NEW METHODOLOGIES IN THE STUDY OF MELODY

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MELODIC comparison is an activity central to the study of music from many times and places. The use of machine-readable information to facilitate such comparison is disclosing significant lapses in our understanding of melody. In ordinary parlance, we often speak of melodies, tunes, and themes interchangeably, but in many repertories it is neither appropriate to consider them to be interchangeable nor is it correct to consider that an incipit represents any of them. Yet the computer process of data comparison could treat any of these melodic phenomena similarly with just cause. As musical information, they all involve pitch and durational elements. The critical issues, in fact, in machine comparisons concern which attributes to take to be defining. In some computer contexts, «melody» means a pitch contour devoid of rhythmic information. In others, accentual information, which must be enconded separately from the music itself, may be essential to the recognition of melodies the ear would consider to be similar.

The aims of this session were to share proven techniques for the management and analysis of such information, to report results from their use in highly diverse repertories, and to pose theoretical and practical questions raised in recent research. The six formal papers presented concentrated on three topics —melodic segmentation, melodic comparison, and melodic concordances. The formal presentations, which are summarized here, were supplemented by software demonstrations given on April 7 [see Appendix]. The full texts of the presentations will be published separately.

Melodic Segmentation

While we normally take for granted the longitudinal integrity of a melody, studies in structural and quantitative liguistics have engendered the belief that melodies are built up (and may be decomposed into) smaller indivisible units of melodic material. While in linguistics the identification of monemes and morphemes is for the most part straightforward and uncontroversial, this is not the case in music, since sound has many aspects —pitch, duration, timbre, dynamic level, simultaneously performed text, and so forth. In addition, music exists in a seemingly infinite number of styles and textures. A series of pitches that constitutes a melodic segment in one rhythmic context may not be perceived as a unit of meaning in a different rhythmic context.

In a series of studies begun at the Tbilisi Conservatory, Georgia [formerly U.S.S.R.], and carried forward at the University of Bochum, Germany, Moisei Boroda has attempted to extend and adapt principles of quantitative linguistics to establish rules for the rhythmic segmentation of melodies in diverse musical repertories. Parallels in the oscillation of structural complexity between musical and literary texts have been sought. The complexity of musical units (motif-type units or *mr*-segments [Boroda, 1988]) is estimated as the number of symbols in the 1:1 representation of their rhythmic structure; in literary texts word length is considered. In both musical and literary texts this oscillation underlies general regularities and is connected with general aesthetic principles of the organization of an artistic text.

In the associated numerical method, each pair of *mr* segments in a linear sequence is considered separately. If the second item is more complex than the first, it is assigned the number 1; if it is the same, 0; and if it is less, -1. Numbers can be concatenated to represent oscillations: *e.g.*, -1,1 represents a «first less, then more» situtation.

In European instrumental compositions of the eighteenth, nineteenth, and twentieth centuries, the pairs -1,1 and 1,-1 have been found to occur much more frequently than other pairs. In examining the entire melody, however, neighboring segments tend to coincide in value. This is not true in vocal music or in literary texts, where oscillations of segment (or word) length tend to be consistent between the overall composition and the component vocabulary.

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The work of Lelio Camilleri at the Florence Conservatory and C.N.U.C.E., Pisa, Italy, has been concerned with segmenting melodies in encoded material automatically according to concepts advanced in the recent literature of music theory and structural linguistics. The concepts explored were those of grouping structures (Lerdahl and Jackendoff 1983) and of the signifying unit in the paradigmatic analysis of Ruwet (1972) and Nattiez (1975). These theories were chosen for implementation on account of their high degree of explicitness.

In Camilleri's view, musical analysis should be thought of not only as the labelling and classification of musical entities but also as process of reasoning about music, and one should integrate into a general framework the way a piece can be scrutinized by means of multiple analytical concepts. New theories of music which have evolved in such recent subspecialties as the semiotics of music, music perception, and cognitive studies are based on more fundamental notions of music than earlier theories were.

