ORPHEUS INSTITUTE SERIES

Sound Work: Composition as Critical Technical Practice

Edited by Jonathan Impett

SOUND WORK

COMPOSITION AS CRITICAL TECHNICAL PRACTICE

Edited by Jonathan Impett

Leuven University Press

Editor
Jonathan Impett

Authors
Patricia Alessandrini
Alan F. Blackwell
Nicholas Brown
Marko Ciciliani
Nicolas Collins
Agostino Di Scipio
Daniela Fantechi
Ambrose Field
Karim Haddad
Jonathan Impett
Thor Magnusson
Scott McLaughlin
Lula Romero
David Rosenboom
Ann Warde
Laura Zattra
Julie Zhu

Production manager
Heike Vermeire

Managing editor
Edward Crooks

Series editor
William Brooks

Lay-out
Studio Luc Derycke

Cover design
Lucia D'Errico

Cover image
© Speculum humanae salvationis, GKS 80 folio, the Royal Danish Library, 47 verso.

Typesetting
Friedemann BV

Printing
Wilco, Amersfoort
(The Netherlands)

ISBN 978 94 6270 258 5
eISBN 978 94 6166 366 5
https://doi.org/10.11116/9789461663665

D/2021/1869/38
NUR: 664

This book is published in the Orpheus Institute Series.

Appendix

Online Materials

As further reference to chapters 2 (Rosenboom), 4 (Warde), 5 (Brown), 9 (Romero), 11 (Fantechi), and 14 (Alessandrini and Zhu) in this book, an online repository of multimedia files was created to enhance the reading of the relevant chapters. The material is hosted on the website of the Orpheus Institute, Ghent. These examples, which should be viewed in connection with a reading of the relevant articles, may all be accessed under the URL: https://orpheusinstituut.be/en/sound-work-media-repository.

Table of Contents

Illusions of Form

David Rosenboom
Composer, Valencia, CA

Frameworks

Extraction

Perceiving forms enacts *extraction*. Forms are extracted by perceivers that are themselves extractions marked by closed boundaries within environments (brains, algorithms, or other natural or artificial machinations). Perceiving forms involves extracting differentiable entities from continuously emerging and evolving phenomena that can be stored and referred to as parts of the fine structures of particular *nows*, each with its synthesised past and projected future (Rosenboom 2018b). In cognition, the boundaries of forms are extracted from interactions among exogenous inputs and endogenous syntheses of representations suitable for storage. Histories and perceived time are extracted from resyntheses. Perceiving forms also engenders perceiving *perceiving forms* and perceiving *perceiving perceiving forms*, up to Nth-order, recursive, self-referential frameworks, which also include extracting the forms of perceived perceivers (von Foerster 1984, 2014). Perceiving and cognising forms are active, imaginative, creative processes (Rosenboom 2014a).

In 1967, at the University of Illinois in Urbana-Champaign (UIUC), I was fortunate to be a student in a graduate seminar offered by the great composer and systems theorist Kenneth Gaburo called Studies of 20th Century Theoretic Systems. The fifth lecture in that class was titled "An Incipient Theory of Structure" (K. Gaburo 1976). It was a reading, indeed a performance, in which many repetitions of the word "extraction" were juxtaposed against a large variety of terms, statements, gestures, and vocalisations. At several points in the presentation, a specific juxtaposed statement was delivered, "At this point (or at some previous point or points) some of the previous statements may have collected relationally to form a group or groups. If so, each element in each collection would have been extracted, recursively, from its ordered place. In addition, each collection would have been an extraction, recursively, from all statements given" (ibid., [3]).

At the end of the performance, a series of six inferences were presented, each investigating specific contextual conditions for relations among elements in the long list of juxtapositions to form groups. The final inference presented a proposition: "The five statements, i.e., inferences ONE through SIX, satisfy the minimal conditions for an incipient theory of structure, and are, in themselves, an extracted group from the Universal set of statements which could be made regarding the structure of this composition, as well as those which should be

made regarding the subject: STRUCTURE" (K. Gaburo 1976, [9]). The key here is that, like in Gaburo's *extraction* composition, the relationships forming groups are extracted through perception and cognition, and the processes for achieving this are recursive and emergent. The great second-order cyberneticist Heinz von Foerster remarked, "I am always seeing form as a structure of relations that can also have different structures of relations than their elements" (2014, 166). Inevitably then, perceivers of forms *are* essential, dynamical parts of the forms being perceived, along with all their differentiations, boundary conditions, and environments. The *eye of the beholder* beckons investigation into the nature of illusion.

Propositional music—models

I sometimes joke that, in the evolution of culture, the primary purpose of labels should be to make themselves obsolete as soon as possible. So be it with *experimental music*, which to my mind, simply underscores the artist's license to establish a unique practice with agency and effectiveness outside the definitions of established practice. So be it also with *propositional music* (Rosenboom 2000c), though after writing about it for some decades now, it still maintains its utility as a conceptual screwdriver for exploring *critical practice* among artists and artist-philosophers, who make work "spanning literary and theoretical discourses" and operate "across art in all its forms and across culture in all its locations" (G. Smith 2018, front matter description). With some degree of consistency, Gregory Bateson's methods for elucidating "metapatterns" connecting mind to nature (1980), and thus to thinking, leaning, and creativity among seemingly diverse domains of human thought and creation, have motivated me to take frequent retrospective looks over my highly heterogeneous work trajectories, now spanning more than five decades in music and its allied arts and sciences, to extract "ideas that connect." This has always revealed self-luminous, sometimes surprising, connecting threads tying together ideas about evolution and emergence within the unfolding nature of musical forms, including those on the scales of individual compositional formulations as well as the superimposed histories of multiple genres and methodologies. This periodic retrospective analysis has become a productive critical practice. Pointedly put, these emergent notions in creative music-making commonly begin with *musical propositions*.

Propositional music is a point of view about composing, in which composers might build proposed models of worlds, universes, evolution, brains, consciousness, or whole domains of thought and life, and then proceed to make dynamical musical embodiments of these models, inviting us to experience them in spontaneously emerging sonic forms. Propositional musical thinking is also contextualised now in the genreless climate from which new generations of musical practitioners are drawing surprising and extraordinary inspirations.

Such a practice fuels creative music methodologies by explicating this idea of *propositional music* as an approach to composition, improvisation, analysis,

and adjacent areas of interdisciplinary—or perhaps *anti-disciplinary*—thought. According to this view, composing involves proposing models for whole musical realities, emphasising the dynamic emergence of forms through evolution and transformation. Their correspondence to proposed realities navigates a profound and complex meeting place for creative license and scientific verification. This is an area where music, science, and philosophy can meet in deep theoretical territory, one in which distinctions may collapse into a new kind of *artscience*.

Ideas about morphogenesis, music as a vehicle for exploring human knowledge, the emergence of global properties, the nature of forms, comprehending initially undefined or imponderable forms, and more meet naturally in this terrain. Furthermore, when we combine this with currently emerging *neuromusical propositions* (Rosenboom 1997; Nijholt 2019), we can be catapulted down our hierarchies of presumption towards necessary first principles again and again, questioning our understanding of evolution and categorisation. Following Frederik Stjernfelt's analysis of Charles Sanders Peirce's categories of *dicisigns* as basic elements in semiotic cognition that even reach down the evolutionary ladder to primitive metabolism (Stjernfelt 2014), we might soon discover a *biomusical semiotics* emerging from neuromusical propositions. Out of this can come inspired rethinking about musical creativity and the profoundly integrative powers of auditory perception—enhanced by musical experience—to *hear* relationships among diverse phenomena and find clues to hidden orders of complexity and unsuspected patterns. With *active imaginative listening* we can learn to distinguish the features of complexity and parse subtle relationships among newly differentiable entities (Rosenboom 2014a).

Propositional music often requires collapsing distinctions among a priori formal percepts in order to investigate the nature of self-organising and emergent musical forms. Along with this comes a concept I call *dynamic dimensionality*, which has implications in both the arts and physical sciences. Dynamic dimensionality invokes the idea that the dimensions of description for processes and forms may continuously materialise and dematerialise. This is analogous to actions of parameterising articulators of forms and processes and their comparative complexities and viewing them as dynamic, not fixed.

Other important composing tools in this work have included: musical configuration spaces with contingent and adjacent possibilities, extended musical interface with the human nervous system, and active imaginative listening as performance and as composition.

In earlier writings on *propositional music*, I tried to challenge the cognitive superglue that seems to bind *form* and *cause* in Western minds—that forms always result from the actions of hierarchies of ordering agents. This worldview obscures the role of minds as order-seekers that extract distinctions among things like sculpture and unformed lumps of raw material. "What we refer to as formed, . . . is usually imbued with the intelligence of the forming agent, which we somehow distinguish from the natural order of the unformed lumps" (Rosenboom 2000c, 213).

Propositional music similarly addresses the activity of model building as one of process. It uses the idea of a *model* as a multi-dimensional framework inviting active engagement in exploration and discovery inside a propositional world. This is not about proposing imperialistic prescriptions for viewing models as hypothetically precise representations of worlds presumed to be unquestionably *real*—real as replicable in the sense of scientific positivism. It is more about a process of discovering palpable substance than about verifying representations of the represented.

We situate the word *propositional* here in a way allowing it to address semantic and aesthetic propositions separately from the idea of provability. The artist here *proposes* in the process of making, and through critical feedback, refines and enriches the field of possibilities for interactive extraction that the making process can produce for the *interactee*.[1]

Of course, the word *proposition* has morphed through myriad presumptive definitions and posited interpretations since the ambiguity of Aristotle's *protasis* (Baratin et al. 2014). We take a mediating position between, on the one hand, idealistic, scientific unification and mandated realist testing, and on the other hand, free *what-if*, *as-if* experimentation in arts and aesthetics with no realist mandate. Still, musical propositions result in sensible things. We imbed research in process with emerging knowledge rather than in product and coded knowledge. This is critical to the reflexive nature of propositional music practice.

Such practice embraces continuous questioning and avoids conclusiveness. Semantic mappings and assessments of meaning are, thus, always evolving. In the natural human quest for stability, this is hard to cognise. It reminds us of the shock to logical positivism delivered by Kurt Gödel's discovery of incompleteness, described here by Rebecca Goldstein: "The idea that the criteria for semantic truth could be separated from the criteria for provability was so unthinkable from a positivist point of view that the substance of the theorem [incompleteness of arithmetic] simply could not penetrate" (2005, 160).

Later in this chapter, I provide some descriptions of music and media examples from my own *oeuvre*, which are offered to describe examples of specific methodologies for composition, performance, improvisation, and interdisciplinary thinking in this domain. The intention is to outline some premises with which to approach making propositional music and some fundamental steps to consider in constructing systems for composition and improvisation with these ideas. Perhaps they will also stimulate ideas about ways to work with naturally emerging networked interactivity, how substantive phenomena can spread through complex dissipative and resonant processes, implications of the *infosphere*[2] for propositional art-making, the relationship of propositional music to society, and potential sources of new mythology for our culture.

1 The term interactee was introduced to me by the brilliant installation artist Sara Roberts.
2 The word infosphere refers to the environment of information enfolding human society, analogous to the atmosphere, biosphere, etc., and usually used in reference to electronically reproducible and transmittable information.

Qualities of change—form as cognitive synthesis

Time is manufactured in music. Music is not *of time*, it creates experienced time through a distribution of *nows* in meta-time-space. (See Rosenboom 2018b for further elaboration.) We may view individual cognitive temporalities as labels for the dimensions on which we *move* in multidimensional, parameterised spaces in order to articulate and extract information about the other dimensions. We note that multiple times (nows) are not imbedded in a meta-time-space. Therefore, perceiving multiple times isn't possible, at least within the dimensional structure that perception materialises inside cognition. Perceived time may also be thought of as a means of generating shared experiences among observers sufficiently *close* to each other about information articulated on the remaining dimensional axes.

We regard this as an anisotropic process, because we experience things individually as one *thing* coming *after* another. *Afterness* is contingent upon storage and memory processes that also engender comparisons and judging *beforeness*. Much of this is relatively unconscious, except when disciplines of internal analysis bring it into awareness, and new consciousness arises. Describing apprehensions engenders dimensionality, axes with scales of measure enabling comparisons, and similarity and dissimilarity judgements among phenomena. Dimensionality (number of discrete dimensions) is then variable and emergent, creating virtual spaces in which strongly entangled things are viewed as *close* to each other, and weakly entangled things are considered *far* apart. Tactual and kinaesthetic senses are necessary for judging close and far. Emergent dimensionality, though, may stimulate imagining an isotropic view of the axes of motion, enabling cross- and auto-correlations forward and backward. It may be fanciful, or maybe not so fanciful, then, to envision a *time-eye-in-the-back-of-the-head* (Rosenboom 1984).

A first illusion about forms is that forms are fixed. Rather, forms are emergent. A second illusion is that stability can be achieved by pre-stating the dynamics among components of forms. The multiplicity of adjacent possibilities among component parts prevents that. Theoretical biologist and complex systems researcher Stuart Kauffman has shown again and again that as reasonably complex systems evolve, the branching possibilities for future system states, produced by the recombinant adjacencies of component parts, explode. For biological systems, this expansion is such that only a tiny portion of possible pathways can be explored during the anticipated longevity of the universe (Kauffman 2016). Furthermore, how boundaries are drawn, delineating what the component parts of a system are and separating them from each other, also involves uncertainties. Consequently, the ability to pre-state the branching pathways a system might follow is extremely limited. This is not adequately described by applying commonly understood notions of randomness. It is, rather, more about what is, indeed, *knowable*.

Attempting to pre-state outcomes into imagined futures, the states of which cannot themselves be pre-stated, can lead to self-contradictions and other illusions when applied to the perception of forms. Each present moment, a *now*—multiple *nows* may be possible—contains a synthesised past and imagined

future (Rosenboom 2018b). Energy, matter, time, and space can interact in ways that collapse useful distinctions among them, questioning their designation as primary. In quantum field theory, a particle can be said to carry its own proper time with it inherent in the waveform of its mass. *Wave* and *particle* are only words representing concepts. In critiquing quantum field theory, Sunny Y. Auyang writes, "Recollection is a kind of imagination occurring in the present" (1995, 179). The role of the past in making predictions and identifying forms is a subtle, non-trivial, creative exercise.

The idea of *precedent*—that the way something was observed or judged to be determined in a particular way in the past should determine how it should be judged or determined in the future—suddenly comes under a light of scrutiny. Two musical analogies come to mind: my own *A Summary History of Humans in the World* (2017) and John Cage's *Lecture on the Weather* (1976). In my *A Summary History . . .* , a video plays showing a hand writing a series of nineteen lines of text with a fountain pen on watercolour paper, capsulising (my view of) how human culture got from forming habits to experiencing non-correspondence among models for tools—deterministic engineering—with ever-expanding observation abilities, beginning with this first line,

> habits develop in primitive states engendering sustainable forms
> — to —>,

and ending with these lines,

> a non-correspondence of idealized tools with the behavior of the universe at observable extremes slowly becomes evident
> — to —>
> illusions of "law" and "precedent"—even of "form"—may be at play here
> — to —>
> now what do we do? (Rosenboom 2018c)

Along with this fixed video, a solo performance emerges, in which interactive software captures samples from the history of musical material developed through improvisation, and makes the samples available for the performer to build new musical forms with collaged histories and in-the-moment extensions. (See MF2.1 in the online repository for this book to view the complete work.[3])

Cage's *Lecture . . .* also questions the idea of precedent in this excerpt from its opening, spoken preface: "Of all professions the law is the least concerned with aspiration. It is concerned with precedent, not with discovery, with what was witnessed at one time in one place, and not with vision and intuition. When the

3 Access the online repository at https://orpheusinstituut.be/en/sound-work-media-repository. Further details of the repository can be found in the appendix to this book on p. 355.

law is corrupt, it is corrupt because it concentrates its energy on protecting the rich from the poor. Justice is out of the question. That is why not only aspiration but intelligence (as in the work of Buckminster Fuller) and conscience (as in the thought of Thoreau) are missing in our leadership" (Cage [1976] 1979, 4). Following the full preface, twelve speaker-vocalists deliver texts extracted by means of I Ching chance operations from the writings of Henry David Thoreau, along with film by Luis Frangella and extraordinary field recordings of thunder and other sounds by Maryanne Amacher. I was fortunate to both assist in the production and perform in the world premiere of *Lecture on the Weather* on 15 June 1976 with Cage at York University, Toronto, in collaboration with the Canadian Broadcasting Corporation. The CBC commissioned the work in observance of the Bicentennial of the USA. The experience was transformative and occurred during a particular atmosphere of discussion in international contemporary music communities about composers and political action. French philosopher Michel Foucault's commentary seems relevant here, "We could . . . say that the law works in the imaginary, since the law imagines and can only formulate all the things that could and must not be done by imagining them. It imagines the negative" (2007, 47).

Perceived forms may be more appropriately thought of like verbs, items of action, rather than like nouns, items of distinction that only seem to be fixed. *A chord is a verb, not a noun*. Forms evolve through actions of perception and cognition, internal endogenous data reduction, and the synthesis of *idiologs* (mental images entangled in memory).[4] Form emerges via *holarchical*[5] processes resulting from simultaneous, up-down, evolution on macro- and micro-scales of time, space, energy, matter, dimensions, complexity, and cognitive extension. The marked description of a particular form results from both bottom-up and top-down evolution mediated by feedback. Its concretisation is illusory.

Forms are also extracted from environments. Environments receive the effects and retain the tracings of emerging forms within them. Environments bear witness to entangled forms dynamically evolving. Individual observers obtain information about dynamical systems and evolving forms from fragments of their environments. If particular effects (tracings) of those systems and forms impinge with considerable *redundancy* upon multiple fragments of their environments, then multiple observers will obtain information about these systems and forms that seems coherent and consistent. They will then agree and judge them as stable and relatively fixed.

This brings up an idea about environments as broadcast mediums. Intelligent entities leave imprints on environments, and detection (extraction) of information (regularities/irregularities) from environments by other receiving

4 A more detailed definition of idiolog would be: the form of processes involved in representing the idea of a quality. Usually used in reference to the encoded form of human percepts or sensory-motor or expressive qualities residing in the electro-chemical activity of the brain's neural networks and memory. (See also a discussion of qualia later in this chapter.)

5 In previous publications, I have used the term holarchy when referring to structural entities that result from simultaneous evolution on both macro- and micro-scales and have both bottom-up and top-down dynamical building processes (Rosenboom 1997, 2000c).

entities completes a communication channel. An analogy in quantum physics emphasises the environment as a communication channel through which observers learn about physical systems. In this case, multiple observers obtain information from fragments of the environment. Observers do not extract their data about a system by directly measuring it, rather "a vast majority (if not all) of our information is obtained *indirectly* by probing a small fraction of the environment" (Ollivier, Poulin, and Zurek 2004, 1).

