Computer Applications: Analysis and Modeling
Author(s): Bo H. Alphonce
Source: *Music Theory Spectrum*, Vol. 11, No. 1, Special Issue: The Society for Music Theory: The First Decade (Spring, 1989), pp. 49-59
Published by: University of California Press on behalf of the Society for Music Theory
Stable URL: http://www.jstor.org/stable/745949
Accessed: 03/11/2009 07:16

Computer Applications: Analysis and Modeling

Bo H. Alphonce

For this presentation I am much indebted to Deta Davis, who very kindly lent me a prepublication copy of her forthcoming bibliography on computer applications in music. With its several thousand entries, it promises to become the standard reference in its field. On the assumption that publication activities reflect the relative importance of trends and currents, my first two figures are based on quantitative data extracted from the Davis bibliography. The remaining figures combine information from several sources, the most important of which is the Davis book. Concerning recent developments I have received valuable advice from my McGill colleague Bruce Pennycook.

Figure 1 shows for a number of areas how the last decade compares to the pre-1977 period. White bars show how much literature in each area falls before and after 1977. They present a clear trend: publication has increased in almost all areas; in fact, it has increased by a factor of about nine if one considers that the late period covers only about a third as much time as the early period. The black bars show the relative output of all areas within each period. From both comparisons it is clear that the areas of aesthetics and musicology, including analysis, have at best held steady, while the other areas have grown very rapidly.

Figure 2 looks at some of the factors contributing to the increase. This graph is based on numbers of entries for the years 1977 through 1984 in Davis's chapters on sound generation hardware and software on micro- and mini-computers, and on articles about MIDI. The micro-computer curve rises early; the advent of MIDI in 1983 pushes both the hardware and software curves sharply upward.

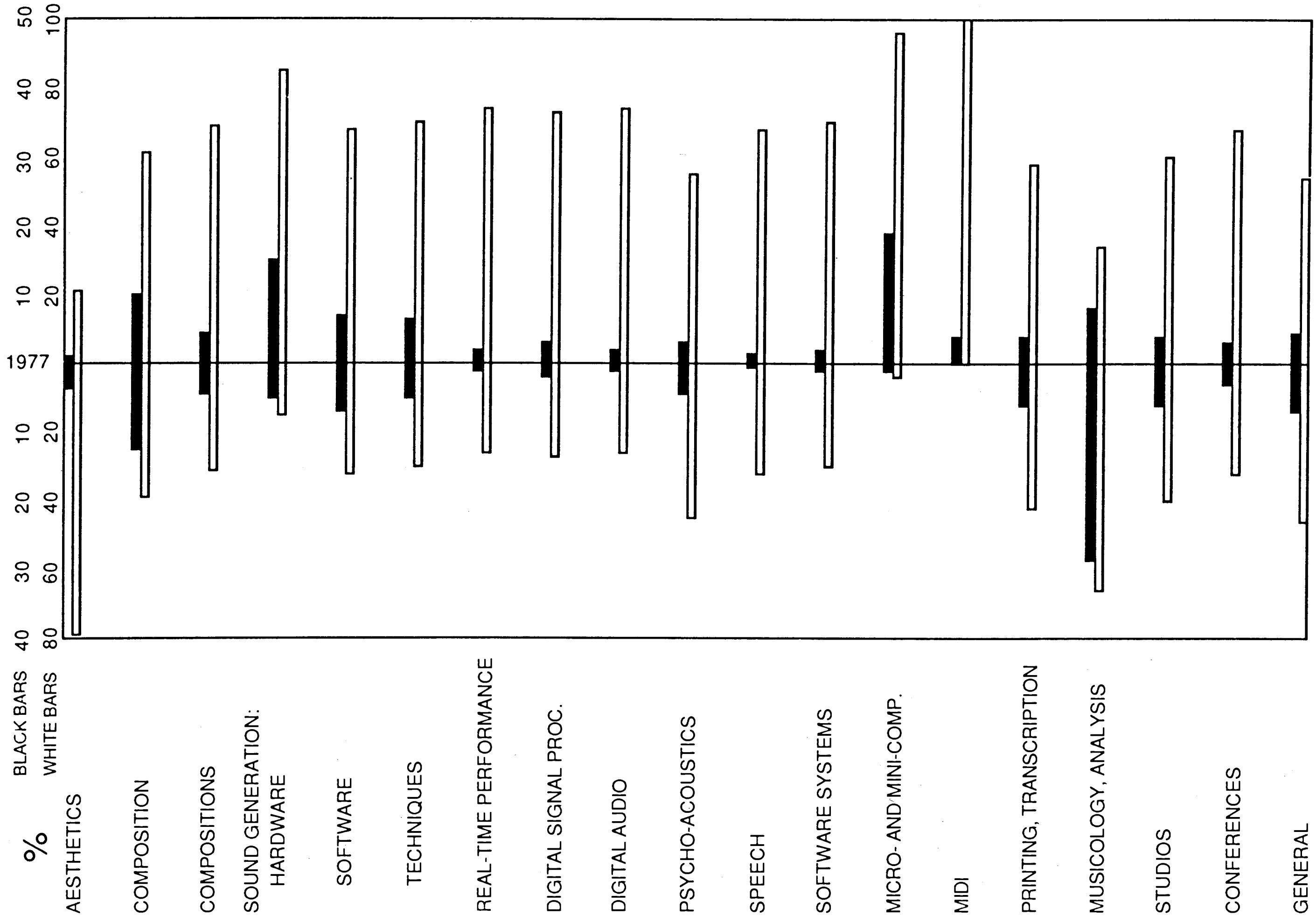
The remainder of this presentation is devoted to some of the trends in computer applications during the SMT decade. As the largest and most influential, the composition area would merit its own separate presentation. Since developments in computer composition are readily available in publications of the Computer Music Association, I am restricting myself here to the areas of music theory and analysis.