The rule system used in the program for paradigmatic analysis formulates a measurable definition of group boundaries by weighting the role of several musical parameters (interval, metrical position, dynamics, and so on). This measure should represent the perceptual space in which the parameters are mapped out. Other factors being equal, a group is perceived when it is composed by any element which differs from the previous element by an interval which is greater than those immediately preceding and following it. A new group perception occurs when a change of degree of similarity between the previous group and the new one occurs.

Melodic Comparison

Melodic comparison is an essential task related to a great array of musicological goals. In the context of this session, the emphasis was on questions motivated ultimately by studies of the process of transmission in monophonic repertories of quite diverse natures. The first group of repertories considered were chant repertories principally of the fourteenth century. John Stinson of La Trobe University (Victoria, Australia) reported on a long-sustained project involving numerous kinds of statistical comparison.

To use the computer as a research tool in repertoires before the seventeenth century it is necessary to represent not only those elements of the notation it has in common with more recent notation —staff, clef, pitch, duration— but also those which are characteristic of early repertories: neumes and ligatures, coloration, mensuration, and proportion.

Even the representation of manuscript accidentals needs to be done in a way which does not further obscure the complex issues of *musica ficta* and microtonality, on which there is still little agreement among musicologists. Moreover, the representation needs to be both graphically accurate and musicologically intelligent, so that whatever is seen on a manuscript folio can be seen on the computer screen and its musical significance registered with the precision and the ambiguity of the original.

What results might justify the labor of re-encoding musical notations in a form which can be processed electronically? Computers are hard of hearing; and while they can be taught to recognize sounds, many of the problems of early repertoires we might wish to solve are problems which must be solved at a pre-auditory stage. Computers have no musical culture and cannot make discriminating musical judgments. They can perform menial tasks such as counting, searching, and indexing quite well. Such menial tasks can facilitate research by providing the researcher with the data on which discriminating judgments might be based. Simple counting procedures, when applied to notes, intervals and syllables can document stylistic features such as the intervallic content of a repertory, the characteristic patterns of notes per syllable associated with particular genres, the relationship of specific intervals to modes and melodic motifs common to works with the same finalis.

This falls short of what many would consider true music analysis; but analytical descriptions of music are full of quantitative statements (expressed by the terms «more than», «frequent», «rare», «common», etc.) which can be easily made precise by having the computer count for us. Counting can provide reliable information about three criteria which have been used since the middle ages for the understanding, categorization, and description of melodies (Jerome of Moravia). Searching for any of the elements of encoded information (neumes, pitches, text or commentary) or descriptive identifiers (manuscript, folio, liturgical function, composer, genre, voice) is an essential research function. Ordering by any of these parameters can give us insights into the textual, contextual, and musical relationships between melodies.

The program SCRIBE has been under development since 1983 for use as a research tool for specialists in the musical repertoires before the seventeenth century. The SCRIBE database currently holds 4564 items of Dominican chant, encoded from an early fourteenth-century set of antiphonals and graduals now in Perugia, checked against contemporary Dominican sources now in Bologna, London, Rome, and Melbourne as well as standard printed editions of the text (Dominican breviaries and missals as well as Hesbert's *Corpus antiphonalium officii*). By their common use of Hesbert's numbering of liturgical texts, the SCRIBE database can be easily related to other large chant projects underway in Hungary, the United States, and elsewhere.

In a recent study of Cypriot chant, three sets of statistics were found to be relevant: the numbers of notes per syllable, the interval set used, and the statistics relating to modal behavior. The number of notes per syllable is strongly related to the genre of the chant. The second stylistically relevant element of liturgical chant is the interval set used. It may be noted that Dominican antiphons, and especially those written for feasts instituted from the beginning of the 14th century, strongly favor stepwise motion. A third set of statistics relating to the modal function of chant melodies reveals an interesting shift in the meaning of modality throughout the middle ages. If the four most frequently repeated notes of each chant are counted, there is a significantly broader spread of the four most frequent notes in the pre-Dominican chants.

All of the analytical techniques applied to this analysis are well established in the chant literature and are not therefore «new approaches to the study of melody». But when the computer can be used for counting notes per syllable and the frequency of particular pitches as well as for analyzing the intervallic content and behavior of large repertories, tedium is diminished and accuracy increased. When large repertories can be differentiated in age and provenance, the simple procedures of counting, searching, and ordering can produce results which contribute to our understanding of the nature of melody and the discrimination of style.

