventually expanded through the transition to digital technology to include the possibility of storing and playing back sounds. Thanks to these primitive elements, we began to explore the new sound world which arose from the transformation of live sounds, inventing new instruments and new performance techniques. Already with the simple electroacoustic chain, we progressively immersed the audience in the sound, amplifying sonic details that in acoustic music were only perceived at a subliminal level and bringing them into the foreground. Moreover, the chain itself became a generator of sound and also an amplifier of the sound environment, opening the performance to new interactions of the music with the environment. Finally, by positioning the loudspeaker far from the acoustic source we began to explore the spatialisation of sounds. At the same time, with instantaneous processing, the sound director made the sound of musical instruments become 'different', as we saw in the first works using ring modulators (*Mixtur, Players with circuits*). But the change in timbre produced by the ring also led to a paradigm shift in the harmonic theory of sounds, traditionally based on the multiplicative logic of transposition. Through the ring, on the other hand, the concept of spectrum translation is introduced, based on an additive logic that alters the harmonic structure of the sound itself. While the ring causes a translation of the sound spectrum, delay produces a translation of the sound in time (echo), effectively adding memory to the performance. When there are multiple delays, these additionally lead to a multiplication of the source in time and, as we have seen in *Solo*, this multiplication can be further increased by the use of feedback, transforming a melodic instrument into a polyphonic one. Finally, the use of pre-recorded and pre-produced sound played live (sampler) has created new possibilities for interaction between musicians and specially composed electroacoustic sounds.

After half a century of technological evolution and musical experimentation, these basic techniques have evolved and multiplied, but the functions have essentially remained the same. As we have seen, the electroacoustic chain has evolved into ever more elaborate and instantly switchable patches. Processing has seen evolutions both within the same typology—as we have seen for example in *Répons* using ring modulation which developed through the Hilbert transform, separating the positive spectral translation from the negative one—and with the invention of new algorithms, but above all with the introduction and then further development

of frequency domain processing. Among other things, this has made it possible to further overcome the already discussed time constraint imposed by recorded musical parts, allowing variations in duration even in live performance. This is most useful when performers of mixed electroacoustic music require greater temporal freedom, something which used to be impossible due to the fixed running times of the magnetic tape. Finally, the control sector has also been enriched with devices designed for musical performance and has expanded to include an ever-widening variety of sensors capable of fostering gesture-sound interaction even with haptic feedback.

These advances in technology and the evolution of performance practice have brought live electronic systems closer and closer to the sound director's idea of a musical instrument. An instrument that must necessarily remain open in order to evolve according to the compositional and performative needs of specific composers and works, while maintaining the structural and functional unity that we have seen grow and develop through the musical experiments of the last half century. After all, the organ is a millenary model of musical instrument that has been able to adapt to and evolve through the various epochs with the help of different technologies. This gives us hope that there will likewise soon be a reference instrument for live electronics able to consolidate the performance practices of this recent past and to develop them in order to meet the challenges that await us in the near future.

Risks, Time and Collaboration
Some Aspects of Performing Live Electronic Music with the SWR Experimentalstudio

Lydia Jeschke

Risk

Musicians tend to be perfectionists. The 19th century in particular saw a rising ambition to perform sportively. Stars on their instruments such as Clara Schumann, Niccolò Paganini, Franz Liszt and others repeated and established concert performances on highest technical levels, and the astonishment at this was no small part of their success. These days we witness ever higher standards of technical perfection in musical performance, often already in very young players.

When electronics appeared on the musical scene, it seemed that they would allow to achieve even greater perfection. Once the music was completely prerecorded and then played back via loudspeaker, sensitive acoustic instruments and musicians would no longer be necessary to realise a concert. In some musical scenes, machines seemed to take over. It was live electronics that brought back the 'aura' of an actual performance into the world of electronic music, including instrumentalists and sound directors operating the newly developed devices as additional musicians—and a new, risky lack of predictability, something the SWR Experimentalstudio, formerly named Experimentalstudio der Heinrich-Strobel-Stiftung des SWF, was committed to from its very beginning. The risks became a part not only of the studio's day-to-day work, but also of its aesthetic DNA.

We have all experienced this in concerts with electronics: Computers go on strike, loudspeakers fail, connections between different tools or instruments suddenly stop working. I remember all electronics for a complicated piece not working for hours because one of the stagehands had accidently disconnected one single cable. Some special moments of unpredictability in performances involving the Experimentalstudio even went down in (known) music history, among them the world premiere of Pierre Boulez' *Répons* at the Donaueschinger Musiktage in 1981. Boulez composed the piece for six soloists, small orchestra and live electronics. The audience at the Baarsporthalle noticed several loudspeakers on the ceiling and elsewhere in the hall as well as massive technical devices sharing the centre of the hall with the orchestra: IRCAM's new *4X* computer and the Experimentalstudio's *Halaphon* (cf. Häusler 1996: pp. 342).

Shortly after the music started, it ended abruptly. Apparently, lightning had struck a substation on the Upper Rhine and caused a power outage. Helplessness prevailed on site and among the listeners of the live radio broadcast. The technicians and performers feared for the sensitive technical setup. Could the power outage have damaged the equipment? After a little more than a quarter of an hour power was back. The piece was started again and played through completely without further disturbance. Although it was only the first part of the later revised and enlarged piece that was presented in Donaueschingen, the risk of such a setup and compositional plan, that became so immediately obvious, made a lasting impression. To this day, many people remember this performance and radio transmission vividly.

At least that's how the story goes. The Experimentalstudio's director at the time, Hans Peter Haller, describes the situation differently in his book *Das Experimentalstudio der Heinrich-Strobel-Stiftung des Südwestfunks Freiburg 1971–1989*. According to him, the live electronics could have worked again after one or two minutes; it was in fact the Baarsporthalle's mercury vapour lamps that required such a long time to come back on… However, Haller tells other intriguing stories about damaged electronic tools and performances that almost had to be cancelled, for example when transporting the sensitive equipment (Haller 1995: vol. 2; 70, 56).

Beyond these instances of *force majeure*, there is risk as a constant companion in the studio's work, whether due to new machines not yet having been tested over a longer period of time, or due to flimsy connections between technology and human musicians that might act up spontaneously in a live concert.

The composers' and sound directors' perspective

One of the first composers working at the Freiburg studio to be fascinated by this on an aesthetical level was Luigi Nono. Not that Nono wanted things to be in disarray or that he wanted to show the destruction of a meticulously prepared scenery. He was however working with the risk of incorporating the latest technical achievements into his performances. He took into account that something would probably not be working under live conditions, at least not as perfectly as planned and tried out at the studio.

Looking back on different performances, for example of his *Tragedia dell'acolto*, he seems to have been more interested in an ongoing journey towards something than in the repetition of a single work. At every venue, in every performance some aspects might come out perfectly while others would for some reason not be heard.

I remember colleagues from the Experimentalstudio telling me after a performance of *Prometeo* at the Kammermusiksaal of the Berliner Philharmonie that

the special gate technique had just for the first time worked perfectly. The idea of the 'gate' was to have a connection between two musicians in such a way that one could directly influence the output of the other's playing. For example, the flute player, maybe positioned far away, could open the gate applied to the clarinet player's sound, thus changing its dynamic. Difficulties arose in balancing the gate actions. It was hard for the sound directors to control the situation by reacting quickly enough for example to sudden unforeseen dynamic accents. This resulted in a rather rough structure.

That Berlin performance (with better and faster technical equipment allowing for much better reaction times and balance) took place in 2011—Nono died in 1990. Thus, he experienced the gate as something unreliable. Nono took into account that the Experimentalstudio's live electronic tools, many of which had been specially developed and arranged for his music, could work in a more or less plannable way. But more than that, this risk involved belonged to the artistic process and became part of Nono's philosophy in the 1980s: not to establish and repeat the stable things, but to live with uncertainties and, at the same time, possibilities. 'Wenn es aber Wirklichkeitssinn gibt, […] dann muss es auch etwas geben, das man Möglichkeitssinn nennen kann.' ('If there is a sense of reality [...] then there must also be something we can call a sense of possibility.')—Nono so often referred to Robert Musil (the quote is from his *Der Mann ohne Eigenschaften*) in texts and interviews of the 1980s.

Today we find a different situation in the studio. Digitisation of the electronic tools made many things easier, smarter and more predictable. A higher degree of preparation with regard to all kinds of contingencies is possible. This does not mean that things are now guaranteed to work as planned. Other things are now becoming complicated, as other, much more complex things have become technically possible. What did not change over the years is the fact that we still find ourselves in a new place for every performance and that the technique has to be transferred to another site. In 2018, the potential complexity in playing with and in special venues became obvious in the first performance of a new piece. The site was the Märkisches Museum in Witten, which the artistic director of the Wittener Tage für Neue Kammermusik Harry Vogt wanted to become a 'whispering house'. He therefore asked two composers to bring something special to this non-concert hall.

It was perhaps not by accident that both pieces by Carola Bauckholt and Mark Andre had been developed in the Experimentalstudio in Freiburg, where delicate, sometimes 'whispering', but nevertheless space-filling sounds have been part of several works. In the case of *…selig sind…* by Mark Andre the basic idea was to have clarinetist Jörg Widmann wander around, behind and between the listeners using 14 stages and stands, while the small audience sat in the middle of the room. The room itself was supposed to correspond to the soloist as in a dialogue—by electronic means. Transducers were supposed to transport the vibrations of whis-

pered texts from the Gospel according to Matthew and several first names as well as clarinet sounds. There had been many rehearsals and try-outs in the studio—but nobody knew how exactly it would come out in the Witten museum. Time for preparation was short. Surprisingly, the walls proved quite resistant to sound. For some hours it looked as if the work to be premiered was more or less going to be a piece for just solo clarinet without live electronics. Finally, Michael Acker, the studio's sound director for this production, built a special construction with pieces of wood leaning against the walls, thus reinforcing the sounds—and the audience witnessed an impressive, several times repeated, half hour of clarinet playing and whispering house.

Mark Andre has furthermore not only accepted that electronic, especially live electronic means entail moments of considerable uncertainty. Even more, he apparently sees something in them that fits very well with (and has possibly influenced) his aesthetic thinking. The more comprehensive the possibilities offered by technology and science become, he says, the more conclusive they are, the more we have to face the insecure, the unstable and the unknown. Physicists of our time would probably say the same (Jeschke & Andre 2015: 62).

In Mark Andre's music, part of this aspect is always at work. It can be a perceivable part of the composition, and it is surely part of the important things he wants to say, to show, and to be experienced by the listener. He might call it 'Zwischenraum' in a certain context, or 'Fluktuation' or 'Übergang'—the latter serving in shortened form as the title for his composition *üg* (2015).

The musicians' perspective

As mentioned above, musicians normally play their instruments (or use their voices) by exercising the greatest possible control—they train for this for many years.. It is what enables them to musically express what they want. Sometimes when an instrument does not offer full control you will hear musicians joking about this fact. This is for example why German-speaking musicians call the French horn (on which because of its long tube and required sensitive approach it can be challenging to hit every note precisely) 'Glücksspirale', alluding to its spiral form, but above all to the famous German lottery of the same name. The idea behind this joke is that musical instruments should be predictable and work as a reliable extension of one's own body.

Despite lacking the long tradition of acoustic instruments, the situation is similar, for a sound director playing electronic devices: This musician likewise aims for control over his or her technical instruments. Swiss composer and sound artist Cathy van Eck has pointed out strikingly close connections between the musician's body, the acoustic instrument and the electronic devices (Van Eck 2017).

What happens though when instrumental musicians and sound directors have to work together as in most pieces with electronics? There are suddenly greater risks on both sides.

'I had the sensation of playing a new and unknown instrument.' I heard several musicians say this while working on a piece at the Experimentalstudio. What is 'unknown' or unfamiliar about this work is mainly due to the fact that control of the sounding results has to be shared between the musician and the sound director. For the instrumentalist this is an unfamiliar situation in two respects. Not is the sound he or she produces electronically manipulated and thus comes out differently than in traditionally trained settings, it is also quite often the case that the musician does not even hear the result from his or her position, making it impossible to control the relation between the instrumental playing and the sound even in retrospect.

