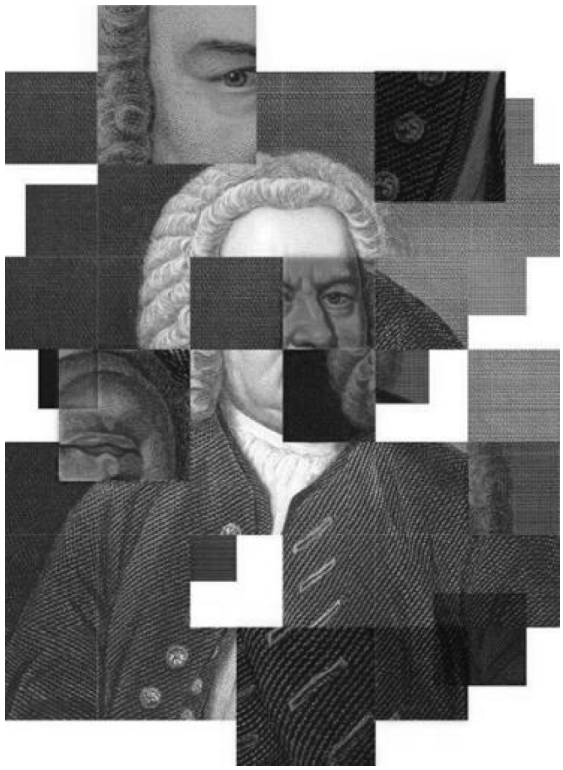
Get unlimited access to breaking news and the full stories from The Boston Globe, subscribe today.

The Boston Globe Ideas

What a little chaos does for music

How Olin College professor Diana Dabby developed a dizzying technique for creating new variations

By Carolyn Y. Johnson | GLOBE STAFF JUNE 16, 2013



DAN ZEDEK/GLOBE STAFF

IN 1983, a young concert pianist named Diana Dabby took a break from practicing for a solo piano concert and found herself absorbed by a journal she stumbled on in the library at Lincoln Center in New York. Written by physicists and engineers, the articles were devoted to the future of music. Dabby, who had two degrees in music and thought constantly about the topic, found that she could barely make sense of its predictions.

Most people would have shrugged their shoulders and gone back to doing what they were good at. Dabby decided to put herself through college—again—by playing concerts and giving music lessons while she earned a second bachelor's degree, in engineering, at the City College of New York. She went on to graduate school for electrical engineering at the Massachusetts Institute of Technology. Dabby dreamed of a future in which musicians would acquire the skills of mathematicians, engineers, and physicists and use their artistic intuitions to, as she puts it, "come up with something for music in our time."

The idea that science and art have something important to teach one another has been trotted out so often that it has become a truism, yet it often falls short of the truth. More often, one field seems to borrow the jargon or aesthetics of the other without bringing over the substance. Dabby, however, wanted to bring science to bear on music directly—and eventually she found a way to do just that, by using math to generate new musical ideas. Late last year, she launched a Web app called CantoVario that uses ideas from chaos theory to generate variations from any music file. (Listen to some variations of notable pieces of music here.)

By design, it's not necessary to know much about math or music to use CantoVario. A would-be chaotic composer need only click on a particular effect, choose a spot on a color wheel to set how close or distant they want the new version to be to the original, and—like magic—the program generates a new audio version of any song. Some variations sound almost unaltered, while others are unrecognizably minced up. A Scott Joplin rag may jag off in unexpected ways. A Franz Liszt piece can evolve so many times that it may become hard to remember which is the original and which merely a computational riff. In effect, it's using math to generate inspiration.

CONTINUE READING BELOW ▼

Related

Listen: Chaos variations of notable pieces of music

Dabby's work has begun to capture the imagination of people drawn to its novel use of mathematical ideas or to its musical potential; the South Korean pianist JongSun Lee, for instance, recently commissioned and performed an original piece and a variation. But it is hardly well known. Dabby, who is now a professor at Olin College of Engineering in Needham, has kept a low profile in the math world, focusing more on her work's creative potential.

In fact, though, Dabby's project touches on a much larger theme: Variation is at the heart of all kinds of creation, and she has invented a new way of generating it. Dabby sees herself following in a musical tradition that stretches from Bach to John Cage. But variation is far more pervasive than that, showing up in all kinds of art and in each of us—down to the slight tweaks in our DNA that make us all recognizably different, though identifiably human. Accordingly, some people are beginning to borrow Dabby's ideas to generate chaotic variations beyond music. The principles of her work have now been

used to create new dance "chaography," computer-generated variations on rock climbing routes, and even a chaotic remix of Lewis Carroll's "Alice's Adventures in Wonderland."

"When I first started dreaming of something new for music, what I really wanted to do was reach the man and woman in the street," said Dabby, who speaks in a light, dreamy voice with the earnest conviction of a character in a Victorian novel. "This is not meant to just generate music; it's meant to take a piece that you or your band or someone has written and allow the composer or the musician or the listener to go on a journey with that piece, into uncharted domains."

***

STEVEN STROGATZ, a mathematician known for his work in nonlinear dynamics, was just developing his class on chaos at MIT when Dabby showed up in his classroom. She had been given a journal on chaos by another professor, and had read it cover to cover.