Figures 3 through 5 contain a number of author names distributed over our decade. The lag in library information processing makes entries sparse in 1986 and 1987; also, despite the abundance of names on the charts, omissions are even more abundant, and there may be inaccuracies. I am anxious to stress that omissions do not reflect a judgment of quality on my part. Moreover, I shall cover only selections from the charts while the rest will provide a kind of context for your reflections.[1]

Figure 3 concerns music input and output. While much ingenuity has been spent on all aspects of music I/O, two particularly challenging areas are those of score input and sound input. The core of the first area is the problem of optical score recognition, which was solved in principle for a small subset of notation by David Prerau in 1968. Problems of practical and financial feasibility, however, have remained. The Helmers, Andronico, and Tojo entries represent important advances, but, so far, Ichiro Fujinaga's current work at McGill promises to become

[1]While the charts do not associate names with publications, these may be traced through the appended bibliography. If a name appears neither under the corresponding year in Section 3 nor in congress reports for that year in Section 2, it is included in one of the bibliographies listed in Section 1. A " + " on the chart indicates more than one author.

Figure 1



Relative Shares of Areas Measured by Numbers of Bibliographical Entries in Deta S. Davis, *Computer Applications in Music: A Bibliography*

Black Bars: Share among all areas before and after 1977. White Bars: Share before and after 1977 within each area.

