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Bruno Degazio
*Sheridan College*, bruno.degazio@sheridancollege.ca

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# The Schillinger System of Musical Composition and Contemporary Computer Music

by Bruno Degazio, MMus
Department of Photo/Electric Arts
Ontario College of Art
Toronto, Ontario
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• Bruno Degazio est compositeur à la pige à Toronto pour le cinéma et la télévision. Ses œuvres ont été jouées au Canada, aux États-Unis et en Autriche. Il poursuit des recherches sur la géométrie fractale. Il enseigne au Ontario College of Arts.

• Bruno Degazio was born in 1958. He has received a BMus and MMus from the University of Toronto (1981) and has received awards from the Canada Council (1987), the Ontario Arts Council (1987), and an award for the film score to "Resurrected Fields" at the Baltimore Film Festival (1986). His concert work has been performed in Canada, the United States and Europe. His computer music research has investigated the musical aspects of fractal geometry, the results of which were presented at the 1986 and 1988 International Computer Music Conferences. His current Canada Council research project involves the application of fractal techniques to compositional strategies first described by Joseph Schillinger. Degazio is presently an instructor in digital arts at the Ontario College of Art and is a freelance composer for film, radio and television. He is a founding member of the Toronto contemporary music ensemble SoundPressure and a founding member of the Canadian Electroacoustic Community (CEC).

## The Schillinger System of Musical Composition and Contemporary Computer Music

### ABSTRACT

The author will describe the results of a research project involving the investigation of Joseph Schillinger's theories of rhythm and tonality as they relate to contemporary areas of algorithmic composition such as fractal music. In particular, the author will describe his work in the following areas:

a) the use of Schillinger's fundamental technique of *interference*
b) the relationship of Schillinger's notion of geometrical projection to techniques of fractal musical composition.
c) the application of fractal processes to Schillinger's emotional and semantic (connotational) schemes (i.e., the *psychological dial*).

### INTRODUCTION

Through the 1920's and 1930's Joseph Schillinger invented a mammoth 'System' of musical composition allegedly based for the first time in human history on 'scientific' principles. The 'System' consists of twelve books, each covering some fundamental aspect of musical composition, such as counterpoint or rhythmic structures. The success of the 'System' in at least some respects has been very well established in the long line of popular music and film composers who have employed it with great distinction, including George Gershwin, Glenn Miller, Benny Goodman, Oscar Levant, Carmine Coppola and many others too numerous to mention. Indeed, so pervasive have been some aspects of Schillinger's 'System' that they constitute a sort of hidden and unacknowledged undercurrent throughout North American music from the 1930's to the present. Unfortunately, the 'System' as it exists today is more a collection of lists and summaries than a clear explanation of the procedures inv●lved. This paper will attempt to explicate some of the fundamentals of Schillinger's System, putting them into the context of a contemporary interest in algorithmic composition.

**Principle of Interference**

Almost every aspect of Joseph Schillinger's 'System' is derived in some fashion from resultants of interference of simple periodic motions. He found ways to project these resultants into the obvious areas of rhythm and structural proportion and also into the much less obvious ones of pitch structures (scales and chords), counterpoint, harmonic progression, orchestration and even into the emotional and semantic aspects of musical composition.

The basic idea was to employ the rhythmic patterns produced as a result of the interference of simple regular patterns, such as that familiar to many musicians as "three against four":

$4 \div 3$

Find the resultant, $r_{4 \div 3}$

3 (4)

4 (3)

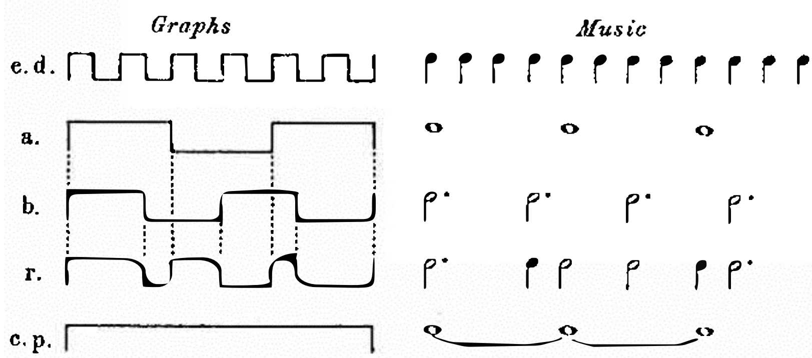


*Figure 1 - 4:3 interference pattern*

Several interesting aspects of these resultants should be clearly stated, because they are ●nly implied in Schillinger's discussion. First their length is always equal to the product of the elements involved. Thus, for the example above, the total length of the resultant, expressed with an eighth-note beat, would be 3 times 4 or twelve eighth n●tes. Similarly, the length of the resultant of seven against eight would be 56. A less obvious characteristic is that these rhythms are always symmetrical; they are, in Olivier Messiaen's terms, *non-retrogradable*, and thus retain what Messiaen calls *"the charm of impossibilities"*.

