Extracts from The Music of J. S. Bach: New Paradigms for the Age of Technology

Abstract

Facile equations between music and mathematics have been drawn for more than two millennia. It would seem that the tools of the past 20 years would be especially adept at providing specific examples of this assumed correspondence. When we look, however, at the paradigms currently being implemented in computer applications in studies of historical repertories, mathematical models are seldom found. This is especially surprising for the music of J. S. Bach, which is often taken as the supremely "mathematical" repertory of the European past. Current paradigms are examined with reference to the particular aspects of musical experience to which they seem best to pertain.

Extracts

One might argue that a systematic approach to sound is not the equivalent of a mathematical approach to composition. Yet to a generation of computer scientists and artificial intelligence researchers, the music of Bach has offered a special challenge to achieve a new level of understanding of the intricacy of design. Douglas Hofstadter's virtuoso study *Gödel, Escher, Bach* draws many parallels between the processes by which physical, temporal, and visual space may be represented. Where others find clarity, Hofstadter finds a significant degree of ambiguity, but this ambiguity results from processes that many would describe as mathematical. In current computer-based research projects concerned with the music of Bach and other common-practice composers it appears that as computer technologies evolve and applications multiply, so also do paradigms for musical understanding evolve and multiply. Apart from essays such as Hofstadter's, mathematical paradigms are curiously few.

New Paradigms: (1) The Musical Experience as a Visualizable Process

One paradigm that is encountered in various ways in the world of music software is that of music as an essentially architectural art. This architectural sense is being redefined, I believe, in our visually oriented electronic culture. The old sense of architecture, based on the completed work, is giving way to a clear sense of the process of achieving the design. One example comes from the work of Stephen Malinowski, who converts scores to dynamic images by creating a scrolling series of rectangular objects that are elongated to indicate relative durations and colored to delineate voice parts. Malinowski's scrolling scores are foreshadowed in Arthur Honegger's statement (*I am a Composer*, 1951) that "music is geometry in time." . . . Malinowski's aim—to make manifest principles of musical organization that are normally available only to competent readers of musical scores—is modest. Yet the sweep of the effect is broad, since the animated image creates a third iteration (the music being the second) of the theological message expressed in the text. In this way it facilitates comprehension in a way that would have been the envy of church composers of Bach's time.

The visualization of the musical process also has something to offer specialists. In the normal process of thinking about music, one listens to a piece, creates by aural or intellectual extrapolation an abstraction of some kind, and then tests the abstraction against other pieces by the same composer or in the same genre to determine the degree to which it is generalizable. With the *Music Animation Machine*, the abstraction is made by visual extrapolation. Since for most of us the serial memory of sound is much less reliable than the parallel memory of a visual image, details that might be discarded and relationships undetected in the first case are necessarily captured and preserved in the second.

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New Paradigms: (3) Musical Performance as Sound Control

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Performing Bach with the *Radio Baton* proves to involve non-intuitive actions that engender a deep recognition of the kinaesthetic dilemma that may increasingly be posed by human performance on electronic instruments [whether ot not the repertory is artificially composed]. This dilemma is precipitated not so much by the need to learn new gestures as by the need to unlearn old ones. As a pianist, one is accustomed to increasing the volume by increasing manual pressure. As a radio batonist, one must learn to increase the volume by moving the baton to the right.

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[There is an] important distinction to be made between a musical composition as a rule-constrained phenomenon and a musical performance as a sound-enabled phenomenon, or, in other words, between the cognitive and perceptual domains of understanding. When the evidence is presented aurally, we can more readily identify a "Bach sound" by the wheezes, squeaks, and dissonant overtones of traditional organs than we can a "Bach texture" by the movement of inner voices in relation to outer ones [in an artificial harmonization of a Bach chorale]. Were the data to be presented visually [as in Malinowski’s MAM], then the sound would be immaterial and the false texture immediately recognizable.

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New Paradigms (6): Musical Analogues of Neural Processing

The trial-and-error approach that lies at the heart of neural computing is an antidote to the rule- and knowledge-bank approach of artificial harmonization and artificial composition. If this approach has applications to the study of historical repertories, they are so far undiscovered. The paradigm seems better suited to unrehearsed and unprepared activities—improvisation, for example, in which learning is not segregated from composition, nor composition from performance.

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New Paradigms: (7) Composition as a Genetic Process

There is no familiar ring to the phrase "biological model of music," no well-worn series of thinkers who have subscribed to the view that musical procedures can be explained by concepts that derive from the study of living organisms. Yet recent experiments with algorithmic composition have revealed that to a striking degree many highly diverse repertories may be simulated, to an extent that makes individual styles recognizable, from procedures that treat musical attributes as if they obeyed the rules of genetics. I refer in particular to the *Experiments in Musical Intelligence* by David Cope, a composer and professor of music at the University of California at Santa Cruz.

