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Climate record my old friend, it's good to hear your voice again

LIKE any great work of art, Marty Quinn's Climate Symphony was inspired. Not by love, anguish or drugs, however. Quinn's muse was a cylinder of ice.

This inspirational ice core was drilled from a glacier in Greenland. The snow that built the glacier contained carbon dioxide, methane and other gases, along with bits of sulphate, potassium and dust. As you go deeper into the ice, the different chemistry corresponds to the atmospheric conditions at the time the snow fell. That way, scientists can see what was happening to the climate up to 110,000 years ago.

But why turn it into a symphony? "I'm really into experiencing data in new ways through music, to enhance perception of information," says Quinn, a musician and artist in New Hampshire. Apparently, he's not alone. Nowadays, data from protein structure, earthquakes, brain waves and lightning on Jupiter are being used to generate music. Some people believe this union of music and science is overdue, and that it may allow scientists to hear patterns in their work that they would otherwise miss. On the other hand, it could just be an artistic gimmick.

It all started with sounds rather than real music. For decades, results been turned into sound as a way to help researchers who are visually impaired, says Larry Scadden, director of science education for students with disabilities at the National Science Foundation in Arlington, Virginia. Making sounds out of information traditionally expressed by visual tools like graphs or tables became known as sonification. More people than ever are now doing it, as they realise the advantages of hearing over vision. Whereas our eyes sometimes slide over mistakes like a repeated word or minor omissions, our ears are better at perceiving subtle changes in volume, pitch and rhythm.

It was perhaps inevitable that scientists should begin to search for beauty in these sounds. After all, they often expound on the elegance of their experiments or equations. Why shouldn't science sound good too? Sonification was about to become songification.

Donald Gurnett, a physicist at the University of Iowa, has seen it happen. Gurnett studies radio waves emitted by the gases of interplanetary space. He takes records of those waves and slows them down so that their frequencies are in a range audible to the human ear. That lets him listen for the characteristic sounds of phenomena such as lightning on Jupiter, Earth's aurora and cosmic radiation belts. He's even heard radio waves in the furthest reaches of the solar wind, sampled by the Voyager I spacecraft.

To Gurnett, the sounds are interesting, even pleasant; but he wouldn't call them music. He plays me a tape of the aurora, putting the receiver of his phone next to a cassette recorder. At first, there is nothing, then a sound like a single, slightly muffled laser gun from Star Wars. Then another, then three more. Soon, it's a full-on intergalactic battle.

High-energy electrons streaming into the Earth's atmosphere cause the aurora. "The electrons aren't coming down like steady rain, they are coming down in organised packets." That mysterious clumping is what makes the staccato burst of sound.

Gurnett has been listening to space sounds for almost 40 years, but it was only last year that NASA came to him with the idea of making music. The agency's art programme, based in Washington DC, commissioned composer Terry Riley to turn Gurnett's collection of sounds into a score. It will be performed in 2002 by the San Francisco-based Kronos Quartet. It's a nice bit of public relations from NASA, a highly image-conscious organisation. But in a way it is cheating--the music will only be inspired by scientific data, not actually generated directly from it.

Physicist Michael Berry at the University of Bristol takes a much more direct mathematical approach. He has tried to hear patterns in the prime numbers using a sequence of numbers called the Riemann zeroes--which are of profound mathematical interest. Among other things, the zeroes are related to the prime numbers in a seemingly arcane way. But Berry says they have a more accessible property. They are notes in the harmony of the primes, reflecting the frequency with which prime numbers crop up. In theory, you can hear these notes.

To test the idea, Berry programmed the first thousand or so prime numbers into his PC. The output is a simple click for each prime, timed according to the size of the number. The many clicks should merge into a set of notes, a mystic chord that encapsulates the essence of number theory.

Unfortunately, this first attempt produced nothing more than a hectic machine-gun noise, says Berry. He'd like another go at it someday, with more computing power to include more primes. But even the unpleasant-sounding mess was informative, he claims. "It's like hearing chaos in the primes."

Most songifiers manipulate their data more heavily, giving the science a music lesson before letting it play. At the University of Exeter, Helen Long generates music based on protein structures (**New Scientist**; 10 February, p 21). Long uses three-dimensional maps of proteins gleaned from X-ray crystallography. She then assigns sounds of different pitch and duration to various atom types. This turns visual features of the protein into coherent musical structures. For example, the spring-like shape of a helix becomes an arpeggio, and polypeptide chains are represented by a succession of identical or neighbouring notes. Later this year, her work will be featured as an interactive exhibit at the Explore-at-Bristol science centre. Through a touch screen, users will pick different proteins found in the body, and then hear them translated into music. Long hopes to find out if these molecular melodies have any therapeutic properties. There is no clinical evidence supporting the notion, but many people have said the mu sic is soothing and uplifting, she says.

