
Situating the *invention* in interactive music

JONATHAN IMPETT

Faculty of Music, University of Cambridge, West Road, Cambridge CB3 9DP, UK
E-mail: jfi21@cam.ac.uk

This article considers the notion of the *invention* as an instrumental concept in designing an interactive music system. The derivation of the idea is traced from Dreyfus' *Bach and the Patterns of Invention*. Issues of the nature of the interactive musical context are problematised on the basis of ideas from Adorno and Lyotard. The *invention* is presented as a mechanism for implementing the concepts of the embodiment and distribution of musical activity, which are shown to be generalisable. The relationship of composer and computer is considered in the light of a 'prosthetic culture'. It is suggested that a crucial property of the invention is that of *self-simulation*.

1. INTRODUCTION

This article considers the notion of the *invention*, as construed by Laurence Dreyfus in his reading of Bach's music; not in the terms of musicological critique, but to look at its potential relevance to the contemporary practice and understanding of music. The article proposes that some analogous construct is necessary in dealing with the multiply- and variably-dimensional space of interactive music. It is suggested that we think of the musical work as a distributed activity (distributed in space, technology and society, but above all in time), that in our present cultural context we must address the need to model our own activity, and that the invention not only constitutes an appropriate tool for doing so, but is situated in our very practice.

Following a very brief summary of Dreyfus' formulation of the invention, the notions of the *embodiment* and *distributedness* of musical activity are introduced on the basis of work in interactive music, and of writings by Adorno and Lyotard. *Self-simulation* is presented as the natural paradigm for contemporary creative activity. The invention is proposed as a suitable vehicle for the embodiment of materials situated in a wide range of temporal scales, in the design of interactive music systems.

2. DREYFUS' INVENTIONS

Dreyfus (1996) proposes the invention as an appropriate unit for his mode of analysing Bach's music. He takes his cue from Bach's own reworking of the Preambulae from the *Clavierbüchlein* as *Inventions*, to which he added a preface making explicit their pedagogical function:

Straightforward instruction, in which amateurs of the keyboard, and especially the eager ones, are shown a clear way

not only (1) of learning to play cleanly in two voices, but also, after further progress, (2) of dealing correctly and satisfactorily with three obligato parts; at the same time not only getting good inventions, but developing the same satisfactorily, and above all arriving at a cantabile manner in playing, all the while acquiring a strong foretaste of composition. (Dreyfus 1996)

Let us leave open the question of any ambiguity as to whether these amateurs are being encouraged to develop invention in their execution, their understanding or their composition. Clearly the Kapellmeisterly range of wisdom Bach had to impart incorporated all of these.

In developing his definition of the invention, Dreyfus draws on its rhetorical implications as they might have been construed in Bach's time. The invention becomes the fundamental unit of inspiration, mediation and composition, such that Dreyfus' approach is explicitly a study of the process of synthesis, rather than a mode of reductionist analysis.

As an example, he provides an analysis of the first of the pieces in the collection (figure 1). He identifies a two-bar invention as the basic structural unit, and demonstrates the process of its development in terms of Mattheson's (1739) five-stage rationalisation of the rhetorical in music – *inventio*, *dispositio*, *elaboratio*, *decoratio* and *executio* (figure 2). A second unit is identified as being 'invented by the first', a concept which will reappear below. All of this is surrounded by caveats regarding Bach's own attitude to the intellectualising of the business of composition. The mechanisms of this development are presented by Dreyfus as they arise, rather than as part of an exhaustive taxonomy: modulate, rotate, invert, modeswitch. He describes these mechanisms as *functions*, and their quasi-algorithmic formulation extends to the use of variable parameters – 'transpose with a value of + 5' – and flags – an asterisk for 'defective' or 'abandoned', for example.

Another open question, then: Does so elegant an exposition bespeak the mental models of Bach's time? Is this pseudo-computer code a construct entirely of our own time or are we really looking at patterns in the dynamics of what Sperber (1996) has called the 'epidemiology of cultural representations'?

3. THE NEED FOR INVENTIONS

Let me explain why I should have felt the need to look for relevance in Dreyfus' invention. My recent work has



Figure 1. Bach: *Two-part Invention no. 1*, as analysed by Dreyfus (reproduced from Dreyfus 1996).

