Reflections on Technology and Musicology

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"Lacking the support of any firm tradition, uncertain in method and frequently questionable in results, it is considered even by scholars rather as an appendix to other disciplines and not strong enough to assert its independent existence. There are many different facets to this new branch of scholarship – philosophical, physical-mathematical, historical and philological – so that it perpetually trespasses on a number of different independent fields of study..." These words, written by Philipp Spitta in 1883[1] and borrowed by Guido Adler to validate the need to establish musicology as an independent field of enquiry, might be considered *à propos* a century later of the challenges to the practice of the discipline posed by the advent of the electronic age.

Adler, it will be recalled, divided musicological activities into two broad divisions—historical and systematic. Under the heading of historical musicology, Adler classified such studies as paleography, classification of "forms", and principles of historical change as they related to "nationality, state, province, region, city" and, at the end of the list, composers. Systematic musicology, in contrast, embraced aesthetics, pedagogy, and comparative ethnic studies in addition to its considerations of harmony, rhythm, and melody.[2] It is useful to bear this distinction in mind, because it reflects an essential split between topics pursued without reference to actual musical information and those dependent on it.

Other Disciplines and Musicology

To appreciate the emerging relationship between musicology and technology, it is helpful to place this distinction within the broader context of musicology's methodological debts to (its "trespasses" on) other disciplines. Source and chronological studies would be unthinkable if we were unable to draw on the traditions of historical and literary studies. Studies of musical form (e. g., arch) and formal devices (e. g., bridges) are metaphorically indebted to architecture, even as studies of timbre ("instrumental color" and the more generic "sound color") are metaphorically indebted to painting. Critical theory of the present springs largely from theories of literary criticism of recent decades. *Rezeptionsgeschichte* is a response of sorts to critical sociology. Interdisciplinary studies of cultural history underscoring the common goals of contemporaneous arts are enormously indebted to a theologian, Wilhelm Dilthey, and his concept of a *Zeitgeist*.[3]

[1] Spitta's remarks, concerning a general theory of art, were delivered at the Königliche Akademie der Künste on 21 March and were published under the title *Zur Musik* in Berlin in 1892. They were quoted by Guido Adler in his *Umfang, Methode und Ziel der Musikwissenschaft*, an essay that appeared in the first volume of the *VfMw*, of which he was the founding editor. Adler's essay, incorporating Spitta's remarks, is reproduced in Martin Cooper's translation in B. BUJIĆ, *Music in European Thought, 1851–1912* (Cambridge 1988), p. 348–55. – I wish to express my sincere thanks to Walter B. Hewlett for his many helpful comments on this article.

[2] A schematic diagram appears in BUJIĆ, *op. cit.*, p. 354–5.

[3] Among Dilthey's many writings, the influence of *Von deutscher Dichtung und Musik* (1895), in its consideration of

Underlying differences of intellectual modality (inference, deduction, hypothesis, etc.) differentiate musicological procedures from those of mathematics and the sciences. Mathematics, being deductive, needs to operate with assumptions. So also in a sense does much of the music of our century. Algebra and predicate calculus provide the foundation for some of the most recent techniques of understanding music of the current century. Scientific thinking, being inductive, is judged by its ability to verify its models of reality and is ultimately pragmatic. The nascent but dynamic field of studies in musical perception and cognition is a truly hybrid one in that it employs methods of research that may be indigenously musical or wholly nonmusical. In working to test hypotheses, however, the field is fundamentally a scientific one.

Of all the areas of musicological activity that Adler foresaw, only a few of those he placed within the systematic side – harmony and counterpoint – concentrate on methodologies that are *indigenous* to music. The study of harmony and counterpoint, of course, may also serve the practical role of preparing students to compose music. There is a useful distinction to be made between these two goals, in that harmony and counterpoint, as traditional disciplines, are based on rules derived after the fact, while the living craft of composition requires obedience to a set of rules currently in force. Because of their practical uses, these indigenous methods predate the establishment of the discipline of musicology by decades, even centuries, and have been known well beyond the precincts of scholarship.