Figure 2

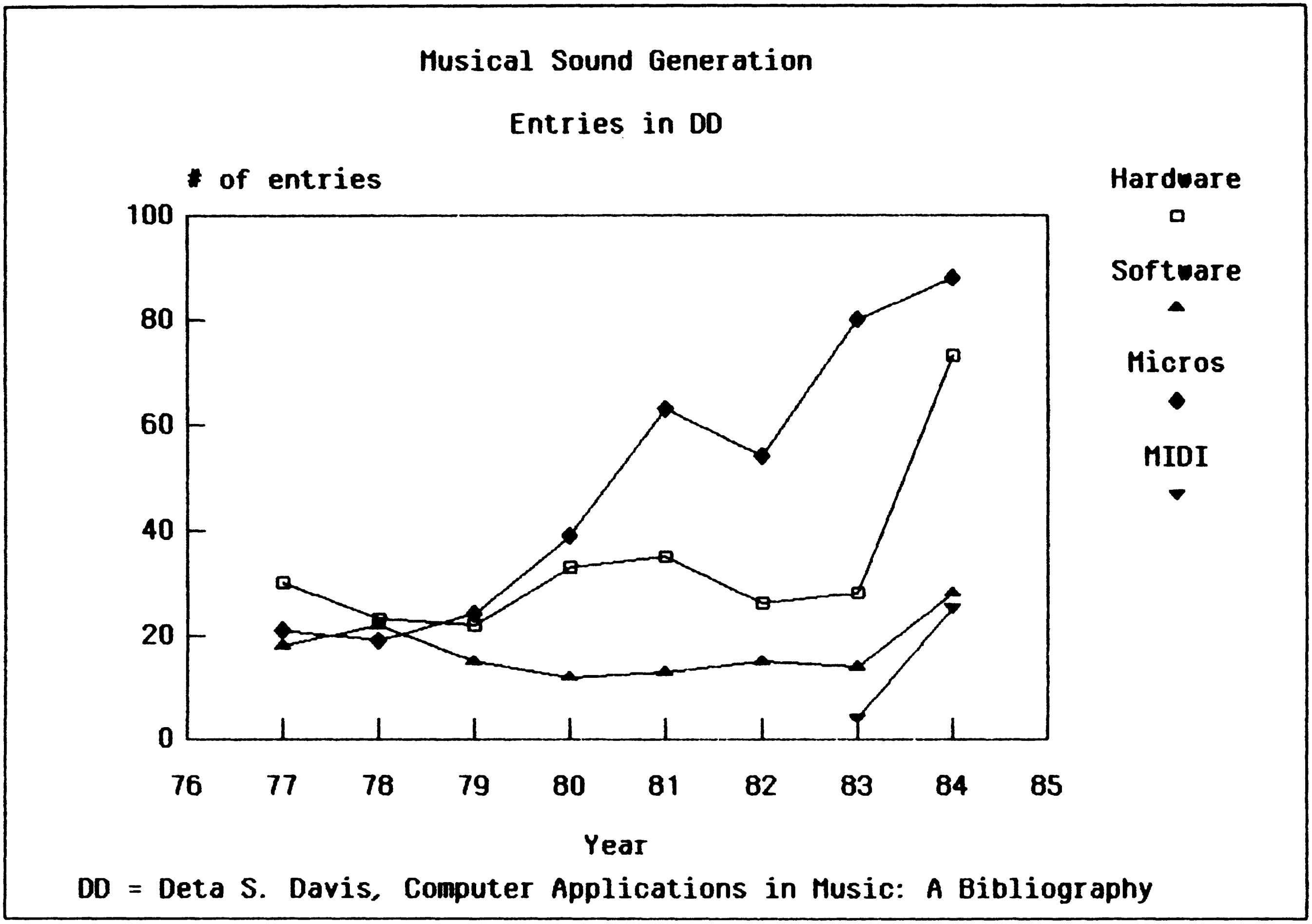

Musical Sound Generation
Entries in DD
# of entries
100
80
60
40
20
0
76
77
78
79
80
81
82
83
84
85
Year
Hardware
Software
Micros
MIDI
DD = Deta S. Davis, Computer Applications in Music: A Bibliography