Sitting in an orchestra or big ensemble and playing with live electronics will quite necessarily cause such a lack of musical communication and interactive control from the musician's point of view.[1] All familiar and learned aspects of instrumentation, dynamics and balance within the group become wobbly. The relationship between the individual's instrumental action and the sounding reaction within the whole context becomes rather enigmatic. It came therefore as a big surprise when in 2007 the musicians' committee of the SWR Sinfonieorchester Baden-Baden und Freiburg chose Mark Andre's piece *…auf 3…* which he had developed at the SWR Experimentalstudio for the orchestra's prize awarded at the Donaueschinger Musiktage. Musicians would leave the stage during the rehearsal in order to listen to the sounding result in the hall and to appreciate the piece's interesting and novel aspects.

Soloists on the other hand very often find their way into the studio, becoming part of the creative process, including not only the performance, but also the development of the piece's live electronics. In Freiburg a good portion of the working time is devoted to experimentation both with the musician and the electronic tools. It used to be that way in the early days, it continued in the years with Luigi Nono, who brought his favourite musicians like Roberto Fabbriciani, Ciro Scarponi or Giancarlo Schiaffini with him or worked intensely with young musicians from the area like the alto Susanne Otto, and it is still common practice these days. Chaya Czernowin's studio work for her big opera *Heart Chamber* (2019), for example, started with long sessions with singer Noa Frenkel. In the end, their experiments became a fundamental part of the recorded samples as well as of the vocal parts to be performed.

1 Projects like the orchestra piece *Utopia III* (2016) by Thomas Kessler aim to get the orchestra musician back into the live electronic game by giving each musician electronic tools to play next to their instruments. But this is up to now a rather unique attempt.

To give one of the most recent examples: In 2023 Christian Billian developed his refined cycle for guitar and electronics *Katalog der Schwingungen* together with guitarist Jürgen Ruck at the Experimentalstudio, pursuing the idea of making 'internal' sounds of the guitar audible through live electronic means. This kind of work enables the instrumentalist to get used to or even play with the changes the electronics effect on his instrumental techniques and output. At the same time the risk he or she takes might be felt even more strongly as (like in Billian's piece) a very small action on the instrument may cause a rather great effect in the sounding result.

The studio's perspective

Joachim Haas, director of the SWR Experimentalstudio since 2022, is aware of risks being part of the game. From his point of view there is also what he calls an 'immense non-technical risk' inherent in the studio's work associated with so many world premieres.[2] New pieces are in some way always new experiences or try-outs. Questions remain open up to the performance: 'How will the composition itself turn out? How does everything that has been experimented with for a long time come together musically? How does this translate acoustically in the concert hall? Was the loudspeaker concept right?' The studio's work thus is in many ways always about the risk of failure, but, as Joachim Haas points out, '[…] all the better [are] the moments after successful performances.'

On a technical level, however, the SWR Experimentalstudio has developed a contingency concept over the last years, aiming to minimise risks during performance. The idea is for example to have with them two pieces of all important equipment to allow for quick replacement in case of failure during a concert.

Time

It is often said that live electronics in general and the SWR Experimentalstudio in particular opened up and still open up new possibilities for designing sounds in space. Although this is obvious on various levels, the factor of time is also a crucial part of the studio's performative work. It might in fact be this aspect that generally creates the greatest tension.

Hans-Peter Haller, who was trained as a musician and composer before becoming a sound engineer and first director of the Experimentalstudio in the 1970s, remembered very well the first experiments with sound transformation in real time. It is amazing how open, undefined and uncertain things appeared, al-

2 Correspondence with Lydia Jeschke, January 2024.

though—or maybe because—the technique was so refined and had been developed over years. According to Haller there were many aspects that could influence the effect of an electronic tool in performance—many of them lacking control options for the performing sound directors. He liked to quote sound engineer and electroacoustic pioneer Fred Bürck who in the 1950s said about an early sound transformation tool that it depended on the weather whether it would work and how: with bad weather it would actually work a couple of minutes, one hour with good weather, if you were lucky (Haller 1995: Vol. 1, 11).

This early setting is already typical of a condition persisting over the years and regardless of technical developments: In music with electronics a great deal of time is habitually spent on a very short result, something which every composer working in the studio has to cope with. Just as present is the experience of ever faster processing—probably felt here like nowhere else in music. When Mark Andre was working on his chamber music with live electronics *ab II* (1996/97) the (at the time quite new) sound convolution tool took several hours per sound to process. 'You could "set up" such a convolution on the computer in the evening, i.e. start the calculation process, and then have the result the next morning', Joachim Haas (Jeschke 2015), at the time collaborator at the Experimentalstudio, explained to me. Now, in the 2020s, the computer processes many convolutions simultaneously within fractions of a second, prominently featuring in pieces like Mark Andre's *…selig sind…*. This small example illustrates that live electronics as an instrument are constantly changing. As a consequence, historically informed performance practice is a particular need in live electronic music performance—its history might be short compared to that of other instruments, but it unfolded in fast-motion.[3]

Faster processing does however not mean that less preparation time at the studio is required. Composers and musicians who are used to processes in instrumental music are still surprised at how much time it takes to choose, define and use electronic means. Patricia Kopatchinskaja, associated artist of the SWR Experimentalstudio in 2023/2024, pointed this out when she was working on her composition *Flügeln.Wund* (2023) in Freiburg. The more meticulously you can work in the studio the more possibilities you have in transforming the sounds, and the longer you work on them. With respect to live electronic music this leads us to an almost paradoxical state: Working on a project requires a great deal of time and patience, going back and forth, whereas live electronics are meant to happen in real time, quickly, directly, and spontaneously during a performance.

It is no wonder that composers were quick to discuss temporality in and working with live electronic means. One of the first composers working at the Experimentalstudio was Brian Ferneyhough. His *Time and Motion Study II* (1973–76)

3 This will probably be a major field of future research. With regard to the SWR Experimentalstudio, see Reinhold Braig's considerations (Braig 2019: 193–209).

for vocalising cellist and electronics was premiered in 1977. Ferneyhough, like Patricia Kopatchinskaja not a specialist in electronics, wanted to discuss memory and its functions in the present, and he refers to capitalistic time structures forcing people and their work to become ever faster. Could time stand still or go backwards while memorising? To deal with this topic, Ferneyhough used electronic delays and modulations; at the same time, the possibilities of live sound transformation show a musician in an extraordinary, machine-like situation. Ferneyhough said in retrospective:

> In *Time and Motions Study II* I used electronics in such a disruptive way that the individual, the cellist, with all the microphones and pedals he has to operate, ends up in such an impassable thicket of memory fragments, of unrhymed phrases thrown together, where everything has been erased over time that contains the possibility of the subject, the exposing subject (the cellist), to realize himself. The human being no longer exists. (Gottstein 2019: 92)

Questions of time and human capacity to deal with them have also inspired one of Luigi Nono's pieces from the 1980s. While the composer was absent from the studio 'his' musicians Ciro Scarponi and Roberto Fabricciani assisted a psychoacoustic experiment led by Hans Peter Haller. How long, he asked, would the human mind be able to recognise a delayed melody as the same melody? In the course of the experiment they concluded that recognition ended with 24 seconds of delay, even earlier with some filtering processes applied. Nono witnessed the experiment at some point and adopted the whole setting for his *A Pierre. Dell'azzuro silenzio, inquietum* (1985).

Real time action and memory, archive and contemporary presence—these time-related topics are still crucial for composers working at the Freiburg studio. More recently, Eivind Buene composed a piece building on this, integrating the individual players' memories with live electronic means. *Personal Best* (2021) for saxophone, percussion, piano and electronics offers sound collages consisting of speech and other preferred recordings of Trio Accanto's members. During the performance, the musicians are asked to improvise to these recorded collages played 'historically' from vinyl records—an interesting, basic balance between 'then' and 'now'. 'The negotiation of the "now"', Buene says in his commentary to *Personal Best*,

> is an ongoing discussion at the heart of live electronics, and a discussion the Experimentalstudio has been a vital part of since its beginning fifty years ago. If one regards the Experimentalstudio as an entity with its own subjective history, its own memories, its own desires, it also becomes a site for archaeological excavation. (Buene 2021)

Buene limited the live electronic means to old devices like ring modulation, filters etc., reflecting the rapidly evolving history of live electronic means mentioned above. 'This hardware', he says,

> is of course a form of "obsolete" technology—"obsolete" in quotation marks, because the instant it sounds on it becomes part of the present. Let us call it a synchronisation of non-synchronous forms, when mechanical instruments meet analogue methods in the digital domain. (Buene 2021)

This synchronisation of musical and technical elements from different times takes place within the concert's real time—it is a fundamental task of live electronic music to do it anew every time. And last but not least there is a third level regarding time (in addition to past and present) that might be important for performances of live electronic music at least in an ideal or maybe utopian sense. Argentinian-French composer Daniel Teruggi mentioned it as a main motivation for composing and performing music upon receiving the Gigahertz Prize awarded by the ZKM Karlsruhe and the SWR Experimentalstudio in 2022. As the long-term director of the Institut National de l'Audiovisuel (INA) in Paris, Teruggi had been one of the first to care about the history and archiving of electronic music. In 2016 he received the SMPTE Archival Technology Medal Award in recognition of this work. Though greatly interested in the past, he put the emphasis elsewhere. 'I always liked the thought that we are in the present', he said about his work with electronic music, 'and that we are having a little look to the future of music. Looking a little bit over the mountain to see what's after, that has always been a strong driving force.' (Teruggi 2022)

Collaboration

In this rather complex, risky and time-driven situation of developing and performing live electronic music at the Experimentalstudio, collaboration is key. Collaboration between composers, musicians and sound directors often starts with collective research—even before a new piece is sketched or written out in notes. Part of it is shared inspiration: A sound a musician plays can be the source of a new type of transformation by electronic means and vice versa. A composer's abstract idea can lead the sound director in a certain direction, and some sounds found in combining acoustic and electronic sources can lead to compositional decisions. In this way, performing a composition quite often begins with developing it. It is difficult to say at what point one merges into the other.

Crucial in this context is the concept of intensive residencies for composers at the Experimentalstudio. Working closely with one or two sound directors (and sometimes with musicians) over several weeks is how the collaboration usually takes place. It is probably not just the fact that it is possible to stay at an apartment in the same building and to potentially work day and night without leaving the house, but also the close, informal support structure that helps create a feeling several composers articulated: the feeling of actually living at the studio for a while.

Risks and time issues, uncertainties and unexpected results, having to hand over part of the responsibility to others—you somehow have to deal with these things when working with live electronics. As soon as somebody starts living not only with, but *in* the studio for a while, performances of live electronic music could turn into and open up a world of 'life electronics': electronics and instruments expressing aesthetic aspects of life.

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Between Piece-Specific Performance Practices and Person-Specific Pieces
An Examination of Post-Instrumental Performance Practices for Integrated Concerts

Thomas R. Moore

Introduction

At the age of 18, I went to college and trained as a musician at Indiana University (USA) and then later at the Royal Conservatoire of Antwerp (Belgium). My focus was trombone performance, and I am trained as a classical trombonist. However, after joining the Belgium-based Nadar Ensemble in 2012, I have performed on a wide array of instruments and in a few non-conventional roles, including: percussion instruments like bells, shakers, maracas, plastic boxes, plastic cups, matchsticks, matchboxes, and glass plates; electronic devices like laptops and tablets, game-controllers, light switches, electric toothbrushes; unconventional instruments like wine glasses, whistles, IKEA baskets, table tops, metal tubes, balloons, and plants. Additionally, I called shows, operated the smoke machine, and performed with puppets; played several conventional instruments like horn, tenor trombone, bass trombone, toy trombone, euphonium, tuba, flutes, and performed as a singer, speaker, dancer, and sometimes I even get to conduct the ensemble. Other than the low brass instruments in this selection, almost all the instruments and roles I learned for projects as part of this ensemble. I did not write the list to boast and was in fact shocked by its length when I first put it together. I listed it here because I think it demonstrates a willingness among the Nadar musicians to throw themselves into a wide array of instrumental practices. This multi-instrumentalism is of course not unique to one ensemble. As clarinettist and member of the artistic board of Ensemble Musikfabrik, Carl Rosman noted, 'the days in which one can earn a living by simply blowing into one tube are long gone' (Rosman 2019). Similar multi-instrumentalism can also be found with groups like Sound Initiative in Paris, Pamplemousse in the USA, and with soloists like Andreas Borregaard, Heloisa Amaral, and Håkon Stene. The sheer breadth of instruments and required transferability of instrumental skills is arguably a defining characteristic of these ensembles and soloists (Devenish 2021).

