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A Talk With John Chowning

By Paul Lehrman

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EXTREME VIBRATO AND OTHER ACCIDENTAL FLASHES OF GENIUS


John Chowning, circa 1986

John Chowning pretty much sleeps when he wants and works when he wants. That is why when I'm talking to him at 10 a.m. East Coast time — and he's on the West Coast — he's been up and composing for about four hours already. "Now that I don't have institutional obligations, I find it's really great," he says. "I remember hearing Buckminster Fuller give a talk about his lifestyle, and he said he'd work all the time, and when he was tired, he'd just take a nap. So I was inspired by that. Of course, Fuller says it's really hard on the rest of the family."

Chowning, for those of you who just got up, was the inventor of FM synthesis, the computational technique that ushered in the era of digital synths, MIDI, desktop music production and much of what we've all been doing for the past 20 years. At the age of 70, he's now a professor emeritus at Stanford, where he was on the faculty for more than 25 years, which means he doesn't have to show up for classes anymore. So what's he doing? He's devoted himself full-time to what a great many of us would like to be doing: composing with all the neat new tools he and those who learned from him helped develop.

Chowning was the founding director of the Center for Computer Research in Music and Acoustics (CCRMA, pronounced "karma") at Stanford, one of the most successful think tanks for music technology in the world. Some of the most important research in music synthesis and digital signal processing that we use today emerged from there, and among the many major figures who worked there were Andy Moorer, developer of the legendary SoundDroid for Lucasfilm and founder of Sonic Solutions; David Ziccarelli, writer of Opcode's original DX7 patch editor and now head of the wildly innovative software company Cycling '74; and Julius O. Smith, creator of what was to become known as physical modeling synthesis.

I ran into Chowning at the recent AES in San Francisco, where he was on a terrific standing room — only panel about the early days of electronic music in the Bay Area. A question came up from the audience (okay, it was me) about the future of electronic musical instruments, and his answer was short but highly thought-provoking. So I went up to him afterward and asked him if he would be willing to elaborate on it. A few weeks later, we had a fascinating 90-minute phone conversation covering that and many other subjects. So many, that this column is going to be in two parts.

Chowning was always a musician, never a scientist. He grew up listening to the big band music of the World War II era and started violin lessons in public school at the age of 7. A few years later, his junior high school band needed a cymbal player who could read music, so he became a percussionist. He served in the military and went to the U.S. Navy's music school where he learned jazz. "It was an amazing place during the Korean War," he recalls. "The Adderley Brothers were there and a future member of the vocal group The Hi-Lo's. There was a very high level of playing."

He then went to college on the GI Bill and studied composition, which he followed up with three years in Paris studying under the legendary Nadia Boulanger, teacher of generations of composers from Aaron Copland to Quincy Jones. In Paris, he heard, and was seduced by, electronic music for the first time, thanks to a concert series produced by Pierre Boulez. "It wasn't Boulanger's music," he recalls. "She was more fond of Stravinsky and the romantic composers, but she had a fascination with it — Boulez in particular — and she encouraged us to go." There he heard many of the great pioneers of the early electronic era like Luciano Berio, Henri Pousseur and Karlheinz Stockhausen.

After Paris, he went to Stanford for graduate study, but there was no electronic music there then. That would soon change: "My second year there, someone gave me an article from *Science* by Max Mathews who was at Bell Labs. I tried to understand it. It made this fantastic claim that any sound that could be perceived could be produced by a computer. So I went down to the computer science department and took a course in ALGOL [one of the first computer languages]. I contacted Max, who was at Bell Labs, and visited him. He gave me a stack of punch cards, which was the BEFAP compiler [Bell Labs' custom FORTRAN language] for the IBM 7094, which you needed to use Music 4, the music composition software that was available. I didn't understand much of what he told me, but then I read an article by James Tenney in Yale's *Journal of Music Theory*, and after that, I understood everything in Max's article.

“So I had this stack of cards, and I was wondering how I was going to get this to happen,” he continues. “One day, I was standing outside the computer center and this student walked up whom I knew, since he was the tuba player in the orchestra where I played timpani, and he asked me if he could help. That was David Poole, who was a sophomore math major, and he was hanging around what was going to someday be the A.I. lab. He taught me everything I needed to know. Among other things, he figured out a way to transfer the computer sample data in a dual-buffer arrangement so it could be output as a continuous stream. Up to that point, it was a two-step process: At Bell Labs, they had to write the output to a computer tape and then send it to a separate D-to-A converter. So this was probably the first online [real-time] computer music system.”