The relationship between musicology and the social sciences is one characterized by a significant degree of recent reciprocity. In the early part of the century the self-consciously "scientific" emphasis of the social sciences sometimes mediated the influence of pure science on musicology. One of the most scientifically oriented books on music of the early twentieth century, *The Rational and Social Foundations of Music*, was written by a preeminent sociologist, Max Weber.[4] More recently active social scientists and philosophers, for their part, have found useful paradigms for their own intellectual constructs in the realms of music theory. Analogies borrowed from diverse expressions of the principles of Western harmony provide a basis for Susanne Langer's study of symbols used in myth and ritual in her *Philosophy in a New Key* (1942). The familiar genres of the variation, sonata, rondo, symphony, canon, invention, toccata, and fugue provide the chapter headings of Claude Lévi-Strauss's structuralist manifesto, *The Raw and the Cooked* (1964), which is dedicated "to music". In its ability to link emotions and ideas, music provides a metaphor by which cultural anthropologists may explain the relationship of nature to culture. Structuralism, conversely, has returned to musicology useful

such topics as the relation of genre and culture, of the origins of "great German music", of Bach as the culmination of German Protestantism, and of the "purity" of instrumental music, has perhaps been the most pervasive. The nationalistic orientation of Dilthey's writings is immediately obvious, while its more subtle delineation of collective spiritualism, growing out of nineteenth-century theological thought, is not always given its due.

[4] Weber's study (tr. Don Martindale, Johannes Riedel, and Gertrude Neuwirth [Carbondale 1958]) deals with such diverse subjects as Javanese scales and the Guidonian hand but devotes much attention to acoustical topics. Weber's view, which was first published in *Wirtschaft und Gesellschaft* (1921–2), was that the increasing rationalization of musical material was evidence of increasing capitalism in the economic activities of a society.

ways of viewing the relationship between the "plane of meaning" and the "plane of content" in music.[5]

In other respects, however, it is through the influence of the social sciences that systematic musicology has gradually come to include more and more that is only quasi-systematic. Take, for example, the great interest that has been invested in the teachings of Heinrich Schenker, whose notion of the *Urlinie*, especially in its foundation of a tripartite hierarchy, is analogous, both structurally and functionally, to Freud's contemporary analytical notion of the *id*. Yet in its elaborate and somewhat arbitrary graphic representations of musical processes, the associated method (wholly rooted in pitch to the exclusion of rhythmic notation) is neither systematic[6] nor complete. Consider the recent interest of systematic musicologists in broad explorations of the relevance of structural linguistics (with its own debts to language study, cultural anthropology and science) to music, extending to the *Generative Theory of Tonal Music* set forth by Lerdahl and Jackendoff in 1983. The analytical method explores hierarchical relationships between monolinear planes. Since most Western art music is not monolinear (Gustave Reese was looking through the other end of the telescope when he provided the wonderfully apt comment that "if there were such a thing as polyphony in prose, it would obviously be a godsend to the writer of history"[7]), the resulting grammatical method necessarily concentrates on melody.

In sum, a century of "trespasses" has engendered an enormous diversity of methods used in the practice of the discipline.

Technology and Musicology

In these cursory distinctions between the historical and the systematic approaches, on the one hand, and the exogenous and indigenous methods of research associated with them, on the other, it is by no means established that what is indigenous is systematic. In all of the above cases any method, when viewed within the context of its discipline of origin, is merely a means to the end of better describing, understanding, elaborating or interpreting a topic or work whose existence lies within a body of material considered primary to the existence of the discipline. Nor

[5] The essence of Lévi-Strauss's view, in which the concept of order is arbitrary and without substantiation in nature, is found on p. 26–30 (from the "Overture") of *The Raw and the Cooked: Introduction to a Science of Mythology*, I, tr. John and Doreen Weightman (New York 1969 [as *Le Cru et le Cuit*, Paris 1964]). The goals of the growing field of musical semiotics are best articulated in J.-J. NATTIEZ, *Réflexions sur le développement de la sémiologie musicale* (subsuming earlier writings, in: *De la sémiologie à la musique*, ed. Nattiez [Montreal 1988]; tr. Katharine Ellis in: *Music Analysis* 8/1–2 [1989], p. 21–75). Volume 5 of *Musique en jeu* (1971), a special number devoted to musical semiology, remains an essential reader containing probing articles by such diverse figures as Umberto Eco, Roman Jakobson, Bruno Nettl, and Nattiez himself.

[6] The diversity of representational practices has recently been examined by K. AGAWU, *Schenkerian Notation in Theory and Practice*, in: *Music Analysis* 8/3 (1989), p. 275–302. Agawu maintains that Schenkerian notation was intended to be "improvisatory" and was not intended for rigorous systematization.