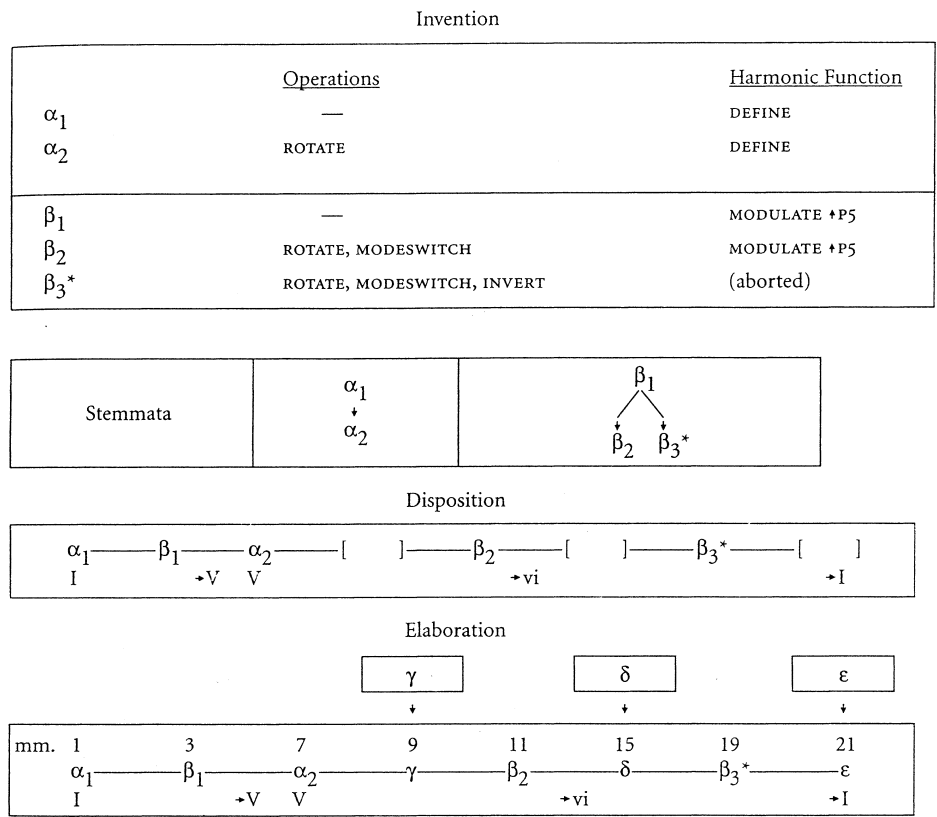


Figure 2. Rhetorical stages in the construction of the invention in figure 1 (reproduced from Dreyfus 1996).

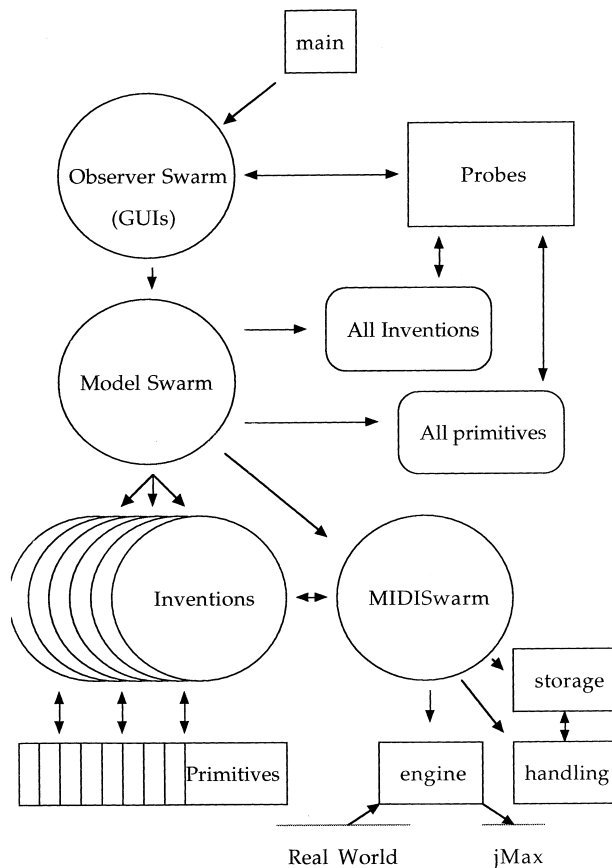


Figure 3. Architecture of an interactive music system in the SWARM environment.

