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ERGODYNAMICS AND A SEMIOTICS OF INSTRUMENTAL COMPOSITION

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BIO: Thor Magnusson is a worker in rhythm, frequencies, and intensities. His research interests include musical improvisation, new technologies for musical expression, live coding, musical notation and digital scores, artificial intelligence and computational creativity, programming education, and the philosophy of technology. His book on new music technologies, *Sonic Writing*, was published by Bloomsbury in 2019. In addition to performing and writing about music, he gives lectures on the topic at the University of Sussex, Brighton.

ABSTRACT: This article examines the techno-philosophical aspects of how we create and understand musical systems in twenty-first century computational media. Arguing that processor-based media have exploded the compositional language of new music, the article proposes a set of concepts that might help us navigating this new space of instrumental possibilities. The term ‘ergodynamics’ – and related concepts – is presented as a helpful notion when describing the phenomenological, historical, and aesthetic aspects of musical instruments, as well as a lens for looking at new compositional practices that can be defined as being either ‘idiomatic’ or ‘supra-instrumental.’ The article explores the difference in composing for acoustic, electronic, and digital instruments, and suggests that new musical practice can be characterised by a move from composing work to inventing systems.

Introduction

Over the past three years I have been working on a research project called Sonic Writing. It involved organising conferences, symposia, and workshops with instrument makers, composers, performers, and programmers. Through conversations and formal interviews, it began to dawn on me that we operate with a rather poor set of concepts when discussing the origins, design, and playability of our musical instruments, and this applies equally to acoustic, electronic, and digital technologies. When discussing our instruments and production tools, we lack the terminology for describing the expressive potential of the technology, in itself but also our subjective perception of it (a distinction that I will not make much out of as they are strongly interdependent). Such a set of concepts might help us analysing where the instrument comes from (the sax from the clarinet, the DAW timeline from the piano roll, the Max patch from analogue synthesizers), its historical uses and how it is adopted in other cultures (think of the violin in Indian music or Max/MSP in electronica), its aesthetics and musical scope (timbre, polyphony, amplitude, and potential for being part of an ensemble), and importantly the interaction and interface capabilities (what are its affordances and constraints, and how does the instrument align to our trained musical body and ideas?).

Talking to computer game creators, who, like digital musical instrument makers, apply diverse interface technologies to create worlds of immersion and investigation, it is inspiring to hear them use the term 'gameplay' for all the above, emphasising concepts of play, narrative, design, and affect. Gameplay is what makes the game what it is, how it plays, what it conveys, its narrative, and how we experience ourselves as players immersed in the game. 'This game has a great gameplay' a gamer might say, with further elaborations as to why. Gameplay is a bizarre word, indeed, as if we were to say that a coffee cup has a good 'cupdrink' or a sport shoes a good 'shoerun,' but it works well: it has a particular functionality at a high level of discourse that can subsequently be granularized through further descriptions.¹

¹ See Laura Ermi & Frans Mayra, 'Fundamental Concepts in the Gameplay Experience: Analysing Immersion' in De Castell & Jenson (Eds.), *Worlds in Play: International Perspectives on Digital Games Research*. (New York: Peter Lang, 2007). Also, see Anders Drachen & Alessandro Canossa, 'Towards gameplay analysis via gameplay metrics,' in

In new instruments and systems we might use terms such as affordances, constraints, playability, remediation, ergonomics, workflow, and expressiveness, but I don't find them sufficient to describe the instrument's unique qualities, its personality (what makes one oboe different from another), and how it appears to us, the human subject who engages with it and explores its expressive potential. In short, its *haecceity* or 'thisness' as the medieval scholastics² would describe the properties that make an individual object what it is. Musicians are very familiar with haecceity, as they have experienced the difference between individual Stradivarius violins, oboe reeds, or, say, different instances of 1954 Fender Stratocasters. Musical technologies are unique, personal, embodied, cybernetic devices that exist in the interstice between our inner self and outer motor movements, constantly attuned and calibrated in real-time practice, and it is this deep and emerging phenomenological relationship that could be better described with an extended vocabulary.