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At Essen University, Germany, more than 13,000 folk melodies have now been stored in a computer database. The stored works range from the context of sixteenth-century *Liederbücher* through nineteenth-century collections of songs from rural areas of Germany and Central Europe to recently transcribed melodies from China. A large number of programs also developed at Essen by Helmut Schaffrath and his students and colleagues facilitate various kinds of analysis. Melodies are represented diatonically in ESAC (Essen Associative Code).

To give a simple example of search procedures, if one requests a search for the sequence of pitches «1 2 3 5 4 3» [*Do Re Mi Sol Fa Mi*] identifying the incipit of the famous German/Austrian song «Innsbruck ich muss dich lassen», 47 variants will be located. Some of them, however, will have different numbers of repetitions of individual pitches or other features, such as the positioning of rests, that distinguishes them from this abstract representation of pitch contour. When a collection of 162 Asturian folksongs was encoded as a contribution to this conference, it was not anticipated that one example relevant to this search would issue from that repertory. Various analytical functions facilitate greater and lesser degrees of abstraction, comparison of rhythmic profiles, the index of tones used in the works, and so forth.

A different use of the data involves manipulating tunes according to various principles of construction. For example, the sequence of accented tones can be rearranged. This method of rearrangement is called «melodic recycling». In one case, segments of all the Asturian songs starting with 1-5-5 were interleaved with phrases of different tunes to form new melodies. In tests administered to five groups of persons with diverse levels of musical training, the least well trained were most adept at recognizing the artificial folk songs.

Melodic Concordance

Finding tune relationships is a fundamental task of music bibliography. Precise, complete transcription can be an unattainable goal, confounding efforts to trace or compare. At the same time, to locate inner essences that match, search programs may have to overlook certain kinds of surface detail. At the present time, all approaches to machine comparison of melodies should be regarded as exploratory.

In its local database, the U.S. RISM office maintains a data element for citing concordances among manuscripts. Concordances comprise a data pool against which the effectiveness of methodologies and sort algorithms can be measured. There is also some potential for estimating the effectiveness of various methodologies in dealing with more than one type of repertory. In this project, led by John Howard and based at Harvard University, musical incipits of seventeenth- and eighteenth-century manuscripts are first encoded in *Plaine and Easie Code. Plaine and Easie* has been found to be excellent for explicit representation of musical detail but somewhat awkward for sorting purposes. The RISM Zentralredaktion has adopted a metacode for such sorting. The US office as alternatively employed a local implementation of *DARMS* to facilitate sorting. [Both codes were first developed in the 1960s in New York].

To approach the problem of generalizing precise incipits to promote the discovery of otherwise undetected similarities, four different approaches to «idealization» of the melody have been explored:

1. Transposition of all encodings to a common pitch register.
2. Elimination of symbols for all non-sounding elements of notation, such as beams and barlines.

3. Elimination of grace notes and other ornaments.
4. Elimination of rhythmic values, rests, and ties in conjunction with transposition to a common register (as in #1).

The results in some cases confirm and in other cases differ from results obtaining with similar kinds of computer sorts run on the incipits held in Frankfurt.

The sample repertory consisted predominantly of unattributed tunes. Full encodings and transposed encodings were effective in sorting works attributed to known composers but they were of less value in sorting the unattributed works. The results of rhythmically neutral incipits (Type 4) were similar. Sort Types 2 and 3 were not successful for either the attributed or the unattributed melodies.

The problem of machine separation of tunes which are easily recognized by the ear as being related can be traced to four possible factors:

1. Differences of detail in notational conventions (*e.g.*, tied versus dotted notes).
2. Variations in the rhythm of specific figures (*e.g.*, dotted eighth/sixteenth versus two eights).
3. Smalls intervallic differences in the initial pitches.
4. Differences in the use of rests and repeated notes.

While each of these problems is conceptually quite simple, they pose complex problems if the relevant question relates to how one manipulates an encoded value for the purpose of establishing musical identity. Most relate as well to text-critical studies of composed music. Development of methodologies for dealing with the most extreme instances of these problems could, therefore, also benefit the study of an entire repertory embraced by RISM Series A/II.