At the outset, Cope's interest was in identifying more precisely than music theorists, historians, and analysts had done the procedures that typified the style of a given composer. . . . He made the assumption, based on readings in computational linguistics and artificial intelligence, that there could be a universal procedure on which most musical composition is founded and in which only the details varied from case to case.

His own explanations of his work favor the language of linguistics and artificial intelligence. The core procedure is a "grammar" and the points at which individual identity is acquired are likened to the parts of speech. I find it easiest to think of this top-down approach as an analogue to the American parlor game *Mad-Libs*. A *Mad-Lib* is a short story missing most of its nouns, verbs, and adjectives. A group of players is asked to construct a list of nouns, verbs, and adjectives in an appropriate order. Then a host reads the story with each entrant's list of words inserted in the appropriate places. Each telling is different. Some are hilarious, some nonsensical.

In place of the players and their lists, Cope assembles lexicons of material gathered from pieces of a like nature that have been closely inspected and carefully dissected. [He segregates short strings of pitches, of durations, and of other attributes of the repertory under investigation. In the pattern-matching phase, he looks for concordances among the stored items. The number found will depend, of course, on the parameters for length and so forth, in short on the quality of the match sought. Only strings that are matched are preserved; those that are matched too abundantly are discarded. In the style-specification phase, he runs a query program that enables him to determine the external specifications for a new work—its meter, key, and so forth. In the generative phase, a composing program is run. This program seeks to conjugate, within the prescribed style, five musical analogues of parts of speech—statement, preparation, extension, antecedent, and consequent—into a grammatically viable whole. Some of these parts may subsume others and most can be used recursively. The number of possible results is potentially unlimited. For each new grammatical item, the program consults an appropriate lexicon and selects at random a verified pattern. In a subsequent pass, the texture-acquisition phase, the skeletal new piece is fleshed out with additional notes appropriate to its genre.] . . . .

It is because *EMI* isolates attributes from events that it so closely parallels the genetic approach to understanding human traits. The dissociation of attributes that occur simultaneously in the previously indivisible musical event leads not only to virtual tonality, virtual meter, virtual instrumentation, and virtual articulation but ultimately also to virtual authorship and virtual composition. For cultures such as ours that value the written artifact above the improvised performance, this sphere of activity poses profound questions about the future roles of composers and performers, as well as music theorists and historians. Since we may soon witness a welter of user-defined, made-on-the-fly experiments in sound engineering, we may wish to ponder what use future generations of musicians will have for the idea of a canonical repertory and for the notion of a composition as "fixed" by its composer? . . . .

[Subtopic] Absence of Gestural Information

At the same time, the work of both Cope and Ebcio\_lu inadvertently reveals that among the uncodified elements of musical practice gestural factors merit considerable attention as a source of constraint on musical composition. In this respect, the biological paradigm can go only so far. Human factors—physical, cognitive, and emotional—remain to be accommodated.

[Lots more to say here . . . .]

[New Topic for SU: Clues to Expressive Performance from Experimental Psychology]

The Mathematical Paradigm as a Paradigm of Perfection

In Bach's age the equation of mathematical and musical processes was indebted to a common capacity to express the idea of perfection. The search for spiritual perfection was, of course, a central tenet of Lutheran theology in Bach's time and remained a guiding force in German musical thought and philosophy through the end of the last century. As in the animation of "Herr Gott, nun schleuss den Himmel auf" [from Malinowski’s tape], its attainment was hypothetically possible but never achieved.

The possibility of perfection inhered in the static rationalization of the musical work, not in the temporal experiences of composition, performance, or listening. The dynamic element of time, to which the expressive aspect of music seems to be so inextricably linked, is better accommodated by models of process and procedure than by those of a complete, fixed product. It proves, on a closer historical examination than can be given here, that the mathematical paradigm has usually been heavily allied with abstract notions of musical material rather than with *KlangArt* in the direct sense [KlangArt was the subject of this conference].

Virtual music belongs to a separate realm from that of abstract rationalizations of musical form and the like. At best, paradigms based on abstract rationalizations absorb what is hypothetically dynamic into what is actually static. The ancient idea of "sciences" of motion still holds something of value, for it concentrates on the ever-changing constellations instead of the snapshot view of the heavens. Yet our world and our extra-musical assumptions differ in profound and fundamental ways from those of antiquity.

One irony of our times is that having gained the power systematically to examine the higher mathematical phenomena long presumed to exist in music (especially the music of Bach), we choose to direct out energies elsewhere, not because mathematics is out of fashion but because we presume that the idea of perfection can only be realized in fixed states and finished products, while the existing tools of technology are better suited to revealing what is endlessly mutable.