Figure 3: Input and output

	Transcription Projects	Code Systems	Optical Recognition	Sound Input	Data Management	Editing	Printing
77	Ducasse+ Charnassé	Gomberg Wolff		Moorer Piszczalski+	Lincoln	LeLouche	Lincoln Geant
78	Hultberg Barenholtz	Wenker Mózi, De Poli Nerheim		Piszczalski+ Galler	Bertoni+	Reeves+ Wallraff	Dal Molin Humphreys
79		Nerheim Bales+		Askenfelt Piszczalski+	Hickey+	Buxton+ Patel	
80		McLean	Helmers		Charnassé	Nelson	Smith Byrd
81	Charnassé Crawford	McLean		Piszczalski+	Inokuchi Jackson		Roads Rumery
82	Monfils	Debiasi+	Andronico+ Tojo+	Rush+		Chafe+ Foster+	
83	Monfils Crawford	Morehen Brinkman					Humphreys Bauge
84		Heineman		Imai Niihara Schloss	Keith Brinkman	Minciacchi Prusinkiewicz	Minciacchi Byrd
85		Schnell		Chafe+ Schloss			
86	Charnassé Stépien				Brinkman	Byrd Dannenberg Assayag+	
87			Fujinaga			Cook, Dydo Free, Hamel Müller+	Assayag+ Hamel

Figure 4: Theory and analysis

	Tone Systems Temperaments	Theory Explication	Knowledge Representation	Analysis: Models	Analysis Similarity	Analysis: Pretonal	Analysis: Tonal	Analysis: Posttonal	Analysis: Systems
77		Kassler Smoliar Vaglio		Baroni+			Brantley	Bernard Tenney	
78				Polansky	Ballo+	Patrick+ Sentieri Zimmerley	Brinkman	Riotte Sward	Lande
79	L efkoff	Rothgeb Smoliar		Bazelow Baroni+, Snell	Böker-Heil	Ambrosini	Brinkman Hofstetter		Lande
80	Yunik Balzano			Rahn Simonton			Ellis, Gross Marillier	Kolosick	
81	Chalmers+			Baroni+, Sward De Stefano		Reid	Gross	Kolosick	Stech
82	Chalmers			Gagliardo Spiegel	Dillon Steinbeck	Trowbridge		De Berardinis	Sukho
83	Blair Dannenberg Vendome			Camilleri, Ellis Escot, Rahn Snell, Spyridis	Foxley	Huglo Pearce		Lagassé Russell Simoni	
84		Deliège		Adamo, Baroni+ Hiller+, Narmour Oppo, Roads		Plenckers Rahn	Ebcioglu	De Berardinis Gross Riotte	Gross
85			Ashley	Mont-Reynaud+ Roads					
86	Barbieri Del Duca		Kaegi Kuipers Lischka+, Pope	Degazio Logrippo+ Morehen			Ebcioglu		Brinkman+ Camilleri+ Dyer
87	Code		Lischka	Polansky Roeder					Code Dembski

Figure 5: Perception, AI, performance

	Perception and Cognition				Artificial	Performance	
	General	Timbre	Other Parameters	Constructs	Intelligence	Human	Computer
77	Laske Wessel	Grey Matthews		Tenney		Bengtsson	
78	Wessel	Ehresman Grey	Gordon Risset	McAdams Tenney	Holtzman		
79	Bamberger Searle	Howe Wessel		McAdams	Meehan		
80	Laske	Charles Matthews Wessel	Rogers Sidiskis	McAdams			
81	Blesser, Doati Laske, McAdams Piszczalski				Balaban Laske, Minsky Segre	Shaffer	
82	Clynes Piszczalski	Charbonneau Risset Strawn	Gordon	McAdams	Balaban		
83		Strawn			Laske	Sundberg	
84	Bianchini McAdams			Longuet-Higgins McAdams Millar	Balaban Duisberg	Fryden+	Clynes
85	Beauchamp	Martens McAdams+ Slawson			Balaban Leman Roads	Gabrielsson Todd	
86	Tedde	Freed+	Balzano Küpper			Friberg+ Mackenzie+	
87		Martens	Holland	Polansky	Cope Lischka		Pennycook

the first optical recognition system within financial reach of most research institutions. The second area is the computer recognition of recorded sound to which Moorer, Galler, Piszczalski, and Askenfelt have all made impressive approaches. Nobody has been entirely successful with polyphonic music; the recent work by Chafe, Mont-Reynaud, and others holds promise for successful frequency discrimination by means of separation of the upper partials.