The extraction of presumptions about palpable forms depends on boundary determinations segmenting component parts, amplification of selected parts (combined effects of attentional focus and lateral inhibition of neighbouring phenomena), and redundancy (reinforcing multiple observations judged to be coherent). "An operational notion of objectivity emerges from redundant information as it enables many independent observers to find out the state of the system without disturbing it" (Ollivier, Poulin, and Zurek 2004, 4). "The whole idea of redundancy is that it allows one to be sloppy in decoding the message and still 'get it right'" (4). "Objectivity comes at the price of singling out a preferred observable of *S* [a system] whose eigenstates are redundantly recorded in *E* [an environment]" (3). "Hence, observers probing fractions of the environment can act *as if* the system had a state of its own—an *objective* state" (3). This brings up the idea of "Quantum Darwinism—the idea that the perceived *classical reality* is a consequence of the selective proliferation of information about the system" (3).

Boundary setting is particularly important in decoding musical forms. It is also critical in assessing the fine graining (as in granular synthesis) necessary for measuring degrees of order or entropy in a collection. It enables groupings to be extracted with internal contingencies in space-time among sublevel parts from which local sequences and local times emerge. Perception of form involves perceiving and extracting presumed contingencies. This enables detection of hierarchies, a kind of data reduction enabling the formation of memories, and thus, personal time. Cognition makes form from entanglements among endogenous and exogenous inputs. The result: form emerges in cognition, and forms are *propositions*. Finally, realities are propositions, and emergent mind is built from a tangled network of mini-reality propositions with interacting resonances. We might call this *searching for form*, or *form-finding* among a field of adjacent possible forms.

In his foundational *Laws of Form*, G. Spencer-Brown writes: "a universe comes into being when a space is severed or taken apart. . . . By tracing the way we represent such a severance, . . . [we] can begin to see how the familiar laws of our own experience follow inexorably from the original act of severance. . . . At this stage, the universe cannot be distinguished from how we act upon it, and the world may seem like shifting sand beneath our feet" (Spencer-Brown 1972, v).

Forms are built in cognition from intertwined endogenous and exogenous processes that can even be trans-sensory. They are fundamentally emergent and *holarchical*, arising from observed regularities and complexities extracted among lower-level units that are modulated by downward feedback from

high-level integrative functions. Emergent, holarchical forms also evolve through the feedback processes of *critical contemplation*. These can be second-order reflections on reflection as well as primary feedback from initially reflecting.

Critical analysis of the *role* of observations when misperceived as causal energies making forms appear static is also pertinent here. Wimsatt (2013) proposes the idea of *generative entrenchment*, in which extracting presumed regularities leads to *tendencies* for forms to grow in robustness or persistence and increase in complexity as a result of *factors* guiding those tendencies. This is quite distinct from characterising forms as resulting exclusively from law-like, physically deterministic, causal fabrications. Thus, critical analysis of interdependencies among observation, perception, thought, form, and cause is crucial in propositional music practice.

Buddhist logic views reality and the forms we extract from it as moving and thoughts as static constructions. The legendary Buddhist philosopher Nāgārjuna writes (stanza 48), "If a mind apprehends a form with inherent existence then the mind will apprehend its own nature. Such a mind has arisen from causes and conditions, so it is a dependent arising which lacks inherent existence. In the same way, form does not exist truly, so how can that mind apprehend a form with true existence?" (Komito 1987, 90–91).

In thinking about how we describe systems producing forms, we might invoke these two delineations:

> *Formal*—systems and forms described by simple axiomatic or combinatorial formulations; but, due to incompleteness, in formal descriptions, some questions always remain that are undecidable within the system.
> *Continuous*—systems and forms are much more difficult to describe, because they have dynamic indeterminacies; introducing discrete factors to try to simplify the descriptions nearly always reduces *continuous* models to *formal* models.

Another approach invoked in propositional music could be:

> *Ponderable*—systems and forms that are thinkable, not necessarily in language or signs, rather in musical intellect; this may require viewing ponderability within entirely new cognitive paradigms.

Returning to Nāgārjuna (stanza 45), "Neither does inherently existent form, having the nature of elements, arise from elements nor from itself and not even from others. Therefore, it does not exist, does it?" (Komito 1987, 90).

The mouse and the sequoia—scales and stability

The time and space perspectives of form perceivers mediate what is retained in memory as palpable substance. Forms with greater temporal and spatial extent than a perceiver's—perhaps something like typical lifespan or breadth of time and space scale awareness and cognitive extension—may appear stable: architectural forms, protons, apparent laws of nature, a sequoia tree, musical traditions. Forms with far less temporal and spatial extent than a perceiver's may appear unstable, fleeting, or ephemeral: quantum resonances, individual

nows, neural impulses, unpremeditated thoughts, a mouse, radical musical appearances.

Human-made musical forms exist largely in relatively mid-range or short-range material extensions. One individual sonata is short-range. *Sonata form* is mid-range. Perhaps all individual sonatas can be heard as particular short-range manifestations of the same mid-range composition: *Sonata Form*. That form is historically emergent, shaped and continuously evolved by many contributors. In contrast, *raga* forms in Indian classical music are culturally emergent, not owned by individuals, yet continuously evolved by the multiple generations of an entire culture, who inject their short-range, spontaneous, creative impulses, which influence evolution. So is the case with the *blues* in Afrological music, a continuously realisable form with infinite possibilities for variations in expression. Composer-performer Wadada Leo Smith has described an integration of evolutionary progression and underlying continuity in jazz, from bebop through simpler forms of hard bop and on to emerging complexities in extension bop: ". . . but the basic music form did not essentially change because the use of the song form and the blues continued to hold this new music within" ([W.] L. Smith 1973, [18]).

We could say then that stability is a relative matter. René Thom suggests that "forms that are subjectively identifiable and are represented in our language by a substantive are necessarily structurally stable forms" (1975, 14). We note here the use of *subjectively identifiable* as key. All forms are subject to perturbations within their environments, and here we are making subjective similarity judgements among multiple iterations of an entity or phenomenon to decide whether it can be called *stable*. This, though, is also a matter of the scale of observation. The most stable musical drone we can produce is likely to reveal wild and scattered instabilities when viewed with a temporal microscope. This, in fact, is a primary proposition underlying my composition *Two Lines* (Rosenboom 1989). The most stable, very long drone I could play on a viola was analysed for microscopic pitch variations, inevitably resulting from physiological dynamics in playing. The variations were then greatly amplified and quantised into the pitches of a score, which composer-performer-philosopher Anthony Braxton and I realised many times in duet form (Rosenboom and Braxton 1995).[6] The result seemed to exhibit very complex behaviour, yet somehow sensible as not being random. Later multi-dimensional complexity analysis revealed that, indeed, attractors around certain pitch tendencies could be found in the notes. Stability and irregularity, in this case, proved to be two factors dancing in intricate balance.

If compositional acts involve situating conditions in environments that engender emergent processes in which forms may be extracted, and if these relationships emerge through selective, recursive, networked processes that are continuously evolving, then composition is a kind of *critical creative practice*. Music-making of this kind involves unconstrained, continuously evolving

6 A recording of *Two Lines* can be streamed at https://www.dramonline.org/albums/david-rosenboom-two-lines.

technical practice, and situates spontaneous music-making as a critical synthesis of composition, research, and performance in *propositional music*.

Intelligence?—Recursive reflexivity and critical practice

We speak about musical intelligence, or intelligence in general, as if we know what it is. Instead, we experience that knowing primarily in the negative; that is, we believe we know, or at least can sense, when intelligence is *not* present. Elsewhere, in writing about paradigmatic parallels and complementarities among experiences in experimental musical composition and some of the primary problems in interstellar communication, I have proffered an idea about regarding *intelligence as a field*. This idea emerges from considering the variety of forms in which intelligence could possibly manifest itself, and particularly, the vast range of physical and temporal scales on which it could manifest. In the search for extra-terrestrial intelligence, or closer to home, non-human intelligence, we must confront the possibility that, because the nature of the intelligence we search for *cannot be known in advance*, and if we engage in such a search only with the perspective of our familiar presumptive models, we might miss apprehending what we search for. This is similar to the problem of approaching a new and unfamiliar form of music without the openness of perception and cognition required to find and recognise the intelligence within it. We simply miss it! To make matters worse, the propensity to regard intelligence as *knowable* leads to causal forming—extraction—of what is regarded as *artificial*, technical forms of something that is *unknowable*.

There are many strong correspondences in what is described above with Phillip Agre's critiques of artificial intelligence (1997a, 1997b). To his critiques, I add the observation that it is interesting to wonder about how we can make artificial versions of something that is defined with only vague presumptions. Agre's inoculation for this disease is *critical technical practice*. "A primary goal of critical technical work, then, is to cultivate awareness of the assumptions that lie implicit in inherited technical practices" (Agre 1997a, 105).

A critical technical practice is one that rethinks its own premises as routine work. We know that classical engineering design principles eventually fail when they are relied upon to create forms objectified to be fault-free, entirely predictable, and fully controllable. Alternatively, *emergent engineering* principles, developed through investigating complexity dynamics, value adaptability over perfect stability.[7] Process is more sustainable than product.

Agre continues, "To this end, it is best to start by applying the most fundamental and familiar technical methods to substantively new ends" (Agre 1997a, 105). An example of this in contemporary music is the prepared piano. Centuries of design engineering have gone into developing the piano to a high level of engineering perfection in an attempt to best serve its presumed purposes. In the twentieth century, though, composer-performers found a new purpose for the instrument by inserting objects inside its mechanisms to open

7 See Krakauer (2019) for a detailed description of the objectives of emergent engineering.

new worlds of sounds. Today, ironically and productively, prepared piano techniques have also been codified and perfected to a very high technical level.

With the development of electronic music, the idea of standardisation in musical instruments was challenged. Previously, an instrument was considered a thing to be mastered, worthy of performers spending lifetimes practising with tools to be relied on by composers for predictable results. Electronics, though, is best thought of as a malleable medium, like clay. Literally, composition, performance, and instrument design began to merge and distinctions among them collapsed. A prime example of this is the legendary SalMar Construction of Salvatore Martirano, which was developed through years of critical refinement in composing, performing, and engineering practice until an individual's personal, integrated, musical system became embodied in circuitry (Rosenboom 2020a).

Artificial intelligence purports to be able to enact artificial reasoning, partially to demystify itself. But is this intelligence? Intelligence is recursively self-reflective and can implement reasoning about reasoning. Artificial reasoning has not been shown, in my judgement, to be able to enact *musical intelligence*. For example, the quest to build improvising programs with presumptive models about what music or a musical style is generally fails. However, other approaches, in which the instrument essentially does a kind of research on the actions of an improvising performer, and then makes the results available to the performer to activate at will, are much more useful. In my work, *Predictions, Confirmations and Disconfirmations* (Rosenboom 1992d, 2012b), a software tool that I wrote, called Hierarchical Form Generator (HFG), uses a simple, partial model of perception to parse improvised input into low-level units (like musical phrases), potentially combine them into higher-level groupings using an expectancy measure derived from extracted patterns, and make the results available to the performer to call up and transform within a continuing improvisation. This tool evolved through critical practice and refinement, beginning with an interactive brain-computer music interface (BCMI) project in the 1970s (Rosenboom 1997). It is not, however, a tool that presumes any extant model of musical form, style, or genre. It permits improvisation to begin from a point of spontaneous intention arising. Its richness grows with the improvisor's proprioceptive skills (practical) for interacting with a self-generated musical environment tuned and sharpened (limiting) through practice and feedback. (See MF2.2 for an introductory talk I gave in 1991 after writing HFG, followed by my first performance with it.)

This practice imbeds research inside creation along with documentation and new frameworks for discovery. It includes establishing ever-evolving principles of interactivity and extending notions of tools. A continuous collapsing of distinctions among terminologies also fuels this critical practice. "By the end of the story, though, deeper technical issues about representation and learning will have arisen through reflection on difficulties encountered along the way" (Agre 1997a, 106).

Concurrent complexities—adaptation and dynamics

Recent developments in understanding complex adaptive processes play a significant role in this new musical landscape. Again, music provides an environment for experimentation. Complexity can be *heard*. It is a phenomenon of apprehension. It is tempting to regard apparent complexity as special and likely to have resulted from intelligent initiation. In perception and recognition, *simplicity* and *complexity* are relativistic and complimentary terms. Cultural artefacts may appear to have simple forms in relation to the perceived complexity of nature. A simple, large-scale form, like a building, may result from a complex arrangement of small parts. The apparent simplicity in the outer form of a sand pile may result from an immensely complex fitting together of grains. The temporal structure of music offers many analogies. A musical drone may appear simple. However, when one listens to it actively for a very long time, the subtle variations in its microstructure may reveal limitless complexity. Similar exposure to apparently random noise (like a waterfall) can activate resonant, recognising circuits, such that many recognisable things are heard inside the noise. The stochastic arrangement of a cloud of sounds may have simple direction in its overall movement. It may be a fundamental trait of adaptive organisms to develop correlations between the derived complexity-simplicity of a perception and the projected complexity-simplicity of a source or cause of that which is perceived. Such correspondences may not always be borne out, and this might be critical to keep in mind when interacting with unknown intelligences. The digit sequence of π appears complex, but can be produced by applying simple rules. Similarly, we dream of discovering simple rules, which when applied, could produce a whole universe. Music composition today includes corresponding ideas.

Note that these notions about complexity differ from some common, impressionistic meanings in music, which tend to equate complexity with something that is difficult to hear or described as unpleasant and "hard" to listen to. We know we can hear, or learn to hear, and make fine discriminations between sound aggregates produced with different probability distributions, or different applications of set orderings. We may not be able to discern the generative methods behind them, but we can differentiate among various results. To each result, we ascribe a sound *quality*. As always, effortful practice opens doors. Without that, the fantastic plasticity of our nervous system will dutifully allocate the brain's resources to becoming ever more efficient at tuning in what is common and tuning out what is uncommon. It isn't unreasonable to question whether this kind of adaptation in intelligence has survival value for the species. Becoming more skilled at tuning in what is common may enhance agency in slowly evolving environments, but it may also narrow focus and increase rigidity in apprehending forms.

It is undeniable from disciplined, active imaginative listening experience that we can hear, or learn to hear, emerging global phenomena from the underlying critical masses of interacting parts. They relate to what we can hear in nature. A way musicians might assist in studies involving the sonification of complex data sets is to contribute what we know about ear training and audiolising sonic

objects. It is often ignored in both the visualisation and the sonification fields that, though we can come up with an endless list of clever ways to audiolise or visualise data, perceptual mechanisms are pliant and respond very well to training. Musicians interested in complexity know that the musical ear can be trained to follow high-speed transformations in complex, sonic relationships. Such training, however, may require very large amounts of practice. The results, however, are clearly evident (Rosenboom 1992a).

My recent work with BCMI (Rosenboom and Mullen 2019) and with a variety of interactive instrumentation concepts has led to the idea of what I call *concurrent complexity*. This begins with placing boundaries around two (or more) systems with internally networked parts that exhibit *interaction states* with each other. For example, in interactive music, one system might encompass a brain with proprioceptive agencies, and another might be an instrument with self-organising affordances (Tanaka 2010). Many other examples can be imagined, more simple and more complex. Preliminary, promising work in analysing dimensional complexities found in music and the EEGs (brainwaves) of active imaginative listeners indicate that correspondences may be observed, and indeed, heard. Particular correspondences may then be delimitated as interaction states. For musical performers and instruments, these interaction states can be treated like compositional elements, just like *notes*. Of course, there are many ways to investigate, define, and measure what we call complexity that may have utility in creating interactive composition and performance systems: complexodynamics, multi-scale entropy, mutual information, sophistication, holographic complexity, and more (Aaronson 2011; Antunes and Fortnow 2007; Birbaumer et al. 1996; Carpentier et al. 2019; Costa, Goldberger, and Peng 2005; Cottrell and Montero 2017; Mainzer 2007).

Studying concurrent complexity models for music and interactive systems opens new cognitive spaces for potential artistic practices. Hearing complexity is a part of perceiving, parsing, and apprehending sonic scenes. This involves detecting emerging regularities from complexities among lower-level units, aspects of symmetry, energy, and endurance, and reflexively evaluating the role of observations as possible causal energies in extracting and making forms.

Complexities observed among resonant networks, acoustic, neural, and others, suggest some principles for emergent forms in art and music.

- A multiplicity of interacting parts is needed.
- Recognition of differentiation among parts is required along with the simultaneous understanding of higher-order unity.
- Phase transitions towards complex structures in a system's dynamics occur at critical points in the process.

Predictions and memory become part of the description of any present moment.

- What is perceived as complex is relative to the observer's perceptual reference scale.
- Extension and prolongation lead to nested, local cycles and larger, global hypercycles in an emerging structure.

- *Power law scaling* among components on small local and large-scale global extensions enables the system to exhibit metastability, common functioning over a wide range, while considerable variation and adaptability takes place among behaviours on each individual scale.

Expressive forms can have elastic distinctions among component parts that can also transcend the idea of information always being carried in sequential symbol strings. René Thom asserts that when we speak of *information*, we should really be talking about *form*. He then expounds on the idea of *topological complexity* for forms and also reminds us: "It is sometimes said that all information is a message, that is to say, a finite sequence of letters taken from an alphabet, but this is only one of the possible aspects of information: any geometric form whatsoever can be the carrier of information, and in the set of geometric forms carrying information of the same type the topological complexity of the form is the quantitative scalar measure of the information" (Thom 1975, 144–45).

Representation and notation—mappings and semantics

Interactive systems permeate our culture: interactive devices, interactive software, interactive installations and artistic realisations, new methods for communicating and new ways of engaging in signifying meaning and new semantic forms. Naturally, interface design—not only via technology—has become a vigorous discipline that is widely discussed, talked about, and taught. As the very conception of what music can be has also evolved, especially in the twentieth and twenty-first centuries, concepts about the functions, meaning, and efficacy of various kinds of music notation have also evolved. Notation has moved from its role in Western classical music as a tool to concretise iconic musical objects into a vast open arena of new functions in the processes of creative invention, realisation, transcription, and co-creation. Performance is process. Notation functions best when viewed as an *interface* in performative interactivity.

Pianist-writer Virginia Gaburo (1977) provides a possible starting point for opening things up: "Meaning takes place in the mind. The sensibly perceivable symbol acts as a stimulus to mental activity" (25) and "musical notation need not be merely inscribed musical sound—a translation with attendant losses and gains of possible indicators of meaning: nor need it be inscribed directions for the production of sound—a contract" (33). Make a mark. A representational system then begins—notation. When a formal representational system (absolute mapping) is constructed with structurally stable states enabling emergence of markers for a descriptive language, minds may then create semantic realisations of propositional worlds by attaching meaning to markers in the representation system, and through co-communication and co-evolution, the system then becomes dynamic and continuous again with its attendant natural uncertainties and adjacent contingencies.