[7] G. REESE, *Music in the Renaissance* (New York 1954), p. xiii. The frequent confusion that results when computer advocates liken music to text can be dispelled by referring to H. S. POWERS, *Language Models and Musical Analysis*, in: *Ethnomusicology* 24 (1980), p. 1–60. Reexamining some concepts of structuralism and linguistic analysis in relation to music, Powers holds (p. 18) that although speech is monodic on the surface, "it can be analyzed and represented polyphonically".

is it established that what has historically been termed "systematic" is logical, self-consistent, or musically valid. Mario Baroni has spoken eloquently on "the lack of a system" in systematic musicology.[8]

"What generally has precluded immediate delegation of a musical or musicological process to a computer is ... that explication of the process has not occurred", say Michael Kassler and Hubert Howe. For them, "'explication' ... refers to the restructuring of a process from an idea apprehended only intuitively to an unambiguous method that affects the process step by step..."[9] Kassler's and Howe's emphasis on an unambiguous method is central to the success of computer applications and there are those who would argue that it is essential to the logical validity of any research. A method may be systematic and still be riddled with ambiguities, as we shall see shortly. In computer applications, lack of ambiguity comes at the price of exhaustive completeness of information.

Technology – in contrast to the arts, mathematics, the sciences, and the social sciences – has no indigenous content. Methodology is its *raison d'être*. In contrast to musicologists, who appropriate so many of their working methods from other disciplines, technologists appropriate content on which to test and refine their methods. Technology is transparent. In providing means of implementing existing methods of research more fully and consistently, it imposes no necessary perspective of its own. Electronic musicology may therefore be expected to continue to pursue the traditional goals of scholarship in both historic and systematic musicology, but in addition it is likely to raise expectations for precision, completeness, and consistency, to foster new methods of research, and ultimately to spawn new theories based on the resulting sources of information.

If technology is slow to attract the interest of musicologists, music is not slow to attract the interest of technologists (including computer scientists, engineers, artificial intelligence researchers, mathematicians, statisticians, and acousticians). Some of this attraction may be based on practical and commercial considerations, but much of it is based on fundamental intellectual challenges. The problems of concurrent identity (sight, sound, mental perception) that have excited philosophers and aestheticians for centuries now excite programmers and artificial intelligence researchers. The familiar practice of representing pitch and duration with a single symbol fascinates cryptologists accustomed to one-to-one symbolic representations. Problems of contextual definition (When does a dot mean staccato and when a prolongation? When is A the first degree of a scale and when the sixth?) set musical information apart from originally numerical and alphabetic data, where the number of symbols used is fixed, the meaning unambiguous, and the processing order unvarying. To appreciate simultaneities and the subtleties that they engender is an exercise in multi-dimensional reasoning that has no exact analog in the processable data provided by other disciplines. These kinds of concerns are explored in the young but growing field of musical informatics. An important task for the future

[8] M. BARONI, *Elogio della musicologia sistematica*, in: *Rivista italiana di musicologia* 20 (1985), p. 332–52.
[9] M. KASSLER and H. HOWE, *Computers and Music*, in: *New GroveD* 4, p. 606.

will be to clarify the relationship between musical informatics, in which the emphasis is on the method, and electronic musicology, in which the emphasis is on the content.

This new relationship is not merely a two-sided one between different species of academic specialists. It is potentially a three-sided one, for, like recording and sound synthesis before them, music technologies only now in gestation may entice an increasingly wider public with easy access to data and procedures previously available only to specialists. Ultimately technology is a democratizing force. Just as microfilms and facsimiles have facilitated wide dissemination of once unique physical sources, so the encoding of musical repertories potentially puts sound reproduction and analytical capabilities within reach of any interested party. Much of the philological work of source criticism is again within the reach of amateurs. The consideration of such impending changes leads to the conclusion that if musicologists do not decide what aspects of music are fundamental to their efforts, technologists and the general public will.

These concerns have prompted the International Musicological Society to establish a continuing study group on musical data. The first objective of the group has been to conduct an assessment of needs associated with the use of musical data; its preliminary report, which incorporates the contributions of many members, is appended to this article. The views expressed here are solely those of the author. The balance of this article explores the new dialogue between method and content.

A New Dialogue

The dominant area of computer activity in historical musicology is information management, in which the main aim is storage and retrieval of information without significant manipulation. When information is stored in a systematic way, access is dramatically improved. Information management sets the stage for study and interpretation. Certain kinds of study and interpretation may be enhanced or impeded by the nature and completeness of the data and the manner in which it is stored. Two philosophies of data storage are represented by full-text and relational databases. In the first, complete texts of works are transcribed to support random searching, retrieval, and analysis by the user. In the second, a predetermined list of data elements (such as authors and titles) governs the construction of a table on which structured searches can be conducted and relations between categories studied.

It might seem that relational databases, in which the input process is structured, provide a more systematic approach to information management than full-text databases, but this is not necessarily the case. Information in its natural state tends to be disorderly and structure may be artificial. Structuring of input may require decisions to be made prematurely. Additional fields of information, different methods of transcription, wider tolerance for difference, or more articulate representations of the original information may prove to be desirable once the data is in use, but emendation is not always practical. The structure, in any event, is in the representation and the access, not specifically in the technique and certainly not in the data itself.