dealt with interactive music – in concrete terms, this usually implies some means of sensing events in the real world, a computer to generate new musical events or processes on the basis of a combination of the real-world information and stored programs or materials, and a means of making the results manifest. The technological innovations which have allowed these developments are essentially in the realms of sensing and data processing. Instances of interactive music might include Tod Machover's music for hyper instruments, Risset's algorithmic treatments of material played by a live performer, George Lewis's improvising companion – a computer program in his own self-image – or a piece by performance artist Michel Waisvisz. The most interesting music works at multiple levels of interaction with musicians, instruments and environment, and in multiple temporalities. In this interactive context, the degrees and modes of human participation and of definition of the musical surface are thus both infinitely variable.

In my work, I needed a name for a particular software construct: a unit of musical behaviour which encapsulates materials and behaviours from multiple sources which is formed by the interaction of several dynamical systems. The system itself (figure 3) is constructed using the SWARM simulation environment (Minar, Burckhart, Langton and Askenasi 1996), chosen for its capacity to

implement dynamically hierarchical complexes of objects, the behaviours of which themselves change in time. The *invention* in this context is the locus of materials, behaviour and relationships. The theory of dynamical systems is a toolkit for dealing with the way a phenomenon changes or 'behaves' as time passes. A system is a collection of related parts that we perceive as a single entity, and is expressed in terms of the states of its constituent properties and of significant variables in its environment. These may be the behaviour of other systems. This toolkit includes concepts such as phase space – the set of all possible states – attractors – likely trajectories within that space – and phase transitions – a change in the nature of the behaviour of the system (liquid to gas, for example). More recently, it has been suggested that we should consider these systems as dynamic windows of order, brought about by a group of parameters exchanging energy with their environment. Such an onset of order is called *emergence*. Van Gelder and Port (1995) provide a comprehensive introduction to the role of dynamical systems in modelling cognitive phenomena.

The elements of this interactive invention might include melodic behaviours inferred from aspects of a live musician's performance, harmonic or stylistic constraints evolved over many performances, or architectural structures which build themselves contextually on the basis of a composer's rules. Equally, the driving parameters might be environmental – the number of people in the room, perhaps – or historical – some representation of musical material formed at an earlier moment. More than a name, an operational definition was required. If the unit is too small – at too low a level – the complexity is intractable and its existence imperceptible. And yet this construct has no unique face, no prime form. It exists throughout a work, but only becomes perceptible at points of interaction with other dynamics. It cannot therefore be identical with the work itself, or even sections of a work. The least we can say is that it has behavioural characteristics in *time* – a duration, a periodicity – and has multiple modes of connection to other systems and behaviours, whether cultural, environmental, performance or note-to-note. Several must be maintained in parallel; they are reconstituted in the course of their interactions; and their relationship to one another is dynamically hierarchical.

The space of interactive music is perhaps best circumscribed by considering together two articles which consider music in its new technological condition: Adorno's *Vers une Musique Informelle* and Lyotard's *L'inhumain*. Adorno considers the possibility of the emergence of an *inherent* rather than an *inherited* musical 'language'. '... if the musical substance is to develop organically, the intervention of the subject is required, or rather, the subject must become an integral part of the organism, something which the organism itself calls for. If appearances do not deceive, it is upon this that the future of

music depends.’ (Adorno 1961: 307) This is far from a purely abstract construction on Adorno’s part: writings by several composers at the time suggest the need to address this issue, of which Boulez’ *Alea* (1957) is perhaps the most eloquent.