Agre's criticism of AI discourse as conflating representations of things with the things that they represent also bears on misunderstandings about the interface nature of music notation. Notation is an invitation for interaction, not a perfectly precise representation. It is more like a window through which the

creators of the notation (composers) and those interacting with the notation (interpreters, performers, interactees) view and co-create with one another.

An illusion of form arises from the persistent confusion of the exogenous with the endogenous, in parallel with Agre's pointing out how confusions in AI result from conflating representations with the represented (Agre 1997b). This persistence seems inherent in human nature, which means discipline is required to transcend it. Galileo describes a 1632 discussion about deception of the senses in which his character, Simplico, complains,

> . . . according to Copernicus one must deny one's own sensations. For, this principle by which we go around with the earth is either intrinsically ours or external to us (namely, a case of being forcibly carried by the earth); if it is the latter, (since we do not feel being forcibly carried) we will have to say that our sense of touch does not feel the very object being touched and does not receive its impression in the sensorium; but if the principle is intrinsic, then we will not be feeling a motion deriving from within us, and we will not be perceiving a propensity perpetually inherent in us. (Galileo 1997, 217)

There is a parallel in Agre's critique of artificial intelligence with the critique here of objectified forms. Agre points to a "strategic vagueness" in AI vocabulary (Agre 1997b, 142). Establishing degrees of vagueness versus precise delineations in structural parameters can be a very useful tool in the intentional forming of interactive strategies for musical engagement. As mentioned earlier, intelligence itself, despite an endless and useful search, has no fully satisfying definition. Intuitively, one can joke that nobody knows what intelligence is, but everybody knows when it isn't there! Despite many attempts to pin it down, in which some practitioners invest astonishing levels of belief, a degree of essential vagueness remains. So, AI could be said to engender artificial vagueness. Then, what is *real* vagueness, and what is *artificial* vagueness? And finally, can artificial vagueness actually be created with discrete state machines (computers)? There is a similar problem with viewing notation as definitive description. Strategic vagueness can also function as a very useful and intentional tool in composition.

Elsewhere, I suggested that the ideal mental state with which a musician may approach a new kind of musical notation might be similar to that of the SETI astronomer looking for extra-terrestrial messages (Rosenboom 1992c). An essential condition of this state would be maintaining the openness of perception and cognition required to find and recognise a form of intelligence, the nature of which cannot be known in advance. This is critical. This newly recognised intelligence would, no doubt, have arisen from a process of evolution that may also not be knowable (Rosenboom 2003). The nearly limitless variety of ways in which intelligence may emerge is not predictable. The ways in which musical intelligence may be imbedded in new notation is limitless. The musician interactee must extract that intelligence to materialise meaningful results.

Notation may also stretch beyond the visual, diagrammatical, pictorial, and verbal. I have used sounds as scores, in which musicians listen to sounds

provided as the signifiers of the score. Here we investigate sounds as signs, sounds as semiotic elements, and sounds as propositions.[8] My work *On Being Invisible* (1976–77), which could be described as an attention-dependent sonic environment in which the environment evolves in response to feedback from detecting auditory event-related potentials (AERPs) in a performer's brain, evokes a kind of semiotic sonification framework that is mutually dependent upon the design of an instrument and the behaviour of the listening performer.[9] Insook Choi (2018) has provided a thorough analysis of these kinds of sonification frameworks, particularly with respect to biological information, listening, and emergent behaviour.

Choi's analysis offers a strong foundation for further development in this domain. She draws on Peirce and reminds me of his illustration using sound and air to dissect elements of consciousness. In *Illustrations of the Logic of Science*, Peirce writes ([1878] 1934, section 395), "In a piece of music there are the separate notes, and there is the air." He describes how a single sound may exist in air for a long time and "might be present to a sense from which everything in the past was as completely absent as the future." He contrasts this with the air, "the performance of which occupies a certain time, during the portions of which only portions of it are played. It consists in an orderliness in the succession of sounds which strike the ear at different times; and to perceive it there must be some continuity of consciousness which makes the events of a lapse of time present to us." Thus, we hear the air via the individual notes, but do not directly here it. By this, he distinguishes things that are present at every instant and those that have beginnings, middles, and ends and present themselves in succession. The two objects thereby distinguished are sensations, of which we are continuously conscious, and thoughts, which are apprehended in successions of sensations. "Thought is a thread of melody running through the succession of our sensations," states Peirce. There is music in this formulation.

Deviant resonances—interfaces and instruments

Instruments, too, can be intentionally designed with a degree of strategic vagueness. They also contain unintentional vagueness, noises, deviant resonances, that can be sources of discovery. Cybernetic uncertainties, emerging from self-organising evolving dynamics, underlie fundamental unpredictability, in that there is no certain succession of states within a known repertoire of states. The differentiables in the system are also subject to fundamental uncertainties, in measurement and interaction dynamics, resonant emergence and interaction, facilitative coincidence and inhibitory coincidence, reinforcement, reduction, cancellation, relaxators, attractors, repellers, feedback interaction, and more.

8 Stjernfelt's extensive exploration of "decisigns beyond language" is very pertinent here (2014).

9 Numerous performances and recordings of *On Being Invisible* have been produced and released over the years. For a good technical description of the work, consult Rosenboom (1997). (See MF2.3 to hear examples.)

In the late 1970s, I drafted "a speculative program for the development of optimal input structures for performance-oriented electronic musical instrumentation" (Rosenboom 1987, 569).[10] It was ambitious. "We can now conceive of the design of instruments which can contain a stored repertoire of complete models of musical reality, are heuristic and adaptive, are capable of doing instantaneous research on an input stream being received to extract salient features with which to differentiate among potential outputs, and of disseminating information around a network of shared resources serving the high-level, real-time needs of an evolved ensemble of human performers" (569). It also completely redefined musicianship technique to extend "far beyond the development of physical and proprioceptive skills in the performance of specific musical vocabularies to include the imbedding and activation of formal structures and entire musical models in an often spontaneous, musical context" (569). Of course, AI was making its way into musical instrument design. "Our idea of performance can then include such forms of interaction as querying associations of attributes, context contingencies, implications, associations, and conceptual dependencies" (580).

What can it mean to *play* such instruments? Maintaining the idea of *play* in instruments imbued with the ability to enter the domain of interactive composing co-creatively with a performer brings up many fascinating questions (Rosenboom 1992b). Where are the various definitions of play imbedded in the interaction states of two complex adaptive networks—naturally intelligent organism (performer-composer) and artificially intelligent system (musical instrument). What are the potential stimulus-response mappings in such instruments that can both extend and support human capabilities?

Kristin Erickson has developed an intriguing merger of algorithmic music and human theatrical performance (Erickson 2018). In her constructions, human beings with opinions, feelings, and urges act within a framework of algorithms, with humans playing roles of logic gates to self-determine their own performance outcomes. To implement this, she developed hardware-software components, in particular, "a browser-based platform for generating, organizing, and distributing performance instructions called Telebrain" (ibid., 337). This creative blending of AI and non-AI with humans and machines is very intriguing.

Imagine the following mappings as a thought exercise, like Gaburo's *extraction* composition. Think of the label *key press* as a *sign*, a *representation*, for the *detection of any discrete event*, a *stimulus* sensible in the structure of an *instrument*: detecting a P300 peak in an event-related potential (ERP) within a brain's EEG, the rising of a seismic wave in the Sun, activation of a strong resonance in a physical object, anything determined to be a *musical event*. A correlative compositional exercise is to answer the question: *What is a musical event?* Any answer is a proposition. Observe that the propositional responses increase in cognitive scope and globality as this list of juxtapositions proceeds.

10 This document was originally drafted during a period of significant collaborations with electronic systems designer Donald Buchla in anticipation of forming a non-profit research organisation. It was later published in *Perspectives of New Music*.

Event		Propositional response
key press	→	pure wave with fixed pitch
key press	→	synthesis patch producing fixed pitch
key press	→	fixed pitch with velocity shaping (piano as example)
key press	→	playback stored audio sample
key press	→	fixed sequence of "notes"
key press	→	fixed deterministic generative algorithm
key press	→	fixed remapping of stimulus-response correspondences for given key
key press	→	fixed remapping of stimulus-response correspondences for entire keyboard (set of sensible stimuli)
key press	→	non-linear deterministic generative algorithm
key press	→	genetic algorithm
key press	→	pseudorandom deterministic generative algorithm
key press	→	probabilistic generative algorithm
key press	→	random (subject to quantum uncertainties) generative algorithm (noise)
key press	→	self-organising system
key press	→	cognitive model of composition/improvisation/ performance
key press	→	cognitive model of music
key press	→	domain of musical thought
key press	→	musical thought itself
key press	→	system of thought
key press	→	idea of thought
key press	→	thought
key press	→	idea of consciousness
key press	→	consciousness
key press	→	idea of sentience
key press	→	sentience
key press	→	self-organising universe

Fanciful or not, we get the point.

Next, we can ask this question: How do we know when and where the key was pressed? A few more questions and observations emerge.

- Detection of any presumably discrete event involves uncertainties at its edges. Deep consideration of this phenomenon may generate very interesting and artistically valuable concepts.
- A piano key is a complex, non-linear mechanical system. A switch is simpler; but then, how do we know precisely when it was closed, and what is interesting about what we can't know?
- Perhaps musical control over the dynamics of boundary detection is essential for *interesting* instruments. The more perfect the stimulus-response mapping is, the *less* interesting the instrument may be.

- Internuncial computation between stimuli and responses offers rich opportunities; but, the more it strives for perfectly reliable predictability, the more it departs from being a valid representation of natural phenomena, in which an inherent unpredictability is always present.
- An enormously potent area for study and creativity now involves this question: *What are the best stimuli to choose for a brain-computer music interface (BCMI) work, and how do we classify them?*

Concepts surrounding the nature of *resonances* are important in this arena of exploration (Rosenboom 2020b). We can imagine the nature of *predictive resonances*, those emerging within the predictabilities of classically engineered systems, and *deviant resonances*, those ballooning out from in between the boundary distinctions of any system or model, interacting in ensemble with each other and creating rich territory to explore for interactive systems that are adaptively engineered (Rosenboom 2019b).

We asked what it means to *play* an algorithm. We might also ask how we got from Simplico's time in 1632 to now, when we play them all the time. Multiple time and space contexts for composition, performance, sound histories, and interactive constructions are all malleable and can be directly modulated and intentionally imbedded inside instruments as part of propositional music thinking—instruments for *music of many nows*.

Thinking composition into being—as situating—as invitation

How do we distinguish sound, perception, hearing, listening, and music? Perhaps, it may be useful to place them in a possible landscape of experience. Here's an attempt. *Sound* is simply *things as they are*. *Auditory perception* is a *bridge between sound and hearing*, a link between the nature of things and experience. *Hearing* is *observing our sensory input* in its totality and *knowing our mechanisms for synthesising memory engrams, our inner representations for sound experiences*. *Listening* is *active practice with the interaction of our own nature and sound as it is*. If we are *making music*, we are *being ourselves with the decisions and actions we make in order to invent inner and outer worlds involving sound*. Practising music-making involves attempting to know and understand these decisions and actions.

How does this work in cognition? Heinz von Foerster presents a sequence of propositional mappings (1984).

COGNITION → computing a reality

He then anticipates an objection: that he is replacing an unknown term, *cognition*, with other unknown terms, *computation* and *reality*, that are "even more opaque than the definiendum" (von Foerster 1984, 294). He then inserts the word *descriptions* as a possible solution.

COGNITION → computing descriptions of a reality

However, to be consistent with the sequential, hierarchical nature of sensory information processing, he adds loopback recursion for descriptions and computations, which makes it *holarchical*.

COGNITION → computing descriptions of descriptions of descriptions . . .

Finally, he proposes "to interpret cognitive processes as never ending recursive processes of computation" (ibid., 296).

COGNITION → computations of computations of computations . . .[11]

To serve the musical context of this writing, I extract the following propositions:

MUSICAL COGNITION → computing musical propositions
and
COMPOSITION-PERFORMANCE → activating musical propositions.

If musical cognitive processes involve thinking, then we are *thinking composition into being*. Propositional music involves thinkable musical processes that also include *rethinking* thinking and *rethinking* rethinking thinking. Things are *things* when we think them into being. Propositional music includes imagining critical frameworks for rethinking musical practice in all its dimensions as regular routine work. There is no end point, no arrival.

To ward off any misinterpretation, it is not my intention to situate music solely within the realm of thinking in its most abstract understanding. The point of inception for any music arriving might lie anywhere, including what appears to be enactment flowing from some ineffable instantiation. Pierre Schaeffer points out that what he terms abstract music may begin with mental conception followed by notated expression (representation) and concrete performance (2012). In counterpoint, he describes alternatively that composition may also begin with experiencing concrete materials and then flow through stages of experimental drafts on to substantive making.

Some reflection on thinking and spontaneous creation may be germane here. For example, in my view, the term *free improvisation* is a misnomer. No matter how spontaneous improvised actions might feel, they are always enacted by an entity that has grown and evolved its self-structure to enable best functioning. In this case, I regard the *performing entity* (human being) as the *composition*, and that as an improviser—and everyone needs to improvise in some aspects of life—one can choose to *compose one's self* by *composing one's practice*. Improvisations will ensue from self-nature and self-conditioning. We can question whether true improvisation is non-algorithmic, emergent from unknowable, unprestatable adjacent possibilities among musical, non-language-based, thoughts.

11 I've slightly rewritten the last two of von Foerster's diagrams. He drew loops in his text that are rendered here as iterations of words: descriptions of . . . , and computations of . . . .

Theoretical physicist David Bohm proposes we think of *thought as movement*, and that the essence of movement may be in the *intention* to move (1994). It may be a vehicle propelling us to grasp and label what we presume to be knowledge; but I add, *thought is not an entity that can know*. As musicians, we sometimes experience what we regard as interruptions in executing complex demanding performances that we blame on thinking. Our musical proprioceptive systems honed by practice should be sufficient, and perhaps necessary, to reach the illusion of perfection. Perhaps, though, it is *thinking with self-consciousness about thinking* that is the source of the interruptions, and thought, perhaps musical thought, still functions in the underlying mechanisms. Back to Bohm, then, "So could we also say, 'can the movement of thought be aware of itself?'" (1994, 123).

To this we add something about ineffable components we recognise and experience in musical inspiration: intuition, feelings, sensations, urges, passions and spontaneous thoughts, intentions and memories. These are self-evident parts of the *nows* of human experiences. Neuroscientist and multidisciplinary aficionado Edgar E. Coons asks, "How can we increase our attentions to the NOWness 'propositions' of experience?" (Coons 2019). The focus of Coons's propositions in this case is on the idea of *qualia* as key to understanding the information imbedded in each experienced *NOW*.

Qualia arise from the endogenous sensibilities extracted from perceived, delineated phenomena. In this chapter, we have referred to entanglements among exogenous inputs and endogenous syntheses as part of the process of extracting forms. Initially, as Coons describes, these remain private, internally felt entities. Coons asserts further that the human impulse to make them somewhat public, to unlock them in expressive representations has yielded "huge benefits" and "makes us so UNIQUE" (2019). Organising and synthesising memories—creative data reduction within hierarchies of contingent, regenerative relations among parsed components—leads to drawing boundaries around and labelling qualia. Materialising palpable exogenous things from perceived endogenous activity in organising experiences brings internalised qualia into a public space and evokes representations: visual, vocal, tactile, sonic, and so on.

The word *quale* refers to something that cannot be treated quantitatively or in a relational manner. This distinguishes it from measurable *sensation*. Qualia can also refer to phenomena "that are not strictly sensorial, such as the impression of knowing or . . . states of the propositional type (such as believing that P or desiring that Q)" (Proust 2014, 877). The domain of experience we label music may enable non-denotatable qualia. Music can function as an internally self-sufficient, non-representational practice. In this sense, it can provide a powerful outlet for externalising and sharing non-labelable, non-languageable qualia.[12]

12 This does not exclude making sounds that are imitative or representational, like bees buzzing, a horse's hooves on cobble stones, fog horns, etc.

We should note that a vigorous dualist debate has raged around the idea of qualia for a long time, the detailing of which is beyond the scope of this chapter. Suffice it to say that for our purposes, we treat qualia as not being reducible to physicalism. It is hard to expunge felt experiences from the debate with purely functionalist approaches. Here again is a deep theoretical territory wherein science and art might meet in fruitful dialogue.

We conclude this section by again asking the question, what is composition? We consider an answer proposition by imagining the possible pathways from endogenous (private) experience to making exogenous (public) experiences. We can posit:

- Imagining *as* composition
- Imagining *as* performance
- Listening *as* composition
- Listening *as* performance
- Composition *as* situating
- Composition *as* inviting
- Composition *as* co-creation
- Form *as* cognitive synthesis
- Composition-performance as situating cognitive synthesis
- . . . . . *as* . . . . . .

Perhaps, as composer-writer-theorist François Bonnet asserts, all that we have created so far is just an invitation for music to reveal itself, and that "What we call music is not music, rather invocations for music to appear. . . . Music is always yet to come" (Bonnet 2020).

* * *

Choose your universe—a few propositional music narratives from recent compositions

We preface this section with suggestions for a few principles in systematic, propositional music practice. Bear in mind that all involve collapsing distinctions among composition, performance, listening, and imagining.

- Consider all interaction to be a process of co-evolution of autonomous agents with each other and their environment, the procedures of which lead to emergent order. These are potentially best implemented with adaptive network structures.

Begin with procedures that return to first principles of composition:

- *Choose your universe*—choose the universal set or domain of compositional attention and the kinds of distinctions that will be made as a result of compositional thought and choice.
- List the potential generative relationships among distinctions in the universal set, that is, how it will be ordered.

- Determine the dimensions of description and scales of measure for parametric values to be used.
- Describe the dynamics and margins of uncertainty associated with making distinctions among entities placed along the parametric scales.
- Design the compositional pragmatics needed to make arrangements among the distinctions in the universal set.
- Consider interaction states as communication and compositional objects, that is, each condition and/or mode of interaction becomes an element for compositional design.
- Consider all interactive processes to have many *nows*, many versions of a present.
- Consider the effects of uncertainties in observables and uncertainties in representations as parts of compositional designs.
- Regard the resulting models as propositional.
- Consider necessary cultural evolution to be as important as technological evolution for this to work with our species.

Could the above actually be considered a *piece*, a *practice*, a way of *working*, a way of *thinking*, a practice with continuous looping back? Yes, this is a continuous, analytically critical practice, fully integrated with spontaneous creativity at its core.

Here are some notes on a few examples from my recent work.

Thinkable ponderable beginnings—apparent origins and transformations

Quartet for the Beginning of a Time *(2019)*

The existence of a beginning is not provable, only thinkable, ponderable. This compositional story may at first appear paradoxically to rely on the idea of a fixed score. To be sure, when the work is viewed inaccurately as being fully represented by marks on paper coming from a lexicon of traditional Western symbols, many things look relatively fixed. Then again, some are not so fixed. A structure lies under the surface, in which a key operator guiding the formation of musical materials is the degree of *diffuseness* versus *clarity* applied to particular musical parameters.

