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Review of Peter Castine's *Set Theory Objects: Abstractions for Computer-Aided Analysis and Composition of Serial and Atonal Music*

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ABSTRACT: *Set Theory Objects* explores the process of developing a computer program for assisting in the composition and analysis of post-tonal music. The author surveys the set-theoretical literature, and deals with various issues related to the design, development, and implementation of such a program. Included are tables detailing formal definitions for most set-theoretical functions.

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1. Contents

[1.1] Peter Castine's *Set Theory Objects: Abstractions for Computer-Aided Analysis and Composition of Serial and Atonal Music* (hereafter referred to as STO) actually represents several texts in one. From the author's straightforward discussion of set-theoretical principles to his fascinating look into the process of developing a powerful computer tool for assisting composers or theorists in the manipulation of these set-theoretical operations, the book offers both a broad and informative look into the complex world of cross-disciplinary study in significantly different domains, while at the same time suffering from the difficulties of trying to place two hats on the same figurative hook.

[1.2] STO (essentially a reprint of Castine's Ph.D. Dissertation in communications science and musicology from the

Technical University Berlin, 1994) is divided into six chapters with three additional appendices covering several rather discrete, yet interlaced, topics. The first and third chapters offer a rather brief, yet interesting, overview of the myriad issues—both historic and current—that the author dealt with in developing his computer project. The second chapter offers a selectively-detailed overview of set-theoretical concepts, enhanced by two appendices presenting a complete set-class table and a compilation of formal definitions and theorems. The last three chapters present a rather detailed, yet incomplete, journey through the actual process of conceptualizing, defining, refining, and implementing a Macintosh-based computer program. A final appendix offers a limited set of programming definitions, primarily useful for those "hard-core" programmers intent on understanding the most fundamental underlying design principles of the project.

[1.3] While Castine is to be lauded for undertaking such a multifaceted project, any real attempts on his part to integrate these materials into a cohesive work appear to be absent. As happens all too frequently in many dissertations, Castine appears simply to have avoided the issue by offering his reader a collection of six relatively discrete chapters, which, upon closer examination, actually divided rather cleanly into three rather self-contained groups. This observation is not intended to diminish Castine's work, but finding value from STO demands that the reader treat the work as two very different texts, bound together for convenience under one cover. For most readers their interest in the work most likely will lie in one or the other of the two camps, relinquishing the composite text primarily to those of us similarly involved in melding computer technology with musical inquiry.

[1.4] Having said all this, a more substantial look at each of the component chapters of the book clearly is in order. I have chosen here, however, not to present the discussion in chapter order, but rather to base my discourse around chapters sharing related content.

2. Group I: Introduction & Overview (Chapters 1 and 3)

[2.1] Castine, in his rather brief (six pages) introductory chapter, begins interestingly enough by laying out quite clearly just what he believes STO is not about. He writes that, while "it had been [his] intention to include a 'critical evaluation' of set theoretic methods and their application to music analysis," as work on the project progressed he became acutely aware that inclusion of such a discussion "would be of only marginal interest, since the usefulness of set theory has been, frankly, discussed to death" (p. 16). Castine also wants his readers to be very aware of his own self-imposed limits regulating the design and function of his computer program when he states that

> This [work does not represent] an attempt to create a program to analyze music without human intervention. Indeed, the fields of computer science (in general) and artificial intelligence (in particular) have made great strides [and computer programs potentially] could produce interesting or even valuable results. There are, however, several reasons why this path was not pursued. . . . [One of these reasons is] aesthetic and philosophical: I am not interested in trying to replace the human being in the musical process; I am interested in giving him tools to allow him to concentrate on his work while making the mechanics of that work easier (p. 17).

[2.2] The author is also concerned that we understand his intended scope and limitations regarding the set-theoretical tools chosen for integration into his work. Castine's project was inspired almost entirely by his desire to expand and enhance an earlier set of computer programs, Contemporary Music Analysis Package (CMAP), developed by Craig Harris and Alexander Brinkman (1987) for MS-DOS and Unix-based computers. While Castine states clearly that "there are significant differences between the work done by Brinkman and Harris and mine, and in certain aspects my objectives have been diametrically opposed to those originally presented in Harris's dissertation," he specifically sets out to document the development of a program that would "provide (at least) the functionality, flexibility, and speed as the original version of CMAP in a form that would be considerably easier to use, that would be available to a far larger number of musicians" (p. 19).