Furthermore, these players are specialised in performing curated and integrated concerts. Questioning, developing, and instrumentalising video, light and sound design (including live electronics), costuming, decor, and even personnel

such as a conductor and other roles typically inherent to an ensembles' tradition, have become an integral part of these ensembles' concert programming. In this article, I will focus on one ensemble, Nadar, and specifically lay out manners in which the musicians of this ensemble approach what they have grown to see as their broadened instruments, including the use of live electronics and newly made instruments. I will also discuss the concepts surrounding the so-called 'attacca-concert', post-instrumental practice, and integrated concerts, drawing on three examples from Nadar ensemble: the event 'Dead Serious' produced for the 2014 Darmstadt Ferienkurse, the concert programme 'ExTensions', premiered at the Gaudeamus Muziekweek in 2015, and the premiere of Michael Beil's scenic composition *Hide to Show* (2021) at the Concertgebouw Brugge in Belgium. I will also look at one comparative example: *PERSONHOOD* (2021), written by Jennifer Walshe and commissioned and premiered by Andreas Borregaard. To conclude, I will attempt to frame the various performance practices that have been developed for this relatively new evolution.

Notes and Definitions

Though I will offer comparisons, my aim here is to delve into and come to a better understanding of the performance practices of one particular contemporary music ensemble. As such, I have used terms that may only be applicable within a single sub-genre of Western art music. Therefore, I would first like to define a few terms in order to create context and find avenues to compare and/or extrapolate these findings to a broader set of ensembles.

Instrumentalisation

To define this term in the context of this paper and my research, I borrow from Giuseppe Torre and Kristina Andersen, who in their paper on designing digital musical instruments designate instruments as tools which are 'developed and continuously redefined by the artist to fulfil artistic and musical need' (Torre & Andersen 2017: 127–136). Instrumentalisation of conductors was a key focus of my doctoral research at the University of Antwerp. In the course of that study, I was able to demonstrate that conductors were regularly instrumentalised by composers and artistic directors to meet both artistic as well as pragmatic and socio-economic needs (Moore 2023).

Integrated Concerts

I use this term to sharpen and delineate the sub-genre that I have studied and thus will refer to throughout this chapter. By integrated concerts I mean concerts in which, among other aspects of a performance, video, light and sound design (e.g. live electronics), decor, and utilisation of a conductor are all integral parts of the concert curation and/or programming. This definition is derived from the research of Tanja Orning (2019), Martijn Mulder (2021), and Iga Batog (2020) and from personal conversations with Pieter Matthynssens (artistic co-director Nadar Ensemble) (Matthynssens 2020), Bas Wiegers (principal guest conductor Klangforum Wien) (Wiegers 2019), Koen Kessels (music director Royal Ballet, London), and Nico Couck (professor of guitar, Royal Conservatoire of Antwerp) between 2017-2020. In regard to this paper, it is important to note that Nadar is not the only ensemble pursuing this path. Other groups include Ensemble Pompelmouse from the US, Sound Intiative in Paris, ICTUS in Brussels, and Ensemble Musikfrabrik in Cologne.

It may be clear to some readers that this definition is also very closely related to (and inspired by) what composer-performer Jennifer Walshe wrote in her well-known 2016 manifesto on The New Discipline (Walshe 2016). Musicologist Monika Voithofer stated in her detailed analysis of Walshe's concepts, that

> The New Discipline is an intermedia art practice, since it integrates various media such as dance, theatre, film, video, the visual arts, installations, literature and even stand-up comedy. Music here is no longer autonomous; it is interdependent with the others arts, and defiantly so. In particular, the digital transformation influences and offers new possibilities of interweaving these various media. [sic.] (Voithofer 2020: 7)

Post-Instrumental Practice

Researcher and percussionist Louise Devenish, building on research pursued by Håkon Stene, defines post-instrumental practice within four parameters: instrumentality, plurality, transferral, and integration (Devenish 2021). For the purpose of this paper, and especially upon reflecting on the inner workings of ensembles like Nader, Devenish's definition of 'transferral' is especially relevant:

> Drawing on and/or application of methods, materials and mediums from multiple artforms in the creation of new musical works. Utilizing 'technique transferral' as a means of exploration and execution, and subsequent development of performance practices specific to individual works, rather than individual instruments. [For example], the transferral of traditional percussive stick techniques to strike various urban objects. (Devenish 2021: 8, 15)

As will be discussed in detail below, this is an essential part of productions like Michael Beil's *Hide to Show* in which Nadar's musicians are asked to step back from their principal instruments and apply their expertly honed single instrument skills in new transferable ways. It is evident it takes musicians to perform *Hide to Show*, however, only 1/6th of the piece is performed on so-called traditional instruments (Gielen & Moore 2023). The rest of the performed material consists of acting, dancing, lip-syncing, singing, and movements, all of which have been notated in great detail by the composer.

Devenish's definition of 'plurality' (in post-instrumental practice) is also relevant for this study. She writes that the 'use of instrumental materials [fulfils] a plurality of sonic and non-sonic roles in performance' (Devenish 2021: 15). As I laid out in the introduction, musicians in this genre regularly apply multi-instrumentalism to fluidly combine several 'sonic' and 'non-sonic' roles both as performers as well as essential artistic roles played out behind the scenes. In Nadar, for example, Marieke Berendsen is both the violinist as well as the scenographer. Nadar's flutist, Katrien Gaelens is the ensemble's yoga coach, Pieter Matthynssens is the cellist and artistic co-director, and I worked for many years as both the technical coordinator as well as trombonist and conductor. All the players in this group have become experts on game-controllers and other electronic-based instruments. Something similar can be said of the musicians in the ensemble Sound Initiative, in which in pieces like Winnie Huang's *tick tock iiiiii* (2022), all the musicians become movement artists.

Curation

The last term I will venture to define for this chapter is curation—admittedly no simple task. Music critic and researcher Holly Tessler offers however a good starting point:

> […] modern curation work is narrative in nature: telling a compelling story not just through a static collection and presentation of artefacts to a single, monolithic audience but through dynamic and multiply iterated discourse with a range of audiences, communities, and stakeholders. (Tessler 2020: 5)

Renowned professor of curation Dorothee Richter proposed that curation specifically of new music[1] should be a 'practice that is deeply involved in the politics of display, politics of site, politics of transfer and translation, and regimes of visibility' (Richter 2019: 11). If we understand politics as, according to Jacques Rancière, giving form to society or to our living together (Rancière 2016: 67), then Richter

1 In this article, I use the term new music to mean music written since 1950 and in the Western art music tradition.

appears to suggest that every thinkable manner in which 'audiences, communities, and stakeholders' relate can, and more importantly, should be taken into account when programming a concert. New music curators should consider how relationships in our world are displayed, consider the interplay involved on site (e.g., the history of specific concert venues), the participation (or lack thereof) of an audience, the participant's ability to understand, enjoy, and be entertained (or not), and even the audience's and presenter's perceived position in society and how those interplay in (a) concert. In other words, all aspects appear to be open and fair game to a curator's artistic notions.

The evolution towards this manner of complete curaton of concerts occurred in a relatively short period. In an interview, Tom De Cock, percussionist, conductor, and concert curator, declared that 'everyone is a curator' these days, 'for good or for ill—and whether you like it or not!' (De Cock 2019). He described an observable and general need within the new music sector to curate concerts, a need that he distinctly feels not only as a receptive concert organiser (at Wilde Westen in Kortrijk, Belgium) but as an artistic advisor for the ensemble ICTUS as well. In other words, both the venue and the performer are now required to actively program and curate their concerts. De Cock noted that in a little more than a decade, a shift away from top-down curation towards two-sided (or even bottom-up) concert programming had become dominant. As an example, he cited a concert he played with quartet Nikel at the 2009 Darmstadt International Summer Course for New Music. (Remember Richter's comments were not made until ten years later, in 2019.) He characterises their concert as noteworthy and relevant 'because the pieces were [individually] interesting'. Nikel played five pieces in 'five different styles'. Upon reflection, he indicated that should he propose (or receive) a concert like this now, 'they would just laugh at' him. For De Cock, 'the curatorial approach is much more based on fixed ideas for one concert; where you propose one idea with a package of music that comes with the idea.' (De Cock 2019) In other words, any other type of concert curation and, but especially the promotion thereof would be ill suited.

According to pianist, researcher, and curator Heloisa Amaral performing ensembles have relatively recently progressed 'from an interpretive tradition of musical performance' towards 'an understanding of performance as relational, critical and, ultimately, performative practice' (Amaral 2020: 29). Furthermore, ensembles and soloists have moved from a reactive approach to a proactive style of playing and, by extension, programming concerts. She cites several examples of musicians and performers who '[take] more responsibility for the content of what they present' (Amaral 2020: 29), including Nikel Ensemble's current programming as well as Nadar Ensemble's. According to Amaral, these ensembles reject traditional models such as '[waiting] for a call from a programmer in need of a performer for this or that work' or '[commissioning] pieces by composer X to get a concert at festival Y' (Amaral 2020: 29) in favour of more cohesive and comprehensive

self-curated projects or initiatives developed in close dialogue with composers, concert organisers, and other interested parties. Amaral views this with a sense of urgency not simply as a requirement to be booked by a concert venue, but as something, like Rancière, integral and 'giving form' to the whole. From the standpoint of the performing musician, she expressed a deep need to be critically reflective of the society within which she lives and plays and observed the same urgency in the two ensembles cited.

Nadar Ensemble's artistic co-directors Pieter Matthynssens and Stefan Prins describe their manner of programming as creating 'curated concerts', in which each piece is 'representative of its author' (composer, writer, improviser, etc.) while maintaining 'the whole presentation as one event' (Prins 2019). Furthermore, these curated concerts can also be understood as integrated concerts, meaning (again) that all aspects of a performance are considered (as is suggested by Richter). This may also include the active choice of how certain roles will be instrumentalised to meet specific artistic aspirations. For example, Prins and Matthynssens have on several occasions described the conductor as 'a visual element', stating: 'if you program concerts in which you think the visual element is really important, then putting it simply, with a conductor, you have a dancer on stage' (Prins 2019)—a component, a role and a person, flush with tradition, and thus ripe for customisation and instrumentalisation. A work that exemplifies this practice is Alexander Khubeev's *Ghost of Dystopia* (2014, revised 2019). Here the composer required a bound conductor to tell the story of the rise and fall of a dictator. The instrumentalised role, again a person, becomes a tactical leader, stepping forward from the 'assembly' as a tool 'to be wielded and discarded when no longer required' (Moore 2022b: 22). Another example of the tactical use of a conductor can be found in Ensemble Musikfabrik's use of a rehearsal conductor. According to Carl Rosman:

> The particular job for a rehearsal conductor in a piece like *Intermezzi* 'Georges Aperghis, 2015/2016' or *Delusion of the Fury* 'Harry Partch, 2013' […] is to streamline the rehearsal process more than, as one might assume, to conduct the rehearsals. There is some of that as well, but not so much in the sense of beating time since they're not going to be doing that in the performance anyway. It is 'conducting' more in the sense of centralising the discussion, so that it's not just a matter of each individual ensemble member piping up when they didn't like what we just did—each individual ensemble member saying STOP, we need to do this. When you are working with 15 or 16 players, then you really do need someone to centralise the discussion—some kind of focal point. (Rosman 2019)

I would now like to return to the heart of this chapter, Nadar's performance practice and curation (and inherently thus, instrumentalisation) of all the aspects of their artistic practice. I would like to discuss this further by going through three example programmes, testing each for the presence of post-instrumental practice, integrated concerts, and instrumentalisation of its musicians and/or their roles. The first is Nadar's 2014 programme titled 'Dead Serious'. This was presented

at the Darmstadt Summer Course for New Music in August 2014, on the Georg-Büchner-Platz. The programme represents a close collaboration with Iraqi artist Wafaa Bilal and the belly dancer Meiver De la Cruz.