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The project to create a *Catalogue des Sources Manuscrits en Tablature* (CDSMT) discloses important differences between lute tablature and common musical notation, especially when efforts to create an encoding system for tablature are made. In developing *TabCode*, Timothy Crawford wished to differentiate between a quick transcriptional process to capture pitch and duration and a complete rendering that would additionally record such prescriptive information as fingering. *TabCode* standardizes on French tablatures in the belief that German, Italian, and Neapolitan tablature features can be represented in French form.

There are certain ways in which tablature and MIDI (Musical Instrumental Digital Interface) code are differentiated from common musical notation: neither can represent enharmonic tones, for example. Tablature provides a two-dimensional grid from which the player can determine at which intersecting frets he should press the string. It does not give the tuning of the instrument, which could vary widely over time and place. Some testing of possible tunings may be necessary for encoded tablatures, which lack pitch information in an absolute sense.

These peculiarities cannot fail to complicate the task of searching for concordances, cognates, and resettings. Cognates are those works in which a basic outline is maintained but inner parts may be altered and new divisions may be provided. Resettings refer especially to composers' treatments of popular tunes and bass patterns. For the present, it may be most fruitful to look for common features between incipits and rank them according to a scoring system such that an absolute identity scores 100, while divergences accrue weighted penalties until a cutoff value is reached.

The CDSMT project has as one of its goals the aim of integrating its catalogue with RISM's, so that the extent of cross-concordances between lute, vocal, ensemble, and other instrumental music can be assessed. Yet significant problems arise within the lute repertory to thwart efforts at automatic melodic recognition and comparison. These include a lack of precision in voice-leading and consequent difficulty in recognizing cadences, recognition of a continuum of match-types that extends to a different setting of the same tune, incompatibilities of musical data between tablature and conventional notation, and the existence of variants between manuscript sources due entirely to the presence or absence of explicit performance data.

None of the solutions to these problems could be described as trivial. It may be best to seek concepts and methods from outside the discipline of musicology. The notion of «fuzzy» matches drawn from the field of artificial intelligence, for example, has obvious value in seeking melodic similarities. List processing, pattern matching, and connectionist models in parallel processing are other procedures from the world of computer science that may hold promise. Facing these problems should offer interesting challenges to computer scientists and musicologists alike and may add to understanding what Thomas Mace in 1676 described as «the best Musick in the World».

[*This compilation was made by Eleanor Selfridge-Field, who chaired the event, from drafts submitted by the authors. Walter B. Hewlett presented the paper of John Howard, who was unable to attend. An extensive and lively discussion followed the formal presentations.*]

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APPENDIX

Demonstration of Non-Comercial Software for Musicologists
April 7, 1992

Centro para la Difusión de la Música Contemporánea

Programs for IBM PC-compatible computers

ASOUND: A program in Turbo Pascal for automatic analysis of chordal structure and function with support for musical display of score and graphic display of results.

Project leader: Eva Ferková, Institute of Musicology, Slovak Academy of Sciences, Dùbravská c.9, 84364 Bratislava, Slovakia.

MAPPET: A family of programs for input, storage, retrieval, display, playback, and analysis of monophonic (especially folk) music linked with a database of musical information and supporting text documentation (provenance, source, type, etc.). More than 13,000 items have been stored using ESAC, the Essen Associative Code for musical information, in an AskSam database.

Project leader and chief programmer: The late Prof. Dr. Schaffrath's work is now continued by Ulrich Franzk Am Eschenbruch 10, W-4630 Bochum, Germany, and Ewa Dahlig, Instytut Sztuki PAN, ul. Długa 28, 00-950 Warszawa, skr. 994, Poland.

PROGRAM FOR PARADIGMATIC ANALYSIS: Supports implementation of theoretical models of musical analysis and conversion of results to the SCORE data format for printing.