[2.3] As part of his rationale for undertaking this project, Castine sets out in chapter three to survey other such projects. By constraining himself, however, to those programs "whose authors have made an effort to disseminate their work beyond an immediate circle of colleagues and students" (p. 76), Castine severely restricts his survey to less than a half-dozen programs, of which only CMAP is privileged with any significant discussion. Given Castine's belief, however, that "None of the

programs available for Macintosh provide the flexibility nor comprehensiveness of CMAP" (p. 91), this shortcoming is at least rationalized.

3. Group II: The Computer Program (Chapters 4–6, Appendix C)

[3.1] Castine's discussion of the development of his computer program encompasses the largest portion of the book, spanning three chapters totalling seventy pages. It is perhaps most likely the fourth chapter (Designing User-Oriented Software for Set Theory) from which the reader will gain the most benefit. Castine devotes over thirty pages to exploring and detailing solutions for what many would consider the most important aspect of any useful program: the user interface. The author is careful to consider such factors as the historical nature of the problem, the target audience, the purposeful definition of specific tasks, and the overall basic design of the user interface. Castine's discussions are both thorough and insightful. He clearly knows his topic and has put a great deal of energy into creating elegant and useful solutions for typical interface problems. The author's solution for this project is elegant and simple: he opts for the use of an "analytic scratchpad," a program window based on a spreadsheet-like metaphor that offers a very powerful and simple way to manage a constantly varying number of music objects (sets) linked by any myriad number of different operational relationships. Being able to place sets into cells anywhere on the scratchpad, and then to be able to apply various set-theoretical operation to either individual sets or combination of sets, clearly allows for a wide range of possible analytical paradigms and working methodologies. Castine offers a solution somewhat analogous to a piece of scratch paper with a built in analytical calculator that does not require the user to push many buttons to make it work—the solution is so straightforward and basic as to have eluded any number of programmers for quite some time. This chapter definitely should be read and digested by any programmer even thinking of undertaking such a project.

[3.2] The remaining two chapters, while offering some valuable insights, do not really carry through the informational richness presented in chapter four. Chapter five does offer an interesting triptych of the process of actually implementing the program. In the absence of any program code, or charts diagramming some of the basic functionings and design considerations of the program, the materials presented at best can offer little more than a taste of how this undertaking unfolds at select points throughout the development process.

[3.3] Chapter six details those things that Castine feels still need to be done to enhance the functionality of his program. In a way, this section presents us with a good lesson in futility, as Castine is so apt to show us—albeit inadvertently—as he begins to explore possible avenues of future program enhancement. Initially, Castine's discussions draw value from their close proximity to the current (i.e., completed) task. Continued musings, however, quickly lead the reader further from the core foundation of the program into a potentially endless abyss. Anyone of us might be able to sit and speculate with a fair degree of fluency as to how this or that of a particular program might be improved, but unbridled flirtations with "what if" scenarios, while they may certainly entertain, will probably offer nothing much new in the end.

4. Group III: Set Theory And Serialism (Chapter 2, Appendices A–B)

[4.1] Chapter two, at around fifty pages, weighs in as the second major component of STO. As a detailed discussion of set-theoretical and serial principles, it is also at best only peripherally related to the other materials of the book, yet it offers the reader perhaps one of the better overviews of the topic—albeit a slightly myopic one—that I am aware of. The materials are not presented in any formal pedagogical manner—Castine opts instead for a decidedly historical perspective. Instead, he presents the basic materials in a concise and well organized descriptive manner. Although Castine's discussion is strongly based on the composite views of many theorists and composers—such as those of Milton Babbitt, George Perle, Edward Cone, David Lewin, and Peter Westergaard—particular attention is paid to ideas expressed in three significant works published at the time of his study: *The Structure of Atonal Music by Allen Forte* (1973), *Basic Atonal Theory* by John Rahn (1980), and *Composition with Pitch-Classes* by Robert Morris (1987), hereafter referred to as CPC. Perhaps most importantly, Castine's discussion is specifically limited (with a few exceptions) to those elements representing the core materials imbedded in CMAP, a fairly comprehensive collection, yet one with significant roots in the three works cited above. Included in this chapter are the following sections:

- Pitches, Pitch Equivalence, and Pitch Classes

- Intervals, Interval Equivalence, and Interval Classes
- Ordered Sets, Unordered Sets, Rows, and Cycles
- Set Membership and Cardinality
- Twelve Tone Operations
- Properties of Unordered Sets
- Set Equivalence and Set Class
- Set Class Relations
- Segmentation, and Other Objections

[4.2] Throughout these discussions, the author employs terminologies and formalizations as promoted by Morris in CPC. Specifically, Castine feels that Morris's notational convention "has the advantages that it is as succinct and precise as any: it reflects most contemporary developments in set theory; it adheres closely to conventions used in mathematical set theory; and has found wide acceptance" (p. 23).

[4.3] Early in the chapter Castine promotes a notion that "the reader will find roughly equal attention paid to both analytical and compositional aspects of set theory" (p. 23); however, I found no real evidence to support his claim. For the most part, the various discussions are presented clearly and without any sense of bias. The chapter contains several excellent charts, such as the one summarizing basic set operations; and the text is abundantly supported with historically informative footnotes. Castine does occasionally make a few problematic statements, such as regard to enharmonic spelling as being "in accord with standard conventions in atonal music" (p. 25) [italics are mine]. The chapter also contains a rather odd section on "dissonance" in post-tonal music—a topic with no direct correlation to traditional set theory as espoused here. Essentially, Castine offers no real insight on the topic except to conclude that "a general theory of dissonance (or musical tension) compatible with set theory is lacking" (p. 61).

[4.4] Two related appendices are also included. Appendix A contains a complete table for all sets of cardinalities one through twelve. The information is presented in tabular form and contains all the basic information found in the original CMAP table for each entry: a Fortean set name, prime form, z-relatedness, m-relatedness, interval-class vector, invariance vector, and adjacent interval vector. Perhaps more valuable as a pedagogical aid is Appendix B, which contains a set of formal definitions and theorems for all the topics covered in chapter two.

5. Conclusions

[5.1] It needs to be expressed again that, to evaluate the effectiveness and usefulness of this book, one needs to be able to see beyond the dual nature of the work. Clearly, the inclusion of two distinctly different topics poses a number of organizational problems that the author seems not to have been able to resolve effectively, leaving a bit of a schizophrenic taste in the mouth of the reader. Each part obviously is more successful by itself, yet the two halves never really join forces. On the other hand, when effectively isolated from one another, the two primary topics each can be of much greater value, particularly depending on individual readers' needs and interests.

[5.2] Perhaps most interesting to the larger theoretical audience is Castine's lengthy discussion of set-theoretical issues. He offers the reader a sound, well-documented historical overview that is presented in a clear and concise manner—yet, perhaps at times, a bit too objectively, as topics such as Forte's K/Kh relationships are typically presented with no discussion of the relative merits of such notions. And, readers must be aware of the CMAP bias driving Castine's discussion, particularly noting the omission of many relevant theoretical concepts such as Morris's work with contour-space and pitch-space, or various other authors' work with similarity measures—all of these notions have been well established long before the writing of this book. Nonetheless, despite the problems and omissions of the text, chapter two perhaps could be utilized quite effectively as an introductory body of materials for a graduate-level course in set theory, particularly in light of the excellent reference materials presented in the appendices. But, then again, what do we do with the other five chapters?

[5.3] More problematic is the status of computer program itself. All of the wonderful and creative ideas notwithstanding, a well-conceived interface married to a powerful set of analytical tools is of real value only to the user of that program. Unfortunately, much of Castine's work exists only on paper. What is coded and running lives up to the promise of the prose,

but is still too incomplete to fulfill its real pledge of offering us a powerful and intuitive analytical tool. As with any large undertaking such as this, the path to success is all too often fraught with worldly pitfalls and obligations. Lest I be blamed simply for casting the first stone, let me first express my sincerest hope that the programming efforts already begun will eventually see the light of day. I have witnessed the beginnings and know that we will all benefit greatly when the end finally comes.

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