Figure 4 shows especially the proliferation of models applied to musical structure. The predominating categories are statistics and grammar models. On the chart, Simonton represents multivariate content analysis, Sward mathematical and statistical models applied to twentieth-century music, Spyridis information theory, and Logrippo and Stépien cluster analysis of Eskimo material. In 1983 Ellis, and in 1986 Morehen, write critically on the validity of statistical models as applied to music. Baroni and Snell work with generative grammar. Camilleri and Rahn in 1983 apply grammar models to melody and harmony, respectively; Adamo investigates a grammar of musical performance; and Oppo discusses a general linguistic theory of music. In 1984 and 1985 Roads presents surveys of musical grammars. Among other models there is Tenney's hierarchical gestalt model (used and further developed by Polansky), geometrical models applied by De Stefano and Escot, the implication-realization model by Narmour, and the general systems theory applied by Lejaren Hiller and his co-investigators.

John Roeder has sent me a copy of his recent paper, "A Declarative Model of Tonal Analysis," where "a declarative system which infers complex musical structures from the elementary musical relations that it identifies" is offered as an alternative to procedural analysis. Roeder's paper reflects a recent trend; this approach is also represented by the Ashley entry (on a "rule- and fact-based program for representing and using musical knowledge"), by Kaegi and Kuipers in the CANON System, the "MIDIM Language and its VOSIM Interpretation," and by the Pope article on "Music Notation and the Representation of Musical Structure and Knowledge."

Among the analysis entries, most of which represent well-known approaches, I would like to draw your attention to the analysis of style change over time, represented by the Tenney paper on Ruggles from 1977 and the 1978 Sentieri paper on a long-range style shift in Renaissance music. Much of the post-tonal analysis is set-theory oriented; see, for example, the Kolosick and Simoni contributions.

Besides the software system reported by Camilleri and co-authors in a recent issue of *Interface,* I also want to highlight Alexander Brinkman's and Craig Harris's CMAP (Contemporary Music Analysis Package) system that is on display at this conference, and two other new systems: a set-theoretic system by David Code at the University of Illinois, and a LISP-based macro-instruction system by Steven Dembski of the University of Wisconsin, primarily intended for composers but with promise also for analysis. Code also contributes to the study of tone systems and temperaments with his Notepro preprocessor program, which is capable of reproducing a number of different temperaments. In the same area Barbieri and Del Duca reported in 1986 on a system that allows reproduction of early music using 19- and 31-tone temperaments.

In the area of perception and cognition (Figure 5), Otto Laske is a central contributor with his essay collection on cognitive musicology from 1977, his essays on psychomusicology from 1981, and his 1980 article on a cognitive theory of musical listening. Piszczalski's contributions also concern musical listening; so do those of Steven McAdams, a former student of Albert Bregman's at McGill, who in a number of reports has developed Bregman's auditory stream theory into a theory of auditory images. Among the timbre entries McAdams addresses the question of "the ability of various dimensions of timbre to carry form." In this context, one of the most significant recent contributions is Wayne Slawson's book "Sound Color," which won SMT's publication award in 1986.

Otto Laske's name is important also under the Artificial Intelligence heading. Among other contributors, Balaban develops his AI applications in tonal music into a discussion of a "formal basis for the computer modeling of music theory." Holtzman's AI-based work in style-oriented music production deserves mention as one of the most successful such programs. In December 1985 Curtis Roads presents a survey of AI applications.

Finally, in studies of musical performance Bengtsson represents a pioneering effort in the study of rhythmic performance "dialects." His work has been shared and developed by Gabrielsson at Uppsala University. Sundberg in Stockholm uses simulated performance in order to formulate a rule system for musicality in human performance. In a similar vein Clynes works towards introducing musicality into computer performances.

One single glance at pedagogy will be allowed into this talk—not in computer-aided instruction but in instruction-aided computing. I refer to the text in computer programming for music researchers currently in preparation by Alexander Brinkman.