Ergodynamics

All musicians are familiar with the experience of picking up an instrument and explore it through action and play. We rotate the instrument and observe at it from all angles; we shake it, pluck it, blow it, study how it fits our body, and then we try to express ourselves through it, discovering its affordances and constraints. Depending on how familiar the instrument is, for example, reminding us of something we have played before, we progress and begin to understand what we can do with the instrument. This applies equally to a flute player trying the nay flute, a guitarist exploring a banjo, a percussionist testing a rubber-pad MIDI controller, or a computer musician exploring analogue synths. Sometimes the instrument is quite alien to our prior experiences, as might be the case of an African drummer playing a Scottish bagpipe, or a club DJ trying an Arabic santoor (a hammered dulcimer). But this experience of encounter with a new musical instrument is precious as it will serve as an extension of the mind and the body; it is one

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2009. pp. 202-209.

² See, for example, *Duns Scotus: Philosophical Writings*, translated by Allan B. Wolter, OFM, (Indianapolis: Hackett Publishing Company, 1987).

of curiosity, joy, frustration, confrontation, and conversation, where we bring our past with us into a new situation that possibly results in affection, indifference, or antipathy.

The encounter with a chosen musical instrument is a lifelong event. We discover new things in the instrument through playing it, and through its response we learn new things about ourselves as performers and expressive beings. We perform and the instrument performs; we work and the instrument works. The Greek term for work is *ergos*, also signifying an operation or a process. A related word is *organon*, or an instrument that performs work: a heart, a hammer, a harp – these are all organa in the ancient Greek understanding of the word. Now, the potential or function of an object is its dynamic character, or *dynamis*. When we investigate what an instrument can do, studying its affordances and constraints, but also historical background, the use of our pre-incorporated motor memory, its musical character as part of a tradition, and imagine the potential relationship we might have with the instrument, we are exploring its *dynamis*. For this reason, the word *ergodynamics* is proposed as a term that somewhat relates to the use of ‘gameplay’ in computer games, but further signifies an awareness and experience of the instrument in embodied, historical, and aesthetic practices. Ergodynamics are of the object studied, but it relates equally to cultural context and subjective personal experiences of it. From this perspective, even if they are the same object, a fiddle and a violin have different ergodynamics as they are part of different traditions. Similarly, Jimi Hendrix ‘discovered’ feedback as an ergodynamic feature of the electric guitar, adding it to the possible array of techniques.³

I have developed these concepts through talks, workshops, conference presentations⁴ and in a forthcoming book.⁵ When inventing new instruments, we often want to reuse the incorporated skills of performers, and relate to their practice. This is why we create MIDI keyboards, wind interfaces, drum pads, and so on. We simulate or imitate what is there, and

³ Hendrix was clearly not the first guitarist to use feedback, but he can be said to have popularised the technique.

⁴ Thor Magnusson, ‘Ergomimesis: Towards a Language Describing Instrumental Transductions,’ in *Proceedings of Live Interfaces Conference* (Porto: University of Porto, 2019).

⁵ Thor Magnusson, *Sonic Writing: Technologies of Material, Symbolic and Signal Inscriptions*. (New York: Bloomsbury Publishers, 2019).

often translate it into a new technology or material substance. Adolphe Sax developed an instrument that transformed from wood to brass (although the sax is organologically still considered a wood instrument, due to the single-reed mouth piece).⁶ Bob Moog installed a keyboard onto the modular synth, to support familiarity and continuity, provoking synth makers like Don Buchla, who argued for the design of new interfaces for new sounds and music.⁷ Ge Wang then implemented a Mesoamerican Ocarina as an iPhone app.⁸ These are all different types of borrowing, simulation or imitation (*mimesis*), but a general term we might apply is *ergomimesis*, or how a feature that allows for a certain performance (*ergos*) is translated into a new technology. The human gesture, the action, exists as a neurological structure in the individual, and as a cultural phenomenon supported by technology and documented in literature and audiovisual material. *Ergomimesis* can apply to the design of artefacts as well as the imitation of gestures in performance, which can be *identical* (say a student of the guitar learning from a teacher), *divergent* (a saxophonist applying their skill when playing the clarinet), or *transduced* (for example where a pianist plays on a touchscreen) technologies. In such cases, new technological design is clearly referencing the musical skill and carrying over the instrumental affordances from one technology to another. This technique and technological element that is ‘carried over’ can be called *ergophor*, like a metaphor, but denoting the gestural action and the material substrata that enables it, such as the act of pressing a button on a press-button on a tablet’s screen.