First, here are some of the key sources of inspiration. One is imbedded in the range of meanings and concepts associated with the word *gravity*: force of attraction, warped space, black hole creation, big crunch, seriousness, momentousness, urgency, consequence, precariousness, perilousness, and so on. Of course, this quartet acknowledges Olivier Messiaen's grand masterpiece *Quartet for the End of Time* and the tragic circumstances under which it was composed during World War II. My *Quartet for the Beginning of a Time* also underlines the persistence of hope and the infinite cycles of renewal and beginning in the universe. But it also emerges during a time of extraordinary angst about divisions in our world, uncertainties about the sustainability of human

occupancy on the Earth, and great inequities in distribution of means for agency in human lives.

Though I am not providing arguments credible to professional cosmologists, I possess an informed, hard-to-describe morsel of doubt about the reality of the widely accepted theory of *inflation*, which is thought to follow the Big Bang at the presumed beginning of the universe we believe we are aware of inhabiting. This standard theory requires an infinitely dense, gravitational singularity at the point of the Big Bang, where the known regularities of physics (laws) break down, and even the idea of *knowing* might be undefinable.

In the late 1970s, particularly around the emergence of my series of pieces labelled with an umbrella title, *In the Beginning*—(with various subtitles) (Rosenboom 1978–81, 2012a) (see MF2.4 for recordings), and in the 1984–85 multi-movement work for percussion soloist with instruments interfaced to a live computer-electronics system, *Zones of Influence* (Rosenboom 2014b) (see MF2.5a and MF2.5b, respectively, for audio and video recordings showing a performance of the complete work), and the violin-piano-percussion trio *Champ Vital (Life Field)* (Rosenboom 2012b) (see MF2.6 for a video showing a performance by the California E.A.R. Unit), I explored compositional paradigms with a kind of black-hole/white-hole diametrical model. Various musical structure parameters were thought of as producing differentiable musical shapes or contours that were mapped into a multidimensional space. The axes of the spaces were scaled in two ways: *linear correlations* of shapes with each other and *mutual information* measured among pairs of shapes. Both were explored as being potentially analogous to perceivable and quantifiable similarities and differences among shapes and were used in transformation processes, for example, in gradually transforming one shape into another. The black-hole/white-hole idea appeared when both stochastic and deterministic tools were used to introduce mutations into the shapes and observe *trajectories* in the multidimensional scaling spaces, as newly transformed shapes appeared and were heard. By tuning the tendencies in these processes, shapes might tend to decrease their distance (perceivable difference) from each other until a maximum packing, with maximum order around a fixed tendency, would occur, and differences would disappear into a maximally ordered black hole. Injection of disorder might then cause an exploding emergence from a conceptual white hole into new listening territory. One section of a composition might tend in one direction and another in an opposite direction—into a musical black hole and out of a white hole, for instance. It was possible to create very exciting and dynamical musical territory with these tools in both fixed scores and more open interactive constructions.

Other ideas for this cosmological conundrum have been proposed. Some invoke the notion of prior universes or multi-dimensional stars collapsing onto an event horizon, from which a new universe emerges, something like the one we believe we inhabit (Afshordi, Mann, and Pourhasan 2014). Of course, the word *prior* already presumes particular knowledge of time, which is also being examined and re-examined these days with newly emerging propositional

models. There is also a holographic principle bearing on this, relating physical laws acting on a volume with different laws acting on a boundary surface. This invokes a potential illusion about gravity stemming from what is known as the Maldacena Conjecture (Maldacena 2005).[13]

I chose to use the geometric form of the *catenary* as a tool for organising musical parameters in my *Quartet for the Beginning of a Time*. A catenary is a curve formed by gravity when flexible cords hang freely from pairs of fixed points near a strongly gravitating body. Thus, a symbolic relationship to gravity is maintained. To make the score, sets of catenaries were laid on their sides, rotated horizontally, and placed along a progression of emerging time.

The amounts of space between sides of various catenaries are related to degrees of diffuseness or clarity applied to particular musical parameters: clarity of tonal reference dissolving into atonal fields and re-emerging later, clarity of perceivable pitch evolving into and out of relatively non-pitched sounds, independence versus synchronicity among players, relational simultaneities, temporal densities and speeds, and shifting *complexodynamics* among simple versus compound time forms and melodic shapes. This measured diffuseness both challenges the perception of palpable forms and invites creative endogenous synthesis of forms by active imaginative listeners.

When an initial set of closing catenary curves reaches a dense horizon, ahead of a point where they meet at a common centre of gravitational focus, sounds and motion stop suddenly. A short, loud sound marks the singular point, *ø*, where the set of closing catenaries and a set of reopening catenaries touch. Sounds and motion remain imperceptible briefly until they re-emerge after the opening catenary curves cross over another density horizon. These expanding curves guide musical forms that articulate a new time. An endlessly rising harmonic progression leads into and out of this process, linking back to the complex dynamics of human interactions within an evolving universe. (See plate 2.1.) (See MF2.7 for a video showing excerpts from a preview performance of this work.)

Notation styles vary throughout the course of the work, from relatively fixed, through insertion of unsynchronised parts, to symbols for raw sounds laid out in a *musical configuration space* (Rosenboom 2019c).

13 Also known as AdS/CFT (anti-de Sitter/conformal field theory) correspondence, this is an idea in the arena of theories about quantum gravity and the holographic principle, in which a description of a volume of space can be encoded on a lower-dimensional boundary to the space. For more critique and discussion, see Penrose (2004).

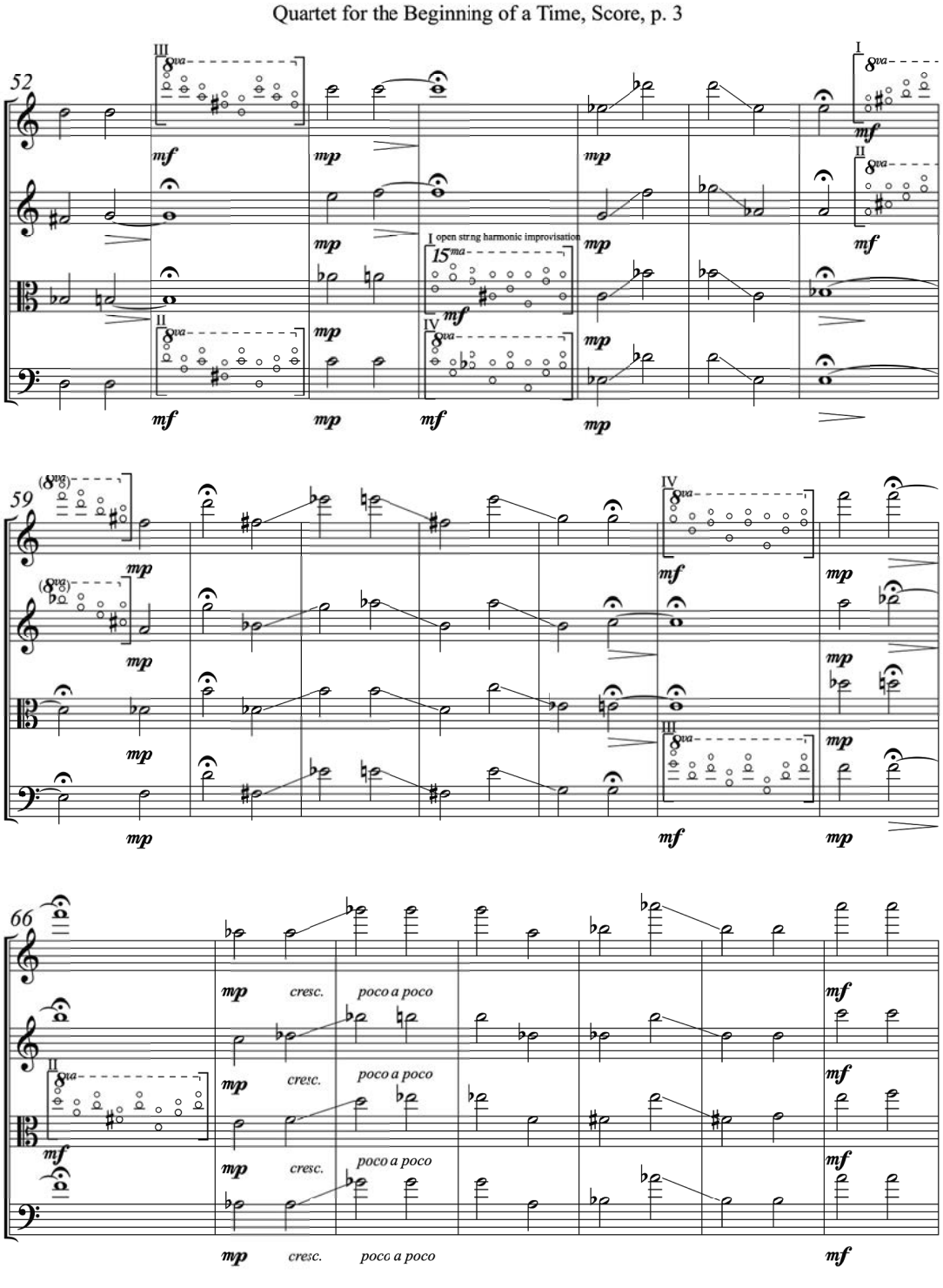

Figure 2.1a

Figure 2.1a–c. Three example pages from the *Quartet for the Beginning of a Time* score, moving from the relatively fixed form of upwardly modulating harmonic spirals being smeared with glissandi, to non-tonal and rhythmic complexities with unsynchronised bracketed parts beginning to appear, and to a configuration space of symbols for raw sound types.

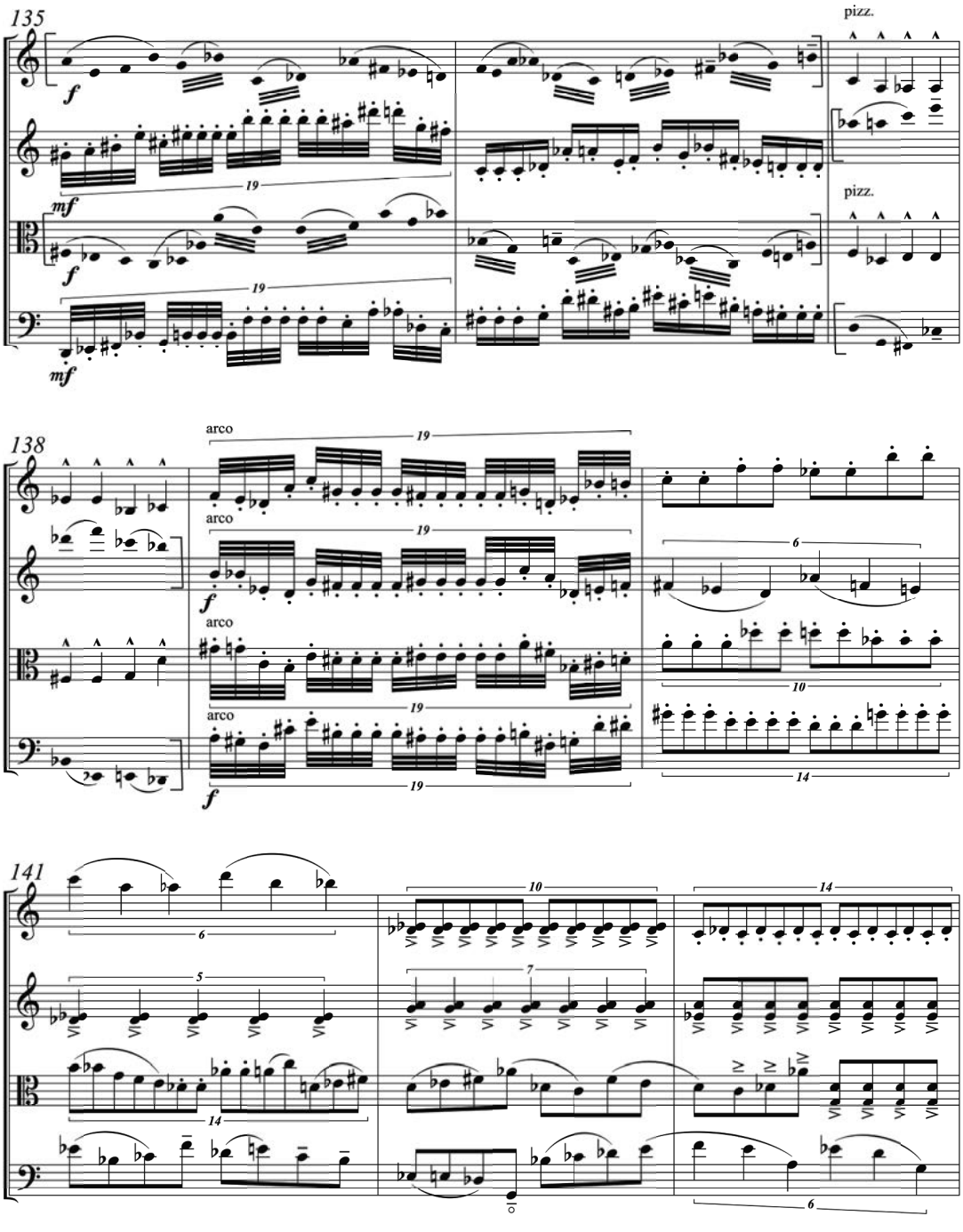

Figure 2.1b

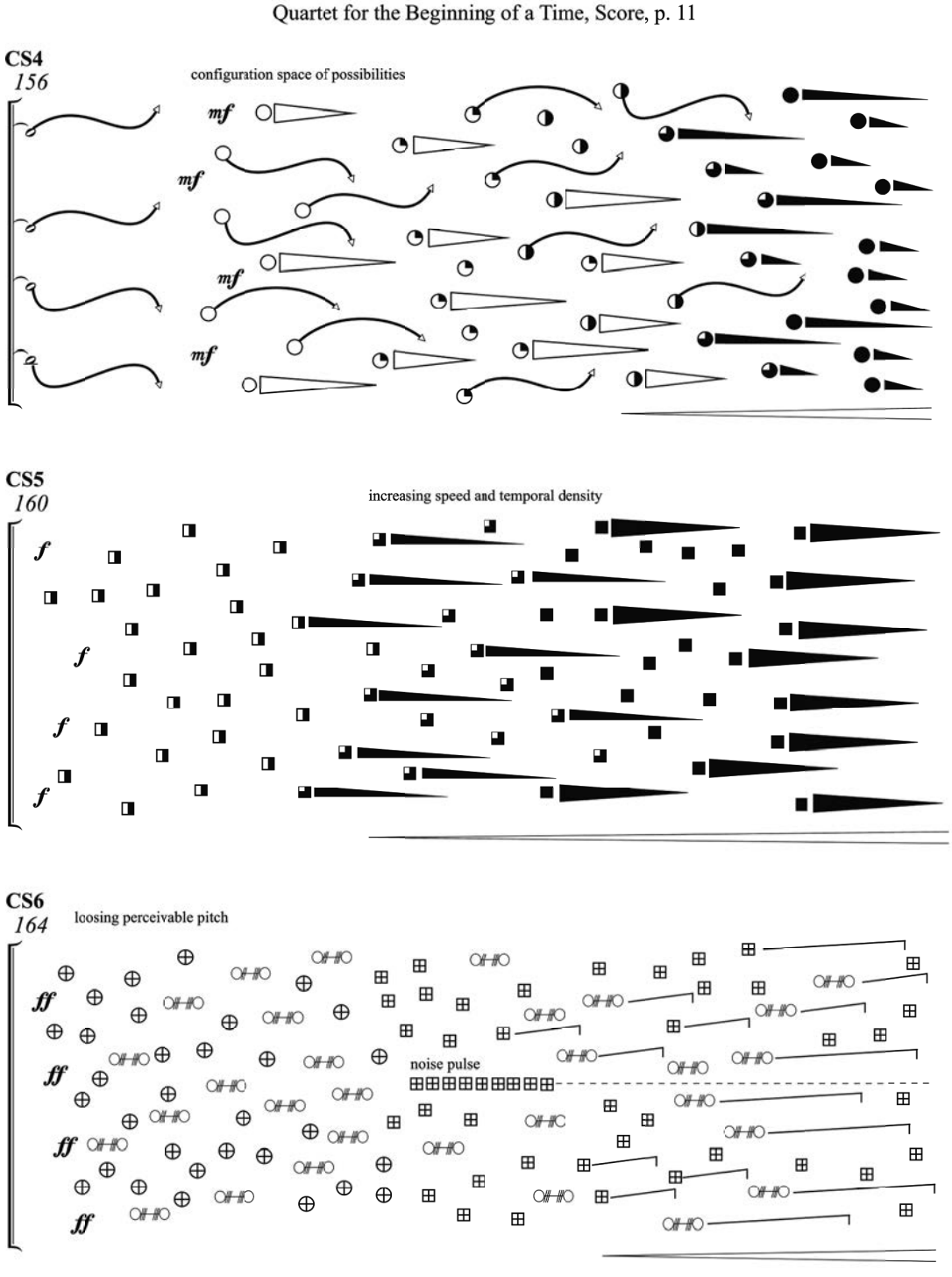

Figure 2.1c

Transient adjacencies—multiple nows

Earth Encomium *with* Nothingness Is Unstable *(2017)*

Non-existence is charged with the potential for existence, a powerful field of potential energy, like a battery, out of which existence can always explode. Non-existence is compressed like a spring, an imbalance waiting for movement to release a version of space defined by this movement. Matter-space is just movement, dramatically transformed by our emotional intellect into a conceptualisation of power and the forms with which we perceive it.

Another way to think about it is that nothingness usually collapses into somethingness—the phenomenal particularities of experience. Kauffman considers how our boundaryless universe could come into existence: "... from the *possible, thus from nothing actual*, a new way to ask: 'Why something rather than nothing?' ... 'Because the universe *could* become, and perhaps because it could become complex'" (Kauffman 2016, 214). Musical particularities, *musics of many nows*, containing fine structures with created pasts and futures, also spring from initially undefined singularities of experience into multiple dimensions of mutual interactivity.

Two compositions are combined here in an integrated form. They are linked together with a system of *harmonic orbits*. These orbits can be heard in ever-descending spirals within spirals that create multi-dimensional harmonic loops. Perhaps mixed feelings of homage, pathos, and inevitability somehow reside inside these descending loops. In *Earth Encomium*, the loops are interpreted in a solo for piano and electronics. The piano's raw acoustic sound is parsed into specific spectral elements, which in turn ring a bank of software-based, complex digital resonators that are also tuned to the same harmonic orbits. In *Nothingness Is Unstable*, delicate natural sounds collected in field recordings in Indonesia and the United States activate the same banks of complex digital resonator circuits. Live acoustic inputs also activate the resonator banks in counterpoint with the field recordings (see plate 2.2). Eventually, more intertwining harmonic orbits can be blended in with instruments that can be computer activated. In my performances this has typically been a Yamaha Disklavier piano playing chords exceeding what can be performed with two human hands.

