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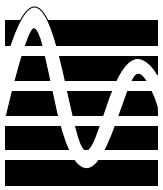

EXPERIMENTS IN MUSICAL INTELLIGENCE

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2nd Edition with New CD-ROM

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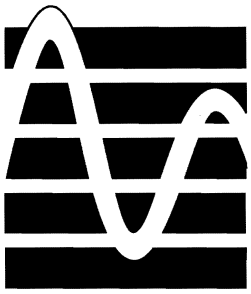
Contents



ONE

Background and Overview

Computers and Musical Style (Cope 1991a) argues that computers can be of significant help in finding musical *signatures*, or often used patterns that signal a composer's style. *Experiments in Musical Intelligence* argues that composers create music by mixing such signatures and using *recombinancy*, or the recombination of elements found in other of their works and in the music of other composers. The program that is described in this book and on the accompanying CD-ROM uses signatures and recombinancy to create music. This program thus parallels what I believe takes place at some level in composers' minds, whether consciously or subconsciously. The genius of great composers, I believe, lies not in inventing previously unimagined music but in their ability to effectively reorder and refine what already exists.

Deryck Cooke, in *The Language of Music*, states that "inspiration is an unconscious re-shaping of already existing material" (Cooke 1959, p. 171). For centuries, composers have experimented with ways of consciously "re-shaping" existing music to create new but stylistically convincing works. For example, Athanasius Kircher (1650) and Wolfgang Printz (1696) wrote extensively about melodic and harmonic permutations called *ars combinatoria* (Ratner 1970). Kircher's lengthy Book VIII of his *Musurgia Universalis* (1650) is dedicated to *ars combinatoria*. Kircher begins with a mathematical exploration of the possibilities of combining melodic elements, complete with charts listing the number of permutations of available notes given certain numbers of repetitions. Unlike later treatises, Kircher devotes little discussion either to histories of music *combinatoriae* (of which there were few in his time anyway) or to compositional and aesthetic processes

involved in making or choosing particular sets of *combinatoriae*. Rather, he delights in large numbers as if he were an astronomer extolling the virtues of a night sky resplendent with stars. *Musurgia Universalis* is important for its time, and it is significant in that such a major section of this work is devoted to the nascent concept of combinatorial possibilities in music.

Printz's *Phrynis Mytilenaeus oder der Satyrischer Componist* (Printz 1696), although not as devoted to mathematical extrapolations as Kircher's *Musurgia Universalis*, demonstrates its author's interest in the extensive combinatorial possibilities of the variety of melodic lines possible above a given bass. He notates these melodic alternatives thoroughly and in a way not inconsistent with more formal *ars combinatoria* of the century to come.

One of the first formal types of music to incorporate combinatorial possibilities was the eighteenth-century *Musikalisches Würfelspiel*, or musical dice game. The idea of these musically sophisticated games was to compose a series of measures of music that could be reassembled in many different ways and still be stylistically viable. Thus, even a very simple piece becomes a source of innumerable new works (a typical *Würfelspiel* of sixteen measures yields 11^{16}, or roughly forty-six quadrillion, works), and each, although varying in aesthetic quality, is stylistically correct. The music of a *Musikalisches Würfelspiel* is typically arranged randomly to obscure the fact (particularly to the musically uninitiated) that all the choices for a first measure, for example, are of the same general musical function. These arrangements no doubt made such games seem all the more fantastic in the eighteenth-century parlor, where they were often played. However, matching the numbers in the pool of choices with their respective measures demonstrates that the music of each measure is in fact functionally specific and note-similar, with each measure often a simple variation of, and interchangeable with, others of the same function.

Acknowledged to be the first such *Musikalisches Würfelspiel*, the polonaise from Johann Philipp Kirnberger's *Der allezeit fertige Polonoisen- und Menuettenkomponist* (Kirnberger 1757) is organized in phrases of six- and eight-measure lengths. The combinatorial possibilities here equal 11^{14}, which, including the minuet and trio (with 11^{32} possibilities), results in a number so large that the "entire population of eighteenth-century Europe, working a lifetime on these games could not exhaust the combinations that lie within Kirnberger's minuets and polonaises" (Ratner 1970, p. 344). Figure 1.1 provides an example of a matrix for a first phrase and a polonaise drawn from this prototype *Musikalisches Würfelspiel*. The numbers

CD-ROM

The *Musikalisches Würfelspiel* shown in figures 1.1 to 1.4 can be heard via MIDI playback by launching the *Würfelspiel* program on the accompanying CD-ROM and selecting the composer desired. Timbre suggestions, which appear in the windows accompanying each selection, are based on the composer's own instrumentation given in the original publications. Listening to these *Musikalisches Würfelspiel*, rather than just studying their layout, provides clues to their musical logic, aesthetic basis, and effectiveness of conveying elements of musical style. ✣

to the left of the matrix in figure 1.1a represent all possible results of the toss of two dice (2–12). Each vertical column of the matrix to the right of these numbers indicates successive measure choices (six in this case because it is the first phrase of a polonaise). Each number in these columns is keyed to a measure of music. To get a first measure of music, one tosses the dice, locates the resulting number to the left of the matrix, and then notates the measure of music corresponding to the number in the square directly to the right of the number tossed. Subsequent tosses complete an initial phrase, and subsequent phrases are produced in the same way (see one resulting polonaise in figure 1.1b). Interestingly, Kirnberger includes a separate guide for the polonaise so that one die or two dice can be used to give six or eleven choices, depending on one's situation.