Semiotics and instrumental composition

⁶ Wally Horwood, *Adolphe Sax 1814-1894: His Life and Legacy*. (Baldock: Egon Publishers, 1983).

⁷ Trevor Pinch and Frank Trocco, *Analog Days: The Invention and Impact of the Moog Synthesizer* (Cambridge, MA: Harvard University Press, 2002).

⁸ Ge Wang, ‘Ocarina: Designing the iPhone’s Magic Flute,’ in *Computer Music Journal*, vol. 38 (2), 2014. pp. 8–21.

The above terminology of the phenomenological study of musical instruments can be explored in more detail, and I do that elsewhere,⁹ but this article is written in response to the *Touching Sound* symposium at City University in London in the autumn of 2017. Exploring the performative, communicative, and tactile experience of music – how we compose for our instruments, play them, and communicate their functionality to the audience – there is a pronounced variation in how different instruments function as objects in the world. The acoustic instrument is there, located in space, the origin of its own sound, and whose touch is not coupled to anything else: it directly responds to the energy of the performer. The electronic instrument needs electricity, amplifier, and loud speakers. Its play involves operating an interface that is mapped to blackboxed functions that are typically hidden behind a metallic surface. And the digital instrument is yet more complex, with arbitrary mappings, and functionality defined by code that is dynamic by nature and easily changed. For a composer, the meaning and significance of composing for each type of these instrumental technologies is therefore a complex question. How does a composer know what the sound of an analogue synthesizer is? Or a complex multi-parametric digital controller? Can the sound, the instrumental function, understanding of the notated instructions, or even the instrumentalist be taken for granted, like we have become accustomed to expect with acoustic instruments?

Mapping is a key difference in the way these types of musical instruments work. From a semiotic perspective, we could apply the Peircian trichotomy that divides signs into the types of icon, index, and symbol.¹⁰ Briefly explained, the *iconic* sign is one where the represented thing resembles, imitates or reflects the qualities of the signified object. A statue, a gendered toilet sign, or onomatopoeic words are iconic. They physically resemble (visually, sonically, etc.) the signified. The *indexical* sign does not have to resemble what it stands for. However, it is directly connected to it, for example, foot prints in the snow are indexical signs, or a phone's ring tone.

⁹ Musical organics, or the critical analytics of musical instruments, are explored in the Sonic Writing book previously referenced, but also in the following article: Magnusson, Thor. 'Musical Organics: A Heterarchical Approach to Digital Organology,' in *Journal of New Music Research*, vol. 46 (3), 2017, pp. 286-303.

¹⁰ Charles S. Peirce, 'On a New List of Categories', *Proceedings of the American Academy of Arts and Sciences* 7 (1868), pp. 287-298.

These are learned signs, but they contiguous with the origin, the referent. Finally, *symbolic* signs are arbitrarily assigned structures where the signifier and the signified might have no relation at all. This is based on convention, and a population of users. Peirce notes that these signs often overlap, and, for example, that a symbolic sign might contain an iconic element.

This semiotic model can be applied to the manner in which musical instruments work, in order to understand and try make explicit a certain unease of qualitative differences between acoustic, electronic, and digital instruments. Here we note that acoustic instruments are of *iconic* nature: the string on the guitar is at the same time the sign, the interface, and the sound source. There is a direct and necessary relationship between interface and sound, one based on acoustics or physical laws. Electronic instruments can be seen as *indexical*. There is a link between the sign and the signified (e.g., between the filter knob and the filter behaviour) and this link is contiguous. A voltage controlled low-pass filter works a certain way, and its behaviour is clear. We might however wire the knob such that it increases the cut-off frequency when we turn it to the left, and decreases the frequency when turned right. That is a convention, an index, but it is not arbitrary, as the behaviour is still based on the principles of electronics. Digital instruments are *symbolic* (and I have used the words 'epistemic,' 'theoretical,' and 'conceptual', to signify from different perspectives that open yet machinic mapping between input and output). The mapping between the interface element, whether screen-based or physical, is arbitrary: there are no natural laws that limit our design options. A soft touch on an interface could result in a loud sound, and vice versa. A lively acrobatic gesture might result in a timbrally simple sound, where no movement could yield a sound of rich sonic spectra.