Lyotard reviews the situation a quarter-century later, when the technology to realise such a concept is in sight. He reinterprets the notion of tele-graphy – inscription at a distance, in both place and time. Lyotard presents his vision of a telegraphic culture in terms of the evolution of cultural memory. From knowledge and meta-knowledge, we pass to a situation of *emergent* knowledge; what we *didn’t know* we knew; new cultural knowledge as the result of forces we *don’t* have direct access to. *Anamnesis* is his term. The Logos of the new technology will be turned against itself, he says ‘... to pass beyond synthesis in general. Or, if you like, to pass beyond the reminder of what has been forgotten. The point would be to recall what could not have been forgotten because it was not inscribed.’ (Lyotard 1991: 54) *A musique informelle* indeed! Lyotard seems to be proposing a mechanism by which the cultural representations whose conscious links Adorno had recognised as being severed might as a consequence find new ways of being dynamically reconfigured.

Is this not almost too complex to contemplate? In the same essay, Adorno tells us that ‘... the idea of *métier* calls a halt to the collapse of meaning’. Saved by the devil in the detail! In compositional terms, we might say simply that you can’t write a piece of music all at once: the grip–slip relationship between vision and realisation. A temporal difference which in the case where composition and performance are indivisible becomes the very object of aesthetic attention – tracked in real time.

Dreyfus is right to insist on a mechanistic, rather than an organic view of the invention. He points out that in pre-Enlightenment Germany, rhetoric was ‘the modelling science par excellence’. Herbert Simon (1996) has given the modern crown to the science of simulation. In an informational context, action and simulation are identical. Composition and musical understanding are of course reflective, reflexive activities. But they are also acts of mediation, users of modelling tools. Both composition and musical understanding are then acts of self-modelling, self-simulation. Celia Lury (1999) refers to our *prosthetic culture*, in which the boundaries of self extend beyond the present place and time, and personal identity is contextually reconstructed at each encounter with an external system.

Adorno again: ‘Material cannot be thought of except as the stuff with which the composer operates and in which he works. And this in turn is nothing less than the objectified and critically reflected state of the technical productive forces of an age with which any given composer is inevitably confronted. The physical and historical dimensions mutually interact.’ The technology of

simulation is thus not only the natural tool for our activity, but its very material.

To realise Lyotard’s *anamnesis* requires the modelling of dynamics on time scales from the historical to the physical present in a single space. As the past informs activity in the present, so this activity of simulation conditions our reading of the past. Put bluntly, the appropriate tools for modelling present and past – composition and musicology – will be contiguous and commensurable. In fact, the computational simulation environment which brought me to need the notion of the invention is also used to model the historical emergence of cultural concepts, political life in fifteenth-century Florence, and the evolution of ecosystems.

If the tools of simulation are already so powerful, why did I need to co-opt Dreyfus’ inventions? Because music is not any of these other phenomena, and one feature that distinguishes it as a creative activity is precisely this crystallisation in a single idea – a single bundle of potential behaviours and relationships – of dynamical forces on vastly different timescales. In a recent essay, Lyotard (1999) provides an image for the musical work which might be better redirected to this level of the invention. The *art* in a work of art, he suggests, lies in the way in which the work separates itself from these determining cultural forces. ‘A gesture in space-time-sound’, he calls it, which, by whatever means the composer prepares for this gesture, and by whatever labour he gives it shape, ‘is not the author’s doing’.

To paraphrase Adorno: the material – our invention – does not just bear the traces of the narrative of its mediation; it is formed of their conjunction through time – *interactive emergence*, in the parlance of simulation science (Hendriks-Jansen 1996). Knowledge known where it was not known. *Anamnesis*.

4. EMBODIMENT AND DISTRIBUTION – INVENTIO IN DISPOSITIO

In the case of interactive music, the blurring of the boundaries between composition and performance, work and environment, is an essential characteristic. It could even be considered, as we have seen, the material itself. Not *inventio then distributio*, but the disposition of invention. Just as the invention in Bach embodies historical complexity at least as much as that expressed in thousands of lines of computer code, so we can likewise think of it as being a focal point, a nexus for the *re-distribution* of musical activity.

Consider the surface of the work as a knot in a tapestry made not just of the inventions that emerge, but of performance practice, instruments, individuals and social conventions. This is as true of Boulez as it is of Dufay. The invention incorporates the means of its own realisation – another instance of self-modelling, if you will. These aspects do not merely inform the invention – it is *invested* in them.