"I understood enough to sense there was something there for music," Dabby said. "It was as if the artistic side of me—every corpuscle of that side—was resonating with what I was reading. So I decided I would find out more about chaos science."

The word "chaos" is often used in common parlance to mean things that are disordered. To mathematicians, chaos is behavior that appears random, but is actually the result of a system that is evolving according to set rules. The reason chaotic systems seem so unpredictable and random is that they are sensitive to slight changes in initial conditions, commonly referred to as the butterfly effect—the idea that something as small and unpredictable as a whisper of air movement from an insect flapping its wings could cause a thunderstorm halfway across the globe.

ESSDRAS M SUAREZ/ GLOBE STAFF

Dabby became interested in something called the "strange attractor," a mathematical entity that pulls trajectories back toward it, sort of like a

Olin College professor Diana Dabby created an app that uses the physics concept of chaos to approach composing music.

whirlpool that draws in nearby currents. Those trajectories are similar, but differ depending on the initial conditions. It reminded her of the musical concept of theme and variation—think of the recurring motifs in jazz, or any number of classical pieces where the theme is played, then repeated and translated into something new. What if, Dabby wondered, it were possible to generate chaotic variations in music?

Strogatz admits to being a little skeptical of his unusual student at first. She was, he recalls, eager and engaged, but weak by any conventional measure.

“She was really noticeably different from the other MIT students, in that she could barely do algebra; she was really mathematically in a different place than everybody else,” Strogatz, now a professor at Cornell University, recalled. “I knew she was enthusiastic, but the jury was still out on whether she could produce anything good.”

For her graduate work, Dabby used chaotic trajectories as a kind of scaffold for music. She would generate a particular curve, then translate a melody onto the curve—meaning that as one moved along the curve, each spot would correspond to one note. She would then map the notes onto a “pitch axis,” a kind of musical yardstick divided not into inches or centimeters, but into notes—one spot is middle C, another A sharp. Then, to create variations, she would generate a new curve, and use the pitch axis to determine the new order of notes. The result would be a subtly changed piece of music, with little and big differences in each phrase.

From the beginning, the technique generated music audio files—some of which Dabby learned to play on the piano. She wanted to show that it would work on all styles of music, so she applied it to a prelude by Bach and another by Gershwin. When she began to think about building a Web program open to anyone, she wanted to make it as open as possible—simply using music files that anyone might have on a computer to generate new music.

As time has progressed, so have the variation techniques, which don’t just rearrange existing notes, but play with rhythm and add new notes. The theory behind each technique is largely hidden, with effects described in simple language on the website. “Brought together by fate” alters the order of notes. “Twirling left” and “twirling right” generate variations that include notes not found in the original. “Dance all night” varies rhythms and pitches, building off the original and the variation as it unfurls.

Despite what you might expect, the results don't sound like some new form of computerized robot music. Instead, the variations end up sounding familiar—each one resembling the original piece, but stippled with unexpected bits.

Strogatz said that despite his early doubts, Dabby's work has been a legitimate contribution. The melding of art and math, he said, doesn't always so successfully produce something that people in both fields can agree is interesting.

"I can't tell you how many people send you files and say, 'This one is a Lorenz attractor played through a loudspeaker,'" Strogatz said. "They'll play chaos in the most literal way, and it's bad. It's uninteresting. Her work is musical. It retains and in some ways improves the musicality, but uses chaos in this interesting way."

***

IF CHAOS CAN be harnessed to generate new ideas in music, what other areas could be ripe for such perturbation? Liz Bradley, a professor at the University of Colorado Boulder who met Dabby when they were graduate students at MIT, talks about the work in a class she teaches on nonlinear dynamics, as a way to wake students up to the practical and creative applications of chaos theory.

"This is something that just hooks them immediately," Bradley said. "It's a fabulous way to make mathematics and computer science real and tangible, and exciting....You have a whole class of students and they're like differential equations, big whoop, and then you show them this and they sit up."

One year, a student came to Bradley with an idea: He was a ballroom dancer and wondered if the technique could be used to generate new forms of choreography. The conversation sparked a project, and eventually the approach culminated in a program called Chaographer that uses a similar idea to Dabby's, mapping an original dance sequence and then varying it, using animation and motion capture. The technique was demonstrated in a 2007 performance in Boston called "Con/cantation: chaotic variations."

These techniques are decidedly not automated creativity. They still require the ear or eye of a person to curate the movements or passages, culling good ideas and tossing the ones that don't make sense. In dance, impossible transitions need to be somehow controlled for or eliminated. In musical variations, gaps sometimes show up in the

variation that make little sense to the human ear. But diversity—the thing celebrated in culture, music, and biology—needs to come from somewhere, and the variation generator is like a brainstorming device that takes the lid off all the possibilities.

Along the way, Dabby's work in chaos seems to have had another, more personal effect. As a pianist friend told her, all this time thinking about variations had changed the way Dabby wrote music. It had become part of her. Over the years since her first encounter with science, the musician, remade as an engineer, had become a chaotic variation herself.

Carolyn Y. Johnson can be reached at cjohnson@globe.com. Follow her on Twitter @carolynyjohnson.

© 2013 THE NEW YORK TIMES COMPANY