While full-text databases superimpose no structure of their own, structure may be imposed by associated software, as it is for the electronic version of the *Oxford English Dictionary*. Although all the words in the dictionary have been transcribed onto a compact disc, relational searches are supported only for tagged fields, while open-ended sequential searching (the analog of reading a book from cover to cover) and random browsing are not supported. Random searching and sequential reading of the *Thesaurus Linguae Graecae*, a compendium of 550,000 pages of literature, is supported on a scale for which there is no current analogy in musicology.

Systematic examination of specified attributes of large full-text data sources may require separate applications programs. At the current cottage-level of operations, owner-operated databases, in which there is no need for the roles of developer and programmer to be differentiated, prevail. As databases become larger and more numerous, however, the likelihood that the people who write the applications programs will be different from those who select and transcribe the data increases. It is at this point that the notions of programmers regarding appropriate systems of enquiry may prevail over the native perceptions of the data by musicologists.

These prospects are far more onerous for the management of musical data, because musical data, being by-and-large nonlinear, is infinitely more complex than text data, and because musical data has diverse representational aspects. Relational databases are of limited value in managing musical data because musical features (let us say "imitativeness" or "tonalness") must be interpreted prior to input and reduced to a word or a number; evaluation thus precedes rather than proceeds from management of information. Full-text databases of musical repertories are not currently available, although several are under development.[10] They hold the promise of bringing to the study of music the same possibilities of precision and consistency of method that are now possible in studies of text.

It is this prospect that raises the specter of a new dialogue between technologists and musicologists. The cause of precision is likely to be argued, in the first instance, by technologists and that of generalization by musicologists, but they both have much to learn from each other. What we must hope is that through continuing consultation and interaction, through constant refinement of techniques and frequent reevaluation of musical material, a synthesis capable of providing a secure and appropriate basis for musical research can be achieved. Let us examine these initially opposing thrusts in turn.

[10] The J. S. Bach Database, under development at the Center for Computer Assisted Research in the Humanities (525 Middlefield Road, Suite 120, Menlo Park, Ca. 94025) since 1985, currently holds full-score transcriptions of roughly half the works of the composer. Databases of the music of other eighteenth-century composers, including Handel, Telemann, and Corelli, are also under development. It is anticipated that sample data will have been made available by the time this article appears. The Center's intention is to make the entire database available at one time. Substantial quantities of the music of Josquin, Lassus, and other sixteenth-century composers were encoded at Princeton University in the 1960's and early 70's.

(i) Towards Precision: Systematizing Random Processes. – Accretions of systematic computer-aided methods of research from outside the discipline of musicology issue especially from lexical analysis and stylometrics. The first approach has been employed in literary studies for many decades, especially to assess questions of authorship, provenance, and chronology. Its potential use in musicology is in providing control over such primary sources as the writings of theorists. The second approach relies on statistical methods to evaluate questions that also often concern authorship or chronology. It often relies on the use of numerical descriptors of particular aspects of musical repertories. Employing the first, one might study the incidence of particular words or phrases to facilitate judgments about authorship, authenticity, or chronology.[11] Employing the second, one might study the incidence of particular pitches, pitch sequences, or incidences of particular rhythmic figures for the same purposes.[12] Both kinds of activities require the complete encoding of the material being examined.

A more prevalent avenue of research with musical data involves both the exploration of existing rule systems and the derivation of new ones. With respect to well-known theories of harmony, for example, Schoenberg's theory of regions, Lerdahl and Jackendoff's rules for phrase segmentation, and Schenker's explications of harmonic elaboration are all the subjects of computer-aided studies in which specific rules are being tested with encoded repertories.[13] Tests of various contrapuntal rules have been undertaken by generating new compositions from Fux's rules for first and second species.[14] Such efforts extend to tests of practical advice as well. The slight gradations of phrase articulation described in the eighteenth century by Engramelle in *La Tonotechnie* have been carefully translated to synthesized sound,[15] for example. Such investigations all concern procedures previously perceived as systematic. While in every case the results must be judged subjectively, it seems a fair comment on such activities that under close and

[11] Lexical analysis is facilitated by the Oxford Concordance Program, which is being used to study works incorporated in the THEMA (Archive of Musical Theoretical Documents of the Middle Ages) project undertaken by Sandra Pinegar, a graduate student in musicology at Columbia University. To date, more than thirty treatises have been encoded and lexically examined with the Oxford Concordance Program. The *Thesaurus Musicarum Latinarum* currently under development at Indiana University aims to include full-text writings from many centuries. Coefficients of correlation are supported by the Savvy PC program of text comparison used by John Walter Hill and Tom Ward (see *Two Relational Databases for Finding Text Paraphrase in Musicological Research*, in: *Computers and the Humanities* 23/2 [1989], p. 105–11) to study the migration of texts in Italian opera (Hill) and the dissemination of music theory in Central Europe in the later middle ages (Ward). These and many of the recent projects cited subsequently are listed in W. B. HEWLETT and E. SELFRIDGE-FIELD, *Computing in Musicology: A Directory of Research* (Menlo Park, Ca. 1989).