This music was originally commissioned by Harvestworks Digital Media Arts Center in New York to be presented with the unique Geluso 3D sound distribution object at the 2017 New York Electronic Arts Festival at ISSUE Project Room in Brooklyn. I developed algorithms for sound diffusion with Geluso's object, which consists of a six-speaker array that must be suspended in the centre of an audience space. The speakers work in pairs, pointing in opposite directions along *X*, *Y*, and *Z* axes. Individual sounds can be positioned in the 3D space by precisely controlling the phase relationships of the sounds sent to individual speakers in the array. Audience members can navigate this space with their ears, and the sound perspectives will vary for individuals located in separate parts of the space.

This led me to also create a modified version of the diffusion software that I could use in performances with a 6.2 surround system when the Geluso object was not available. This version produced a quasi-3D experience, which was not the same as with the Geluso object, but did create a unique surround-sound experience that I had not heard before. I have used this approach in many performances since that time. A stereo mix-down version can be heard on my double CD *Deviant Resonances* (Rosenboom 2019b). (See MF2.8 to hear this version.) I dedicated this immersive musical wrapping to our stressed planet.

When possible, a series of close-up images of textures found in the natural world are projected with superimposed text. The penultimate image shows a quotation from Sun Tzu's *The Art of War* (Sun-tzu 2003, 37). (See MF2.9 for a concert video including a performance of *Earth Encomium*.)

Choose Your Universe *with* Natural Scores *(2018)*

This is a newly developing work in which a process of continuous, endless beginnings belies the very idea of style. A genre-less musical world unfolds. This work reflexively recycles itself. It is intended to draw both listeners and performers into a set of complimentary and contrasting sound worlds that challenge the meanings of *natural* and *artificial*.

The instrumentation is based on analogue electronics that are not *played* by hands, only by the acoustic inputs from separately played instruments. So far, I have used a five-string electric violin. The electronics are *played* only by sounds from the violin. My analogue instrumentation does not use oscillators. Rather, libraries of carefully composed waveforms, either originating in field recordings or extracted from prior performances are employed. In the later case, the idea is for the work to be continuously cumulative and evolve by means of playing with its histories. The work can also be realised in multiples, as long as other performers engage in the subtle articulation of the work's intentions. So far, a duet version has been performed successfully with composer-trumpeter-technologist Sarah Belle Reid, using instrumentation compatible with the concept. (See MF2.10 for a video showing excerpts from a performance of this duet version.)

Regarding the conceptual scores for this work, the idea is that they also continuously evolve with their histories. New score components are generated in response to new performance experiences. There is no fixed score, rather a collection of articulated concepts represented in various ways to be used as interactive guides. Here are two examples. The first is a set of word juxtapositions.

Potential framing, something emerging . . .

Intrinsic Spin	< – >	Existential
Harmonic Loops	< – >	Gravity
Multidimensional Oscillator	< – >	Dimensionality of Time
Glide Paths	< – >	Field-less Change
Fields	< – >	Curvature
Resonance Network	< – >	Spontaneous Singularities
Potential Dimensions	< – >	Discontinuities
Dilation	< – >	Continuities
Coherence	< – >	Reductionist
Highlighted Identity	< – >	Infinite Uncertainties
Apparent Discreteness	< – >	Contacts
Quasi-coherence Structures	< – >	Bounded Tension Field
Emergent Dimensionality	< – >	Differentiations
Essential Tension	< – >	Spontaneous Resonance
Marking	< – >	Integration
Holistic	< – >	Salience
Abstractive	< – >	Contiguous
Causal	< – >	Contingencies
Binary	< – >	Exciter Function
Dissipating Resonances	< – >	Decoherence
Polarized Fields	< – >	Particle Horizon
Adjacencies	< – >	Qualitative
Convergent Dimensionality	< – >	Apparent Continuum

Not propositional opposites, sense of compositional pairings . . .
DR 3/29/2020

Figure 2.2.

The second example shown in plates 2.4a–c includes three images selected from a book of drawings I call *Natural Scores.*

Synthesising transformed histories

Battle Hymn of Insurgent Arts *(2018)*

From time to time, an artist's eternal aesthetic investigations into the evolution of humanity in the universe can encounter detours when it is necessary to search for light in times of great divisions. Far from obfuscating the ongoing aesthetic agenda, however, such detours can serve as key informants. The irresistible impulse is to not look away, and to reach for the values of equality, tolerance, and access, while simultaneously trying to avoid causing harm in reaching for the non-absolute of perfection in practice. From time to time, I have engaged in making "musical interventions"—exploring ways to confront forces of division with music. Over time, a collection of pieces with sociopolitical content resulted. They emerged from contemplating the perplexing,

Figure 2.2. A component in continuously evolving score elements for *Choose Your Universe.*

pluri-perspective character of what could be a principled aesthetic regime of political order. How could such a regime arise and be nurtured from within the natural flesh of society and "the ungraspable identity of the people that makes democracy an enigma"? (Plot 2014, 25).

Battle Hymn of Insurgent Arts is written for brass quintet with electric rhythm section and electrified singer delivering a new setting of Mark Twain's little-known rewrite (ca. 1900) of lyrics for the *Battle Hymn of the Republic (Brought Down to Date)* (Twain 1972, 15; Rosenboom 2018a). Twain's pen was, in part, energised by his reaction to politics surrounding the Philippine-American War, "Mine eyes have seen the orgy of the launching of the Sword. . . ." The score for this work uses relatively standard notation, suitable for the pointed message of the work. It encourages the singer to use electronic voice processing of their own design, though, and includes a somewhat transformed *Battle Hymn* chorus and a brief nod to Ray Charles's 1972 album *A Message from the People*. (See MF2.11 for a concert video including a performance of *Battle Hymn of Insurgent Arts*.)

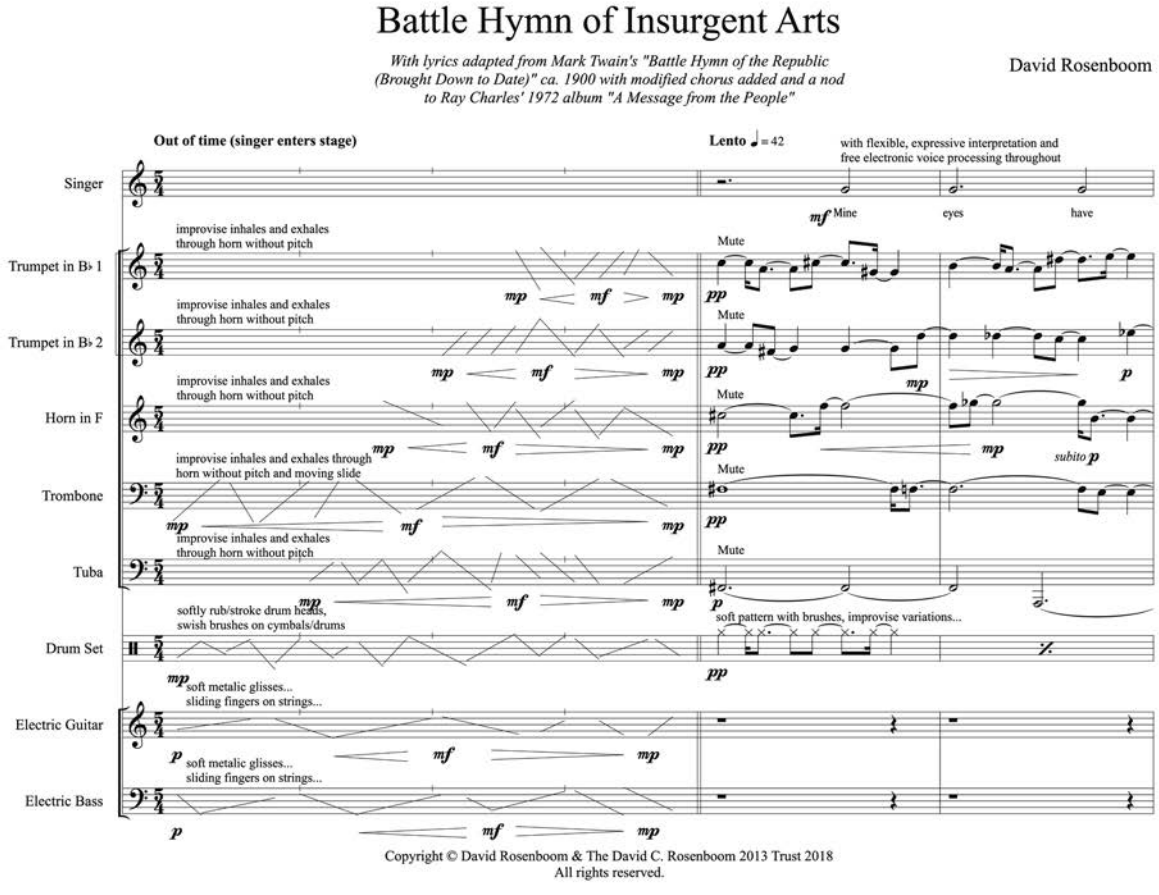

Figure 2.3.

Figure 2.3. First page of the score for *Battle Hymn of Insurgent Arts*.

Listening as performance and composition

The Experiment *from* Hopscotch *(2015)*

In 2015, an extraordinary collaborative opera project, called *Hopscotch—A Mobile Opera for 24 Cars*, was produced in Los Angeles by The Industry opera company. Conceived and directed by Yuval Sharon, several composers and writers created a narrative and music in which the city of Los Angeles became a character, and audiences experienced performances inside limousines driving them from place to place, where site-specific scenes were also performed (Sharon 2015).

Among the compositions that I wrote for this opera is a scene called *The Experiment*, with a libretto written by Erin Young (Rosenboom 2015, 2019b). It engages audience members as participants in a paradigm that involves *listening as performance and composition*.

In this scene, a principal *Hopscotch* character, Jameson, reaches a personal crisis. In his desperate search to understand the meanings of heaven and hell and the liminality of imagination and reality, Jameson pursues the path of a mad scientist probing for illusive clues in the brain and mind, which he believes will answer his dilemmas. Audience members don headbands that transmit their brainwaves to software that extracts features common to particular states of mind mediating their reactions, especially those that might indicate agitation, alert shifts of attention, and a meditative focus. When Jameson sings questions to the audience, features detected in their group brainwaves—averaged together in a kind of hyper-scanning—call up a mix of pre-recorded responses sung or chanted by a soprano in three distinct styles, again representing the presence of agitation, alert shifts of attention, and meditative focus. In this way the states of the group mind hearing the questions—they begin relatively simply and slowly become more challenging—determine the mix of vocal replies heard in a collage of song. The brain responses direct which song styles will become momentarily dominant in an ever-shifting musical landscape. Finally, when audience members' brainwaves exhibit significant and sudden changes all at the same time, a special chord sounds to signal the group mind shifting in synchrony. From this, Jameson derives his answers. Ironically, his blind determination dooms him to declare the conclusions most consistent with the substance of his own imagined reality. (See MF2.12 to hear a recording of *The Experiment*.)

The propositional model of this work calls to mind how exogenous and endogenous creative actions intermingle in creating meaning. As von Foerster writes, "the listener and not the speaker determines the meaning of a sentence" (2014, 81). In retrospect, the specific case of *The Experiment* also brings to mind how Julian Jaynes's prescient investigations of *bicameral theocracies* from decades ago may bear significant relevance to this scenario (Jaynes 1976). The full libretto for *The Experiment* unfolds a narrative in a non-linear fashion that also integrates stories about migrants that are especially relevant to south-western US history.

Two other recent works that enact listening as performance and listening as composition, also employing BCMI (brain-computer music interface), are *Portable Gold and Philosophers' Stones (Deviant Resonances)* and *Ringing Minds* (Rosenboom 2019b; Rosenboom and Mullen 2019). (See MF2.13 for a recording of *Portable Gold and Philosophers' Stones (Deviant Resonances)*; see MF2.14 for a concert video that includes an explanation of how *Ringing Minds* works and a performance.) Works preceding these that involved measuring auditory event-related potentials (AERPs) in performers' brain signals, which could be described as self-organising attention-dependent environments in performance, include *On Being Invisible* (see MF2.3, referenced earlier), and *On Being Invisible II (Hypatia Speaks to Jefferson in a Dream)* (Rosenboom 1997, 2000a, 2000b, 2019a). (For a video showing recorded imagery with electronic sound and voices, as they might appear in a live performance, see MF2.15.) All these works involve Nth-order cybernetic feedback configurations, sometimes also enfolding creative transformations of histories and socio-cultural engagement.

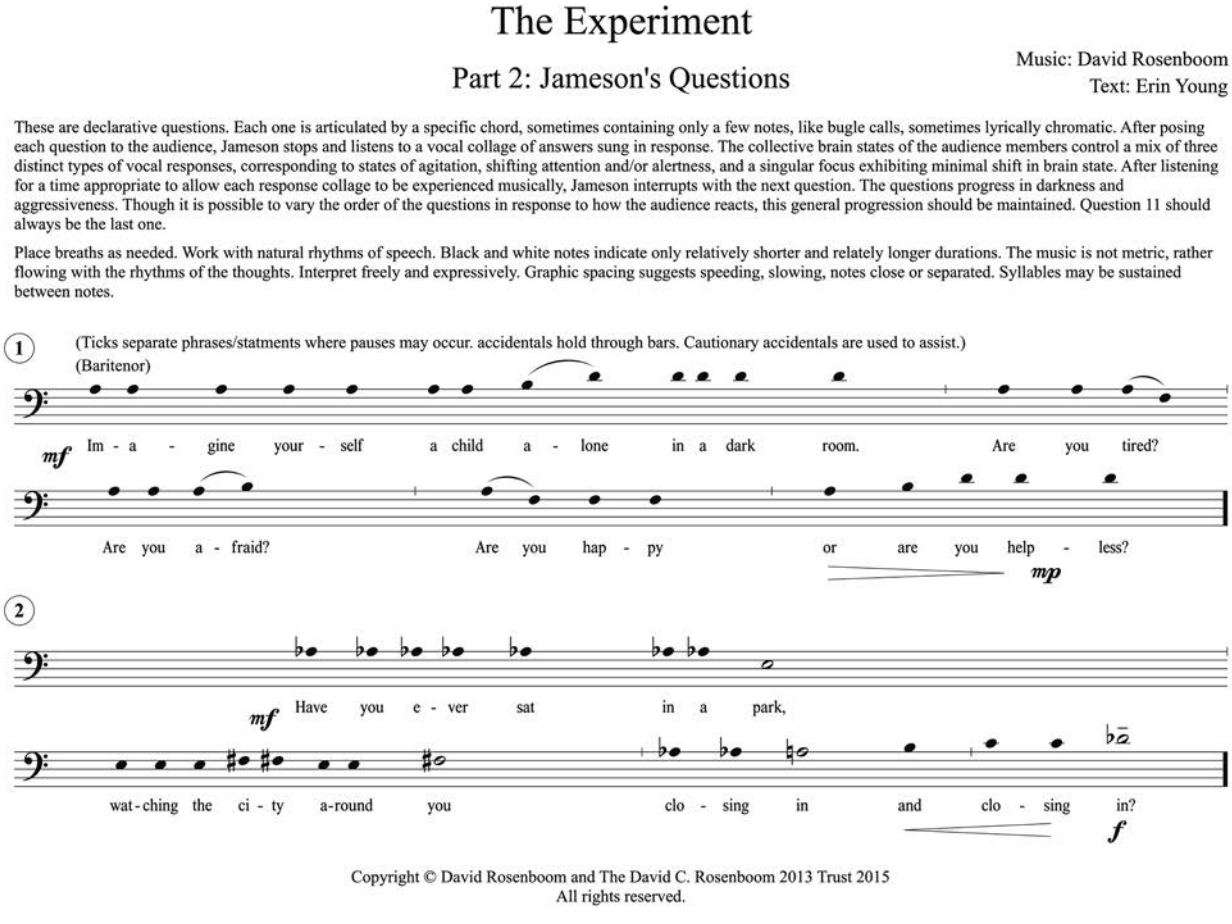

Figure 2.4a–d.

Figure 2.4a–d. Examples of *Jameson's Questions* and the three kinds of vocal responses mixed by audience group-brainwave spectra in *The Experiment*.

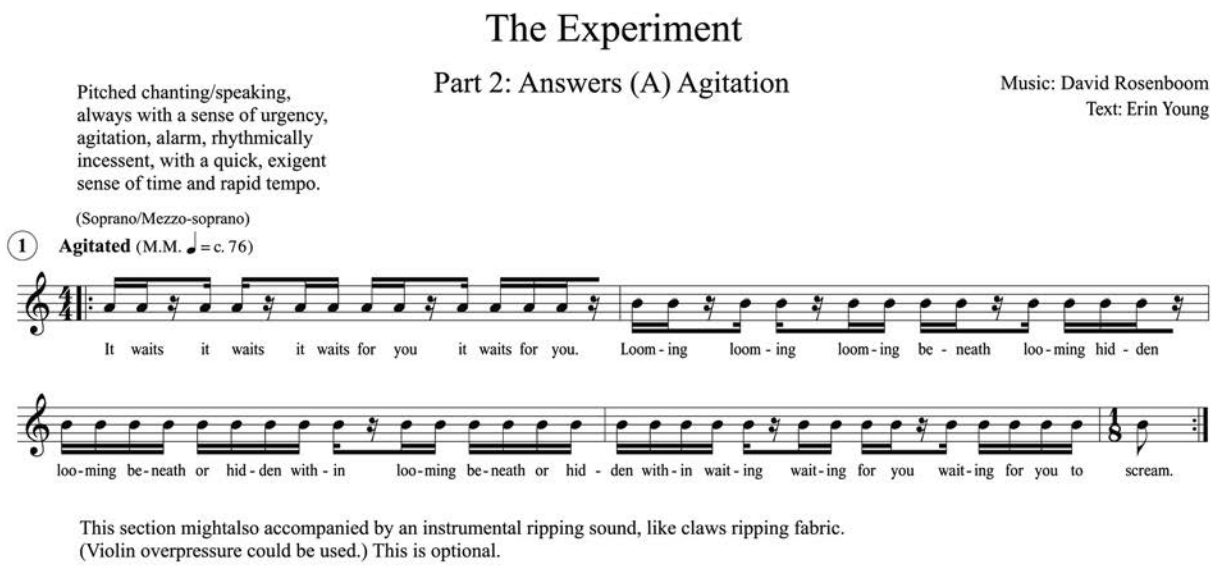

Figure 2.4b.