Because of the limited number of rhythmic patterns possible from the handful of small number values employed in the System, Schillinger devised several methods for extending and varying them. Using more than two generators is an obvious place to begin.

One variant of this that receives a lot of attention throughout the 'System' is the technique of 'fractioning' –an apparently arbitrary procedure that does indeed systematically extend the scope of these rhythmic resultants. In 'fractioned' resultants, the smaller generator is repeated after an interval corresponding to larger generator.

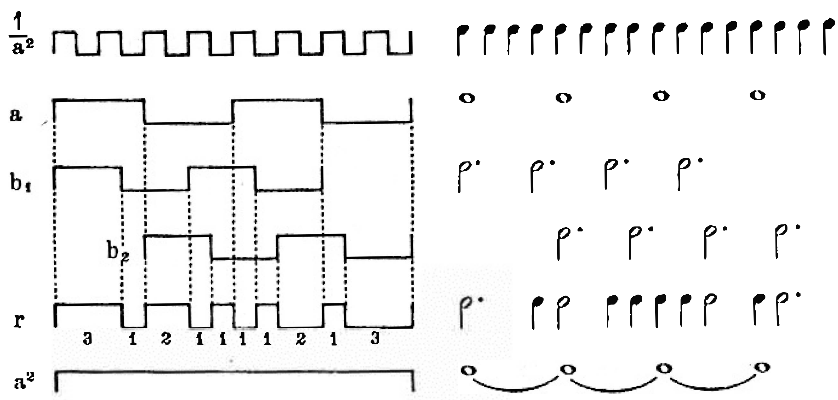


*Figure 2 - 2:3 with fractioning*

One of the most important ideas in the 'Schillinger System' relates to the study of rhythm beginning here with simple rhythmic resultants. Schillinger looked upon the rhythmic stratification of a piece of music as a continuity, very much akin to the continuous unfolding of levels found in fractal geometry. For Schillinger, harmonic rhythm, the pacing of underlying or implied chord changes is the next level of rhythmic structure after that of individual notes. Beyond this lie the rhythms of phrase lengths. The final level in most pieces of music is the rhythm of section proportions. While the analytical paradigm (notes, harmonics, phrases, sections) is not particularly original, Schillinger's application of a single creative device to all layers amounted for the first time to a comprehensive theory of rhythm.

In practice, the application of these principles to small scale musical rhythms becomes tedious; therefore portions of different resultants are generally pieced together to form a 'rhythmic continuity' (Schillinger's name for any extension of a technique employed systematically). Larger scale rhythm, such as phrase structure and section lengths, seems to work much more successfully. In general I have found these techniques to provide an organizing principle for the problem of antecedent-consequent phrase lengths that retains a sort of coherence while still provides a sense of freshness and relief from a 'four bar plus four bar' regularity.

Schillinger did not stop with rhythmic structures. Through an intimidating variety of clever and apparently arbitrary devices, he applied the notion of interference-caused patterns to many aspects of composition. In contrapuntal composition he employed rhythmic resultants to pace the entrances of successive voices. He employed a vertical projection into the realm of pitch structures to produce scales and modes of all types, as well as to organize the vertical structures of block harmonies. Schillinger's methods often betray considerable mathematical and analytical thought, since his applications are often comprehensive in their scope. For example, in his vertical projections he claims to not only produce every scale structure known throughout the history of music, European or otherwise, but to be able to produce in a systematic way every scale structure possible within the tempered tuning system. And usually these are not empty claims; one reason for the book's bulk is that it contains endless lists such as the scales described above, or the permutations of all two, three, four and five element rhythmic groups.