It is easy to see how the invention analysed by Dreyfus fits under the hand – or rather, flows from the hand. Bach's preface implies as much. Anner Bylsma has shown how for him as an interpreter the articulation marks in the Cello Suites are the very essence of their inventions; the clues to both their origins and their re-instantiation (Bylsma 1998). He talks of 'Bach the fencing-master', and situates the inventions more deeply still, in the cultural codification of movement in fencing and the dance. The dynamics of movement, of actions upon an instrument, become the very material of composition through the virtuoso tradition of the nineteenth century, until they can be abstracted completely, transforming the conventional cause-and-effect relationships of the player/instrument system. This is the case in Ferneyhough's *Time and Motion Studies*. In the cello study, the movement of each limb becomes a separate strand of development, a physical polyphony.

In informational terms, *mapping* is the key concept: information derived from one space is projected onto another. At the same time as we increase the degree to which an invention embodies its own physicality, we detach physical cause from sonic effect. Laetitia Sonami's sensor-glove (figure 4) (Bongers 1999) is an elegant and powerful instrument, but taken alone tells us little of the sonic world which it might shape. Also in Bach we could talk of the re-mapping of a keyboard or violin-derived invention to another context – the constant lament of singers.

The essential difference in the new case would seem to be the potential for inventions to embody not just their behaviour in time but the dynamics of their distribution in time. Sonami's glove can not only make things happen in the future, it can make *processes* happen, contingent on other future events.

Except in so far as it matches the institutions of music or known performers, the investment of an invention in social structures and individuals is more complex to define. This perspective does make clear, however, that *authenticity* is not a question rooted only in historical distance. This is as surely the issue in the apocryphal stories of Stockhausen's anger at wrong notes in free improvisations, or Scelsi's removal of his scores from the music stands of ethically unsuitable performers, as in matters of style and taste in divisions or continuo playing. In the interactive context, the invention can be situated not only at the level of the contextual evolution of the compositional process, but at that of the relationships between musicians. An example which predates its appropriate technology will demonstrate the point – the relational pieces of Christian Wolff. In his *For Pianist* (1959), the score notates precisely how the performer should adapt his material to sonic events in the environment, and in *For 1, 2 or 3 People* (1964) the actions of each player are explicitly contingent on those of the others.

A major factor in either composing or understanding

music must therefore rest in finding the right level at which to situate its inventions, such that they correctly characterise the appropriate dynamics of embodiment and distribution. The inventions for the two activities may not be identical, but their similarities and resonances give an indication of proximity in the space of cultural dynamics. (The reverse could also be true – inventions-based analyses of, say, a Beethoven scherzo and a mechanistic piece by Birtwistle might look very similar in algorithmic terms, but their respective webs of embodiment and distribution would be quite different.) The invention separates itself from these dynamics, however: a state change or phase transition in the terms of dynamical systems, brought about by critical conditions. It must also remain autonomous from the work itself which is formed of the *interaction* between inventions.

5. DYNAMICS AND SELF-SIMULATION

Inventions are the artefacts of the distribution of the act of composition itself, and therefore the embodiment of its nature and circumstances. The technological composing environment – by which I mean everything that is not biological – constitutes an extension of the contributing human faculties. The mediation of inventions through these extensions is a time-critical activity. If this explanation seems far-fetched, consider the changing use of paper in the eighteenth century, in the light of Lyotard's account of the evolution of categories of cultural memory. From Bach we have copies, corrections, revisions – a fairly full archive – but no sketches. By contrast, Beethoven's working method – also keyboard-based – effectively assumes a limitless space in which to sketch, test, rework and retrieve, over his entire career; a complete and ongoing random-access memory of his own creativity. This distinction offers a very efficient characterisation of the differences in their music.