It is therefore relatively simple to notate for iconic instruments, a blob on staff represents a pitch (or even an action), but it has a location on the fingerboard, a clear configuration between the performer's body and the instrument. There is a centuries-old tradition of how to interpret the symbol and render it as sound. However, it is somewhat trickier to create notational symbols to define the behaviour of electronic instruments. The instruments are unstable, they are never the same (it is well known that you can never get exactly the same sonic structure on a modular synthesizer), so the symbolic notation can hardly refer directly to a defined outcome. Thus, we might resolve to a more imprecise notation for imprecise instruments. The trouble then triples

with digital instruments. They change like the wind and altering a parameter in the code could result in a very different instrument. The physical attributes can change, the mapping engine between gestural input and sound result, and the sound engines change. The question arises: what is being notated for? Here the notation has to be not of pitch or tempo, but of general design: the notation becomes the structure of the instrument itself, for example in a Max, Kyma, Pd or SuperCollider patch. The program patch, the software, often becomes the notational piece, just like a graphic score or Greek music theory, and the performer improvises from that technical and conceptual framework.

Strategies of notation

How do established compositional practices respond to the current changes in instrumental nature? This is not an easy question, but since the 1950s, well exemplified by Gordon Mumma and David Tudor, composers have increasingly become instrument makers, fusing the instrument and the composition, and subsequently often performing the piece themselves.¹¹ Such an approach would have been unheard of in the nineteenth century, for good reasons involving the materialities used in the instruments and the technical demands of notated pieces. The roles are coalescing into heterogeneous practices that are defined by each practitioner. Modern media technologies, accompanied with an openness in aesthetic thought in postmodernism, enable people to take such diverse paths in their musical practice that we do not find the group forming around specific -isms as in the past so easily. However, it is not just the human roles that are converging: the distinction between a piece, an instrument, and a performance are fusing, and these musical performances might not even be given a title on a festival programme.

The above argument is that the composer-performer and the instrument-piece paradigms are being transgressed in new musical practices, but this does not necessarily signify a total rupture and discontinuation of older practices. Established cultural structures are persistent, for example evident in the various laptop orchestras around the world, where the setup tends to be quite traditional: the composer, the written score, the conductor, the orchestra on stage, and

¹¹ Michael Nyman, *Experimental Music: Cage and Beyond*. (Cambridge: Cambridge University Press, 1974).

the audience off stage. It is evident that new technologies will not destroy older musical cultures, and unlike the Futurists or anarchists a century ago, no one is calling for this destruction. But new technologies do bring with them a new episteme,¹² which becomes the ideological signature of the age. And threads will cross the diverse epistememes – for example, a composer writing a notated score for a new musical instrument, or a pianist working with brain-controlled robotic hands.

From an abstract viewpoint, two general compositional approaches have emerged for composers in this new musical paradigm: the ‘idiomatic approach’¹³ and the ‘supra-instrumental approach.’¹⁴ In the former, the composer writes work specifically for the new instrument, thus supporting its *raison d’être*, its continuity, and development. This establishes a tightly knit relationship between the composer, the instrument maker, and the performer, and can be a rewarding process for all involved which can equally impact change in compositional ideas as well as technological design. The problem that typically surfaces is that new instruments are rarely in a solid state – they are fluid processes – so a composition written for an instrument in 2018 might not be realisable in five years, unless specific effort is taken to preserve the state of the hardware, software, operating system, protocols, and physical gear and cables. Will, for example, the Bluetooth standard even be supported in computers in ten years’ time? Will the software work on the next update of the operating system? The supra-instrumental approach, on the other hand, represents a compositional strategy where the composer writes more general notation that could be for any instrument, through high-level musical gestures and instructions which can be further explained in natural language. Writing supra-instrumentally can involve quite nuanced definitions of sound (e.g., synthesis type, spatialisation, change in filtering, sonic mass, granularisation, sound sources), but neither the software nor the interface is specified. Such a