Schillinger's contribution to the rhythmic study of music has several interesting facets. For the first time this sort of generating principle was systematically presented in all its possibilities for all generators between two and nine. Furthermore, Schillinger presented an analytical paradigm along with this surplus of possibility with his concept of rhythmic 'families'. This amounts to a method of cataloguing and grouping the multitude of resultants by means of their relationship to one of several 'series of distributive powers'. The principle ones are:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1/16 | 1/8 | 1/4 | 1/2 | 1 | **-2-** | 4 | 8 | 16 | ... |
| ... | 1/27 | 1/9 | 1/3 | 1 | **-3-** | 9 | 27 | 81 | ... |
| ... | 1/64 | 1/16 | 1/4 | 1 | **-4-** | 16 | 64 | ... | |
| | ... | 1/25 | 1/5 | 1 | **-5-** | 25 | 125 | ... | |
| | ... | 1/36 | 1/6 | 1 | **-6-** | 36 | ... | | |
| | ... | 1/49 | 1/7 | 1 | **-7-** | 49 | ... | | |
| | ... | 1/64 | 1/8 | 1 | **-8-** | 64 | ... | | |
| | ... | 1/81 | 1/9 | 1 | **-9-** | 81 | ... | | |

It is clear that within each line the elements are simply a series of powers and inverse powers of the central element (in boldface). The numbers to the left of the central element represent rhythms within the measure, while those to right represent rhythms of the measures themselves (i.e., phrases and section lengths). Our entire musical history, according to Schillinger, amounts to a thorough exploration of the two series, with occasional excursions into the three and five series. Whatever its intrinsic value, Schillinger's theory of rhythm deserves some serious recognition for being the first to take the problems at all rhythmic levels seriously. Indeed, not until Cooper and Meyer's Schenkerian extensions has an equally comprehensive system been proposed. And his unity of technique at all scales makes it a natural kin to the self-similarity of fractal structures.

### Techniques of Geometric Projection

In many ways Schillinger's 'System' of composition was a sort of computer music before the computer. He presaged many developments of algorithmic composition that were not taken up in full until many years later, such as:

- graphic notation systems
- the techniques of projection onto musical parameters
- use of strict rulebound methods
- notion of self-similarity
- music as imitative of natural dynamics

While some of these ideas had a long history prior to Schillinger, such as the notion of music as imitative of natural dynamics and the use of the Fibonacci series, few had ever been systematically elaborated to the degree presented in his System.

### Notation

Schillinger employs many different forms of graphic representation in his 'System'. One that has become commonplace in small computer music systems is based on a simple Cartesian co-ordinate system, the *y-axis* corresponding to pitch and the *x-axis* corresponding to duration. This type is easy to understand and may owe its origins to methods used for transcribing folk music. Schillinger believed this to be a more 'scientific' method than traditional music notation, although several years of use in computer music systems has pointed up its many deficiencies.

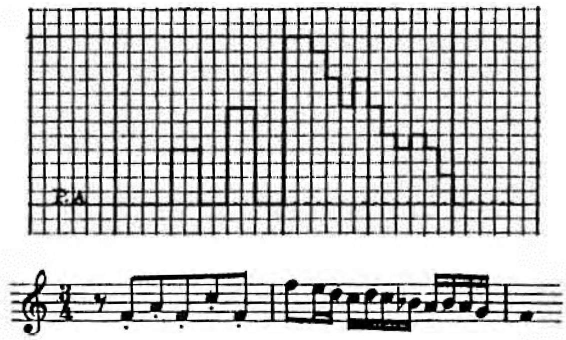

*Figure 3 - graphic notation where each horizontal square represents a 16th-note and each vertical square represents a semitone*

A more original and interesting system of notation is used initially for a discussion of melodic trajectories, and later on for representation of emotional responses to music. The various diagonal line segments are named the *a*, *b*, *c*, and *d* axes, and represent melodic tendencies toward or away from a central pitch, the 'primary axis'.