[12] Among the more persuasive examples of a purely statistical approach is Alison Crerar's preliminary study (*Elements of a Statistical Approach to the Question of Authorship*) of the works of Valentini, reported in: *Computers and the Humanities* 19 (1985), p. 175–82. Lynn Trowbridge's assessment of the conflicting attributions of 90 Renaissance vocal works (*Style Change in the Fifteenth-Century Chanson*, in: *Journal of Musicology* 4/2 [1985–6], p. 146–70) gives some idea of the kinds of multi-faceted queries that can be made when complete encoding of large repertories is accomplished. John Morehen's work-in-progress on manuscript attributions to William Byrd of Latin sacred works promises to take cognizance of the issue of musical validity, which has been discussed in an earlier work by him.

[13] The implementation of Schoenberg's theory was undertaken by Walter Colombo for a dissertation on mathematics at the University of Milan; the implementation of Lerdahl and Jackendoff's theories has been investigated by Lelio Camilleri and his associates in the Florence Conservatory/CNUCE collaboration (Pisa); Michael Kassler has worked on elaborating Schenker's "explications".

[14] For example, by William Schottstaedt at the Center for Research in Music and Acoustics at Stanford University (internal report, 1984) and by several authors of software for teaching counterpoint.

[15] By George Houle, with programming by Roland Hutchinson, at Stanford University.

systematic scrutiny, the original sets of rules often prove to be neither fully self-consistent nor consistently verifiable. In computer implementations of the precepts of practical music theory the most consistent "systems" (such as that of Engramelle) may be the least likely to provide uniformly convincing results.[16]

The generation of new rule systems (related to the development of grammars, heuristic systems, and expert systems) is being attempted for both notated and unnotated repertories. Sometimes leaning on structural linguistics for its operating principles, sometimes oriented toward the simulation of new works in a designated style of the past, this kind of work promises to be important because it lays the groundwork for a multitude of applications in both sound synthesis and semantic analysis. For Baroni and Jacoboni it has led to the identification of several hundred particular melodic and metric procedures used in the chorale melodies harmonized by Bach,[17] while for Ebcioğlu it has revealed that the harmonization of these same chorales involves at least 300 rules of procedure, including dozens that are not identified in existing theoretical works.[18] Grammars of jazz and other unnotated repertories, which are under development at several locations, promise to define similarly detailed rules of musical improvisation. The results that inspire the greatest confidence in this approach may be those concerned with monophonic repertories.[19]

It is inevitable that new perspectives on the principles of musical organization are occurring to those who have long been immersed in these seas of detail.[20] Some of those involved in the mechanization of musical processes are discovering contradictions and inconsistencies that challenge traditional explanations of tonal music theory.[21] Such consequences of efforts to systematize the methodology of the discipline reaffirm the ultimate interdependency of theory and practice.

(ii) Towards Generalization: Humanizing Mindless Uniformity. – Given perfect data and perfect programs, computers are tireless and unfailingly consistent workers. Consistency as a goal is a two-edged sword, however, because much of the work of musicology involves the recognition of likenesses where literal duplication

[16] Paul Brainard's electronic realizations of prescribed ratios of conversion from duple to triple meter in seventeenth-century music serve to identify another area in which literal and consistent application of principles from the canon of contemporary writings on performance practice may produce results that are unconvincing, even absurd.

[17] M. BARONI and C. JACOBONI, *Proposal for a Grammar of Melody: The Bach Chorales* (Montréal 1978).

[18] Ebcioğlu's work-in-progress is reported under the title *An Expert System for Harmonizing Four-part Chorales*, in: *Computer Music Journal* 12/3 (1988), p. 43–51.

[19] David Halperin, in *Contributions to a Morphology of Ambrosian Chant* ... (Ph. D. thesis, Tel Aviv University 1986), examines in minute detail the melodic material in chant phrases and identifies significant differences according to liturgical function (possibly reflecting the process of accretion in the formation of the liturgy, although no claims of this kind are made). As examples of the findings, (1) doxologies have the greatest number of pentatonic phrases per chant (p. 61); (2) unsuspected pentatonicism is revealed in many components when melodies are reduced to a "skeletal form"; and (3) the Lucernarium, which opens the office of Vespers, is the most melismatic component (p. 70).

