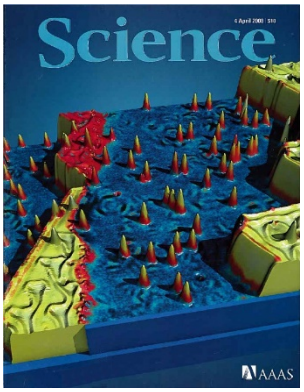
SUPPLEMENTARY MATERIALS III-E: PUBLICATION IN *SCIENCE*: "CREATING MUSICAL VARIATION", APRIL 4, 2008



MUSIC THEORY

Creating Musical Variation

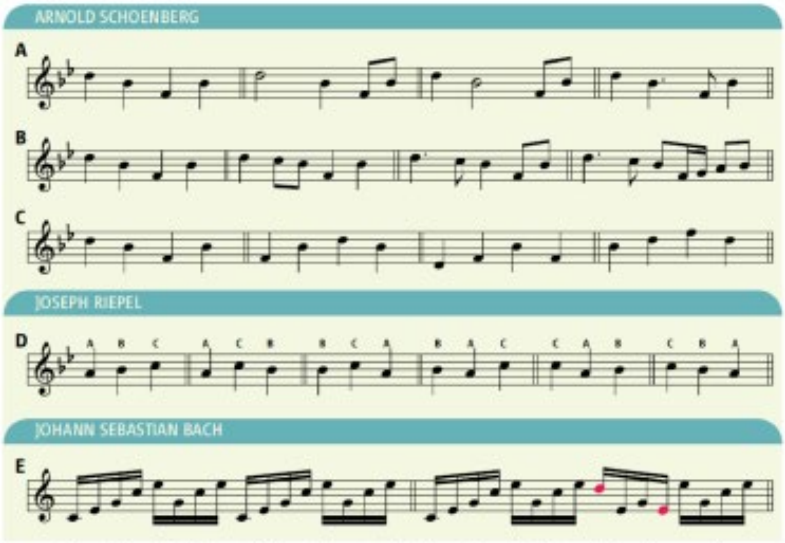
Diana S. Dabby

Inspiration for composition may come from natural sounds, chance, and methods based on chaos theory.

In the 21 letters that Mozart wrote to his friend Michael Puchberg between 1788 and 1791, there exist at least 24 variants of the supplication "Brother, can you spare a dime?" Mozart ornaments his language to cajole, flatter, and play on Puchberg's sympathies (*1*, *2*). He varies his theme of "cash needed now" in much the same way an 18th-century composer might dress a melody in new attire by weaving additional notes around its thematic tones in order to create a variation. Such ornamentation could enliven and elaborate one or more musical entities, as can be heard in the Haydn F Minor Variations (1793) (*3*). The Haydn represents one of the most popular forms of the 18th and 19th centuries—variations on original or borrowed themes. Yet myriad variation techniques existed besides ornamentation, including permutation and combination, as advocated by a number of 18th-century treatises. More recently, fields such as chaos theory have allowed composers to create new kinds of variations, some of which are reminiscent of earlier combinatorial techniques.

In a broad context, variation refers to the technique of altering musical material to create something related, yet new. Recognizing its importance to composers, the 20th-century composer and teacher Arnold Schoenberg defined variation as "repetition in which some features are changed and the rest preserved" (*4*). He wrote numerous examples showing how a group of four notes, each having the same duration, can be varied by making rhythmic alterations, adding neighboring notes, changing the order of the notes, and so on (see the figure, panels A to C) (*5*). Changing the order of the notes reflects the 18th-century practice of *ars combinatoria*. Joseph Riepel advocated a similar approach (see the figure, panel D) (*6*). How might a composer use such ordering techniques?

Franklin W. Olin College of Engineering, Needham, MA 02492, USA. E-mail: diana.dabby@olin.edu



Idea and variations. Variation techniques illustrated by Schoenberg, Riepel, and a chaotic mapping example. Schoenberg offers numerous ways to vary a given four-note group, shown in the first measure of each line. (**A**) Rhythmic changes. (**B**) Addition of neighboring notes. (**C**) Changing the original order. (**D**) One of many examples given by Riepel of *ars permutatoria*, a branch of *ars combinatoria*, where six permutations of the notes A B C are given (*15*). Note that Riepel writes above the staff the German musical spelling of the notes so that "B" translates to B-flat. (**E**) The first measure of a Bach prelude (pitches only) followed by the first measure of a variation generated by the chaotic mapping.

Igor Stravinsky offers one of many possible examples in his *Variations: Aldous Huxley in Memoriam* for Orchestra (1964): "My Variations were composed on the following pitch series, a succession of notes that came to my mind as a melody: D C A B E A♯ G♯ C♯ D♯ G F♯ F. After writing it out, I gradually discovered the possibilities in it as material for variations. … Veränderungen—alterations or mutations, Bach's word for *The 'Goldberg' Variations*—could be used to describe my Variations as well, except that I have altered or diversified a series, instead of a theme or subject…" (*7*).