Perhaps the most prolific songifier is Marty Quinn. He has made music from DNA sequences, the flux of energetic particles form the Sun, the variations in El Nino and, most recently, earthquakes.

Seismologists gather records of ground shaking to find out where an earthquake was, what type of fracture caused it and how much energy was released. They also want to know if seismic waves will be strengthened or weakened as they travel through the rock. If the waves travel over long distances, they can reveal details of the Earth's internal structure.

But most people think of seismology as simply an up-and-down wiggle on a paper trace, says Christel Hennet of the Incorporated Research Institutions for Seismology in Washington DC. So Hennet teamed up with Quinn to create the Seismic Sonata, to give people a better feeling for the nature of seismic data.

The sonata was based on ground motions recorded after the 1994 Northridge Earthquake near Los Angeles, California. Quinn simply matched up a set of 45 different notes to the violence, or amplitude of the shaking at each moment. An oboe plays the corresponding notes over the entire 15-minute selection.

Because most of the notes correspond to moderate or violent shaking, the beginning was a little flat. For a while before the main quake strikes, the oboe plays a single note, as if the Earth were absolutely still. But closer inspection of the data reveals background noise, whether from distant earthquakes or nearby vibrations, which seismologists pay attention to and which Quinn wanted to incorporate in the music.

To convey this deeper complexity Quinn used what he calls an "audio-zoom". Scaling the data to represent more detailed, 3-second intervals, he assigned a piano to play this more fine-grained portion. He then overlaid the piano with the oboe in the final version, "as if you were looking at a diamond with your naked eye and a jeweller's lens at the same time". This way, the listener experiences the general trend of the wave motion over time, while also hearing the complexity and commotion of Earth's tiniest movements.

At first, Quinn tried to bounce back and forth between records from three separate monitoring stations throughout the sonata, but the result was too disjointed, he says--the listener would not have been able to grasp any sense of the waves travelling through time and space. "You have to ask: what aspects of the information do you want to leave in, and what is most important," says Quinn. To preserve the continuity of the wave sounds, he decided to use a single monitoring station in Albuquerque, New Mexico, so the listener could clearly hear each of the different waves hit over time.

The result impressed Hennet. "With 20 data points coming in every second, when you listen to the rapid up and downs, the complexity of the information jumps out at you. You really get a sense of the motions. It ends up being this fascinating, cascading sound." Could a person ever play it? "It's just about at virtuoso level," says Quinn. "Maybe Yo-Yo Ma."

Quinn's greatest success so far is his Climate Symphony. This was composed using data supplied by Paul Mayewski, a climatologist then at the University of New Hampshire. Mayewski helped to extract patterns in the Earth's past climate from the traces of gases such as carbon dioxide and potassium in the ice. Changes in the Earth's orbit and variations in the brightness of the Sun will cause fluctuations in temperature over different timescales. Other climate factors are recorded directly in the ice--dust from volcanic eruptions and ammonium from burning forests.

Quinn's aim was to make the symphony portray all these natural patterns over the past 110,000 years. Arpeggios of three notes represent the tilt in the Earth's axis. High notes for greater tilt, lower for less. The instrument that plays any particular set of arpeggios represents the vigour of the ocean circulation during a particular period. Tom-toms play in the background when the world is warm, bells ring when it is cooler, and other climate factors have their own signatures, or modify each other's sounds. Throughout the piece, the string section plays a rising scale, over five octaves, to represent the passing of time.

Instead of just looking at "squiggly lines on a page", says Quinn, people can experience the changes in climate as they listen to his symphony Maybe so, but all the massaging and crunching of numbers for the sake of easy listening leaves me wondering whether the point of the exercise is lost in the process. To my ears, untrained in music or atmospheric chemistry the symphony sounds like a storm of mostly aimless notes. It is possible to notice short sequences of notes scaling up or down, especially one booming portion--vaguely reminiscent of Tchaikovsky's 1812 overture--corresponding to a period of particularly violent volcanic eruptions. But without the guidance of Quinn or another expert, making connections between changes in the music and changes in climate history is nearly impossible. Quinn says that's not his goal. "Of course listeners are not going to hear all of the data, but they'll get something out of it, and they're going to feel the changes in the Earth on a gut level."

Purely as music, how does it rate? Well, knowing the derivation of the notes makes it kind of cool, but I'm not rushing out to buy the CD. For a museum exhibit or alternative teaching tool, songified tunes are great. At a candlelight dinner for two, however, I'd stick with music inspired by something other than science.

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