'Dead Serious'

'Dead Serious' was an evening length show that took over an entire public square. It consisted of an introductory film, and four pieces that were each placed in different parts of the *platz* with at one point the performers standing more than 70 metres apart. A short video clip of the fourth piece can be seen via the link provided in the footnotes.[2] In the video one can see De la Cruz belly dancing with three drones piloted by players from the ensemble. Nadar incorporated other guest performers into the program as well, namely hot air balloon pilots for *EXIT F* (2011) by Michael Maierhof and light operators who played important roles throughout all four pieces. This programme is also a clear example of, among other characteristic approaches, Nadar's attacca style concert curation. All the pieces are played one after the other with detailed and rehearsed segues between pieces.

In 'Dead Serious', the musicians played in the first, third, and fourth pieces of the programme (the second piece, *The Patriot Act* (2014), was a film produced by Wafaa Bilal). The fourth work was for three drone pilots, belly dancer, and follow spot operator. Nadar's scenographer and artistic team staged the belly dancer in the centre of the square. The third piece, Stefan Prins' *Generation Kill* (2012), was positioned at the edge, giving the musicians who surrounded the audience in Maierhof's *EXIT F* (the first piece) the chance to move position without being noticed by the audience. The drone pilots Matthynssens (cellist), Dries Tack (clarinettist and game controller) and Yves Goemaere (percussionist) flew using remote controls, which also gave them the chance to change positions on the sly. To aid in drawing and holding the audience's attention between works, lighting design and sound effects were deployed as well.

Another example programme demonstrating a similar, idiosyncratic approach towards transitions are the 'Doppelgänger' concerts.[3] Here, the ensemble's musicians and crew must often transition between *Generation Kill* and *exit to enter* (2013), a work by Michael Beil. Both pieces have fixed settings vastly different from each other. In *Generation Kill* the ensemble sits in two rows of four musicians spaced five metres apart with the musicians sitting upstage, each staged behind a semi-transparent screen. In *exit to enter*, the ensemble sits bunched together on stage left, while the middle of the stage must be kept free for video recordings and

2 'Dead Serious' (extract): Dancing with Drones (live @ Darmstadt 2014): https://www.youtube.com/watch?v=gIz_pltxO2o, accessed on 13 April 2023

3 See https://nadarensemble.be/events/der-doppelganger/



Fig. 1: Nadar Ensemble performing *Exit F* by Michael Maierhof during 'Dead Serious' in 2014. © Nadar Ensemble

projection. This represents one of the ensemble's more complicated stage changes. Since both pieces use video as an instrument and because Beil admittedly was heavily inspired by filmmaker David Lynch,[4] it seemed appropriate to Matthynssens and Prins that the ensemble's musicians mimic Lynch's style and record themselves doing the transition backwards during rehearsals. This recording is then played in reverse and synchronised with the live concert segue.

Prins and Matthynssens apply and have further developed the attacca-approach found in 'Doppelgäger' and 'Dead Serious' because they are convinced of the need to create and especially maintain an arc in a concert's programme (Matthynssens 2020). Though this may not be new in a curational sense, Nadar's directors are concerned that any break, be it for typical 'performance ritual' (c.f. Schwartz 1993), activities like applause or (technical) transitions disturbs the tension (c.f. Huizinga 2014) and their active care (c.f. Groïs 2022) for the audience. Both artistic and pragmatic considerations are relevant to creating this attacca-style, as well as tools borrowed from theatrical performing arts. As discussed above, the musicians' roles are fluid and the same players in each piece, in large part, remain the same. As an ensemble, Nadar often works together on and are coached in getting from one position and/or instrument as smoothly and unobtrusively as possible. The ensemble and production team writes and rehearses these transitions fanatically, devoting precious rehearsal time to each 'changement' (Beil 2019).

4 For example, the Red Room scenes in the 1990x series, *Twin Peaks.*

According to Torre and Andersen (2017, see above) a tool rises to the level of instrument when it has passed two tests. First, it must be 'developed and continuously refined by an artist', and second, that development and refinement must occur to 'meet an artistic need'. The segues in Nadar ensemble's attacca-style concerts meet both tests. Prins and Matthynssens have expressed an artistic need to maintain tension in their programs. The tool they choose includes not just the pieces in a program and their order of presentation, but the way the players transition from one to the next. They have developed a practice of literally performing segues. In 'Dead Serious', they did this with the help of technical devices such as hot-air balloons, décor, lighting, and drones. In 'Doppelgänger', the ensemble doubled themselves turning the practical action of moving a chair or lowering a projection screen into a well-choreographed and slightly bizarre ballet. Nadar has developed and continues to refine a technical necessity into artistically functional elements of their performances. In this sense we can then consider Nadar's transitions in attacca-style concerts to have been instrumentalised. Perhaps more compelling is that this instrument is performed collectively by the entire ensemble.

The 'Dead Serious' programme can also be considered an integrated concert. Not only are the transitions performed and part of the curation, so too was the way the audience was welcomed to the square. As an opening act, the hot-air balloons were only inflated twenty minutes prior to the beginning of the show. They were subtly lit, drawing the public's attention to the literally growing tension. And lastly, a video showing a top-down view of Darmstadt was also shown during inflation. This film was recorded during a balloon flight (made a few weeks prior). Nadar's integrated curation of the evening further included:

- Both the **video** material shown, and the manner of presentation were considered during preparation. The video piece by Wafaa Bilal, *Patriot Act*, the live feed from the belly dancer, and the opening sequence were projected on the four sides of a cube in the centre of the square. The videos for the third piece, Prins' *Generation Kill*, were not only projected on original 1,8 m wide semi-transparent screens, but they were also doubled on a large horizon screen behind the musicians, allowing a larger audience to also enjoy the avatars.
- **Light design** in this performance was not simply functional, it was used to guide the audience throughout the performance.
- Because the ensemble and pieces were spaced around the square - sometimes performers were 70 metres from each other—the **amplification** was designed by Nadar's sound engineer in a manner that assisted the players, but also guided the audience through the performance. For example, when the drones entered for the final piece of the show, a pre-recorded tape of drone sounds accompanied their flight, drawing the audience's attention to their presence.

- Nadar's scenographer and violinist Marieke Berendsen, along with the production team, specifically designed a **décor** for the performance that would best deliver not only the four pieces but carry the entire evening.
- It is key to note that Nadar considered the balloon pilots for *EXIT F* and the light operators (both desk operators and follow-spotters) to be **performers** in their own right throughout the concert. The regular ensemble members rehearsed pieces and transitions with these performers and provided instructions via track-sheets, something very much akin to what Nadar's musicians could consider to be scores.

In regard to post-instrumental practice, evidence of 'technique transferral' and 'plurality' are in abundance throughout the performance of 'Dead Serious'. During *EXIT F*, the percussionists (three are needed, but only one was a classically trained percussionist) play composer-made and piece-specific instruments. During the work with the belly dancer, the three drone pilots, also musicians in the ensemble, took on non-sonic roles. And lastly, during *Generation Kill* (which will be discussed in greater detail below) all four game-controllers found ways to transfer their expertise on their main instruments (respectively: piano, flute, violin, and clarinet) to playing *Sony PlayStation 3* controllers.

ExTensions

The second example I would like to discuss is the concert programme 'ExTensions', premiered by Nadar at the Gaudeamus Muziekweek in 2015. The ensemble opened the programme with Alexander Khubeev's *Ghost of Dystopia* (2014, rev 2019), pictured below. Second on the programme was Simon Steen-Andersen's *AMID* (2004), from which you can see the Gravity Guiro pictured in the bottom right corner of figure 2. The third piece was Alexander Schubert's *Point Ones* (2012). The final work on the program was Stefan Prins' *Generation Kill*.

In the first three pieces of the programme the conductor has a unique role. It was the explicit intention of the concert's curators Prins and Matthynssens to question the role of the conductor within the context of Western contemporary art music (Matthynssens 2020). This is especially apparent in the pieces by Schubert and Khubeev, in which the composers created new instruments (and new notational methods) to bind the conductor to create a tension between reality and the virtual world, and in the latter case, to tell the story of the rise and fall of a dictator.

The oldest work on the program, *AMID*, is arguably a preface to Steen-Andersen's self-described 'hyper-concrete' (Steen-Andersen 2010) manner of composing. (Steen-Andersen 2019) Hyper-concretism is the practice of tenaciously applying an instrument-specific technique and playing method uniformly across a range of instruments. In *AMID*, Steen-Andersen first rationalised the winds'



Fig. 2: Nadar Ensemble Performing *Ghost of Dystopia* by Alexander Khubeev at the Gaudeamus Muziekweek. © Anna van Kooi

breathing in percentages which were then directly transcribed to each of the other five instruments. For the strings (violin and cello) this was articulated as bow movements. For the piano and guitar, the composer used pitch range. And for the percussionist, Steen-Andersen designed a new instrument he dubbed the gravity guiro (Steen-Andersen 2004) in which the player must raise and lower a weighted piece of sandpaper across an incline. Each instrument was assigned a full potential (100%): full lungs for the winds, bow position at the frog for the strings, low registers for the piano and guitar, and at the top of the incline for the percussionist. They were also assigned a 0% potential that is respectively the opposite for each instrument. In *AMID* the composer zoomed in on, applied and employed the musicians' movement repertoire, turning what is normally associated with preparatory and production gestures into the musical material itself.

Steen-Andersen's compositional practice is applicable to not just writing music, but also to performing it. For the Nadar ensemble, this has conceivably become a central pillar of their artistic practice as an ensemble and can serve as a prime example of post-instrumental practice. By applying a hyper-concrete transferal of instrumental skills, the musicians can dexterously switch between instruments (which are mostly composer-made) and the respective new styles of notation, applying the skills gained on their principal instruments (such as breath control and coordinated timing) to both live electronic instruments and even more non-conventional instruments such as light switches and non-sonic roles like show-calling.

The composers of the first two works of 'ExTensions' very explicitly instrumentalised the conductor and questioned its accepted role in Western art music performance rituals (Schwartz & Godfrey 1993). In Alexander Schubert's *Point Ones* the conductor's movements fulfil two sometimes simultaneous functions. They are choreographed to trigger live electronics and are utilised to conduct the live ensemble. Both sets of gestures, those choreographed and the conventionally employed, fall within the realm of generally recognisable movement repertoire. The latter functions as we might expect in a performance ritual; the conductor's gestures mark time and cue the musicians who then respond accordingly. The choreographed and electronic-cueing gestures also look like normal conductors' movement repertoire. However, they are instead deployed to trigger live electronics. By instrumentalising exactly these conducting key-gestures, the conductor's conventional responsibility to direct and cue the live musicians has not been limited, but rather augmented and enhanced. Their gestures cue both live performers and trigger virtual musicians, sometimes at the same time (Moore 2020).

In the opening piece, Alexander Khubeev's *Ghost of Dystopia*, the role of the conductor is instrumentalised as the subject of the piece (Moore 2022a). The conductor-soloist begins the piece bound hand and foot to a composer-made instrument. As the piece progresses, he/she breaks the bindings, and using conducting-like gestures, appears to take charge of the ensemble. As the piece comes to an end, Khubeev has the conductor take up a Christ-like pose, purposely begging the questions, 'Is he dead? Who killed him? Is he a god?' Though Khubeev attempts to make it appear as though the conductor continually finds more freedom, it is only a veneer. In an interview, Khubeev admitted that 'the more freedom [he] wants the audience to see, the more he dictates' (Khubeev 2019) the role to his performers. Khubeev, therefore, was very clearly willing to instrumentalise and develop the role of the conductor to meet his artistic needs.