[20] The writing of Moisei Boroda are illustrative. Many (including his thesis, *Principles of the Organization of Repetitions on the Micro-level of the Musical Text*, Tbilisi 1979) are available only in Russian or Georgian, but the flavor of Boroda's thought can be captured in translations of his work appearing in the first issue of the series *Musikometrika* (Bochum 1988), of which he is the editor. (Orders [DM 44,80] may be placed with Studienverlag Brockmeyer, Querenburger Höhe 281, D-4630 Bochum 1.)

[21] For example, in unpublished research my colleague Walter B. Hewlett has discovered mathematical implications in common musical notation that challenge classical theories of tonality.

either does not exist or is of little interest if it does. Consider, for example, the migration of cantus firmi through parts, through works, and through repertories; divisions, variations, and embellishment on or of themes; motivic development; and paraphrase of whole works. Such processes, all central to the European tradition in music, depend on a recognition of similarities that cannot be defined numerically. In fact some of the greatest triumphs of musicological discovery have involved recognition of extremely remote, but nonetheless valid, paraphrase of musical content.

Computers are easily able to locate exact matches, but to support inexact searches, they require careful instructions. In attempts to define musical similarity, one begins to appreciate how intuitive the "rational" process of human recognition is. Musicologists called on to provide explication of the recognition process may wish to reexamine some of their prevailing notions about the traits that are most significant in defining musical identity. This activity understandably has significant implications for the reconsideration of such fuzzy global concepts as "meaning", "interpretation", and "beauty". How large the number of traits that pertain in even simple musical queries is can be suggested by the following series of examples.

The six-note motive,

which can be traced to the hymn "Lucis creator optime", occurs in a number of Venetian sonatas of the seventeenth century.[22] It is either set out in whole notes and used as a skeleton for contrasting motives in smaller note denominations or it is used as a head motive that is repeatedly used in imitation by other voices. In either case it appears with equal stress on all six notes and without immediate repetition of individual notes. It is also the dominant (sometimes the only) theme present.

Its apparent simplicity suggests that corollaries can be sought purely on the basis of melodic contour. One place to look for possible matches thus is the highly systematic, computer-produced index by Harry Lincoln of Italian madrigals printed in the sixteenth century.[23] Surprisingly, all but three of the thirty-five matches for "Lucis" that result from searching for this six-note contour fail an intuitive test. The reasons for this failure are numerous and highly instructive. Some of the major ones are exposed by the following four examples:

– Match # 1 [S. Festa, "L'ultimo dì de magio", 1526]:

[22] E. SELFRIDGE-FIELD, *Venetian Instrumental Music from Gabrieli to Vivaldi* (Oxford 1975), p. 25, 141.

[23] H. LINCOLN, *The Madrigal and Related Repertories: Indexes to Printed Collections, 1500–1600* (New Haven 1988), lists 35,000 madrigal incipits. While there is an index of melodic contours, based on melodic motion rather than pitch identity, rhythmic information (required for printing of the incipits) is excluded in the sorting routines. The comments made in this article are intended to illustrate conceptual frontiers in computer-assisted research. As an example of information management, Lincoln's book is a magnificent achievement. If it did not exist, these observations would not be possible.

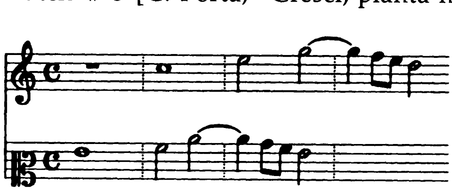
If this melody were reduced to its simplest melodic outline, it would be

which involves a sequence of intervals different from that of "Lucis". What has been ignored here is the attribute of stress, which is an apt example of a musical property that is universally acknowledged but not explicitly notated. Preliminary computer studies demonstrate that stress cannot always be reliably inferred from encoded rhythmic notation; in this case information concerning rhythm, meter, and accent have all been excluded in the sorting routine. Further, in this case, the fact that repeated pitches are excluded from the melodic profile that was indexed is conducive to a false match, but in other settings it might be conducive to a more accurate representation of stressed pitches. This kind of choice – what to represent and how to represent it – is typical of many others that could benefit from the collaboration of systems experts and musical experts.