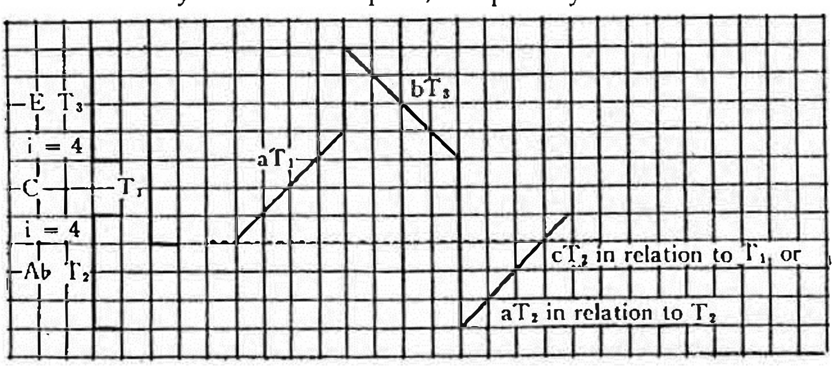


***Figure 98. Another illustration of first tonic surrounded with other tonics.***

*Figure 4 - melodic tendency graph*

## The Techniques of Projection

As anyone who has worked in contemporary algorithmic composition knows, the musical validity of some technique, for example fractals, is entirely dependant on the means by which the abstract is *projected into* the concrete. What this amounts to usually is finding some way of making the numerical output of a computer program perceptually and musically valid. Schillinger devoted an entire book (*Book III - Variations of Music by Means of Geometrical Projection*) to the subject of the techniques of projection. In it he discusses certain elementary techniques such as inversion and rotation of the pitch materials, and their expansion in vertical or horizontal directions. Some ideas are obviously logical (but not necessarily musically valid) extensions of traditional techniques such as melodic inversion, and other are clearly motivated by visual rather than musical impulses. (These latter betray Schillinger's preoccupation with developing a unified aesthetic theory that later became *The Mathematical Basis of the Arts*.) These techniques have since been incorporated into many computer systems ( the

Structured Sound Synthesis Project, the Computer Assisted Music Project, MIDIFORTH, Dr T's KCS) and are nowadays familiar to anyone who has used a computer to assist in composing music. In addition to these simple techniques we owe to Schillinger the notion of *projection* in a more general sense –the solution of the problem of making an abstraction perceptually valid. This he does over and over again in virtually every volume of the System. For example, he discusses ways in which each of the following mathematical abstractions may be made concrete in melody, harmony, rhythm and structure:

1. Natural harmonic series.
2. Arithmetical progressions.
3. Geometrical progressions.
4. Involution series.
5. Various logarithmic series.
6. Progressive additive series (Fibonacci series).
7. Prime number series.
8. Arithmetical mean.
9. Geometrical mean.

*(Theory of Melody, Ch 8 –Use of Organic Forms of Melody, p 352)*

**Rulebound Composition**

Much of Schillinger's 'System', especially the 'special' theories of harmony and counterpoint, amount to an elaborate system of rules of composition. These are, unlike the 'rules' of traditional composition, laid out in a systematic and self-consistent manner. This is similar to the approach taken by Hiller and Isaacson in their first pieces of computer music from the 1950's, such as the *Illiac Suite for String Quartet*. The choice of rules is left to the composer-programmer, and it is this choice that determines the character of the resulting piece. It is curious that, to my knowledge, Schillinger's 'System' has never been implemented to any substantial degree on a computer.

**Music as Natural Dynamic**

Schillinger's 'System' contains frequent references to music as natural dynamic. His use of the Fibonacci series (which he calls the 'growth' series in reference to its use in describing growth patterns of plants, seashells, etc.) is just one of many examples scattered throughout the System. This is clearly related to the recent developments in fractal geometry, particularly the studies of chaotic (strange) attractors and non-linear dynamics as models of natural phenomena. Schillinger even at one point compares the multi-levelled character of music to one of the archetypal fractal structures - the self-similar coastline:

> "The shoreline of North America, for example, may be measured in astronomical, or in topographical, or in microscopic values. The difference between melody from a physical or musical standpoint is a *quantitative* difference." (p 229)

Compare a story related by Benoît Mandelbrot, the founder of fractal geometry:

> "After a 'sensible' guess *(of the length of the East coast of the United States)* had been made... he would... point out that this figure increased enormously if you measured the perimeter of every bay and inlet, then that of every projection and curve of these, then the distance separating each small particle of coastline matter, each molecule, atom, etc. Obviously, the coastline is as long as you want to make it." *(The Fractal Geometry of Nature, p 28)*

In another chapter Schillinger is quite explicit about the relation of musical to natural forms:

> "Thus we see that the forms of organic growth associated with life, well-being, self-preservation and evolution appeal to us as a form of beauty when expressed through an art medium." (p 352)

And he bases the whole of his complex Theory of Melody on relationships to natural forms:

> "The important stages in evolving a theory of melody:
> 1. Study of the general properties of melody with respect to its convertibility and other forms of geometric projection.
> 2. Comparative study of the patterns appearing in natural configurations (crystal, vegetable and mineral forms).
> 3. Study of the properties of curves and of statistical records specifically (technology of events).
> 4. Recording and analysis of (human) reflex patterns (respiratory, muscular, nervous, etc.).
> 5. Study of the trajectorial curves evolving linear design in the visual art."
>
> *(Theory of Melody, p 228)*

## Self Similarity

One of the more subtle implications of Schillinger's theories of musical form is the notion of self-similarity, mentioned above in regard to fractal structures. In a footnote by the books editors, "(Schillinger) does not regard what is ordinarily called 'musical form' –i.e., the organization of the entire composition by phrases, etc.— as something separate from the rhythms of the measures themselves. Rather he regards the two (rhythms *within* measures ... and rhythms of the measures) as two aspects of the same central situation".