The final piece on the 'ExTensions' programme was Stefan Prins' *Generation Kill*, pictured below. In this piece, I am often fascinated by the manner in which each of my colleague game-controllers hyper-concretely applies their personal instrument techniques to the 'new' instrument. Elisa Medinilla, the pianist, for example, wrote all the finger settings for her game-controller into her part as if the instrument were truly a piano. Woodwind players Dries Tack and Katrien Gaelens did something similar. The three wind players, myself included, also applied breathing structures to help play in a more chamber music-like fashion. It is key to note here that each of the musicians accepted the game-controllers as their instruments. They bought the computers, sound cards, game-controllers, and webcams to use and practice at home, practicing under concert conditions. The musicians do not view the electronics as something extra that a technician will handle and play. Instead, they all view them as their personal responsibilities and take the initiative in finding and practicing the material. For all four pieces in the 'ExTensions' programme, all the new instruments were practiced at the players'

homes (or in the case of the Khubeev at the ensemble's rehearsal space) under concert conditions. This may sound simple, but of course takes time (and precious funding) to realise.



Fig. 3. Nadar Ensemble performing *Generation Kill* by Stefan Prins at the Gaudeamus Muziek Week. © Anna van Kooi

Nadar's programme 'ExTensions' is a straightforward example of the instrumentalisation of one of its musicians' roles, namely the conductor. Schubert and Khubeev explicitly developed the role for their artistic ends and in *AMID*, Steen-Andersen deployed musicians' movement repertoire as a compositional tool. Though the role of the conductor was not originally envisioned, it has become the common performance practice for the piece (Steen-Andersen 2019). And since the conductor can only use movements, it is arguable (and argued by Pieter Matthynssens) that the conductor's movements become a visual 'extension of the musicians' (Matthynssens 2020). Furthermore and as mentioned, Prins and Matthynssens specifically programmed and curated these three pieces as a way to explore the dimensions and complexities of conducting new music today. They began with the Khubeev, literally chaining the conductor to the stage before the audience entered, knowing as well that the freedom gained throughout the piece is simply an illusion, thus immediately questioning 'performance ritual' and contemporary understanding of hierarchy on stage (Schwartz & Godfrey 1993). *Point Ones* was the second piece presented, and in Nadar style, it was played attacca (without segue). In other words, while the conductor may now have been free of Khubeev's instrument, he was charged with immediately banging off into the rock'n'roll style introduction of *Point Ones*. Unlike the first piece, Schubert's bindings are far less restricting. However, specific composer-made choreography does make up roughly 80% of the piece (Moore 2020: 89). In *Point Ones*, the conductor becomes an instrument to question the tension between the virtual and real in our daily (musical) lives. The question posed in *AMID* is more subtle. Here, he/she fulfils a role closer akin to a chamber-musician (Boltanski & Thévenot 2006) helping to articulate and highlight physical gesture as musical sound.

These three uses of the conductor and their piece-required performance practice are also direct evidence of post-instrumental practice (as it has been described above). Khubeev and Schubert required the conductor to learn a new instrument, one electronic and the other acoustic. The performance practice for *AMID* is also quite restricting, requiring the conductor to match specific patterns and timings to the musicians and leaving little to no room for spontaneous artistic interpretation or even correcting gestures (Moore & Gielen 2021: 1). If we understand the practice of conducting as having a basic and trained skill set (Schuller 1998), then each of these three composers and their curation appears to choose which (available or created) skills are required for their pieces and programme and then are reassembled, à la carte, to meet their artistic needs.

This tactical deployment of the conductor also demonstrates a key component of integrated concerts, in which multi-disciplinary elements are implemented into the curation of a concert. Besides the clear curation of the conductor's role, Nadar also integrated costuming (in *Generation Kill*) and lighting in all four pieces) into their programme. Furthermore, the decision to begin the program with the Khubeev, in which the audience upon entry is presented with a bound conductor, demonstrates the curators' intention to integrate extra-musical elements into their presentation of the concert programme.

Hide to Show

As a final example, I would like to discuss Michael Beil's evening-length scenic composition *Hide to Show* (2020) commissioned by and specifically for the musicians of Nadar.[5] This is the third piece Beil wrote for Nadar's musicians, and each seemed to push the ensemble's practice further, challenging the musicians to use their bodies as instruments and borrow elements from other performing arts disciplines, such as precisely timed movements, singing, and acting. Beil, like Steen-Andersen, also deeply studied the musicians' movement repertoire and applies it in innovative ways in all three of the 'Nadar compositions'.

The first piece Beil wrote for the ensemble is *exit to enter* (2013). This work laid the foundations for the aesthetic video choices and instrumentalisation, or à la carte application of the instrumentalists' movement repertoire that we will later find in *Hide to Show*. In *exit to enter*, actions performed and recorded live by the musicians become a moving tafereel of images and avatars, each substituting the other for the perceived performance of the rigorously composed sound- and movement-track. This first work cites and deploys both movements from everyday life like answering the telephone or changing hats to instrumental gestures like

5 Co-commissioners: De Singel & Concertgebouw Brugge.

blowing a flute and bowing a violin. In 2015, Beil wrote *Bluff* for Nadar[6] in which staged actions like entries, exits, filming, and transitions become instrumentalised musical material. An additional piece, *Key Jack* (2017) by Beil for pianist without piano[7], delineates a clearer line to *Hide to Show*. Not only does it expertly combine the video processing and aesthetics found in *exit to enter* and *Bluff*, it further develops Beil's instrumentalisation of the musicians' roles in his pieces. In both *Key Jack* and *Hide to Show* he actively and continuously develops their movement repertoire and personal idiosyncrasies as artistic tools he immediately uses. *Key Jack* is for pianist without piano. However, this piece can only be performed by a trained pianist. The musician must perform with the fingering, posturing, and attitude of a concert pianist, 'jacking' the traits in a performative exhibition. Each movement, from eye-blinking to snapping to chord-playing, is timed perfectly with the composer's tape and recorded. The playback occurs simultaneously and immediately in three-fold: on two life size projection panels and live.[8]



Fig. 4. Nadar Ensemble Performing *Hide to Show* by Michael Beil at De Singel, Antwerp, Belgium. © Wim Hierbaut

In an earlier study, culture sociologist Pascal Gielen and I discussed *Hide to Show* at length (Gielen & Moore 2023). We suggested that through this work, Beil explored the possibilities and limitations of digital communication in music, raising questions surrounding cooperation on stage and artistic practice when performers cannot see each other. Analogue and/versus digital communication were/was also tested by Beil by forcing the musicians to be in separate, isolated physical spaces

6 This piece and particularly its rehearsal process built the trust between ensemble and composer required to produce an evening-long composition. For the third performance, the ensemble collectively opted to perform the complicated, through-composed and action-filled piece by memory. *Hide to Show*, a work lasting 75 minutes, must be performed by memory too. Without the collective experience of *Bluff,* neither side would have engaged in this monumental project.

7 Commissioned by Frederik Croene.

8 The material in this paragraph first appeared in (Gielen & Moore 2022).

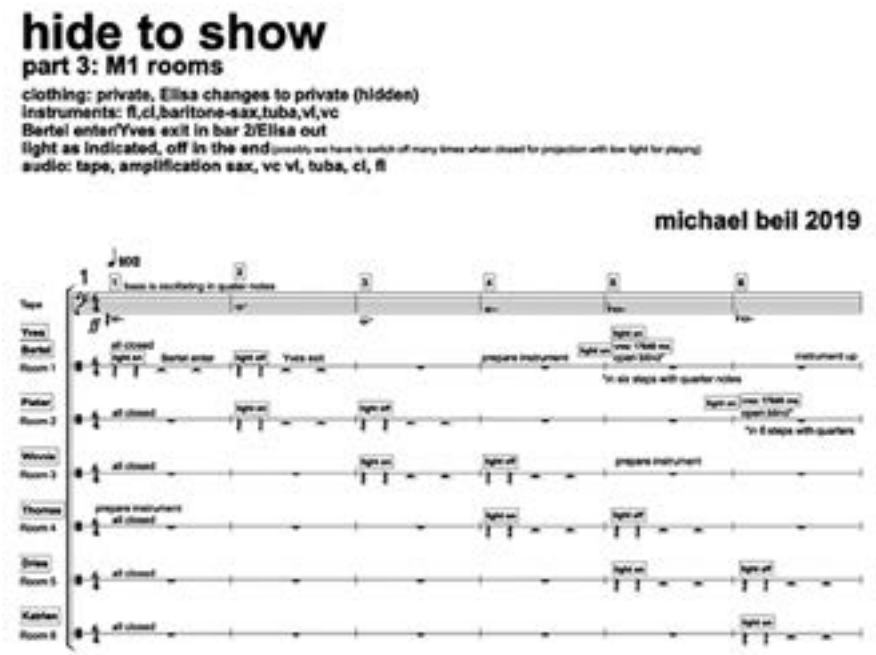


Fig. 5. Score of *Hide to Show* by Michael Beil. ©Michael Beil

in which they could only hear each other through headphones. Beil and Nadar conduct similar experiments in relation to the audience, using digital images to mediate the live performance. The musicians are recorded live and then endlessly played back on the décor; a doppelgänger play emerges. Beil also deploys technology to fix audible or visual missteps or even exaggerates them. Gielen and I argued that live music's 'sound' and especially its 'feel' become increasingly ambiguous and unpredictable when reality is simulated in this fashion.

Returning to the ensemble's performance practice, *Hide to Show* is an ideal example of Stene's post-instrumental practice. Stene writes that there is 'no unifying technical legacy towards which [pieces in this genre] gravitate'. *Hide to Show*, (as well as *AMID* and *Generation Kill*) 'are multi-directional and thus constitute the need for continuous re-orientation on behalf of the practitioner' (Stene 2021). With this statement, Stene suggests that musicians take the learning methodologies that have been acquired through years and years of classical training on one instrument and adapt those to become specialists at 're-thinking and invention' on the new and often composer-made instruments. In the case of *Hide to Show*, the Nadar musicians all played their 'principal instruments', but they were also asked to expertly play-back (fake), sing, dance, and act. In other words, the Nadar musicians stepped back from their fixed instrumental roles and applied their bodies

and selves through techniques acquired over the years to a broader selection of instruments and roles.

It is important to note that Beil was very much aware of this practice. As you can see in the score fragment above (figure 5), it is not the instruments that are listed at the beginning of each stave, but the names of the performing musicians instead. In an interview Beil elaborated further on this idea, explaining that 'basically […] I wrote the piece for certain people because I know Nadar well. I imagined the people I worked with. It was not: a trombone player, or a cellist, or a typical contemporary pianist. I wrote for Thomas, Pieter, and Elisa.' (Gielen & Moore 2022)

Hide to Show, written by Beil and created by Nadar, Warped Type, and Beil, is, according to Beil, a scenic composition. The title given to this genre seems to originate with the composer,[9] however, the elements encapsulated by the piece also appear to be synonymous with what I have set out above as an integrated concert. This performance's creative team have clearly considered and applied many versatile elements of the performing arts and from the standpoint of a single curating team of authors. The lights, their intensity and colour are programmed into the software running the video processing. Musicians must dance and operate blinds according to strict and musically notated scores. The staging (blocking) and even the stage-sized décor for this concert has also been strictly designed. Though not unique to theatre, this is arguably still rare in the music scene. Furthermore, the ensemble approaches the décor as if it were an instrument, rehearsing the opening and closing of the blinds in a fashion similar to more traditional ensemble play. For example, the musicians prepare and time lifting the blinds (the attack) and locking the blinds (the release), these actions being metrically organised. The décor travels with Nadar for each performance, and it, like the availability of the players, is crucial in deciding whether or not a venue can program it.

PERSONHOOD

As part of the defense of his PhD in the Arts, accordionist and specialist in bodily performance Andreas Borregaard asked Jennifer Walshe to write a concerto for solo accordionist and sinfonietta.[10] The piece that resulted from their close collaboration is titled *PERSONHOOD* (2021). In Walshe's own words it is 'about how difficult it is to be a person, [or in other words] how difficult it is to have a body and be a person in that body today' (Walshe 2023). To me, the piece unfolds in three distinct sections each demarcated by the loud whirling of a starkly illumi-

9 There are admittedly clear references to and links with what Jennifer Walshe dubbed the 'New Discipline' and Kagel's 'Instrumental Theatre'.