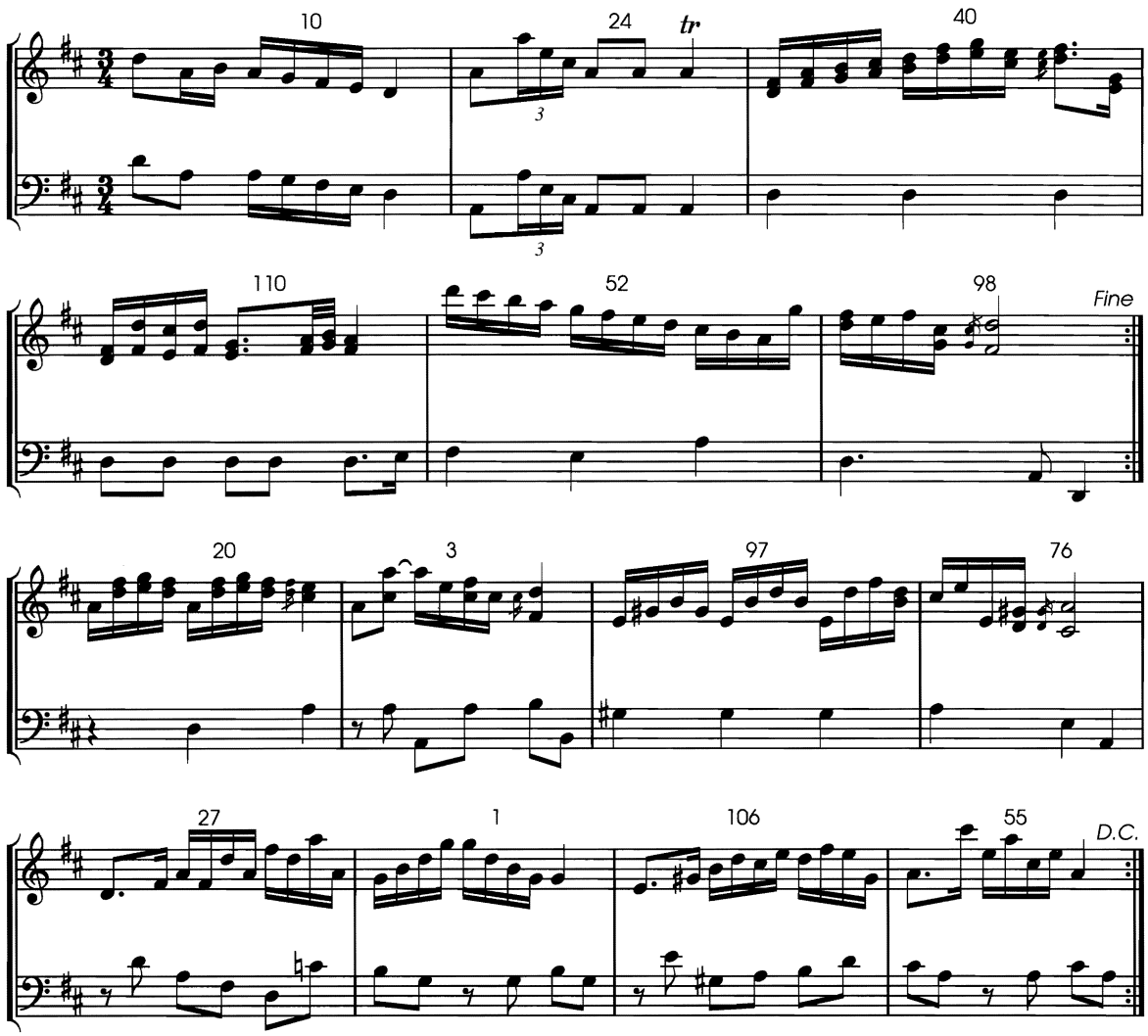
C. P. E. Bach's *Einfall einen doppelten Contrapunct in der Octave von sechs Tacten zu machen ohne die Regeln davon zu wissen* (Bach 1757) differs from Kirnberger's *Musikalisches Würfelspiel* by combining individual notes rather than measures from tables. Figure 1.2 gives both a sample from his tables and an invention as output. The arcane process used to create this invention involves choosing six random numbers from the numbers 1 to 9 (inclusive) for each of two voices. Numbers may be repeated as desired. These numbers then represent entry points into the six respective tables, each representing one measure of music for one of the voices. Once the initial note is found, one continues to select successive ninth members of the table until an "X," signaling a barline, is found. Eventually, six complete measures of music are produced in this manner.

Figure 1.1 Excerpt from Kirnberger's *Der allezeit fertige Polonoisen- und Mennuettenkomponist* (1757): a) Matrix for a first phrase.

Measure: / Dice:	1	2	3	4	5	6
2	70	34	68	18	32	58
3	10	24	50	46	14	26
4	42	6	60	2	52	66
5	62	8	36	12	16	38
6	44	56	40	79	48	54
7	72	30	4	28	22	64
8	114	112	126	87	89	88
9	123	116	137	110	91	98
10	131	147	143	113	101	115
11	138	151	118	124	141	127
12	144	153	146	128	150	154

Thus, a selection of 1 for the first table yields the quarter note E followed by the quarter note G, nine elements to its right. Then E and C quarter notes complete the first measure for the upper (descant) voice. The bass voice is constructed in the same manner from a separate set of tables. The resulting six-measure, two-voice coun-

Figure 1.1 b) A resulting polonaise.



terpoint may then be successfully inverted by transposing either the top voice down one octave or the bottom voice up one octave. Eugene Helm (1966) computes the possible number of works from Bach's tables to be more than 282 billion, with inversions giving an identical amount.