ACOUSTICS

String Theory

A WEAK SUN MAY HAVE SWEETENED THE STRADIVARIUS **BY LAURA WRIGHT**

STRADIVARIUS VIOLINS may have benefited from colder than average temperatures.

Myriad proposals have surfaced in the past several centuries to explain how Antonio Stradivari imbued his now priceless wares with transcendental sound. Some have suggested that Stradivari used beams from ancient cathedrals; others argued that he gave his wood a good urine soaking. The latest theory proposes that the craftsman should thank the sun's rays—or lack thereof.

Stradivari could not have known that his lifetime coincided almost exactly with the Maunder Minimum—the 70-year period (from 1645 to 1715) of reduced solar activity that contributed to colder temperatures throughout western Europe during what is called the Little Ice Age.

Stradivari and the Maunder Minimum "began life a year apart," says Lloyd H. Burckle, a paleobiologist at the Lamont-Doherty Earth Observatory of Columbia University. "Which means that during his later years, the golden period, he had to build violins out of wood that grew during the Maunder Minimum." The reduced radiation from the sun would have slowed the movement of the warm air over the Atlantic Ocean to western Europe, setting off a decades-long period of colder, drier climate. Such conditions would have been especially harsh for a tree adapted to temperate climes, such as the Norway spruce, Stradivari's favorite for making soundboards. The result was slower, more even tree growth, which would yield a stronger and denser wood—positive attributes for violin crafting.

A changing climate probably didn't act alone in the Alpine forest of northern Italy, where Stradivari is said to have harvested trunks, Burckle notes. But when coupled with a unique amalgam of environmental factors—such as the regional geology, soil chemistry and moisture and slope and direction of the mountainside on which chosen trees grew—the altered climate becomes a more viable player. Burckle presented his hypothesis to Henri Grissino-Mayer, a tree-ring scientist from the University of Tennessee who has studied the influence of the Maunder Minimum on trees in western Europe, and the pair published the idea in the summer 2003 issue of the journal *Dendrochronologia*.

If indeed the Maunder Minimum led to the superlative sounds of the Stradivarius instruments, then it might appear that future violins would never produce similarly dulcet tones. "If you say it's the climate and it will never return, that makes it all seem hopeless," remarks Joseph Nagyvary, a chemist and violin maker at Texas A&M University. But having studied for three decades how various wood treatments can enhance the sound of instruments, Nagyvary thinks Stradivarius-like quality is achievable without an ice age: "We can now make the sound just as good."

Laura Wright is based in New York City.

MIGUEL VILLAGRAN *EPA*

NEUROLOGY

Aching Atrophy

MORE THAN UNPLEASANT, CHRONIC PAIN SHRINKS THE BRAIN **BY LISA MELTON**

An occasional headache is a nuisance, but severe, unrelenting pain can blight one's existence. Scientists have now learned that chronic pain, which often leads to anxiety and depression, can also effect neurological changes. It can shrink the brain and impair one of the most valuable mental functions: the ability to make good decisions.

Pain is a defense system that indicates when something is wrong, comments Marshall Devor, a pioneer in pain research at the Hebrew University of Jerusalem. "When

there is a persistent tissue disorder or there has been injury to the nerves, it's like an alarm that is broken. Pain becomes a disease in its own right," Devor points out.

Pain signals originate at the site of injury but soon lay siege to the entire nervous system. When pain is unremitting, dramatic changes follow: spinal cord neurons become hypersensitive and start firing in response to weak stimuli. This hyperexcitability ratchets up all pain responses, which explains why people with diseases such as arthritis, cancer and diabetes or with nerve trauma caused by surgery sometimes experience widespread pain from even the lightest touch.

"Pain always travels to the brain" and could cause damage, surmises A. Vania Apkarian, a bioelectrical engineer and physiologist at Northwestern University. To test his hypothesis, Apkarian turned to magnetic imaging. Zooming in on the brain chemical *N*-acetyl aspartate—the amount of which correlates with the density of neurons—he identified a striking difference in the prefrontal cortex. Pain was apparently triggering brain atrophy there.

Apkarian compared the overall volume and regional gray matter density in patients who had chronic back pain with those features in nonsuffering control subjects. The preliminary results were revealing: the average atrophy was greater in those with lower back pain than was normal. "The difference is highly significant," he states.

Because the prefrontal cortex is crucial for emotional decision making, Apkarian wondered if constant pain might be clouding people's judgment. He asked 26 people who had suffered lower back pain for more than one year and 29 normal volunteers to play a gambling card game called the Iowa Gambling Task. The test was originally developed by neuroscientist Antonio R. Damasio of the University of Iowa and his colleagues to study decision making in risky, emotionally laden situations.