10 Co-commissioned with Oslo Sinfonietta, Ultima Oslo Contemporary Music Festival, and New Music Dublin.

nated blender.[11] Borregaard, by requesting Walshe to 'push him as far as possible' (Borregaard 2023) in his bodily performance, ends up putting on an incredibly elaborate and virtuoso 40-minute performance, moving dexterously across the stage both with his instrument and without, as well as dancing, singing, acting and much more.

This piece, its performance, curation, and creation are relevant for this study for several reasons. The first can be found in Walshe's own stated motivations for composing (in general). Returning to her manifesto, she writes:

> The New Discipline is a term I've adopted over the last year. The term functions as a way for me to connect compositions which have a wide range of disparate interests but all share the common concern of being rooted in the physical, theatrical and visual, as well as musical; pieces which often invoke the extra-musical, which activate the non-cochlear. In performance, these are works in which the ear, the eye and the brain are expected to be active and engaged. Works in which we understand that there are people on the stage, and that these people are/have bodies. (Walshe 2016)

In *PERSONHOOD* the 'physical, theatrical, visual, as well as musical' elements are clearly integrated into one whole, authored from a unified perspective. During our interview, Walshe at multiple times talked of visual elements in the same breath as the musical, as one complete concept, the one not thinkable without the other. The lights, designed by scenographer Aedin Cosgrove, merged with the costumes (also designed by Cosgrove) and Walshe's video to create the '80s feel' that the composer had found on old 'self-help VHS cassettes for meditation cults and instructional films' (Walshe 2023). Sound, in the hands of Una Monaghan, was also presented theatrically and physically. The blender was tactically deployed to 'disrupt the flow' of the piece. Its 'white noise', performed by the percussionist, 'blasts' the audience to 'stimulate the auditory nerve' and help to 'reset their listening' and focus. Just as Voithofer concluded, *PERSONHOOD* and Borregaard's performance thereof, are 'characterized by the interdependency of different analogue and digital media and the revaluation of the body and physicality. [It calls] for a multisensory, instead of a merely auditory, perception' (Voithofer 2020). In Walshe's words, 'It's like world building'.

Above I cited Devenish's research into post-instrumental practice, in particular her (sub)definition of technique transferal that leads (in part) to the 'development of performance practices specific to individual works, rather than individual instruments' (Devenish 2021). Based on Walshe's instructions for Borregaard to physically prepare for *PERSONHOOD* by taking 'all sorts of dance lessons' (Borregaard 2023) and learn to imitate Britney Spears' iconic 'award ceremony appearances and video clips' (Walshe 2023), that definition is well suited to describe this piece and its practices in particular. Arguably, Walshe also applies this technique

11 A closer look at the score shows fourteen through-composed sections.

transferal in the return direction as well. During our interview she remarked that 'if somebody else, another accordionist did *PERSONHOOD*, that would be really interesting for me, because the piece would be modified, and it would have a different meaning with a different body on stage' (Walshe 2023). Borregaard agrees, 'I think the knowledge that she knew me as a performer already was quite essential in terms of what she could put into the piece.' (Borregaard 2023) In other words, it was not just Borregaard that developed piece-specific practices, but Walshe also developed a Borregaard-specific piece.

Performance practices that are also specific to this piece can also be found in the sinfonietta's parts. The concerto begins with the percussionist caressing the skin of the snare drum with 'cans of skin care and cosmetics' creating a palate of white noise that allows the piece and its décor to 'spill into an art installation'. The players surrounding the solo accordionist are all staged 'like in a strange laboratory'; in *PERSONHOOD*-costumes (and labels) and their postures and movements have all been detailed in the score. 'The musicians are not fully theatrical', but their presence on stage must be 'taken very seriously' (Borregaard 2023). Walshe explicitly expects that everything and everyone on stage should at all times be experienced as part of the performance.

In regard to the question of instrumentalisation Jennifer Walshe at the opening of our interview,remarked on how striking Andreas Borregaard is as a performer, his unique 'Andreas-ness'. She was also not shy about using that to her full artistic advantage, pushing him to expand bodily performance (something he admittedly requested and 'flung himself into' (Walshe 2023)) and find new ways to be on stage. *SELF-CARE* (2017), their first collaboration (which then led to the creation of *PERSONHOOD*) combined solo accordion and video with things like yoga-positions and TED-talk-like lectures on cryptocurrency white papers. That said, determining the presence of instrumentalisation, at least in the manner in which I defined it above, is difficult in this case. It is certainly not the one-way, à la carte, fashion I discerned in Khubeev's *Ghost of Dystopia* or Schubert's *Point Ones*. Walshe does not pick and choose which parts of Borregaard's 'Andreas-ness' she wants to apply in *PERSONHOOD* and then re-arrange them, creating a new role. Instead, they seem to work together, collectively pushing the full range that Borregaard offers as a soloist into a new dimension.

PERSONHOOD is clearly an example of an integrated concert and a continuance of post-instrumental practice. However, it seems to escape the narrow definition I have used for instrumentalisation of musicians' roles. Borregaard and the Oslo Sinfonietta were clearly 'developed' by Walshe, but there is limited evidence of 'continuous redefining' or tactical deployment of the musicians' roles and/or individual skills in the piece. The musicians, soloist, and conductor were accepted and developed in their roles as a whole. Here, Borregaard finds himself balancing a piece-specific performance practice with a person-specific piece.

Returning to Nadar Ensemble, I think perhaps a defining element of our performance practice and strategy is that each of the players claims or owns each new instrument presented. Not only did Matthynssens, Goemaere, and Tack learn in 'Dead Serious' to expertly fly the drones, they learned to dance with them, acting out both a scripted scene as well as gaining enough proficiency with the instrument to improvise with an experienced belly dancer. For two of the examples cited from the concert programme 'ExTensions', *Point Ones* and *Ghost of Dystopia*, I personally spent many months in the physical concert setting of both Schubert's electronics and Khubeev's bindings. I, too, became proficient enough to improvise comfortably on both and can now (for reprisals) practice them outside of the setting, visualising the feeling of each instrument. In the third example, *Hide to Show*, the décor became an instrument for the musicians, something that each spent many hours studying in the rehearsal space. Furthermore, our bodies and movement repertoire were instrumentalised by Beil to be used in new ways throughout the piece. Each new approach cited here demands significant study and ownership on the part of the player involved. Though not specifically cited by Devenish (or Stene), ownership seems to be inherent to 'technique transferral' which, again, is a 'development of performance practices specific to individual works, rather than individual instruments' (Devenish 2021). To develop piece-specific performance practices, Nadar has persisted in claiming these instruments as their own, drawing on previously created expertise to incorporate them into each musician's artistic practice.

I think it is also important to reiterate that our sound engineer Wannes Gonnissen is a permanent member of our ensemble. Though the responsibility or initiative to find and study the new (electronic) instruments lies with the performer, we have an in-house expert who rehearses with the ensemble throughout the entire process. Only in this way are we able to realise this style of 'owning our instruments.'

Regarding integrated concerts, Nadar's artistic co-directors Matthynssens and Prins have an approach towards concerts and the ensemble that is founded on caring for the audience. As demonstrated in the three cases above, to the extent possible, this has led them to curate all aspects of the concert programme, including the ensemble's personnel, their roles, lighting-, sound-, and video design, décor, and most importantly creating segues that become part of the artistic presentation itself.

On a final note, the instrumentalisation of roles and musicians' movement repertoire, skills, expertise, and abilities discussed in the three cases presented above has granted more artistic freedom and variety to the instrumentalising actors, namely the composers and artistic directors. Arguably, this was also their intention. The transferability of highly honed instrumental skills and taking on

non-sonic roles offers a greater range of presentation possibilities (see the segues in the 'attaca concerts') and room for experiments (see Beil's three 'Nadar compositions'). The realisation of this kind of post-instrumental strategy also benefits the players in the form of a larger artistic commitment from the artistic directors (and composers). As Michael Beil said in an interview, he wrote *Hide to Show* specifically for the people involved in the performance itself, making each player essential to any further reprisal of show. In other words, the flexibility demanded of the musicians in all four examples allowed the composers and artistic directors to explore new artistic horizons while consistently working with the same team and simultaneously pushing them to expand their own practices also offered a certain amount of socio-economic stability.

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Embodiment and Presence in Electroacoustic Performance
Challenges and Possibilities from a Performer's Perspective

Joan Jordi Oliver Arcos

Introduction

In contemporary music, the role of the performer has been continuously changing in parallel with the emergence of new musical languages and aesthetic positions. In recent decades, the improvement and proliferation of technological tools have encouraged new practices in which the performer interacts with electronic sounds that can be controlled by humans, fixed in a medium and reproduced on stage, or automatically generated in real time. In a new hybrid context this role needs to be reconsidered. With a growing repertoire exploring the many perspectives this interaction can provide, today's performers face a new set of challenges usually going beyond their traditional academic training.

Exploring several of these musical tendencies, analysing their challenges and systematically laying out possible strategies and solutions was the task defined for ICST's research project *Performing Live Electronic Music*. Within the project, a selection of historical and contemporary works was studied covering different approaches to composition for instruments and electronics, including fixed media, sound processing in real time, integration of multimedia elements, design of new instruments, and others.

As a saxophonist, I enjoyed the opportunity to collaborate closely with the project team, performing several pieces in different constellations and with radically different setups. Each piece presented an individual compositional proposition and thus required a unique approach to preparation and presentation. This experience led me to reconsider my function as a performer, and to re-evaluate many concepts surrounding instrumental musical performance. Among several aspects of great interest, and based on the experience of performing two pieces that are very different regarding the use of electronic sounds and the resulting function of the performer—*Shifting Mirrors* by Horacio Vaggione (2016) and *... of Silence* by Marco Stroppa (2007)—I decided to focus particularly on the question of presence and embodiment in electroacoustic performance.

I should emphasise here the subjective nature of this evaluation, reflecting my personal perspective, having prepared both works during an extensive period of time. Personal preferences, musical choices and the knowledge I had at the time

informed my exploration and interpretation, which I will describe here focusing on aspects important to me as a performer.

It should also be noted that the comments referring to *Shifting Mirrors* by Horacio Vaggione correspond entirely to the specific format of the piece's 'standard' version, which we prepared in the project, having discovered the original, 'participative' version only at a later stage of the project.[1] The two versions show fundamental differences that might change some performative choices or even lead to contradictory interpretations. While awareness of the existence of multiple possibilities greatly informed my interpretation choices at a late stage of preparation, we decided to stick to the version with score, since much of the work had already been done and a very detailed interpretation had been elaborated. The ideas expressed in this text refer specifically to this one, non-exclusive, approach to the piece.

The electroacoustic gesture—two different approaches

Before discussing the topic, we will give a quick overview of how the two composers approached the use of electronic sounds in their pieces. The comparison is useful not only because both pieces share a similar constellation (solo saxophone and electronics) but because, in my opinion, they aim for a similar musical result, something that I subjectively and arbitrarily refer to as 'electroacoustic gesture'. This concept greatly influenced my approach to preparing and especially performing the pieces. The electroacoustic gesture is the (perceived) result of my physical activity, the enhancement of my saxophone sound through the electronic medium producing a hybrid, electroacoustic sound. Both compositions are rich in gestures where the acoustic sound merges with electronic transformations, resulting in the perception of the musician as the main agent for the production of a sound evolving in time beyond the acoustic limitations of the instrument.

At this point, it would seem obvious that the use of real-time sound processing would be the ideal approach to realise this performative proposition, which is indeed the case in … *of Silence*, where a complex Max patch follows the saxophone line and affects it through several transformation modules. In *Shifting Mirrors*, on the other hand, Vaggione follows an apparently counter-intuitive strategy to achieve a similar result: there is no live processing at all. Instead, all the electronic sounds have been pre-recorded, carefully produced and set in a fixed structure designed by the composer. The saxophonist plays the instrumental line constricted by a rigorously defined temporal grid. A precise execution of the saxophone part creates the illusion of real time electronics, as the gestures are carefully placed

1 More information about the differences in between these two versions and the genesis of the piece can be found in the *Electroacoustic Performance Practice Database* database: http://ppeam.zhdk.ch [last accessed 23 May 2024].

in relation to the sounds of the fixed electronic part. If performed adequately, both compositions give a similar impression: the gesture of the performer triggers processes that transform the sound of the instrument, thus creating the piece's particular language.