In general, it is evident that some of the most exciting current ideas and developments emanate from those who are active in or close to centers for computer music composition. The computer's demand for concept analysis and precision down to the most minute detail may have contributed to the relative slow-down of new research in computer-assisted music analysis. Fast technological developments and recent imaginative advances in general music theory, however, are likely to encourage also scholars in analysis to contribute to the accelerating increase in computer research. Closer cooperation among theorists and composers is one way in which computer-assisted musicology can be revitalized.

BIBLIOGRAPHY

In order to keep this bibliography within space limits, literature up to about 1977 was excluded; for a selective list, refer to the first entry below. Since *Dissertation Abstracts* and *Master Index* have their own efficient indexing, a number of significant dissertations and theses have not been included. No references have been made to *Computer Music Journal*—by far the richest source of pertinent papers; the Bernardini indexes listed in the third through fifth entries below offer a convenient short-cut to volumes 1 through 9. In selecting papers from other sources, only a few of Bernardini's subject areas were considered; in general, papers dealing with computer composition (technology, software, actual compositions) were not included. Instead, the emphasis is on Artificial Intelligence, theory explication, models of musical structure, perception and cognition, approaches to music analysis, studies of performance and simulated listening, automatic transcription of sound, and score I/O.

Entries are listed in chronological order by year within each section. The first section lists a few bibliographies which, in turn, refer to other bibliographies. The second section contains a selective list of congress proceedings where a significant number of papers deal with the topics mentioned above. The third section contains selections from other sources; many of them contain extensive bibliographies.

I. BIBLIOGRAPHIES

The New Grove Dictionary of Music and Musicians. 6th ed. S.v. "Computers and Music."

Hewlett, Walter B., and Selfridge-Field, Eleanor. *Directory of Computer Assisted Research in Musicology*. Menlo Park, Calif.: Center for Computer Assisted Research in the Humanities, 1985–87. Annual issues beginning in 1985.

Bernardini, Nicola. "Contents of *Computer Music Journal* Volumes 1–9, 1977–1985." *Computer Music Journal* 10/1 (1986):17–36.

———. "Author Index of *Computer Music Journal* Volumes 1–9, 1977–1985." *Computer Music Journal* 10/1 (1986):37–39.

———. "Subject Index of *Computer Music Journal* Volumes 1–9, 1977–1985." *Computer Music Journal* 10/2 (1986):51–55.

Davis, Deta S. *Computer Applications in Music: A Bibliography*. Madison: A-R Editions, 1988.

II. CONGRESS REPORTS

Centre national de la recherche scientifique. *Informatique musicale 1977, Textes des conferences, Equipe ERATTO*. Edited by Henri Ducasse. Paris: Centre de documentation sciences humaines, 1978.

Computer Music Association. *Proceedings of the 1978 International Computer Music Conference*. Compiled by Curtis Roads. San Francisco: Computer Music Association, 1979.

———. *Proceedings of the 1980 International Computer Music Conference*. Compiled by Hubert S. Howe. San Francisco: Computer Music Association, 1982.

Institut de Recherche et Coordination Acoustique/Musique. *Le compositeur et l'ordinateur* (17/21 février 1981). Paris: IRCAM, n.d.

Computer Music Association. *Proceedings of the 1981 International Computer Music Conference*. Compiled by Larry Austin and Thomas Clark. San Francisco: Computer Music Association, 1983.

Conciglio Nazionale delle Richerce. *Atti del Quarto Colloquio di Informatica Musicale*. Pisa: CNUCE-CNR, 1981.

Computer Music Association. *Proceedings of the Venice 1982 International Computer Music Conference*. Compiled by Thomas L. Blum and John Strawn. San Francisco: Computer Music Association, 1985.

Baroni, Mario, and Callegari, Laura, eds. *Musical Grammars and Computer Analysis: Atti del Convegno* (Modena, 4–6 Ottobre 1982). Florence: Leo S. Olschki, 1984.

Conciglio Nazionale delle Richerce. *Atti del Quinto Colloquio di Informatica Musicale*. Edited by Goffredo Haus and Gianni Orlandi. Ancona: Università di Ancona, 1983.