¹² On epistememes in history and music technologies of Europe, see Foucault’s *Order of Things* (Michel Foucault, *The Order of Things* (New York: Pantheon, 1970) and Attali’s *Noise* (Jacques Attali, *Noise: The Political Economy of Music* (Minneapolis: University of Minnesota Press, 1985)).

¹³ Juan Carlos Vasquez, Koray Tahiroğlu & Johan Kildal, ‘Idiomatic composition practices for new musical instruments: context, background and current applications,’ in *Proceedings of the international conference on new interfaces for musical expression*, (Copenhagen, Denmark, 2017), pp. 174–179.

¹⁴ Claude Cadoz, ‘Supra-instrumental interactions and gestures,’ in *Journal of New Music Research*. vol. 38 (3), 2009. pp. 215–230.

compositional approach is in many ways reminiscent of Renaissance music where composers did not tend to write music for specified instruments,¹⁵ at a time when innovation in instrument design was booming, and where performers were more than mere interpreters of music.

Beyond the work concept

Lydia Goehr has written an influential thesis about the emergence of the work-concept in the nineteenth century, or more precisely in 1800, the year of Beethoven's first symphony.¹⁶ The concept relates to a certain ontology of music that emerged at during this period that set the music that followed apart from earlier music. Here, in the new music, the notated score represents an expression of a piece that should be executed with full fidelity by the performer, whose interpretative role is to connect to the composer's real ideological and emotional intentions. This is clearly different from the notated music of previous periods which was written in relatively basic notation that offered more scope for co-creation of the music, often with dedicated parts for improvisation by the performers. In what followed, notational languages, their symbols and syntax became increasingly complex until the mid-twentieth century, when composers began to explore indeterminacy, randomness, group emergence, improvisation, and performer creativity through means such as graphic scores, verbal scores, action scores, and free improvisation.

Since the mid-twentieth century, musicians have been experimenting with the elasticity of the work-concept. The advent of sound recording represents a crucial event in this story, as here music could be written not merely as symbols to be interpreted, but as actual signal to be reproduced. If anything, phonography strengthens the ontology of the musical work, as can be observed in rock music, where the recorded track becomes the primary reality of the music and subsequent stage performances of the work become renderings of the real thing.¹⁷ Bernard Stiegler similarly argues that phonography is what makes jazz possible. The reality and potential

¹⁵ David Schulenberg, *Music of the Baroque* (New York: Oxford University Press, 2001).

¹⁶ Lydia Goehr, *The Imaginary Museum of Musical Works: An Essay in the Philosophy of Music*. (Oxford: Oxford University Press, 1992)

¹⁷ Philip Auslander, *Liveness: Performance in a Mediatized Culture* (London: Routledge, 1999)

of the phonographic recording constitutes the music: 'The real time of the recording is already present when the jazz musician plays. It is the condition of possibility of a space and a time of jazz, its horizon.'¹⁸

Similarly, with computational media the conditions of music-making change. When music is stored as a binary file, executed through the central processing unit of the computer or the phone (CPU), there is no technical reason to adhere to the fixed linearity of the sound recording. In the post-recording or post-linear age, music can be written as software or data structures to be interpreted by specific software. This includes generative music, audio games, virtual reality worlds, new instruments, sound apps, and deep machine learning. There are hardly any limits to the direction music can take as a format in the new media.¹⁹

Inventions

What transpires when the ontology of music and the affiliated descriptive terminology departs from the linear models we find in the symbolic writing of the musical score and the signal writing of the phonographic recording? This is not a simple question, as the move is not *towards* a new and clear set of practices, but rather *away* from hegemony of twentieth century musical practices, characterised by the recording and supported by previous developments of musical notation. Composers such as George Lewis, Alvin Lucier, Laetitia Sonami, Tristan Perich, Pamela Z, Claudia Molitor, Nicolas Collins, Trimpin, Edwin van Heide, Susanne Ciani, and Marianthi Papalexandri-Alexandri are just few examples epitomising a new diversity where music is written as systems whose ergodynamics are explored in performance. Composers of this new systematicity build on musical history, theory and practice, but not necessarily of a particular shared canon. However, their practice is deeply rooted in the traditions of questioning, rethinking, and experimenting with what sound and music might mean as culture evolves.