Despite both pieces sharing this performative proposition, their completely different approaches with respect to the relationship between the performer and the electronic medium present distinctive challenges. Stroppa, for example, looks for a more intimate relationship between the performer and the electronic sounds, enhancing the acoustic identity of the instrument through real time processing and designing strategies for an effective interaction allowing for flexibility in the performance of his scores. *… of Silence* is part of a series of pieces in which the composer elaborates his concept of 'Chamber Electronics', rejecting the idea of the electronic medium as fixed, non-interactive and non-flexible and instead favouring a system that is able to establish a dialogue with the performer and adapt to different conditions and performative licenses taken by the instrumentalist, just as a human partner would do in a traditional chamber music setting.

In the context of the project, we used some rehearsal time to test the ability of this patch to adapt to my performative decisions. The 'Score Follower' function of the patch worked very effectively and was able to adjust the electronic processes to the smallest changes in tempo. This provided me with great freedom of interpretation, reinforced by Stroppa's score, which is rich in details and suggestions concerning musical character, thus encouraging an imaginative approach rather than a mechanical execution of the piece. Here, the electroacoustic gesture is genuine; as a performer, I'm able to perform the music without any temporal constraints, confident that the electronic medium will adapt to my playing and my musical choices. Rich sound transformations enhance my physical gestures and surround my saxophone's sound with me maintaining control over the overall dynamic envelope and duration. *… of Silence* creates a rather comfortable environment that encourages flexibility in musical expression and allows the performer to focus on colour rather than on synchronisation issues. The electroacoustic gesture is an intrinsic part of the composition's sonic vocabulary and is immediately apparent to the audience.

In *Shifting Mirrors*, a similar relationship between the saxophonist and the electronic sounds is suggested to the audience. However, as mentioned above, Vaggione creates this illusion by carefully structuring the acoustic gestures in relation to the fixed electronic sounds within a very precise and strict temporal grid. In Stroppa's piece the electroacoustic gesture occurs in real time with the saxophone as the main source and trigger of the electronic processes. Vaggione, on the other hand, achieves a similar result through precise control of the piece's temporal structure. Similar gestures happening simultaneously in both parts define a clear sonic relationship between acoustic and electronic sounds, giving the impression of the live saxophone being processed in real time. Through this approach,

Vaggione is not limited by the possibilities of real time transformation; he records, produces and re-organises his sounds, able to access unlimited possibilities and a greater range of interaction modes in which the acoustic instrument does not necessarily have to be leading the musical discourse. This facilitates the creation of different types of interaction; sometimes the electronic sounds anticipate the live gesture. Interaction in *... of Silence*, on the other hand, is rather linear, with the performer triggering all electroacoustic processes through his gestures.

Vaggione, in my opinion, doesn't want it to be apparent how the relationship between performer and electronic medium takes place. The mechanism behind the sonic result remains invisible: he doesn't show how the interactions occur, focusing instead on the musical result, in which the sonic dialogue between the acoustic and electronic parts becomes the main focus. Conversely, in Stroppa's composition this relationship and the mechanism enabling it is rather transparent and can be readily perceived by observing the flexible, fluctuating performance of the saxophone part, putting the process or the 'how' in the spotlight and letting it permeate the language of the piece. From the audience's perspective the perceived result is similar in both pieces: the performer interacts with the electronic layer, whether the sound transformation or triggering occurs in real time or has been pre-produced by the composer. Vaggione composes these interactions and encourages their perception. He uses only saxophone sounds for the electronic part, so that the blending of acoustic and electronic elements effectively produces the impression of a real-time transformation.

When working on and performing *Shifting Mirrors*, accomplishing an effective interaction simulating real-time sound transformation requires an approach very different from the one taken for *…of Silence*. Here, the performer doesn't benefit from the flexibility offered by the 'Score Follower' function of Stroppa's live electronic system. Instead, he or she needs to fully adapt to the temporal structure as determined by the fixed electronic part, allowing for no flexibility; each gesture needs to be executed with great precision regarding timing, articulation and colour in order for the interaction to be perceived. The quality of the electronic processes is not determined by the interaction with a signal-based system. The required precision (including a very regular tempo) can be achieved using tools[2] to facilitate synchronisation between the live instrument and the fixed electronics. For this, Vaggione provides a rhythmically defined score with a precise and stable tempo that the performer needs to study and execute with as much accuracy as possible. Vaggione's musical language is strongly influenced by the aesthetics and processes of granular synthesis, and all musical gestures incorporate a small degree of temporal contingency, which might help masking small imprecisions in

2 In the context of *Performing Live Electronic Music*, we used the *Polytempo* software designed by Philippe Kocher and programmed in collaboration with Christian Schweizer at ICST.

the performer's playing, and contribute to the effective blending of acoustic and electronic sounds.

Stage presence and embodiment as musical expression

At this point, we can appreciate how both pieces, despite their radically different approaches to realising the interaction between performer and electronic medium, aim for a similar result. The audience should perceive a close relationship between the acoustic instrument and the electronic sounds. The blending of these elements shapes the sonic worlds of both pieces, and the enhancement of the saxophone sound through the electronic medium, transcending the instrument's acoustic boundaries, is a fundamental part of their sonic vocabulary. We have observed how achieving this effect and making this relationship transparent to the audience requires different strategies for each piece.

It is important for the performer to understand the effect that these pieces should produce and to learn how to handle the benefits and limitations of the medium or environment provided by the composers. Revealing and celebrating the relationship between my live performance and the electronic sounds felt quite straightforward and intuitive in Stroppa's piece, as the system uses highly reactive electronic processes following the fluctuations of the performance. The appropriate musical expression became apparent, encouraging not only purely musical decisions on the interpretation of the text, but also a certain presence and corporal language to effectively convey this expression to the audience.

In *Shifting Mirrors*, it took me longer to find a suitable musical expression for the piece and a body language that would enhance it. I realised that the instrumental part was closely related to the electronic sounds and that I should find those relationships and make them apparent to the audience, but because I wasn't triggering those sounds, and because I had to act within a strict temporal grid that often felt limiting, this musical and corporal expression at first didn't feel intuitive. It felt strange and uncomfortable to celebrate those interactions when they were somehow 'faked', when the transformation of the saxophone sounds was not a result of my own doing but of a precise rhythmical performance coordinated with pre-produced material. However, and despite the personal relationship that the performer could have with the score, those interactions were an essential part of the piece and defined its musical expression. They had to be enhanced, requiring not only a very thorough study of my part, but also of the fixed electronic part in order to figure out where exactly those interactions were taking place, what my role was in each of them and how I could better deliver them.

After months of work, I became very familiar with the electronic sounds, recognised those important moments of composed interaction and made musical decisions accordingly. It was often somewhat humorously remarked in rehearsals

that the piece was 'indestructible'—the meticulously elaborated electronic part already provided most of the sonic and musical content of the piece, making the contribution of my live performance at times seem irrelevant. *Shifting Mirrors* could have been a very effective acousmatic piece. But Vaggione decided to incorporate a live component and the presence of a performer, thus converting the piece into a work for the stage. The traditional connotations of this setting and the visual language surrounding live performance cannot easily be ignored and play an important role in the perception of the piece. The performer of *Shifting Mirrors* has to embrace these conditions, understand the musical expression the piece aims to convey and adjust his or her choices accordingly.

For this reason, my personal solution for the interpretation of the piece was to aim for a very active, intense physical expression. Although the sonic results were not a direct consequence of my movements, as was at least to a certain degree the case in the live electronic processes of *…of Silence*, I realised that Vaggione had composed those interactions with clear intentions and that they were musically relevant. I resolved that my physical expression could in fact contribute to making those interactions more transparent and decided to embody those fixed electronic sounds in my own expression, as if they were the result of my musical choices despite their being locked in a rigid medium.

Naturally, these choices applied to the live performance of the pieces. For the CD recording, purely musical decisions were made, and focus was put on details of sound production that in some instances didn't take as much priority in the live performance. *Shifting Mirrors* and *…of Silence* were however conceived as stage pieces, and I consciously made musical and expressive decisions in consideration of this setting. Presence and embodiment played an essential role in realising an engaging and convincing performance of these pieces and served to explore and unify the musical expression of completely different electroacoustic practices and compositional approaches.

Re-Thinking the Instrument through Electroacoustic Performance

Panel Discussion with Joan Jordi Oliver, Martina Schucan, Matthias Ziegler and Germán Toro Pérez[1]

Germán Toro Pérez: Martina Schucan is professor of cello here at ZHdK and has had a wide career as a soloist and ensemble player in the context of contemporary music. We were very fortunate to be able to count on her as well as on Matthias Ziegler who was a professor of flute for many years here at ZHdK. He retired some months ago but is still very active in research and has also had a long career as a performer of electronic music. Martina performed two pieces; the piece by Hans Tutschku [*pressure-divided*], an excerpt of which we saw in the video before, and a piece by Peter Ablinger [*Instrumente und ElektroAkustisch Ortsbezogene Verdichtung ('Das Blaue vom Himmel')*], and Matthias played Thomas Kessler's *Flute Control*. So, I would like to ask both of you the same question. How would you as performers describe the different challenges in the sense that Joan has listed them in his presentation?[2] And what do you take away from this experience?

Martina Schucan: Of course, I can agree with a lot of what Joan has explained; these different ideas concerning the ways of playing with electronics… Maybe I'll focus on some other aspects. What was very special for me was to have these sonic experiences, these possibilities of exploring the cello's sound. Not only can you make the cello sound a lot bigger, but you can also be very intimate. And because of the electronic possibilities, you can, much like a pop singer, just do very intimate things and it fills a void, I think especially in a piece like the one by Hans Tutschku. This to me was very impressive, because as a performer, you are always fighting to be heard. But here, this was not an issue. And I think the possibilities of exploring sounds in this way are fantastic. The other aspect for me, which I do think is a problem, is always the issue of time synchronisation, which you also spoke about, because when we have all this counting of seconds and this alarm clock feeling, we are not free, we cannot breathe and just have to act as objective interpreters filling out the time. We may merely fill out. And in the piece by Peter

1 The panel discussion took place on 24 September 2022 at the auditorium no. 1 of the Zurich University of the Arts. The present text is a redacted version of the spoken discussion.

2 In his preceding lecture, Joan Jordi Oliver had focused on the aspects 'Presence as a body on stage; Possible interpretations of a musical text; Understanding location as a musical agent; New sensitivities in the listening situation; Re-discovery of the musical instrument; Preparation and new modes of performance'.

Ablinger there was a bit of this feeling. We were always counting seconds, and once the piece was started, we couldn't stop and get back in ten minutes later. So we couldn't rehearse. We just had to play through and through and through, which was very difficult in terms of time organisation. And in the piece by Hans Tutschku I was using a pedal, which for a cellist is also a challenging experience. In fact, I was operating not only the pedal for the iPad, but also the one for the electronics. So, it's good for the brain. But there I felt that I was able to control the time myself, which lets me act more like the performer I am and which makes the communication with the audience much easier for me, because I'll feel the time, I feel the tension, I can react. So, I think for me as a performer of works with electronics these questions of time coordination are a crucial aspect. Finally, a question that arises for both works and generally in contemporary, also non-electronic, compositions is whether my role is that of a subjective interpreter or that of an objective sound producer. Both imply very different ways of playing. I think both can be very interesting. But for me, it's very important to know what a composer wants and what possibilities there are with respect to time synchronisation and listening to the loudspeakers while I'm performing. All these questions are very important for me, and I discovered them during our work.