– Match # 2 [J. Arcadelt, "Così mi guida amore", 1542]:

Not only does this example fail on the same two grounds as the first example; it also fails on the more fundamental ground of being in a different mode. This was missed by the computer because the melodic representation on which the sorting was based was diatonic. The human researcher has no difficulty in distinguishing a descending half step between the fourth and third degrees from a descending whole step, for the concept of diatonicism is a generalized plane of understanding subordinate to which there are many precise planes in which the interrelationships of elements vary. The vacuous mind of a computer cannot recognize hierarchies of information. Without additional information, it does not know what size interval exists between any two scale degrees, nor whether all intervals are of uniform size, nor whether there are recurrent sequences of intervals that match (i. e., modes). This example illustrates the need for greater precision in the pitch representation of the input. Uniformity that appears to be mindless frequently results from ignoring traits that were mistakenly assumed to be unimportant.

– Match # 3 [C. Porta, "Cresci, pianta novella", 1583]:



In this example the melodic contour is a by-product of contrapuntal considerations more nearly than it is a melody in its own right. The sequence of melodic intervals

will vary from entry to entry and voice to voice. The stress profile, in which the contour is essentially compressed, is again different from that of the model.
– Match # 4 [V. Ruffo, "Ove son quei bei chiari raggi", 1557]:

In this case the match is nothing more than a harmonic by-product of a homophonic setting of a different melody. Both this and the preceding example illustrate the critical importance of context in the assessment of similarity and difference.

Far from being neutral in key, meter, and accent, as one might originally have believed, the "Lucis" theme is brimming with concealed elements of musical information that must be disclosed if articulate and meaningful searches are to be supported. Further hidden elements of information could no doubt be identified if one carried the same thematic search into later centuries (for example, to the finales of Mozart's "Jupiter" Symphony or Saint-Saëns' Third ["Organ"] Symphony), where thematic extension and truncation, intervallic expansion and contraction, and other processes of transformation provide the stocks-in-trade of musical development.

The shortcomings of purely mechanistic approaches are acknowledged by technologists, but it takes human musical intelligence to determine what the best remedies are. Although solutions to the kinds of problems exemplified above have sometimes been proposed by researchers in artificial intelligence and musical informatics, there can be no true dialogue about them without the participation of musicologists. Without the interest of musicologists in the consideration of how to temper specificity with generalization, there can be no new dialectic.

Adler was providing embellishments of his own when he paraphrased Chrysander as having said, "The chief reason ... for doubting whether musicology can match the scientific study of the visual arts in depth and precision is that the nature of music is too indeterminate to permit of any scientific study that will satisfy the strictest requirements".[24] This paraphrase strikes at the heart of the matter. While the task of developing precise methods of enquiry may be possible, the art itself, which provides the entire motivation for the effort, will continue to captivate through its propensities for subtlety, ambiguity, deception, and contradiction. As we attempt to *precisare* our methods of investigation and to develop research strategies for the future, we may rest assured that our estimation of what we don't know will increase. In this respect, the goals of research will remain elusive and, in human terms, happily so.

[24] Chrysander's original statement of 1863 and Adler's paraphrase, to which he expressed his own objection, are both found in BUJIĆ, *op. cit.*, p. 353.

Report of the IMS Study Group on Musical Data

The IMS Study Group on Musical Data was formed in 1989 at the invitation of the directorate. Its formation is an outgrowth of the study session and technical exchange that took place as part of the Society's Fourteenth Congress, held in Bologna in August 1987. The study group is co-chaired by Walter B. Hewlett and Eleanor Selfridge-Field, who may be reached at the Center for Computer Assisted Research in the Humanities, 525 Middlefield Road, Suite 120, Menlo Park, Ca. 94025; its electronic addresses are XB.L36@Stanford.bitnet and XB.L36@Forsythe.Stanford.edu.

At present there are twenty additional members of the group. All are recognized contributors to the field and are currently involved in research projects involving machine-readable data. They are Mario Baroni (I), Moisei Boroda (USSR), Garrett Bowles (USA), Lelio Camilleri (I), Nicholas Cook (UK), Étienne Darbellay (CH), David Halperin (IL), Laura Callegari Hill (I/USA), John Walter Hill (USA), Alan Marsden (UK), John Morehen (UK), Leeman Perkins (USA), John Rahn (USA), Helmut Schaffrath (D), Herbert Schneider (D), Alexander Silbiger (USA), John Stinson (AUS), Andranick Tanguiane (USSR), Arvid Vollsnes (N), and Thomas Walker (I/USA). While considerable regard for geographical distribution and for diverse intellectual perspectives has been paid, additional members, especially from underrepresented countries and branches of the discipline, are being sought. It is likely that much of the work of the group will be carried out by task-oriented subgroups, and additional participants are welcome.

Each member of the group has made an assessment of the current use of computers in musicology from the perspective of his own area of expertise. Given that the initial enquiry was completely unstructured, there is a surprising degree of consensus on what the most important issues are. The areas identified by study group members fall into five general areas – (1) software, (2) hardware development, (3) research applications, (4) communications issues, and (5) issues related to use, reuse, and fair use of musical data.