¹⁸ Bernard Stiegler & Robert Hughes, 'Programs of the Improbable, Short Circuits of the Unheard-of,' *Diacritics*, vol. 2 (1), 2014, pp. 70-108.

¹⁹ I explore this further in: Thor Magnusson, 'Sound and Music in Networked Media,' in *The Routledge Companion for Sound Studies*. (London: Routledge, 2019).

These musicians²⁰ are inventors. They invent systems that might be notational instructions through symbols, text, or other materials, build instruments, tools, and equipment, and engineer machines of computational intelligence that can be controlled, explored, or conversed with in live musical performance. The musical stage becomes a laboratory and the instrument a device for experimentation. The act of composition involves creating an ergodynamic space in which the composition can be explored through performance, rendering instances of the piece, as if the system was the genotype and the resulting performances phenotypes. By applying the term ‘invention’ here, I am reaching back centuries to medieval rhetoric whose five canons involved *inventio*, *dispositio*, *elocutio*, *memoria*, and *pronuntiatio*.²¹ The invention is the discovery of the space that will later be disposed, elocuted, stored in memory and finally performed (typically as speech). This search space is the *topoi*, the place where arguments can be discovered, found, realised. There is no coincidence, then, that musical practices often take names such as *ricercata*, *study*, and *trouvriere*. Indeed, Plato in *Cratylus*, a study in etymology, says that the origins of the term ‘music’, and the ‘Muses’, derive from the search for truth: “The name of the Muses and of music would seem to be derived from their making philosophical inquiries (μῶσθαι)”.²² St. Augustine and Isidore of Seville would later echo this statement in their writings on music.

Medieval music was based on inventions, and, clearly, before the advent of notation, the mnemonic technique of medieval rhetoric would be highly relevant for the preservation, transmission and performance of music. Bach wrote his Inventions in 1723, as demonstrations for imitation and learning. They were models ‘not only of arriving at good original ideas [*Inventiones*] but also of developing them satisfactorily.’²³ The inventions are systems of thinking that could yield further variations, through a search within that system. More recently Jonathan Impett has applied the term ‘invention’ to his musical practice, ‘In my work, I needed a name for

²⁰ I deliberately prefer the word ‘musician’ to terms such as composers, producers, designers, performers, or instrumentalists.

²¹ Michael J. MacDonald, *The Oxford Handbook of Rhetorical Studies* (Oxford: Oxford University Press, 2017).

²² Plato in *Cratylus* 406a.

²³ Heinrich F. Plett, *Rhetoric and Renaissance Culture*. (Berlin: Walter de Gruyter. 2004), p. 141.

a particular software construct: a unit of musical behaviour which encapsulates materials and behaviours from multiple sources which is formed by the interaction of several dynamical systems. [...] The *invention* in this context is the locus of materials, behaviour and relationships.’²⁴ Impett applies the concept to his swarm-based musical system, but it is also relevant to embodied musical systems, such as Laetitia Sonami’s sensor glove, or software-based systems, like generative systems or live coding environments. Invention is therefore not a musical work, but something that supports it by engendering action and interaction.

Invention, understood in the context of new musical practices, is a form of composition where a system is created in which the musician explore the space, the *topoi*, discovering the potential of the system and rendering versions of it through performance. This system can be a notated piece, a software, an instrument, or a mechanical device, but what characterises this approach is a new form of ontology where the recording of the work cannot be seen as a sufficient representation of it, particularly as in this music the performance is about much more than the sound only: it involves a focus and interaction with the instrument, co-performers, audience, architecture, and machines. Clearly, this should apply to most types of music, but whilst factions of twentieth century music accepted the reduction of music down to the phonographic recording, the point here is that the recording can never be a sufficient representation of the music itself.