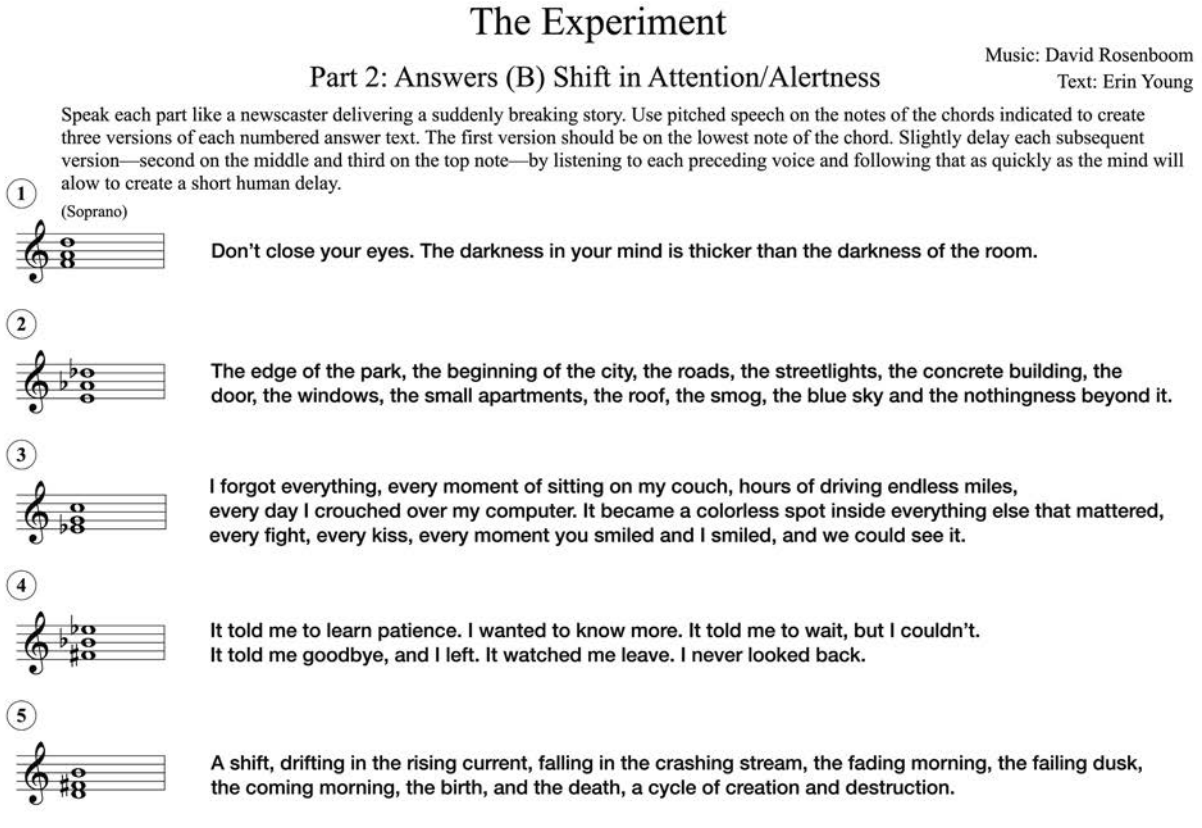

Figure 2.4c.

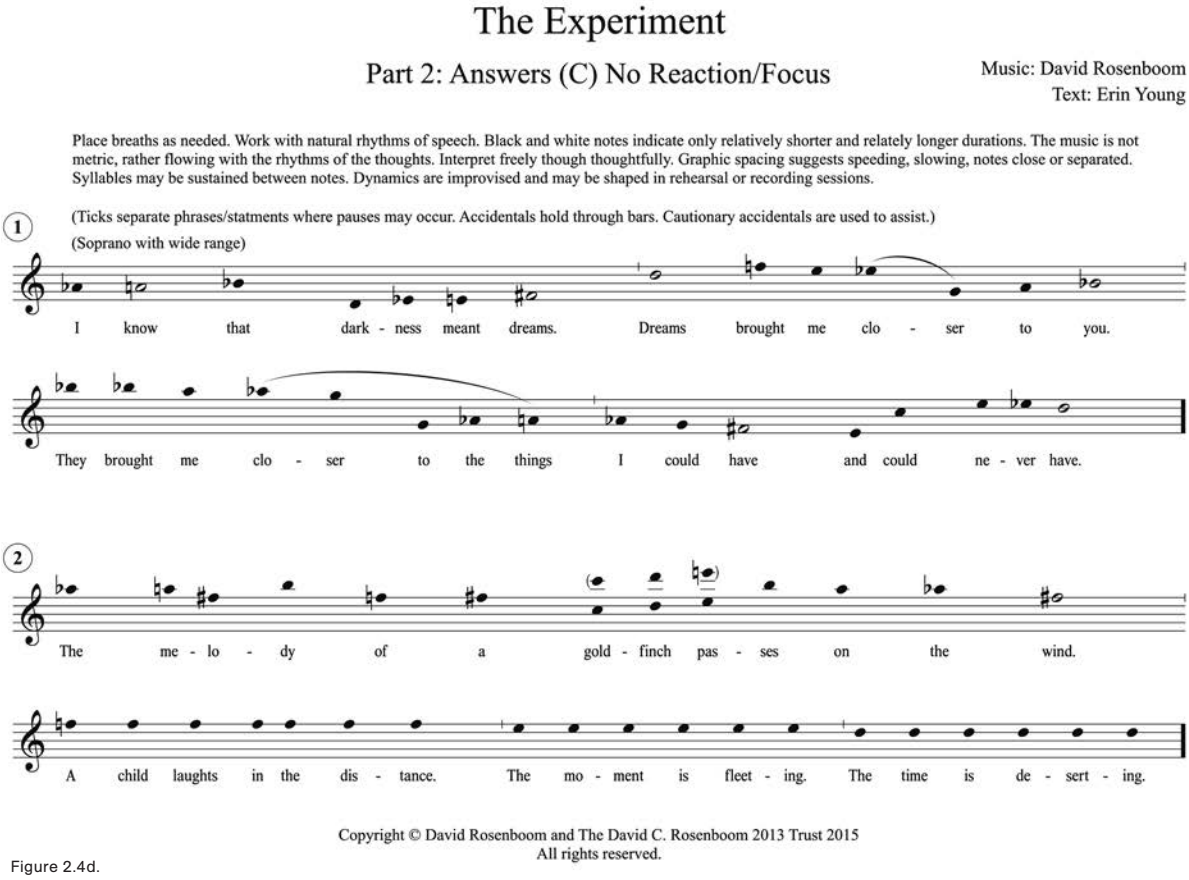

Figure 2.4d.

(See plate 2.5 for an image of the software control surface developed for *The Experiment.*)

Configuration spaces—emergent time

Unverifiable Intuitions (2016)

Some of my scores are constructed as *musical configuration spaces* with contingent and/or adjacent possibilities. The term is loosely related to how it is used in physics as a tool for mapping the possible states of a system. Various ways to navigate these spaces are developed for each configuration.

Unverifiable Intuitions is a solo for creative pianist (Rosenboom 2016). There is no metre. Only relatively longer and shorter notes are shown. Time is emergent. It depends upon the pianist maintaining a still and inquisitive mind. The score is constructed in four continuous sections, each beginning with a musical "Question" followed by a musical "Investigation." The "Questions" are all related to one another. The pianist determines their own progress through

the piece, guided by listening actively and imaginatively to the interacting symmetries and asymmetries emerging from the resonant sound fields within each "Investigation." Music appearing between bold bar lines makes up what are called *musical units*. Each one is characterised by a particular musical cohesiveness and is interpreted as a distinct entity within the structure. *Unverifiable Intuitions* was written for renowned contemporary music pianist Satoko Inoue.

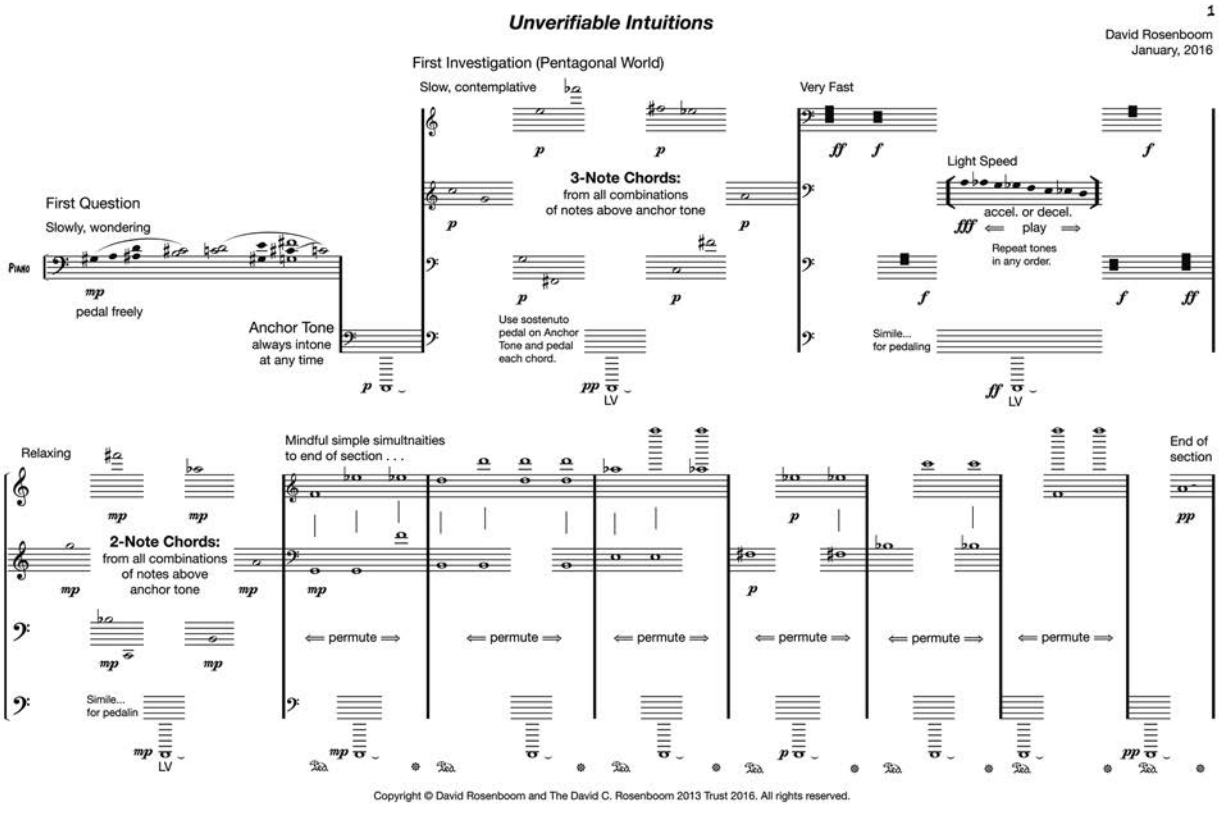

Figure 2.5.

Collective interactive emergence—intelligence as a field

Swarming Intelligence Carnival (2013)

Interactively collaborative and emergent projects have been a focus of periodic investigations throughout my work. This example was a spectacle with dance, video, and music, realised with my major collaborators, legendary dancer-choreographer-painter-film-maker Sardono W. Kusumo, and composer-performers Otto Sidharta and Dwiki Dharmawan. It was the opening event of the 2013 World Culture Forum held in the Lotus Pond of Garuda Wisnu Kancana (GWK) Cultural Park in Depasar, Bali, Indonesia. The venue is a trans-

Figure 2.5. "First Question" and "First Investigation" from the score to *Unverifiable Intuitions*.

formed, limestone quarry, which we transformed again into an instrument for making art. Hundreds of artists were involved in this collective creation.

Elsewhere, I have written about a concept in which the phenomena of intelligence can be thought of as existing in a field (Rosenboom 2003). This project examined the dynamics of swarming behaviour as a form of global intelligence, as a field that can emerge from the unified actions of many members of a large group. In particular, the intention of this convergence of artists was to demonstrate a culture that can emerge when open minds mutually reinforce each other in forward-looking action.

Part of our task was to organise an emerging art form with nearly six hundred participating musicians, dancers, and other artists. A primary conceptual tool we used was to mimic simulations of swarming behaviours (flocks of birds, schools of fish, swarms of insects, and other animal groups) with sets of very simple rules for movement, enabling this very large group to organise its mass movements in, out, and around a very large outdoor venue.

Well in advance, we took measurements of the acoustic properties of the Lotus Pond, by capturing its audio impulse responses, to see how it transforms sound, to capture the rhythms of its echoes and find its resonate frequencies. With this data, I was able to transform soundscapes from field recordings of swarms in nature and sounds from urban human swarms. For the performance we were able to make use of an immense 5.1 surround-sound system installed along the ridges of the venue's high limestone walls. I was then able to play these transformed sounds back into the Lotus Pond, producing doubly transformed soundscape compositions, and mix them to create an immersive live-electronic musical surrounding for the event.

Other collaborating artists used video projection mapping to fit related images onto the rock wall surfaces of the venue. These were also meant to depict dynamic behaviours of swarms in geometric patterns and forms from nature. Finally, hundreds of dancers and musicians moved in swarming choreography, circling continuously, in and out of the Lotus Pond. This was meant to celebrate the beautiful complexity of humanity for all the international cultural emissaries attending this unique World Culture Forum. Artists have ideal minds for intuitively comprehending the nature of complexity. (See plates 2.6a–f.) (See MF2.16 for a video showing selected views from this event.)

* * *

Concluding commentary

Hopefully this tour of ideas reveals some of the places where languages of sciences and arts can meet fruitfully in deep theoretical territory. Our habits of description lie at the centre of this terrain. By being open to collapsing distinctions among formal percepts in a reflexively critical practice, though, we may find the means to cognise and describe a kind of useful *artscience discourse*.

Music now is experiencing a kind of post-instrumental practice—at least in the classical sense—where notation is a thin transparent surface at the interstices

of co-creative representations. We can explore stripping temporal contexts from sounds and examine both the possibilities and the limitations of trying to imbed knowledge in waves. We can usefully perform with histories, both on micro-time scales, with recording, sampling, and delay technologies, and on macro-scales, by unpacking artefacts of musical archaeology in collages of *nows*.

Nothing in this invalidates in any way musical actions that have been created in our synthesised pasts or will be created in our projected futures. In the acts of drawing boundaries, we also create endless beginnings and endless endings. Could they be called *pieces*?

The arts are well primed to work with constant critical awareness that when we construct modes for describing phenomena for the essential purposes of co-communication and collaboration, we also narrow the possible pathways to substantively experiencing those phenomena. By delineating what algorithms in discrete state machines can do, we also confront the possibly non-algorithmic aspects of brains, thinking, intention, and self-identification in thought. *How do we know that knowing is happening?*

Spontaneous music-making in our age of malleable technologies and emergent forms challenges us in particular ways. Agre investigates improvisation in relation to complexity, planning, and environments: "I propose that activity in worlds of realistic complexity is inherently a matter of *improvisation*. By 'inherently' I mean that this is a necessary result, a property of the universe and not simply of a particular species of organism or a particular type of device. In particular, it is a *computational* result, one inherent in the physical realization of complex things" (Agre 1997a, 156). He focuses improvisation on "the continual dependence of action upon its circumstances" (156), in contrast to AI's focus on actions being dependent upon *planning*, which is itself an extremely challenging idea to break down. Attempts to integrate computation with musical improvisation are rife with conundrums. Agre continues, "The Cartesian roots of contemporary computational ideas obstruct the project of reconceiving 'computation' in interactionist terms" (159). Furthermore, in the list of complexity, planning, and environments, it is also necessary to situate *improvisation in social structures*.

So, what are we representing with our mappings of natural phenomena (brains, hands, bodies, ecosystems, asteroseismologies, energy-matter-time-space dynamics . . .) onto the parameters articulating our propositional music systems? What is the size and complexity of the algorithm required for me to always know that my thoughts of raspberry gelato will eternally map to E♭ major, and why do I care?

Here is a potential description for a kind of experimental music activity:

- Integrated mind-body energy enacts supposed empirical measurements of proposed differentiable categorisations to which it attaches meaning for creating shareable propositional models of temporary causation, from which emerge proposed mappings of observables onto propositional worlds of differentiables inside a chosen world of entities and their comparative relationships in scales of measure—a propositional world we choose to call musical—*choose your universe*.

References

Aaronson, Scott. 2011. "The First Law of Complexodynamics." *Shtetl-Optimized* (blog). Accessed 21 April 2021. https://www.scottaaronson.com/blog/?p=762.

Afshordi, Niayesh, Robert B. Mann, and Razieh Pourhasan. 2014. "Black Hole at the Beginning of Time." *Scientific American*, August, 37–43.

Agre, Philip E. 1997a. *Computation and Human Experience*. Cambridge: Cambridge University Press.

———. 1997b. "Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI." In *Social Science, Technical Systems, and Cooperative Work: Beyond the Great Divide*, edited by Geoffrey C. Bowker, Susan Leigh Star, William Turner, and Les Gasser, 131–57. Mahwah, NJ: Erlbaum.

Antunes, Luís, and Lance Fortnow. 2007. "Sophistication Revisted." University of Chicago. Accessed 21 April 2021. https://people.cs.uchicago.edu/~fortnow/papers/soph.pdf.

Auyang, Sunny Y. 1995. *How Is Quantum Field Theory Possible?* New York: Oxford University Press.

Baratin, Marc, Barbara Cassin, Sandra Laugier, Alain de Libera, and Irène Rosier-Catach. 2014. "Proposition / Sentence / Statement / Utterance." In *Dictionary of Untranslatables: A Philosophical Lexicon*, edited by Barbara Cassin, translation edited by Emily Apter, Jacques Lezra, and Michael Wood, 859–74. Princeton, NJ: Princeton University Press. First published 2004 as *Vocabulaire européen des philosophies: Dictionnaire des intraduisibles* (Paris: Seuil; Robert).

Bateson, Gregory. 1980. *Mind and Nature: A Necessary Unity*. Toronto: Bantam Books.

Birbaumer, N., W. Lutzenberger, H. Rau, G. Mayer-Kress, and C. Braun. 1996. "Perception of Music and Dimensional Complexity of Brain Activity." *International Journal of Bifurcation and Chaos* 6 (2): 267–78.

Bohm, David. 1994. *Thought as a System*. London: Routledge.

Bonnet, François J. 2020. *The Music to Come*. Rennes, France: Shelter Press.

Cage, John. (1976) 1979. "Preface to 'Lecture on the Weather.'" In *Empty Words*, 3–5. Middletown, CT: Wesleyan University Press. First published 1976 in *Lecture on the Weather* (New York: Henmar Press).

Carpentier, Sarah M., Andrea R. McCulloch, Tanya M. Brown, Sarah E. M. Faber, Petra Ritter, Zheng Wang, Valorie Salimpoor, Kelly Shen, and Anthony R. McIntosh. 2019. "Complexity Matching: Brain Signals Mirror Environment Information Patterns during Music Listening and Reward." *Journal of Cognitive Neuroscience* 32 (4): 734–45.