This self-similarity of rhythmic structures from the note levels through to phrase levels, ending in large scale structures, i.e., the section lengths of the piece, is perhaps the clearest parallel to contemporary research in algorithmic composition, such as fractal methods (Degazio 1986, Dodge 1986). It is another example of Schillinger's attempt to build a comprehensive and unified theoretical system for the whole of musical knowledge.

## The Psychological Dial

Perhaps one of the strangest and yet possibly the most practical portions (as attested to by three generations of film composers) of Schillinger's 'System' involves his notion of the 'Psychological Dial'.

This dial represents an attempt to circumscribe the entire gamut of human emotional response to a stimulus, typically musical. With the use of this dial and an elaborate system of connotational symbols, a composer is be able to assemble a continuity of emotional responses as the basis for his work. These might follow some preconceived plan such as a narrative outline, as in traditional programme music; or they might be arranged according to more abstract patterns such as those produced as a result of interference; or, unknown even to Schillinger, a fractal process of a suitable sort could be employed to guide the composer through the maze of possibility. In fact, one of my pet ideas for a theatre project (unfortunately turned down by the arts councils) involves the amalgamation of Schillinger's psychological dial with a little known book called *The Thirty-Six Dramatic Situations* (which claims to reduce all possible human interaction to some combination of prototypical situations), each controlled by a meandering fractal process that would produce a continuous and unending stream of Wagnerian music drama.

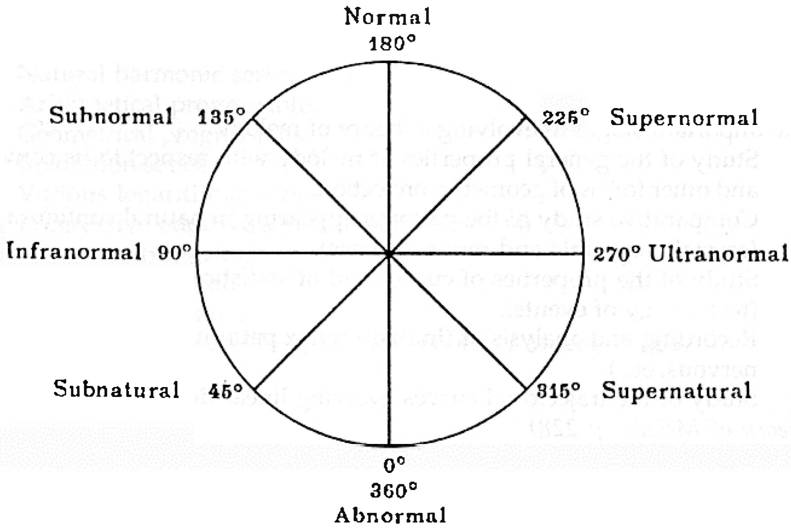


*Figure 5- the psychological dial*

CONCLUSION

Schillinger's *System of Musical Composition* can be looked upon as a unique, perhaps misguided attempt to discover the atomic structure of music, the smallest indivisible element, the simple ground from which all complexity emerges. In this respect it has interesting parallels to other currents of thought in the mathematical and physical sciences of the time, such as the quantum theory of atomic structure, Einstein's attempt to unite all physical laws into a 'Unified Field Theory', Bertrand Russells's and Alfred Whitehead's bid to relate the whole of mathematical thought to a handful of elementary postulates in the Principia Mathematica. Like Whitehead and Einstein, and possibly also the quantum theorists, Schillinger was unsuccessful in the attempt. But the attempt itself was, despite this, highly worth making nonetheless. Although he may have failed to convincingly relate all aspects of musical thought and perception to a handful of fundamental principles, Joseph Schillinger nevertheless provided, and continues to provide a fresh outlook and an invigorating force to a potentially moribund musical culture.

Bruno Degazio
Toronto, Ontario

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    Recommended 'Books'

        Overture to the Schillinger System by Henry Cowell
        Introduction by Arnold Shaw and Lyle Dowling
        Book I - Theory of Rhythm
        Book III - Variations of Music by Means of Geometrical Projection
        Book VIII - Instrumental Forms
        Book IX - General Theory of Harmony (strata harmony)
        Book XI - Theory of Composition
        esp. Part Three - Semantic Composition
        and Ch 18 - Composition of Sonic Symbols

- Schillinger, Joseph, *The Mathematical Basis of the Arts*, Da Capo, New York.