The computer is similarly a compositional prosthesis, a vehicle of mediation. To take two direct examples: Tristan Murail, in his 'spectral' compositions, uses analyses of the harmonic content of the instruments themselves to generate harmonic and timbral material. Ferneyhough uses the computer to calculate the modulation or interpolation of conceptually simple musical processes, giving greater choice and freedom in the use of material which would take days to work out by hand (Malt 1999). Distributed activity in a prosthetic culture: the conventional image of a fixed human-computer duality as the basis of interaction begins to look too crude for a phenomenon as rich in its web of connectedness as music, however intimate the dialogue.

By embodying such techniques and the dynamics of their use in a single environment, it becomes possible to 'grow' or 'evolve' *families* of inventions. The experiments of Peter Beyls (Beyls 1991) and the 'musical information organisms' of Marco Stroppa (Bramani

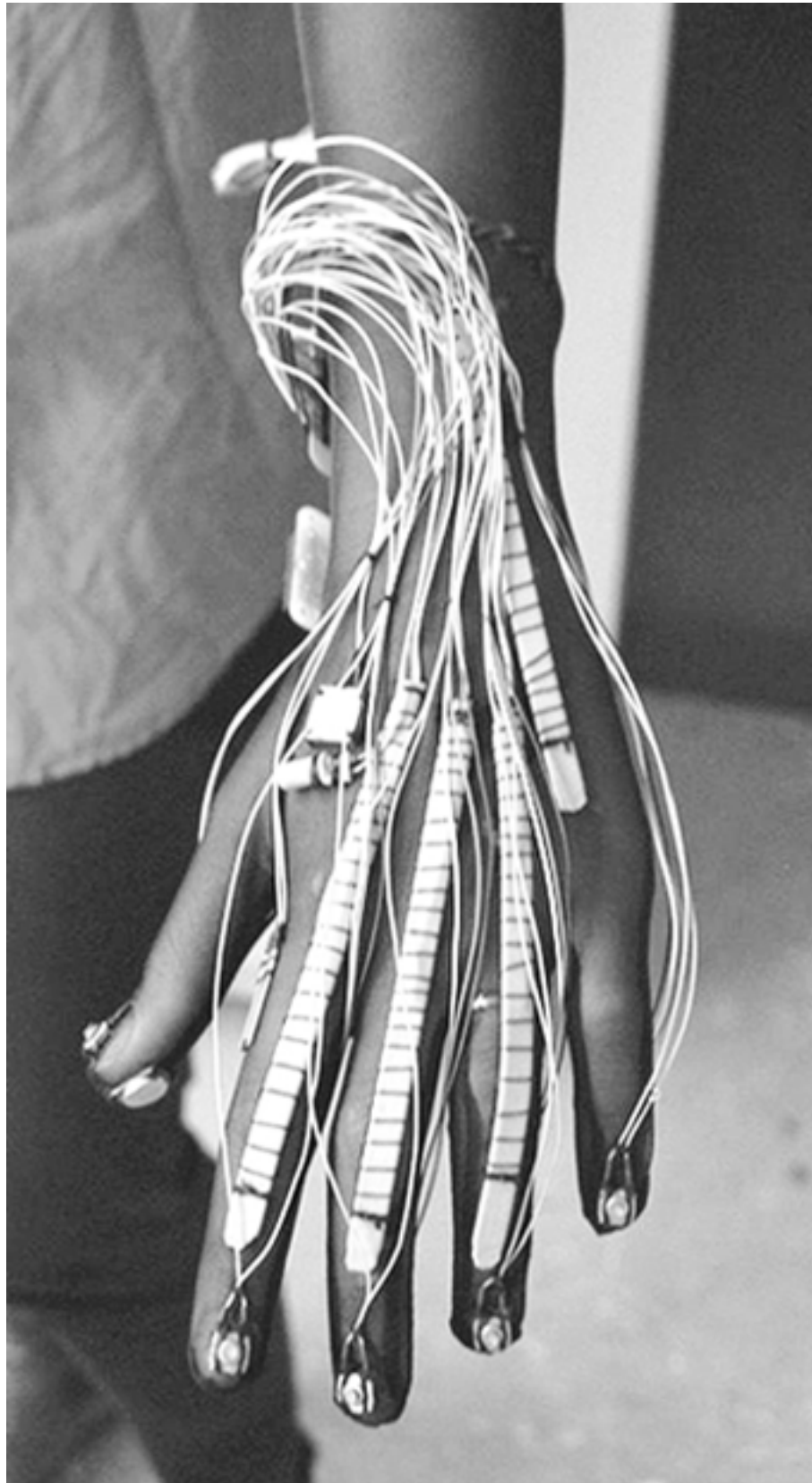


Figure 4. Laetitia Sonami's sensor-glove (photograph by Bert Bongers).