Choi, Insook. 2018. "Interactive Sonification Exploring Emergent Behavior Applying Models for Biological Information and Listening." *Frontiers in Neuroscience* 12: 197. https://doi.org/10.3389/fnins.2018.00197.

Coons, Edgar E. 2019. "From RATionalize to ARTionalize." From a talk given at the Institute for Doctoral Studies in the Visual Arts and personal communications.

Costa, Madalena, Ary L. Goldberger, and C.-K. Peng. 2005. "Multiscale Entropy Analysis of Biological Signals." *Physical Review E* 71 (2): 021906.

Cottrell, William, and Miguel Montero. 2018. "Complexity is Simple!" *Journal of High Energy Physics*, article 39. https://doi.org/10.1007/JHEP02(2018)039. Preprint version available at https://arxiv.org/pdf/1710.01175.pdf.

Erickson, Kristin Grace. 2018. "Performing Algorithms." In *The Oxford Handbook of Algorithmic Music*, edited by Roger T. Dean and Alex McLean, 335–42. New York: Oxford University Press.

Foucault, Michel. 2007. *Security, Territory, Population: Lectures at the Collège de France 1977–1978*. Edited by Michel Senellart. Translated by Graham Burchell. New York: Picador.

Gaburo, Kenneth. 1976. *Paper Play: Extraction*. San Diego, CA: Lingua Press.

Gaburo, Virginia. 1977. *Notation (A Lecture to be Performed by Solo Speaker to Attentive Audience)*. La Jolla, CA: Lingua Press.

Galileo Galilei. 1997. *Galileo on the World Systems: A New Abridged Translation and Guide*. Translated and edited by Maurice A. Finocchiaro. Berkeley: University of California Press. First published 1632 as *Dialogo . . . sopra i due massimi sistemi,*

Tolemaico, e Copernicano (*Dialogue on the Two Chief World Systems, Ptolemaic and Copernican*) (Florence: Landini).
Goldstein, Rebecca. 2005. *Incompleteness: The Proof and Paradox of Kurt Gödel*. New York: W. W. Norton.
Jaynes, Julian. 1976. *The Origin of Consciousness in the Breakdown of the Bicameral Mind*. Boston: Houghton Mifflin.
Kauffman, Stuart A. 2016. *Humanity in a Creative Universe*. New York: Oxford University Press.
Komito, David Ross. 1987. *Nāgārjuna's "Seventy Stanzas": A Buddhist Psychology of Empiness*. Text translated by Tenzin Dorjee and David Ross Komito. Ithaca, NY: Snow Lion Publications. Includes a translation of the Śūnyatāsaptati of Nāgārjuna (c.150–c.250 CE).
Krakauer, David C. 2019. "Emergent Engineering: Reframing the Grand Challenge for the 21st Century." In *Worlds Hidden in Plain Sight: The Evolving Idea of Complexity at the Santa Fe Institute 1984–2019*, edited by David C. Krakauer, 349–55. Santa Fe, NM: Santa Fe Institute Press.
Mainzer, Klaus. 2007. *Thinking in Complexity: The Computational Dynamics of Matter, Mind, and Mankind*. 5th ed. Berlin: Springer.
Maldacena, Juan. 2005. "The Illusion of Gravity." *Scientific American*, November, 57–63. Accessed 22 April 2021. https://inpp.ohio.edu/~inpp/nuclear_lunch/archive/2009/maldacena_illusion_of_gravity_qpdf.pdf.
Nijholt, Anton, ed. 2019. *Brain Art: Brain-Computer Interfaces for Artistic Expression*. Cham, Switzerland: Springer.
Ollivier, Harold, David Poulin, and Wojciech H. Zurek. 2004. "Objective Properties from Subjective Quantum States: Environment as a Witness." *Physical Review Letters* 93 (22): 220401. https://doi.org/10.1103/PhysRevLett.93.220401.
Peirce, Charles S. (1878) 1934. "How to Make Our Ideas Clear." In *Collected Papers of Charles Sanders Peirce. Volume V: Pragmatism and Pragmaticism*, edited by Charles Hartshorne and Paul Weiss, section 388–410. Cambridge, MA: The Belknap Press of Harvard University Press. First published 1878 as the second of Peirce's "Illustrations of the Logic of Science" (*Popular Science Monthly* 12: 286–302).
Penrose, Roger. 2004. *The Road to Reality: A Complete Guide to the Laws of the Universe*. London: Jonathan Cape.
Plot, Martín. 2014. *The Aesthetico-Political: The Question of Democracy in Merleau-Ponty, Arendt, and Rancière*. New York: Bloomsbury Academic.
Proust, Joëlle. 2014. "Quale, Qualia." In *Dictionary of Untranslatables: A Philosophical Lexicon*, edited by Barbara Cassin, translation edited by Emily Apter, Jacques Lezra, and Michael Wood, 877–78. Princeton, NJ: Princeton University Press. First published 2004 as *Vocabulaire européen des philosophies: Dictionnaire des intraduisibles* (Paris: Seuil; Robert).
Rosenboom, David. 1978–81. *In the Beginning*—(scores for a series of nine works). Valencia, CA: David Rosenboom Publishing. Available to download from https://davidrosenboom.com/compositions-2.
———. 1984. "On Being Invisible, I. The Qualities of Change, II. On Being Invisible, III. Steps towards Transitional Topologies of Musical Form." *Musicworks* 28: 10–13.
———. 1987. "A Program for the Development of Performance-Oriented Electronic Instrumentation in the Coming Decades: 'What You Conceive Is What You Get.'" *Perspectives of New Music* 25 (1–2): 569–83.
———. 1989. *Two Lines*. Valencia, CA: David Rosenboom Publishing; Hanover, NH: Frog Peak Music. Available to download from https://davidrosenboom.com/compositions-19811990.
———. 1992a. "Complex Adaptive Systems in Music." Unpublished talk given at the 124th Meeting of the Acoustical Society of America. Abstract published in *Journal of the Acoustical Society of America* 92 (4): 2403.
———. 1992b. "Interactive Music with Intelligent Instruments—A New, Propositional Music?" In *New Music across America*, edited by Iris Brooks, 66–70. Valencia, CA: California Institute of the Arts; High Performance Books.
———. 1992c. "Music Notation and the Search for Extra-Terrestrial Intelligence." In *Frog Peak Anthology*, edited by Carter Scholz, 103–6. Hanover, NH: Frog Peak

Music. Republished in *Leonardo* 26, no. 4 (1993): 273–74.
———. 1992d. "Parsing Real-Time Musical Inputs and Spontaneously Generating Musical Forms: Hierarchical Form Generator (HFG)." In *Proceedings of the 1992 International Computer Music Conference*, 186–89. San Francisco: International Computer Music Association (ICMA).
———. 1997. *Extended Musical Interface with the Human Nervous System: Assessment and Prospectus*. Rev ed. Leonardo Monograph 1. San Francisco, CA: ISAST. First ed. published 1990. Available to download from https://davidrosenboom.com/writings.
———. 2000a. *Invisible Gold: Classics of Live Electronic Music Involving Extended Musical Interface with the Human Nervous System*. Pogus Productions, P21022, compact disc.
———. 2000b. "Music from—On Being Invisible II (Hypatia Speaks to Jefferson in a Dream)." On *Transmigration Music*. CDCM Computer Music Series 30. Centaur Records, CRC 2490, compact disc.
———. 2000c. "Propositional Music: On Emergent Properties in Morphogenesis and the Evolution of Music; Essays, Propositions, Commentaries, Imponderable Forms and Compositional Methods." In *Arcana: Musicians on Music*, edited by John Zorn, 203–32. New York: Granary Books / Hips Road.
———. 2003. *Collapsing Distinctions: Interacting within Fields of Intelligence on Interstellar Scales and Parallel Musical Models*. Valencia, CA: David Rosenboom Publishing. Available to download from https://davidrosenboom.com/writings.
———. 2012a. *In the Beginning (1978–1981)*. New World Records, 80735-2, 2 compact discs.
———. 2012b. *Life Field*. Tzadik, TZ8091, compact disc.
———. 2014a. "Active Imaginative Listening—A Neuromusical Critique." *Frontiers in Neuroscience* 8. https://doi.org/10.3389/fnins.2014.00251.
———. 2014b. *Zones of Influence*. Pogus Productions, P21074-2, 2 compact discs.
———. 2015. *The Experiment*. Valencia, CA: David Rosenboom Publishing. Available to download from https://davidrosenboom.com/compositions.
———. 2016. *Unverifiable Intuitions*. Valencia, CA: David Rosenboom Publishing. Available to download from https://davidrosenboom.com/compositions.
———. 2018a. *Battle Hymn of Insurgent Arts*. Valencia, CA: David Rosenboom Publishing. Available to download from https://davidrosenboom.com/compositions.
———. 2018b. "Propositional Music of Many Nows." In *Tradition and Synthesis: Multiple Modernities for Composer-Performers*, edited by Dusan Bogdanovic and Xavier Bouvier, 121–42. Lévis, Québec: Doberman-Yppan.
———. 2018c. *A Summary History of Humans in the World*. Vimeo video, 17:08, posted by "David Rosenboom," 24 April 2021. Accessed 28 April 2021. https://vimeo.com/541144268. YouTube video, 17:08, posted by "David Rosenboom," 25 April 2021. Accessed 28 April 2021. https://youtu.be/dDSH9meVfoE.
———. 2019a. *Brainwave Music*. Black Truffle Records, BT048, 2 LPs.
———. 2019b. *Deviant Resonances: Live Electronic Music with Instruments, Voices and Brains*. Ravello Records, RR8009, 2 compact discs.
———. 2019c. *Quartet for the Beginning of a Time*. Valencia, CA: David Rosenboom Publishing. Available to download from https://davidrosenboom.com/compositions.
———. 2020a. "Exploring Compositional Choice in the SalMar Construction and Related Early Works by Salvatore Martirano." In *Between the Tracks: Musicians on Selected Electronic Music*, edited by Miller Puckette and Kerry L. Hagan, 113–51. Cambridge, MA: MIT Press.
———. 2020b. "Resonance Morphogenesis." In *Spectres II: Resonances*, edited by François J. Bonnet and Bartolomé Sanson, 65–72. Rennes, France: Shelter Press.
Rosenboom, David, and Anthony Braxton. 1995. *David Rosenboom / Anthony Braxton: Two Lines*. Lovely Music, LCD 3071, compact disc.
Rosenboom, David, and Tim Mullen. 2019. "More Than One—Artistic Explorations with Muilti-agent BCIs." In Nijholt 2019, 117–44.
Schaeffer, Pierre. 2012. *In Search of a Concrete*

Music. Translated by Christine North and John Dack. Berkeley: University of California Press. First published 1952 as *A la recherche d'une musique concrète* (Paris: Seuil).

Sharon, Yuval (concept and direction). 2015. *Hopscotch—A Mobile Opera for 24 Cars*. Performed by The Industry. Accessed 23 April 2021. http://hopscotchopera.com.

Smith, George. 2018. *The Artist-Philosopher and New Philosophy*. New York: Routledge.

Smith, [Wadada] Leo. 1973. *notes (8 pieces) source a new world music: creative music*. N.p.: self-published.

Spencer-Brown, G. 1972. *Laws of Form*. New York: Julian Press.

Stjernfelt, Frederik. 2014. *Natural Propositions: The Actuality of Peirce's Doctrine of Dicisigns*. Boston, MA: Docent Press.

Sun-tzu. 2003. *The Art of War*. Edited and translated by John Minford. New York: Penguin Books. Text written c. fifth century BCE.

Tanaka, Atau. 2010. "Mapping Out Instruments, Affordances, and Mobiles." In *Proceedings of the 2010 Conference on New Interfaces for Musical Expression (NIME 2010)*, 88–93. Sydney, Australia: NIME.

Thom, René. 1975. *Structural Stability and Morphogenesis: An Outline of a General Theory of Models*. Translated by David Fowler. Reading, MA: W. A. Benjamin. First published 1972 as *Stabilité structurelle et morphogénèse: Essai d'une théorie générale des modèles* (Reading, MA: W. A. Benjamin).

Twain, Mark. 1972. *A Pen Warmed-Up in Hell: Mark Twain in Protest*. Edited by Frederick Anderson. New York: Harper & Row.

von Foerster, Heinz. 1984. *Observing Systems*. 2nd ed. Seaside, CA: Intersystems Publications.

———. 2014. *The Beginning of Heaven and Earth Has No Name: Seven Days with Second-Order Cybernetics*. Edited by Albert Müller and Karl H. Müller. Translated by Elinor Rooks and Michael Kasenbacher. New York: Fordham University Press. First published 1997 as *Der Anfang von Himmel und Erde hat keinen Namen: Eine Selbsterschaffung in 7 Tagen* (Vienna: Döcker).

Wimsatt, W. C. 2013. "The Role of Generative Entrenchment and Robustness in the Evolution of Complexity." In *Complexity and the Arrow of Time*, edited by Charles H. Lineweaver, Paul C. W. Davies, and Michael Ruse, 308–31. Cambridge: Cambridge University Press.

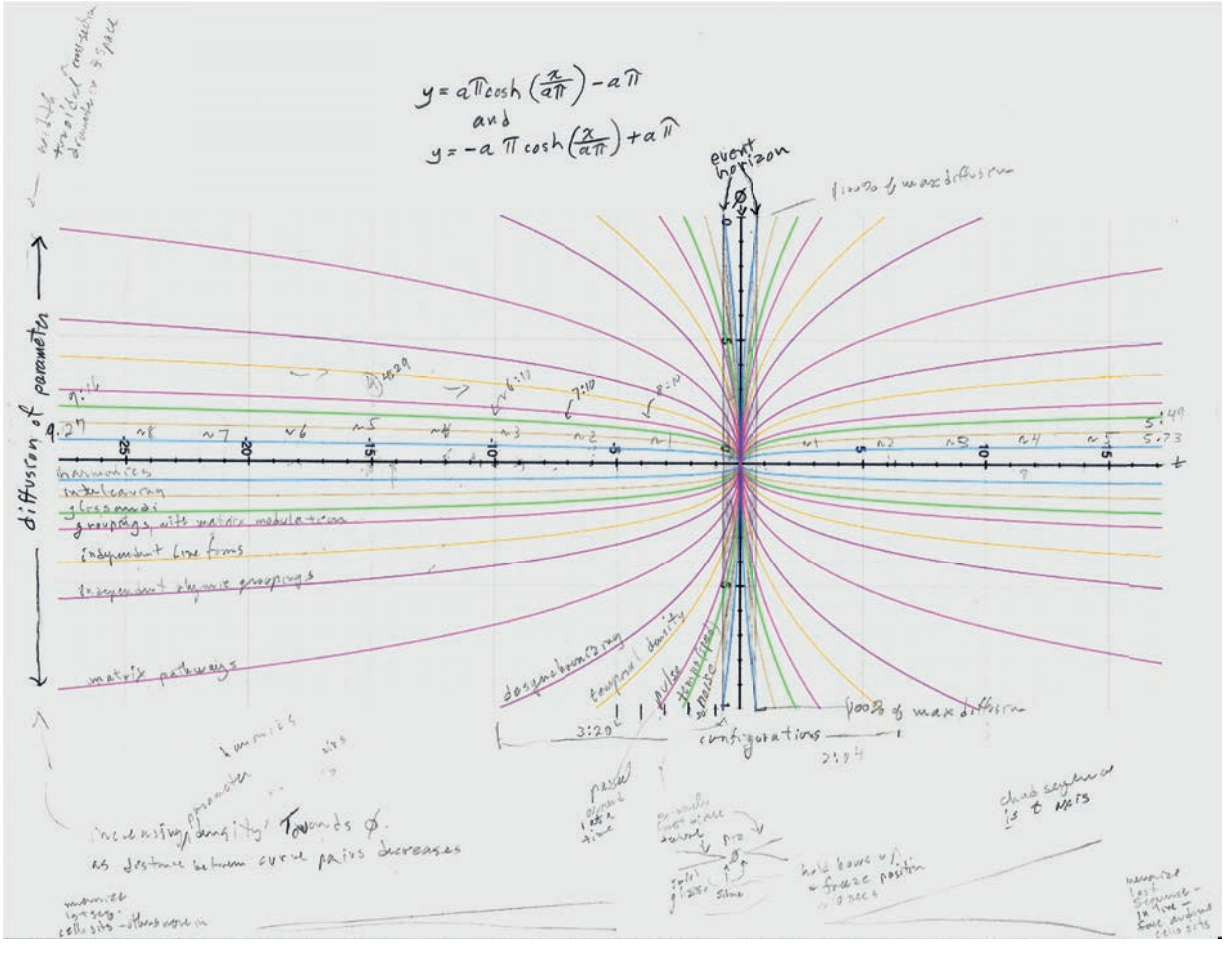

Plate 2.1.

137

Plate 2.1. Page from composer's sketches showing how rotated catenaries outline the diffuseness of compositional parameters, event horizons marked by silence and frozen motion, and the Ø point where one time ends and another begins.

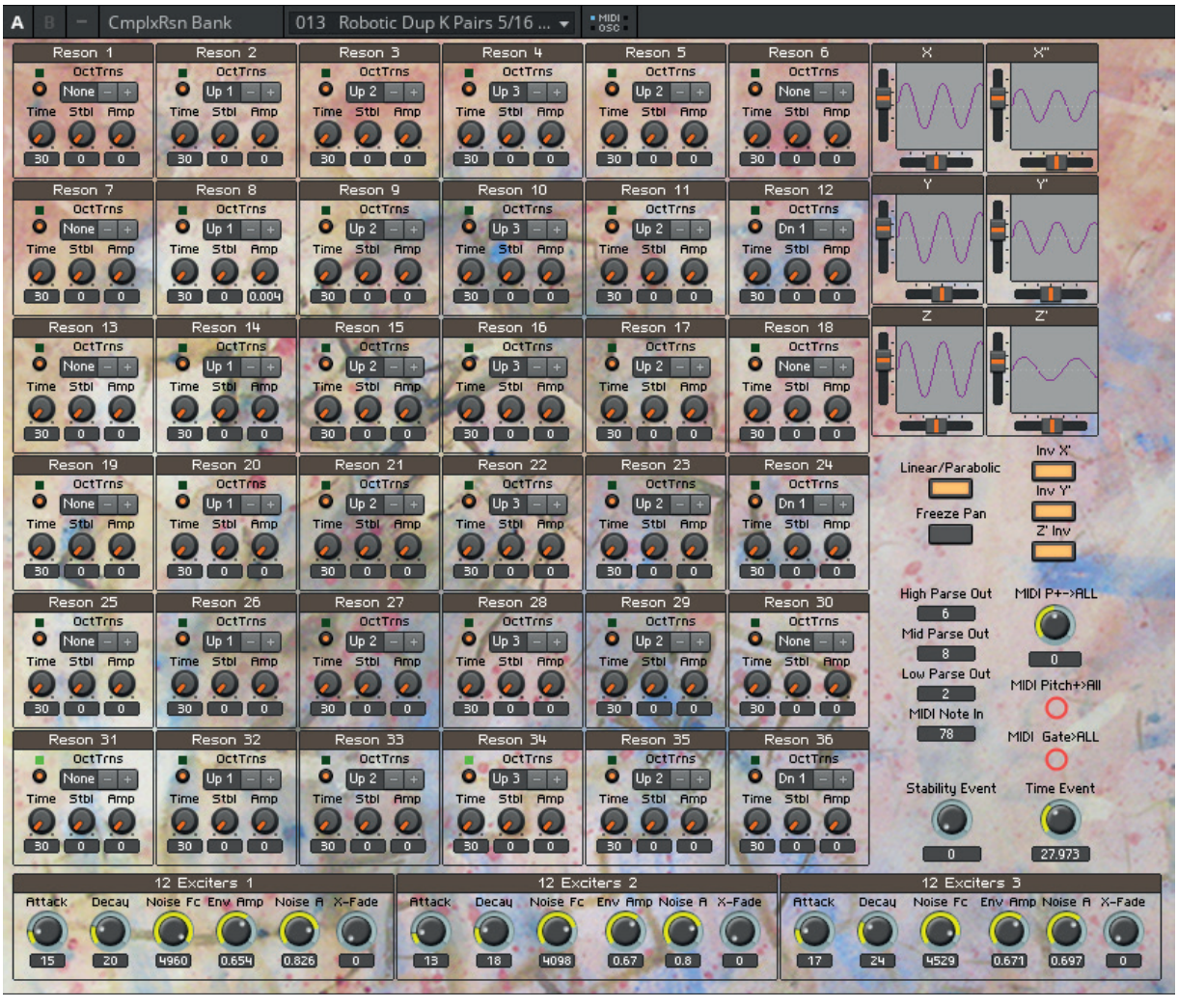

Plate 2.2.