Matthias Ziegler: Well, I think the first time I played Thomas Kessler's piece was in 2006. It was an earlier version of the same patch still working with all computers at the time. And that was already a big step from the original setting with the *Fairlight* computer and a huge load of equipment that had to be hauled to the gig with a big van, you know, so now you could go there with just your laptop, which was really nice. It was a big step. And I was always asking myself why this piece in particular just fascinates me so much? Because, you know, I have played [Chaya] Czernowin pieces, pieces by [Pierre] Jodlowski, *Das atmende Klarsein* [by Luigi Nono], [*Musica su due dimensioni* by Bruno] Maderna and none of those pieces, well, maybe with the exception of *Das atmende Klarsein*, intrigued me this much, so I asked myself what's going on here. I'm a part of this huge machine. And then of course, all the questions it raises concerning agency, which you were also mentioning, you perceive the electronic system as an agent, knowing that it isn't, but you perceive it as one and that is why you start to listen differently. So, for me, the answer was that there were several levels connected to each other. It was not just the flute playing as an extension of my body, but the composer used language as a connecting element.[3] The voice you heard belongs to Aurèle Nicolet to whom the piece was dedicated. The first performance was done by Philippe Racine. The piece starts with 'voyage' in the original voice of Nicolet. And then I speak, and I hear things played back to me, so I get many levels of connection. And that was the

3 Cf. Lucas Bennett's and Germán Toro Pérez' contribution in this book ('Re-staging Live Electronic Performance Environments'), pp. 163–172

thing that really drew me in. No other piece for flute and electronics ever drew me in like this, and I think this is because of its different layers of connection.

GTP: What I found interesting right now is the question of control that of course is at the core of Thomas Kessler's piece. [To Joan Jordi Oliver] You got two different manifestations of that question in the two pieces. On the one hand you speak of the importance of having a high degree of control, for instance in tuning the instrument according to your own way of playing. But on the other hand, you pointed out regarding the piece by Agostino Di Scipio [*Modes of Interference /2*] that you found the situation where you don't have complete control especially intriguing. How do you see that? Because on one hand you would like to know what you do, but you also would like to be surprised by the system in the way it reacts and so on. How do you see this tension between control and not being able to control everything?

Joan Jordi Oliver: Yes. It is demanding and as I said, something that I find interesting as well, it goes a little bit against our baggage relating to normal performance. I'm very interested in this suggestion of subjective and objective performance, but once you understand that you set a clear goal that you have to achieve through practice, you can improve your performance and make it effective. So, the moment you act as an agent in a system where other components are equally important or even make decisions for you, in a sense transforming the way in which you will have to perform, is mentally very demanding, because you need to be prepared for any kind of outcome, you need to train the ability of being flexible, of being able to adapt and make decisions. And it can happen that you did some really good rehearsals where you explored a gesture that was working very well, but then you changed the room, and the same gesture is not going to be well received by the system or by the space anymore. Then you have to give it up. And I feel that's a very challenging position where you know that if you had the possibility to rehearse many times, as we did in the large concert hall where we had the last concerts, you can get to a certain degree of expectation of what's going to happen, but you are never fully in control. And for me, going on stage and feeling that something can go wrong is just something that awaits me. This aspect relates a lot to improvisation; and while this piece is certainly not an improvised piece, I think it has a lot to do with that ability to let go, to be open, to be able to be excited by the positive surprises, and to be very flexible with regard to the negative surprises that we all sometimes get in these settings.

MS: I actually like that it's not always controlled and that you have to be open to react. I think it makes a performance more artistic and more alive. I think it forces us to be very present in the moment and to not just reproduce something. I think that's fine. What I hate in terms of lack of control is when I don't hear what's going

on [laughs]. And I think we had this speaker-related problem in the piece of Peter Ablinger where I couldn't hear exactly what was happening and because of that I couldn't react to anything. So that's the moment when you actually feel a little bit useless. But I think when the system is working in a way that you have to react to, this is only positive, because it's like playing chamber music, where there are sometimes also surprises you have to react to. I think it's real.

MZ: The question of being in control of what's happening is especially relevant for the Kessler piece. Very often I would feel controlled by the electronics, not in command anymore. And that was the thing that most fascinated me. How do I give up on controlling the piece? How do I adapt so that something comes out which I read in the score, which I feel is what is intended in the composition. For example, Kessler works with thresholds, and I just have to keep my sound down to a *pianissimo* and only twice during a long note go above the threshold to make that 'jøde' or 'siuvoja' speak [cf. score, p. 3, 14], but if I'm a bit above it I will immediately get four of those. So, I'm partly controlling it, but I feel that it's balanced, I'm conversely being controlled by what's going on. And if you get used to that feeling, it's actually fantastic. You know, it's a real booster for musical experiments, also in different contexts.

GTP: There's an additional aspect, especially related to Peter's piece which is fascinating as an object of study with all the challenges it presents, and to some extent is also present in the pieces by Vaggione and Di Scipio. It has to do with the fact that in these pieces the performer to some extent steps back and becomes part of a system. In the case of Vaggione you are just producing one additional layer, it is not about you playing a solo piece. You mentioned something similar with respect to Di Scipio's piece. The Ablinger piece presents an extreme situation in that the cellist has an extremely difficult virtuoso part to play, yet Ablinger wants one to hardly hear it, not to be sure if one is actually hearing it or not, the cello part remains almost hidden. How do you deal with that?

MS: As cellists we're actually used to this problem [laughs] that you sometimes play and try to have a clear presence and that it's not through the acoustics that the people will understand what you're doing, but it's done by being there, by thinking and imagining it, and this can get something across. I think it's great if you are able to integrate yourself completely to the electronic system, it can be very nice. For me it's more this time restriction that makes me unfree and un-artistic. But it was quite funny, we rehearsed the piece for a whole semester and then at the end did the recording. Once I played my part without electronics and all of a sudden, all the technicians were saying 'my God, what are you playing there? This is unbelievably difficult. We didn't realise during the whole semester what it

was.' So I was very grateful for the recording, because I was able to show that I had practiced. [laughter]

GTP: Do you think that this repertoire is challenging the basic elements of ethos in performance, in terms of failure, errors and imperfection or in the sense that it differs from the way in which you normally play?

MS: I think that we deal with these questions in each piece that we play, such as the issue of not being in control, of playing in a certain hall with its specific problems, I think this is part of a performer's life. Perhaps we think that we can put more trust in electronics, but we cannot. So, I think it's similar to what we feel otherwise, at least for me it is.

MZ: Yes, but we have to rethink the staging of those pieces, because if I enter the stage holding a flute, I'm perceived as a flute player, not as a musician with a game console in hand who is triggering something. So, do I really want to be perceived as a solo player in what is by no means a solo piece? It might be right for some pieces where you're just playing in a space, and you do have a soloistic role. But I was thinking now that in the Kessler piece, knowing it really well, I couldn't even tell whether it was me speaking into the microphone or if the composition was speaking to me? I thought this side angle was actually quite nice. And having the composer present was another thing because he said after the concert 'you know this is the first time in my life that I'm not doing the sound for this piece. And I'm realising how different it sounds when I don't have to do the whole electronic setup.' And we might have to rethink the staging of these compositions, possibly including the composers in that process.

JJO: Absolutely. And it's often not immediately apparent what the setting should be. You normally get a set of instructions regarding musical and technical aspects and sometimes also specific settings like the staging and so on. The case of Vaggione's piece [*Shifting Mirrors*] was particularly interesting because I thought I would like it to be perceived as a solo piece. The interactions between the numerous voices in the electronic part suggest a lot of physical investment, since one can mostly recognise the sound source and the physical actions realised by the saxophonist in this pre-recorded part. It was a personal decision to react accordingly to this suggested energy and to make my own interventions very physical as well in order to match the musical energy with my bodily presence.. This was to some extent our choice, I don't think we discussed it much with Vaggione, but I feel this it is something that also happens in acoustic music, in chamber music and so on. But with all these [different]concepts in electroacoustic performance, there are many interesting settings to explore. Here, for example, I encountered for the first time this phenomenon of stepping on stage thinking that you're playing a solo

piece [*Modes of Interference /2*], however, it isn't, you are the only human being on stage, but there are very lively sounds going around and how do you interact with that? For me, this particular setting of electroacoustic performance was a new experience.

GTP: I'm wondering to what extent this repertoire makes it possible to rethink the question of the performer's presence according to the different roles you are playing in a piece.

MS: For me, it is interesting to hear from a composer what kind of presence he wishes to have; if he wants me to have a strong presence, of course I can, or if he wants me to just be what I call objective, just cool and doing my duty. They're different ways of performing. And I think composers should know what they want of us because we can do both, and both are equally interesting if they're thought of by the composer as an element.

MZ: I agree with this. I think it should be part of the composition process for composers to outline how they want their pieces to be staged, since you have so many more possibilities than in a Brandenburg concerto.

GTP: But is this not also a part of interpretation, to understand and define the right kind of presence?

MS: Yes, it is, but I think we can play with this. We can say 'tonight, I do it more in this direction, and another time I'll do it in another way.' It also depends on the audience. With some audiences I may feel that I have to do more to keep them with me, while with other audiences I know they just listen, they don't need to see what I'm doing. There are many factors that influence this, because we are performing and so, the interpretation is not fixed; while we have a concept, we have ideas and we make decisions, we also adapt them to the situation and not just to the piece itself.

GTP: We still have a couple of minutes and I have another question concerning the relationship to the other performers present in the room, who are often working behind the mixing desk; in the pieces we discussed they were Carlos Hidalgo and Leandro Gianini. Does the fact that you have somebody taking a great deal of responsibility for the resulting sound as well as the fact that sometimes you are facing a black box create a different kind of experience than when you are working without electronics? Kilian was speaking about the black box yesterday, the issue of how to deal with a system that you don't completely understand or know and perhaps don't even want to know in order to be free of that. How do you deal with

the situation of having this black box and working together with another agent whose work greatly impacts your sound?

MS: I basically try to trust and to speak with them; we spoke a lot, especially with Leandro and Carlos, and it's really like playing chamber music with somebody, you have to trust, you have to know that he or she is doing his or her best. And here it was the same. Personally, I had the feeling of being understood in terms of what I wanted to do. And I also tried to understand what was happening from their side. For me, it was very much like a chamber music feeling.

MZ: I have an innate interest in technology, and I play solo programs with internal microphones on my bass flute and my laptop next to me, which led to a pocket version of the Kessler piece as well as of Saariaho's *NoaNoa* which I can include in my solo programmes. I just open another patch and play this in a stereo setting. At the same time, I have eight outputs on the *Metric Halo*, and if active speakers are available, they can be hooked up. So, for me, that's a different way to approach the piece, more stressful of course because I'm responsible for everything. But if there's a team with someone like Leandro, such as we had for the recordings and for the concert, you can really focus in detail on what you're doing, which is fantastic, but I think requires some understanding of the musician's part of what's going on technically. It's the same if you are a race car driver, you need to know what to tell the mechanic when you stop at the box and say 'I feel the break is reacting too early', and this will go back and forth, then they will come up with a solution and you'll feel more comfortable. And here we get to the aspect of having enough time. For example, if the coffee machine powers itself on in the middle of the Kessler piece, who runs over there to switch it off? [laughter]

JJO: I agree with both of you, I think these are really good points about trusting and this feeling of a chamber music situation and the fact that you have to be able to make and react to requests on a technical, but also on a musical level. And regarding that black box, I think, the more we can learn about the system, the better, because this will influence our expectations and how we can really play with the system. For example, in Di Scipio's piece, a really nice documentation is provided with the score explaining how everything should operate on a technical level. As performers, we really appreciate this, as opposed to receiving perhaps a cryptic Max patch that we can start up but otherwise don't know much what to do with. So, these are nice contributions.

GTP: Should we try to educate performers in that direction too?

MS: Yes, I suggest to all my students to take classes involving electronic music and to try to exactly understand the black box and to develop their own ideas about it. I'm sure that this will help in this back-and-forth process we have mentioned.

MZ: Yes, and more could actually be done in this respect at the university, so that for example when a student plays a piece for flute and electronics, I would be charged with explaining to that person what he or she needs to understand, I think it usually requires quite a push, because in daily life students are busy with scales and patterns and… and Haydn [laughs]. And maybe more people would then go to events like this.

GTP: I think this touches on another level of responsibility regarding the institution's tasks in that context. We, too, have this responsibility. Well, I think this is a good stopping point. Thank you very much, Joan, for the introduction [applause]. And thank you, Martina and Matthias and all of you for your collaboration during all these years. Thank you very much. [Applause]