Project leader: Lelio Camilleri, Conservatorio di Musica «L. Cherubini», Piazza delle Belle Arti 2, 50122. Firenze, Italy; tel: + 39 55-282105; e-mail: *CONSERVA@IFIIDG. FI.CNR.IT*

RENARC: A structured relational database program for input, storage, and retrieval of archival documents concerning Renaissance musicians.

Project leader: Leeman Perkins, Dept. of Music, Columbia University, New York, NY 10027, USA.

RICERCAR: A program for storing, indexing, and retrieving archival documents input as unstructured ASCII text

Version A —uses conventional upper ASCII diacriticals

Version B —provides *sui generis* support for the use of diacriticals and obsolete abbreviation signs.

Programs by: Thomas Griffin, 1255 Taylor Street, San Francisco, CA 94108, USA; e-mail: *griffin@lib.ucsf.edu*

RISM: Software for storage, display, searching, and pattern-matching of musical incipits entered into the RISM databases in Plaine and Easie Code.

Project leader: Klaus Keil, RISM Zentral Redaktion, Sophienstr. 26, 6000 Frankfurt 90, Germany; tel: +49-069-706231; fax: +49-069-706026.

SCRIBE: A family of programs for the input, storage, retrieval, display, printing, and analysis of fourteenth-century monophonic music notated in neumes and early polyphonic music in mensural notation. More than 2300 works have been encoded.

Project leader: John Stinson, Scribe Software Associates, La Trobe University, Bundoora, Victoria 3083, Australia; tel: +61 03-479-2879; fax: +61 03-478-5814; e-mail: *MUSJS@lure.latrobe.edu.au*

Programs for the Apple Macintosh

CHATULL GADOL: A program that operates with HyperCard to search for characteristics (text incipit, mode, source, liturgical function, etc.) and pitch patterns in multiple chant traditions (Gregorian, Old Roman, Beneventan, Ambrosian).

Program by: Max Haas (Basel University) representing Tristram Shandy Software Laboratories, Leimenweg 10, CH-4419 Lupsingen, Switzerland.

EXPERIMENTS IN MUSICAL INTELLIGENCE (EMI): A family of programs (in LISP) that provide intensive analysis of musical style in works of a specific repertory and then generate new works employing user-defined parameters of key, mode, meter, etc. in the same style. A tape of sample results was demonstrated.

Programs by: David Cope, Porter College, #88, University of California, Santa Cruz, CA 95062; tel: (408) 423-2418; e-mail: *howell@cats.uscs.edu*

Mozart and **Palestrina.** Two courseware programs to introduce the concepts of *musikalisches Würfelspiel* («Mozart») and species counterpoint («Palestrina»).

Programs by: David Evan Jones, UC Santa Cruz [see above], *dej@cats.ucsc.edu*; previously distributed by Dartmouth Music Courseware, Humanities Computing, Dartmouth College, Hanover, NH; a newer program, *Counterpoint Assistant* is under development.

Subtilior Press: A program for late-Medieval and Renaissance mensural notation running with *HyperCard.* Supports facsimiles of illuminated initials, ligatures, and white mensural notation.

Program by: David Palmer, 292 Maurice Street, London, Ontario N6H 1C5, Canada; tel: (519) 642-4510.

TabCode: System for ASCII encoding of musical information in tablatures (fingerboard positions and hand strokes) and its use in cataloguing, printing, pattern-matching, and analysis. Developed on a Macintosh but intended to be machine-independent.

Program by: Timothy Crawford, Department of Music, King's College, University of London, Strand, London WC24 2LS, England; tel: +44 071-836-5454; e-mail: *UDWM045@OAK.CC.KCL.AC.UK*

Thesaurus Musicarum Latinarum: A database of Latin writings on music theory from the early Middle Ages through the Renaissance available by list server. Runs with standard text search software on most computer systems; development is chiefly on the Macintosh.

Project leader: Thomas J. Mathiesen, Dept. of Music, School of Music, Indiana University, Bloomington, IN 47405 (*MATHIESE@IUBACS.BITNET* or *MATHIESE@UCS.INDIANA.EDU*).

[*This event was organized by Eleanor Selfridge-Field, facilitated by Zulema de la Cruz, and administered by Helmut Schaffrath and Arvid Vollsnes.*]

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