Plate 2.2. Control surface for the complex resonator bank used in *Earth Encomium* and *Nothingness is Unstable*, programmed with Reaktor software.

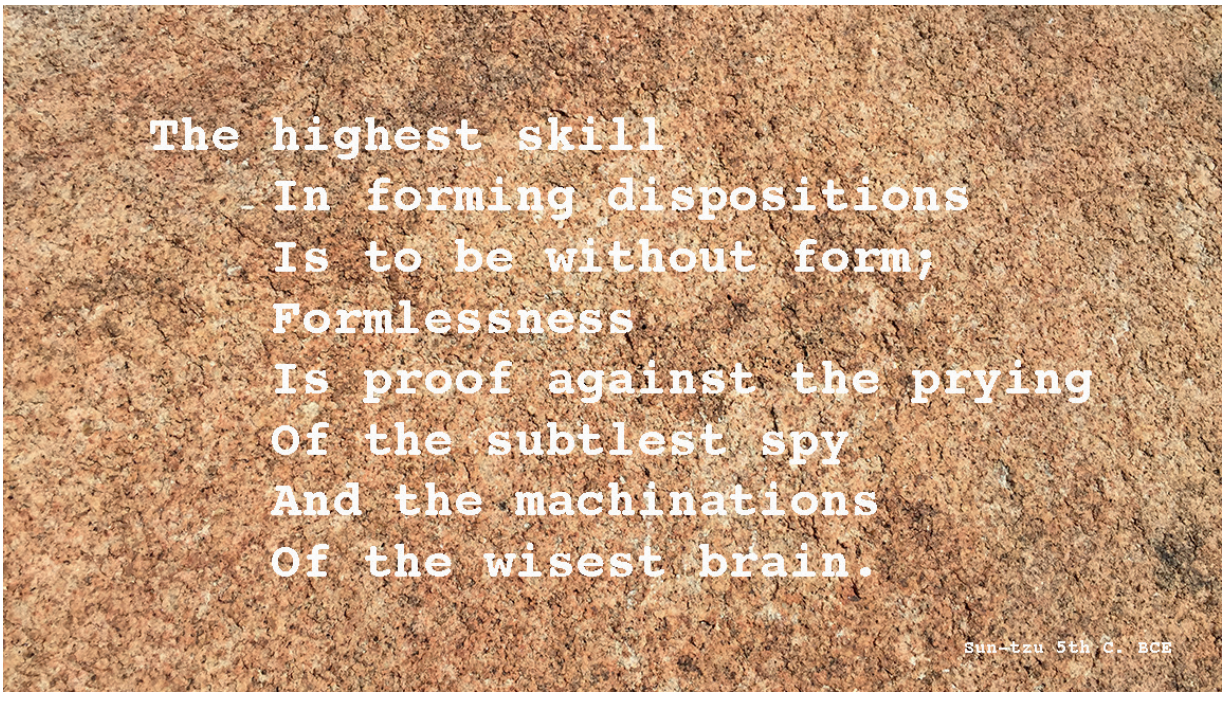

Plate 2.3.

Plate 2.3. The penultimate projected during performances of *Earth Encomium* with *Nothingness is Unstable.*

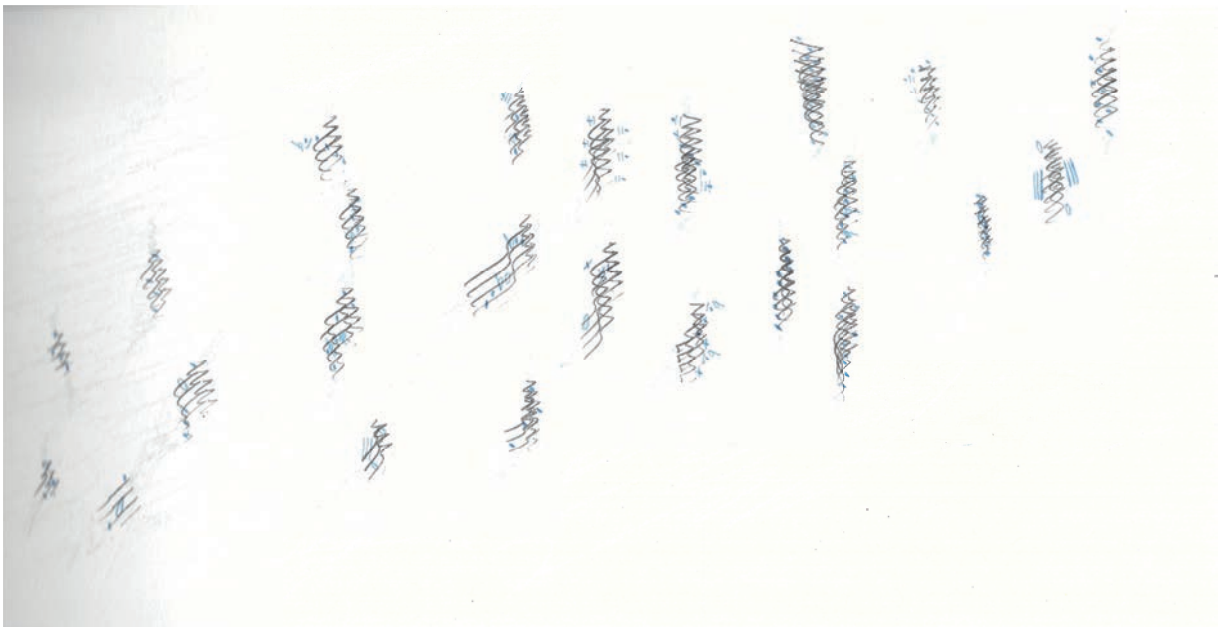

Plate 2.4a.

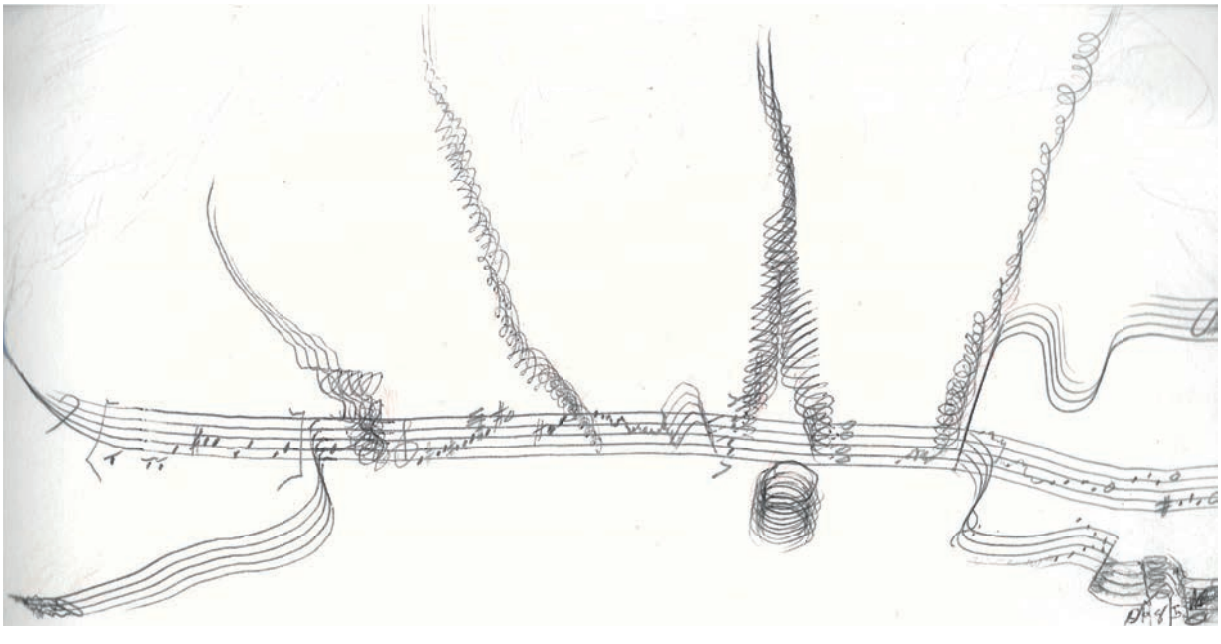

Plate 2.4b.

Plate 2.4a–c. Drawings from my book *Natural Scores* also used in *Choose Your Universe* performances.

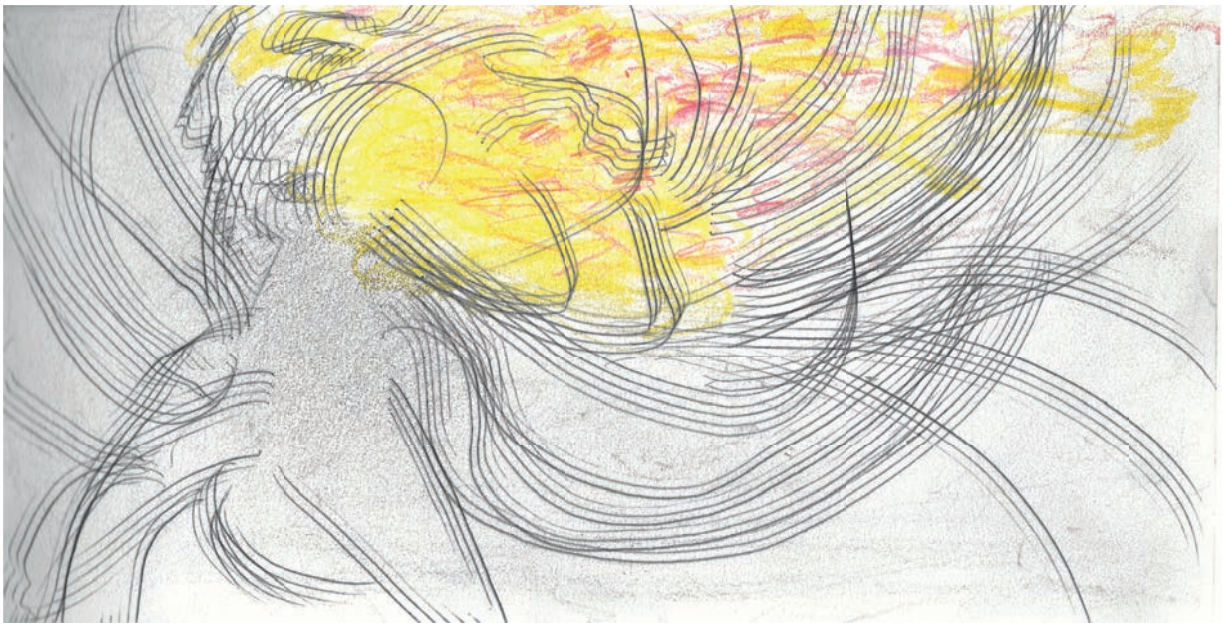

Plate 2.4c.

Plate 2.5.

Plate 2.5. Control surface for the software developed for performances of *The Experiment*, written in Reaktor. This version accommodates four audience members at one time, who were brought into a limousine where the performances took place. A separate concert version of *The Experiment* has also been created, which permits various kinds of expanded presentations.

Plate 2.6a.

Plate 2.6a–f. Images from *Swarming Intelligence Carnival*: preparations taking place in the Lotus Pond, participants getting ready, three performance snapshots from ground level, and a computer control and performance station.

Plate 2.6b.

Plate 2.6c.

Plate 2.6d.

Plate 2.6e.

Plate 2.6f.

Plate 16.1.

Plate 16.2a.

Plate 16.1. Set-up of *Rave Séance* with a circular arrangement of five tables and the laser projection in the middle (photo: Katja Goljat).

Plate 16.2a–b. Audience members interacting with the performance of *Rave Séance* via illuminated buttons (photos: Katja Goljat).

Plate 16.2b.

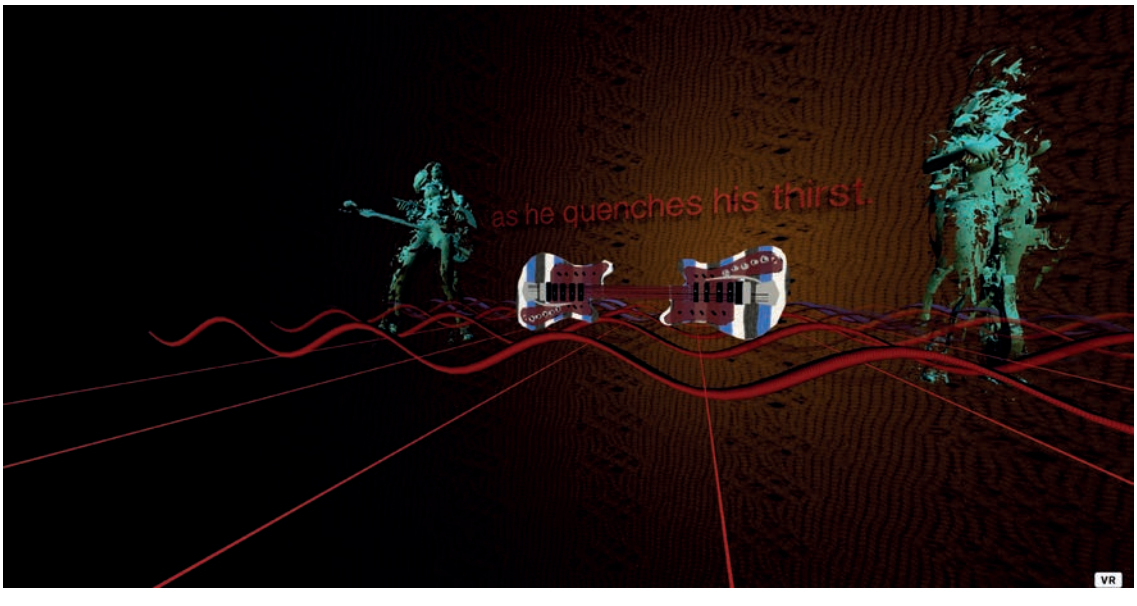

Plate 16.3.

Plate 16.3. View of the net-art part of *Why Frets?* (photo by the author).

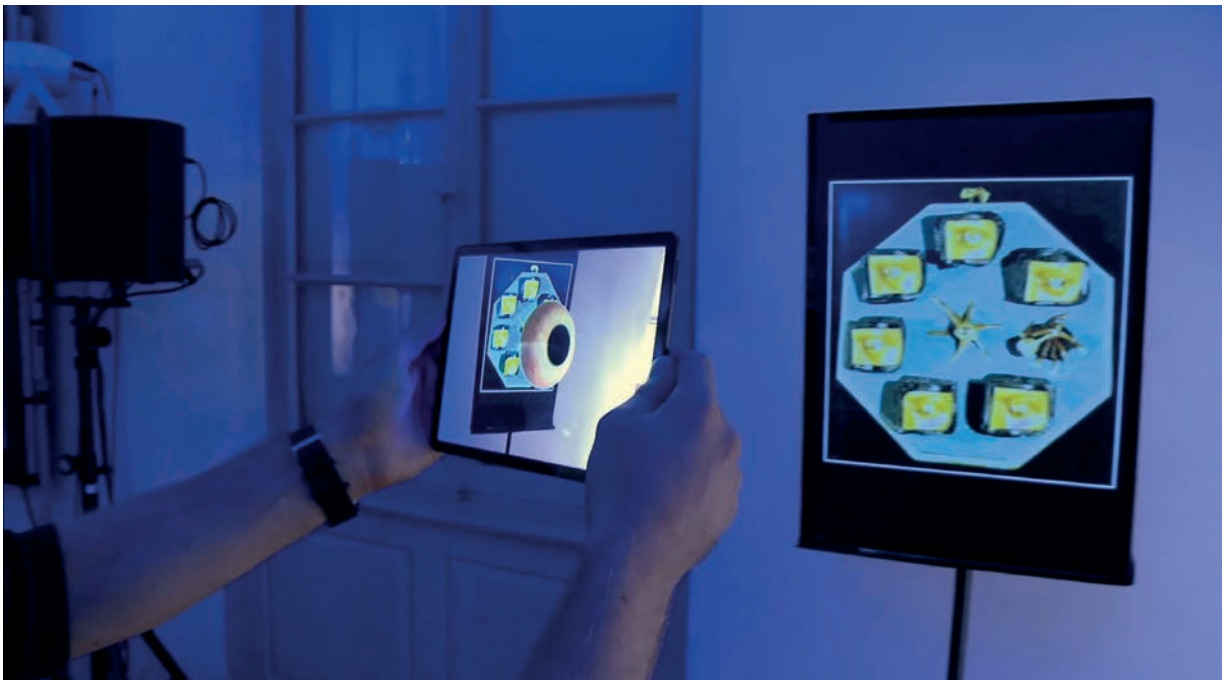

Plate 16.4.

Plate 16.5.

Plate 16.4. An audience member using a tablet to generate augmented reality (photo: nmzMedia).

Plate 16.5. Arrangement of the space of *Anna & Marie* with the violinists in playing positions and no audience members (photo: nmzMedia).

Plate 16.6.

Plate 16.7.

Plate 16.6. Audience members listening to the narrative using earpieces during the installation phase (photo by the author).

Plate 16.7. Hot plates with beeswax were used in *Anna & Marie* in order to create a subtle odour of melted wax throughout the venue (photo by the author).