I. Software issues

1. *Standards* for the encoding and transmittal of musical information constitute the biggest single area of concern. In the pursuit of this goal, the study group has been preceded by countless others. One of its members, Garrett Bowles, currently sits on the Musical Information Processing Standards group of the American National Standards Institute as a representative of the Music Library Association. The representation of musical information for academic use is a complicated issue to which an enormous amount of time has already been devoted. One practical proposal that encourages consolidation of encoding languages without cutting off debate prematurely is that the study group produce a handbook of the encoding schemes most widely and successfully used in musicology.
2. *Data and software design to support reuse* is so obviously a sensible objective that those uninvolved in computer applications might be surprised to discover the extent to which musical works may be encoded again and again according to different schemes. The group very much favors consolidation of such schemes and exchange of data. It urges those in the initial stages of project design to study existing systems carefully before deciding that only a new scheme of representation will do. Twenty-eight methods of encoding used in musicological research were briefly illustrated in the 1987 *Directory of Computer Assisted Research in Musicology*, which is available from the Center for US $ 10 plus postage.
3. *A cataloguing system for programs* is needed to facilitate rapid determination of what exists, where it is located, and in what format and under what terms it may be available. A program bank has also been proposed.
4. *The development of a query language* for musical information revives an idea that was first explored in the Josquin project at Princeton in the 1960's and was subsequently studied by Stephen Page in a D. Phil. thesis at Oxford University. It requires further study.
5. *The development of guidelines for new codes* has also been proposed and might follow as an addendum to a handbook of existing codes.

II. Hardware issues

1. *The development of a music workstation* has been proposed, although the implementation of such a proposal falls well outside the study group's charge. It is anticipated that a number of workstations capable of supporting a broad range of musical applications will be available within a few years.
2. *Data acquisition research* refers both to the optical scanning of notated music and to the automated transcription of electronically produced and electronically recorded music. While research and modest successes have been reported here and there, optical scanning of most music is not expected to be a practical or cost-effective alternative to other methods of acquisition in the near term. The study group lends its moral support to those exploring this technology but urges the IMS membership not to count on miraculous breakthroughs any time soon.

III. Research application issues

1. *The articulation of new methods of research* is discussed in a general sense in the preceding article. These will evolve naturally and undoubtedly will be evaluated in turn.
2. *The articulation of new concepts and theories* may be greatly facilitated by computer-based methods of research and these are certainly encouraged, but they too will evolve at their own pace. What is needed now is a forum for their discussion [on which, see IV].

IV. Issues related to communications and coordination of activity

1. *Greater coordination of research efforts* is considered essential to curtailing redundancy and fragmentation of research efforts. The question is, who should be responsible for this coordination?
2. *The establishment of a clearinghouse for databases* is a specific proposal that could facilitate exchange of information already stored. Outside musicology, a large number of machine-readable texts have been archived. Should newly created machine-readable material be deposited in such facilities as the Oxford Text Archive or an analogous facility, or should archiving be handled within the discipline?
3. *The resolution of issues related to rights and permissions* [see V] is fundamental to the success of schemes for reusable data and programs.
4. *The formation of a new society, the institution of an on-line journal, and the publication of a newsletter* are all suggestions that reflect the frustration some members encounter in trying to find a forum for the discussion and exchange of information concerning current happenings involving computers. What alternatives are available to facilitate this exchange without fragmenting the discipline?
5. *Interdisciplinary communication* with the technological community is essential to the furtherance of the possibilities discussed in the preceding article. How should it be organized?
6. *Initiation* of novices into the field could be facilitated by the formation of regional working groups of computer users and/or by the creation of an entry-level bibliography of instructive manuals, books, and articles for the novice user.

V. Issues related to use, reuse, and fair use of materials

1. *Reissue on mass storage devices* of machine-encoded material such as RILM abstracts is of interest to some members of the group and its feasibility is being explored.
2. *The development of machine-readable reprints* of text sources in the public domain is also under investigation.
3. *Examination of legal issues* relating to edited works protected by copyright and to unedited works requiring library permission to edit is deemed to be of fundamental importance to the accumulation of large bodies of encoded material. Currently, encoded versions of editions in copyright cannot legally be distributed. New technology is only legally applied to old editions. The same data that supports computer-driven printing processes is in many cases suitable for analytical and phonological uses, but its availability for such purposes may be contractually prohibited or impeded by the use of proprietary systems. Scholars participating in editorial projects based on computer-produced copy are urged to explore these issues prior to settlement of contractual agreements.