Centre national de la recherche scientifique. *Informatique et musique, Second symposium international*. Edited by Hélène Charnassé. Ivry: ELMERATTO, CNRS, 1983.

Computer Music Association. *Proceedings of the Rochester 1983 International Computer Music Conference*. Compiled by Robert W. Gross. San Francisco: Computer Music Association, 1984.

———. *Proceedings of the International Computer Music Conference, 1984*. Edited by William Buxton. San Francisco: Computer Music Association, 1985.

———. *Proceedings of the International Computer Music Conference, 1985*. Edited by Barry Truax. San Francisco: Computer Music Association, 1985.

———. *International Computer Music Conference, 1986*. Edited by Paul Berg. San Francisco: Computer Music Association, 1986.

———. *Proceedings of the 1987 International Computer Music Conference*. Compiled by James Beauchamp. San Francisco: Computer Music Association, 1987.

III. BOOKS AND ARTICLES

1977:

Gomberg, David A. "A Computer-Oriented System for Music Printing." *Computers and the Humanities* 11 (1977):63–80.

Kassler, Michael. "Explication of the Middleground of Schenker's Theory of Tonality (1)." *Miscellanea Musicologica* 9 (1977):72–81.

Laske, Otto E. *Music, Memory, and Thought: Explorations in Cognitive Musicology*. Ann Arbor: University Microfilms International, 1977.

Wolff, Anthony B. "Problems of Representation in Musical Computing." *Computers and the Humanities* 11 (1977):3–12.

1978:

Bengtsson, Ingmar; Gabrielsson, Alf; and Gabrielsson, Barbro. "RHYTHMSYVARD: A Computer Program for Analysis of Rhythmic Performance." *Svensk Tidskrift för Musikforskning* 60/1 (1978):15–24.

Forte, Allen. *The Harmonic Organization of "The Rite of Spring."* New Haven and London: Yale University Press, 1978.

Frankel, Robert E.; Rosenschein, Stanley J.; and Smoliar, Stephen W. "Schenker's Theory of Tonal Music—Its Explication through Computational Processes." *International Journal of Man-Machine Studies* 10 (1978):121–138.

Tenney, James. *Hierarchical Temporal Gestalt Perception in Music: A "Metric Space" Model.* Toronto: York University, 1978.

Wittlich, Gary; Byrd, Donald; and Nerheim, Rosalee. "A System for Interactive Encoding of Musical Scores Under Computer Control." *Computers and the Humanities* 12 (1978):309–319.

1979:

Askenfelt, Anders. "Automatic Notation of Played Music: The VISA Project." *Fontes Artis Musicae* 26 (1979):109–120.

Hofstetter, Fred T. "The Nationalistic Fingerprint in Nineteenth-Century Romantic Chamber Music." *Computers and the Humanities* 13 (1979):105–119.

1980:

Brinkman, Alexander R. "The Melodic Process in Johann Sebastian Bach's *Orgelbüchlein*." *Music Theory Spectrum* 2 (1980):46–73.

Holtzmann, Stephen R. "A Generative Grammar Definition Language for Music." *Interface* 9 (1980):1–47.

Simonton, Dean Keith. "Thematic Fame and Originality in Classical Music: A Multivariate Computer-Content Analysis." *Journal of Personality* 48 (1980):206–219.

1981:

Laske, Otto E. *Music and Mind: An Artificial Intelligence Perspective.* Boston: Otto Laske, 1981.

Piszczalski, Martin B.; Galler, Bernard A.; Bossemeyer, Robert W.; Hatamian, Mehdi; and Looft, Fred J. "Performed Music: Analysis, Synthesis, and Display by Computer." *Journal of the Audio Engineering Society* 29 (1981):38–46.

Stech, David A. "A Computer-Assisted Approach to Micro-Analysis of Melodic Lines." *Computers and the Humanities* 15 (1981):211–221.