1996) are formulated in the language of dynamical system theory and simulation. If music can be expressed directly in these terms, there is no reason why longer-term cultural representations cannot be incorporated – indeed, that was the spur which led me to Dreyfus’ inventions.

Dynamical systems theory provides the tools for working with such state spaces. Boon and Prigogine have examined the possibility of analysing musical works and characterising styles in terms of the dynamics of their constituent time-series (Boon and Decroly 1995, Prigogine and Boon 1998). In his earlier work, Boon constructs phase space portraits of the temporal dynamics of individual works, and seeks to define their dimensionality and complexity. This approach is then considered in the light of Prigogine’s theories of dissipative systems. The musical work becomes an open system – one requiring constant energy input – creating order against the inevitable flow of increasing entropy. Perhaps in this idea we can find a tool for dealing with the paradoxical nature of musical time described by so many writers.

The ‘work’ is misappropriated to build a barrier, however. ‘Il n’y a pas de continuité dans l’univers musicale: la musique nâit du silence et retourne au silence.’ (Prigogine and Boon 1998). Where then is this external energy, this flow of entropy? Prigogine would perhaps better embrace Serres’ notion of a ‘sea of noise’:

Background noise is the ground of our perception . . . No life without heat, no matter, neither; no warmth without heat, no logos without noise, neither. Noise is the basic element of the software of all our logic, or it is to the logos what matter used to be to form. Noise is the background of information, the material of that form. (Serres 1995: 7)

In other words, to take advantage of Prigogine’s physical metaphor, our dynamical system must incorporate dimensions and parameters beyond both the immediate temporal scope of the particular work and its apparent sphere of determination – it must embody both the cultural and physical environments of the activity itself. If the interactive invention is ever to achieve the critical richness of satisfactory musical experience, it must be constituted of behaviours which embody its stylistic context and historical narrative, as well as its physical present.

To interact with each other or with cultural constraints, as Dreyfus suggests they do, the prescription or description of inventions must include their behaviour in respect of other inventions. In other words, we must posit some capacity for modelling or simulation on the part of the invention itself. This brings us back to the starting point with another question: if inventions proceed by interaction, the invention is not identical to the work, and the piece analysed by Dreyfus has only one – how does it come into being? Because of the capacity for *self-simulation*; to self-replicate in dynamic contexts

and *generate* interaction (exchanging energy with a background of cultural noise). As a final example, take the piano *Études* of Ligeti. Likewise single-invention pieces, their complexity develops as successive iterations of the invention interact with others already transformed by their encounters with hard-edged constraints of physicality, instrument and hearing. Self-simulation is the defining property of an invention, and for this reason there can be no prime form. A major challenge for the designer of an interactive music system is the implementation of emergent self-simulation in inventions encompassing timescales wider than the present performance.

6. CONCLUSION

It has been suggested that Bach’s education in rhetoric amounted to a set of pocket pass-notes of Latin terms. Without wishing to doubt Dreyfus’ grasp of dynamical systems theory, we might imagine that an informed, culturally active person today will at least have encountered its key ideas, knowingly or not. The sciences of simulation condition our everyday existence as surely as rhetoric informed the off-duty banter of the lawyers of Leipzig.

The temporal distribution of musical activity is a key concept in defining the relationship between composition, performance and technology in contemporary music practice, and equally in resolving apparent incommensurabilities between cultural and analytical modes of musicology. It is hoped to have shown inventions as phase transitions in cultural dynamics, emerging into autonomy from the interaction of those dynamics; that a characteristic of this autonomy is the capacity for self-simulation; and that as such they are an appropriate tool for musical activity in our world, synthetic or analytical. Some such tool is necessary for interactive music to realise its potential as distributed cultural synthesis.

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