The game involves selecting cards from decks with different potential cash payouts and penalties. Normal subjects

PUTTING UP WITH PAIN

Percent of Americans reporting chronic or recurrent pain in the past year: 57

Percent reporting pain "all the time": 40

Percent reporting constant pain in the U.K.: 14

European average: 19

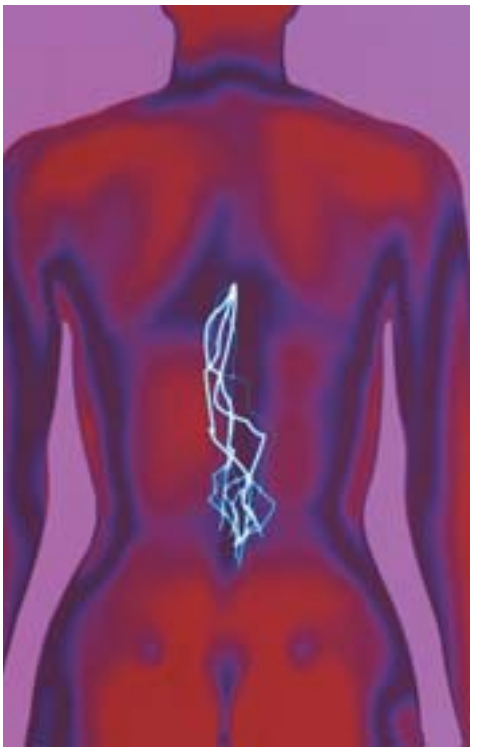
Most common type: back pain

Estimated U.K. health costs related to pain syndromes, 1998: £1.6 billion

Cost when informal care and productivity losses are factored in: £10.7 billion

Annual cost to U.S. employers, estimated as lost productivity: $61.2 billion

SOURCES: Research!America 2003 telephone survey of 1,004 adults; Pain Society of the U.K.; European Federation of IASP (International Association for the Study of Pain) Chapters; Journal of the American Medical Association, *November 12, 2003.*



STRAIGHT TO THE BRAIN: Chronic pain, such as that from a bad back, not only saps the joy of living but also shrivels neurons.

COMPUTER IMAGE BY ROBERT S. WINTER *Photo Researchers, Inc.*

learned to optimize their choices, tending to select cards from decks that made them money. But participants with a pain history tended to select cards randomly: they seemed to lack a master plan, which resulted in 40 percent fewer good choices compared with those made by nonsufferers. What is more, the amount of suffering correlated with how badly they played. "Chronic pain is driving these people to make poor judgments," concludes Apkarian, who presented these findings at a Novartis Foundation symposium last fall in Tsukuba, Japan.

Yet other cognitive abilities remained intact. "None of these patients are dramatically impaired," says Apkarian, who, to avoid confounding factors, excluded from the study people with high depression or anxiety. "This study raises the question of whether these people are making appropriate decisions in everyday life," speculates Apkarian, who found similar effects with sufferers of chronic complex regional pain syndrome, a nerve disorder that may follow injury to the arms or legs.

"These are very interesting results, but we need to know more about what these changes really mean. Are they reflecting changes in brain metabolism," or do they indicate "true nerve cell loss?" wonders Anthony Jones, director of the human pain research group at the University of Manchester in England. "It seems unlikely that a strong sensory input would cause brain damage, since we know the brain is so good at protecting itself," he adds. If the loss is real, then the next step would be to determine if the damage can be reversed—and compensate for painful choices.

Lisa Melton is based in London.

PHYSICS

Seeing Single Photons

A SUPERCONDUCTING WAY TO SPOT PHOTONS ONE BY ONE

BY GRAHAM P. COLLINS

Charge-coupled devices, or CCDs, have become commonplace in modern consumer electronics. They are used in digital cameras and camcorders and in document scanners. Introduced in the late 1970s, they have become the workhorse light detector for astronomers. But CCDs have a number of limitations. In particular, they do not detect the wavelength (and hence the color) of light. Digital cameras get around this by having red, blue and green filters over individual pixels or over three separate CCD arrays. Filters, however, reduce the sensitivity and are of no use for measuring wavelengths with any precision. Now a group of researchers at the Jet Propulsion Laboratory and the California Institute of Technology, led by Peter K. Day of JPL, has demonstrated a detector based on superconducting technology that can detect individual photons and identify their wavelength. Best of all, the detector seems well suited to being engineered into a large array like a CCD.

The heart of the detector is made out of a thin film of aluminum on a sapphire substrate. The aluminum is etched by standard photolithographic processes to form a meander-