1982:

Clynes, Manfred, ed. *Music, Mind, and Brain: The Neuropsychology of Music.* New York and London: Plenum Press, 1982.

Steinbeck, Wolfram. *Struktur und Aehnlichkeit: Methoden automatisierter Melodienanalyse.* Kieler Schriften zur Musikwissenschaft, vol. 25. Kassel: Bärenreiter, 1982.

Tojo, Akio, and Aoyama, Hiroshi. "Automatic Recognition of Music Score." In *Proceedings, 6th International Conference on Pattern Recognition,* edited by Manfred

Lang (Silver Spring, Md.: IEEE Computer Society Press, 1982), 1223.

1983:

Baroni, Mario. "The Concept of Musical Grammar." Translated by Simon Maguire and William Drabkin. *Music Analysis* 2 (1983):175–208.

Spyridis, H., and Roumeliotis, E. "Fourier Analysis and Information Theory on a Musical Composition." *Acustica* 52 (1983):255–262.

Sundberg, Johan, ed. *Studies of Music Performance.* Stockholm: Royal Swedish Academy of Music (Publication No. 39), 1983.

1984:

Duisberg, Robert. "On the Role of Affect in Artificial Intelligence and Music." *Perspectives of New Music* 23/1 (1984):6–35.

1985:

Arnold, Wasiuddin J. "Raga Rupa: Computer Analysis and Sangita-Shastra." *Sangeet-Natak* 76 (April-June 1985):9–35.

Leman, Marc. "Dynamical-Hierarchical Networks as Perceptual Memory Representations of Music." *Interface* 14 (1985):125–164.

Roads, Curtis. "Research in Music and Artificial Intelligence." *ACM Computing Surveys* 17 (1985):163–190.

Slawson, Wayne. *Sound Color.* Berkeley and Los Angeles: University of California Press, 1985.

Todd, Neil. "A Model of Expressive Timing in Tonal Music." *Music Perception* 3 (1985):33–57.

1986:

Brinkman, Alexander R. "Representing Musical Scores for Computer Analysis." *Journal of Music Theory* 30 (1986):225–275.

Camurri, Antonio; Haus, Goffredo; and Zaccaria, Renato. "Describing and Performing Musical Processes by Means of Petri Nets." *Interface* 15 (1986):1–23.

Gabrielsson, Alf. "Interplay between Analysis and Synthesis in Studies of Music Performance and Music Experience." *Music Perception* 3 (1986):59–86.

Kuipers, Pieter. "CANON: A System for the Description of Musical Patterns." *Interface* 15 (1986):257–269.

Logrippo, Luigi, and Stépien, Bernard. "Cluster Analysis for the Computer-Assisted Statistical Analysis of Melodies." *Computers and the Humanities* 20 (1986):19–33.

Mackenzie, C. L.; Vaneerd, C. L.; Graham, E. D.; Huron, D. B.; and Wills, B. L. "The Effect of Tonal Structure on Rhythm in Piano Performance." *Music Perception* 4 (1986):215–225.

Pope, Stephen Travis. "Music Notations and the Representation of Musical Structure and Knowledge." *Perspectives of New Music* 24/2 (1986):156–189.

1987:

Bennighof, James. "Set-Class Aggregate Structuring, Graph Theory, and Some Compositional Strategies." *Journal of Music Theory* 31 (1987):51–98.

Camilleri, Lelio; Carreras, Francesco; Grossi, Pietro; and Nencini, Giovanni. "A Software Tool for Music Analysis." *Interface* 16 (1987):23–38.

Kowalski, David. "The Construction and Use of Self-Deriving Arrays." *Perspectives of New Music* 25/1–2 (1987):286–361.

Lewin, David. *Generalized Musical Intervals and Transformations.* New Haven and London: Yale University Press, 1987.

Morris, Robert D. *Composition with Pitch-Classes: A Theory of Compositional Design.* New Haven and London: Yale University Press, 1987.

Roeder, John. "A Geometric Representation of Pitch-Class Series." *Perspectives of New Music* 25/1–2 (1987):362–409.