Authorship vs artistic signature

The ideas we have of the musical work might be changing, evolving, and perhaps receding if we subscribe to the definition described by Goehr and Goodman.²⁵ This does not mean the work will disappear: musical practices seldom do. However, the idea of the complete and fully notated work to be perfectly rendered by a performer, ensemble, or orchestra that spend days practicing it might be fading. As a colleague once expressed, ‘it is not the first performance of your piece that’s impressive, it is whether you get a second performance of it.’ There are simply more

²⁴ Jonathan Impett, ‘Situating the *invention* in interactive music,’ in *Organised Sound*. vol 5. (1). 2000. pp. 27-34.

²⁵ Nelson Goodman, *Languages of Art: An Approach to a Theory of Symbols*. (Indianapolis: The Bobbs-Merrill Company, Inc. 1968).

composers around, less funding, and music has spread onto an extremely wide heterogeneous space that questions how realistic it is that established nineteenth century practices continue to maintain their central position in musical culture. The composers of this new systematicity are interested in exploring new technology, material qualities, visual media, interaction, machine intelligence, non-linearity, emergence, design, audience participation, location, architecture, and more as compositional material. This does not box well onto a CD!

The musical work might be transforming into a system of sorts, with a correlated questioning of the author-function (as explored by Foucault and Barthes), but that does not mean that the artistic signature of the musician disappears. There are very strong characters in contemporary music, writing pieces that are uniquely theirs, in terms of aesthetics, musical material, and technological materialities. Composers like Rioji Ikeda, Eliane Radigue, or Onyx Ashanti are more idiosyncratic and unique in their artistic approach (including considerations of performance, instrument, space, audience role, event design, etc.) than we could have dreamed of with composers of the past centuries. And I argue that this is because our new musical materials, of composition and design, have become more easily available, understood, and affordable.²⁶ If anything, music is becoming more of a personal exploration, unique in style and material, than in previous periods – a statement that might seem to contradict the rise of machine intelligence in musical practice, but it is precisely at the time when the machines begin to reproduce the common and the popular that we begin to desire the unique, the idiosyncratic, and the deeply personal.

Conclusion

This article skims the surface of a topic I presented at the *Touching Sound* symposium. It is my hope that the result of this skimming, the scum, has a relevance in a position paper like this one, but the above topics are covered in more depth in my book, *Sonic Writing*. After years of designing new music technologies, performing, and thinking about instruments as extensions of

²⁶ Creating a sensor glove in the 1980s required access to well-equipped research labs like STEIM, but today a £25 microchip computer can be ordered online and tutorial videos followed in how to program and solder it into a unique musical system.

our human organs, I have begun to see instruments as places (*topoi*) we enter and navigate in our search for music, for ourselves. This search and retrieval involves the ergomimesis of past music and musical training in new devices, but also the unique phenomenological relationship we have with our instruments – whether a cello, a synthesizer, or a live coding language – and the ergodynamic discovery of potential expression there within.

It should be clear from the above that the proposition is not that new practices will override or efface our historical past: there will be composers writing scores for string quartets, rock bands recording albums, and DJs mixing dance tracks, but the drastic change we are witnessing is not one primarily related to the material storage or communication of music (e.g., symbolic score versus signal recording or vinyl versus streaming music), but one of methods of reproduction, where the reproduction device is now computational and supporting the ergodynamic potential of sensing, learning, reacting, conversing, evolving in tune with our play and performance practice. New musical works will increasingly become invented systems (consider the parallels in the etymology of system (Greek: *sys-histanai*) and composition (Latin: *com-ponere*) – both signifying the act of placing something together) with potential for search. Instead of composing a piece we can talk about inventing a system that is to be explored in the laboratory we call the musical stage. Musical practice thus folds into its historical past of *ricercare*, of exploring and studying the *inventiones* in order to discover what it means to be a sensing being and part of a human culture in the twenty-first century.

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