Stravinsky derived additional material from his array of notes to produce 12 variations by, for instance, taking his original series and reversing the order to generate a second row of notes: F F♯ G D♯ C♯ G♯ A♯ E B A C D. He then rotated this row to create five more rows by placing the first note at the end to generate a second row. To construct the third row, he rotated the second, and so on. Clearly Stravinsky built a 6 × 12 matrix of notes. He then exploited the rows and columns to construct his variations of the original series by, for example, deriving the opening chords of his *Variations* from the first six columns of the matrix (*8*).

Yet an array of material does not have to consist of single notes, as demonstrated by Pierre Henri in his 48-minute *Variations pour une porte et un soupir* ("Variations for a Door and a Sigh," 1963). Using recordings of a breathed sigh, the sung sigh of a musical saw, and a squeaking door, Henri created his variations by mixing, then transforming these sounds in their entirety and in fragments, while varying rhythm and intensity (*9*).

Flash forward to 1987 when DJ Lil' Louis, using much more sophisticated analog equipment, produced *French Kiss*, the first house music hit to sell a million copies in Europe and North America. House music typically features a sampled audio clip that undergoes successive transformations, engineered through electronic effects and instruments. Louis started with a simple repetitive array of rhythms heard on kick drum, synthesizer, and hi-hat, which he gradually varied by adding shakers, electronic brass instruments, hand claps, and more (*10*, *11*).

John Cage broke with tradition by leaving the elemental material of the array and its order unspecified. The "score" for his *Variations IV* consists of handwritten instructions providing a schematic that enables chance not only to decide the musical material but also to determine its order. Cage allows "any number of players, any sounds or combinations of sounds produced by any means, with or without other activities" (*12*). Cage's piece will drastically change from performance to performance—much more so than, say, Stravinsky's *Variations*—by virtue of the chance and randomness he deliberately inserts into his score.

However, if a composer wants to vary an entire work from one hearing to the next, and even from performance to performance, without Cage's randomness, a different kind of variation technique has been helpful—one that uses a chaotic mapping to make musical variations of the entire work (*13*). Such a technique harnesses a natural mechanism for variability found in the science of chaos—that is, the sensitivity of chaotic trajectories to initial conditions. Two chaotic trajectories map the pitch sequence of a musical score into a variation where the same set (or subset) of pitches appear, but in modified order (see the figure, panel E). Virtually infinite in number, these variations can be close to the original, diverge from it substantially, or achieve degrees of variability between these two extremes. Unlike the above methods, the technique offers a post-compositional process in which a composer can go on a journey to someplace new or unimagined with an already completed piece (*14*).

The several music files available online (*3*, *11*, *14*) are intended to serve as only a sampling of the richness of musical variations. Just opening one's ears makes it possible to hear the variations that pervade our musical lives, from jazz improvisations on popular songs to the tinkling pitches caused by rain on a tin roof.

References and Notes

1. *The Letters of Mozart and His Family*, E. Anderson, Ed. (Norton, New York, 1985).
2. E. R. Sisman, *Haydn and the Classical Variation* (Harvard Univ. Press, Cambridge, 1993).
3. Audio example 1: Haydn theme 1, variation 1 (tracks 1 and 2).
4. A. Schoenberg, *Fundamentals of Musical Composition*, G. Strang, L. Stein, Eds. (Belmont, Pacific Palisades, CA, 1967).
5. Even if one does not read musical notation, the variations in Schoenberg's examples can be understood "graphically."
6. J. Riepel, *Anfangsgründe zur musicalischen Setzkunst* (Regensburg, 1752–1768).
7. I. Stravinsky, R. Craft, *Themes and Episodes* (Knopf, New York, 1966).
8. P. S. Phillips, *Mus. Anal.* 3, 69 (1984).
9. P. Henri, liner notes, *Variations for a Door and a Sigh* (Limelight, 1963).
10. S. Hawkins, in *Analyzing Popular Music*, A. F. Moore, Ed. (Cambridge Univ. Press, Cambridge, 2003), pp. 80–102.
11. Audio example 2: Lil' Louis, *French Kiss*, www.youtube.com/watch?v=kBnIBL1AdBY&feature=related. This piece includes explicit content.
12. J. Cage, *Variations IV* (Peters/Henmar, New York, 1963).
13. D. S. Dabby, *Chaos* 6, 2 (1996).
14. Audio examples 3 to 5: Original Bach Prelude in C (track 3), chaotic mapping–generated variation of the Bach (track 4), composed variation based on the chaotic mapping generated variation (track 5).
15. N. Reed, thesis, Eastman School of Music, 1983.
16. Supported by the Research Fund of Olin College.

Supporting Online Material
www.sciencemag.org/cgi/content/full/320/5872/62/DC1
Audios S1 to S5

10.1126/science.1153825