This process of going around to various sources until he could get his hands around a concept came to define Chowning's development. “I thought maybe I should go back and take some math,” he says. “So I enrolled in Algebra A; I think they called it Bonehead Algebra. I was already 30, 31 years old, and my last math class had been in high school. I struggled through it. I understood everything, I just didn't have the capacity to get through these tests in the few minutes we had. I had to beg the teaching assistant for a passing grade. I said to him, ‘Imagine you were taking a music course and I asked you to play an augmented sixth chord in the key of A-flat major. Musicians can do it right away. You could figure it out, but it would take some time.’ He said, ‘Yeah, yeah, I understand.’ So he didn't give me an A, but he did pass me. But I decided this was no way to learn what I felt I should know. Finding out answers to the immediate questions at hand was more important, but I needed to find the right person to explain it to me.

“At the computer center, the environment increased the number of timeshare users from eight or nine to 20 or more, and now there were all these people there I could talk to: engineers, psychologists, philosophers, linguists. So I built up an incidental education. If there was something I wanted to know, I would ask the same question of all these people, until I could finally get an answer in a way I could understand it. That's how I learned physics and acoustics.”

Chowning's first work at the computer center at Stanford in the early '60s was with reverberators and other spatial illusions in a 4-channel surround environment. “When I started out,” he says, “someone told me I would need vector algebra, and I said, ‘Yeah, right,’ but instead I thought, ‘How else can

I capture this information about distance and Doppler Shift?’ Well, I just did it graphically. The lab had an arm with potentiometers in two angles, like a drafting machine, that plotted points on a CRT — sort of a precursor of a mouse. It plotted the points at a constant rate, so if you moved more slowly, the points were closer together, and if you moved faster, they were further apart. So I would just measure the points and that would give me the velocities. And it worked. Some of the mathematicians there laughed at me, but I got this 4-channel system to make these sound paths.

“That was the single most important point of learning for me: the importance of programming. I couldn't solder — I still can't — but I could make all these things with just a modicum of programming skill. I could bypass all the [engineering] detail and go directly from brain to output with just programming. I would write a subroutine to do a spatial path and another to do a circular path, and just use them whenever I needed to. The essential notion of efficiency came to me like a knock on the head.”

In Chowning's view, musicians and computers are not at all an unlikely combination. “Music is a symbolic art,” he says. “A painter gets the sensory feedback immediately, but musicians are used to writing things on paper and hearing them later. So they have to deal with symbols, things that are some distance away from where they are at the sensory level. It might be why music was the first of the arts to make so much artistic use of the computer. I know that other artists were working with computers at the time, but there wasn't this rush of activity — ‘I've got to get back to the computer center to work on my piece’ — that musicians had. And this wasn't the electronic music I heard in France. There was now this whole other dimension besides just producing electronic sounds.”

The idea of a musically oriented research environment with a variety of brains to pick resulted in the founding of CCRMA. Chowning usually gets the credit, but, he says, “I didn't create it — it just sort of happened. Andy Moorer, John Grey and Loren Rush were grad students there, and we were doing projects that came out of a collegial need. We'd ask each other, ‘What are you doing?’ ‘Can you modify that?’ Lots of applications would develop from that. Because what we were doing was interdisciplinary, it didn't fit in the music department, which was dominated by musicologists. So we decided we should form some sort of center that would allow us to apply for funding. I was the one on the faculty, and so I became the director. I chose good people — the idea was to make an open, accessible system and then leave people alone. The downside was that I became the administrator. There were fights to keep it intact and funded.”

Initial money came from the National Science Foundation and the National Endowment for the Arts, but a big break came when the Systems Development Corporation came across with $2.7 million. “Systems Development Corporation was a Defense Department contractor, and they had made an enormous amount of money,” says Chowning, “which they had to dispose of. We were one of four centers to get grants for computer music.” The grant came in large measure because of the efforts of John R. Pierce, another Bell Labs scientist (among whose myriad major accomplishments was coining the word “transistor”), who was so enamored of the center that he worked at CCRMA for more than 12 years as a “visiting” professor without ever asking for a salary.

It was in 1967 when Chowning first discovered the idea behind FM synthesis. “I was experimenting with extreme vibrato,” he recalls, “and I heard these inharmonic sidebands. I did a bunch of experiments, and I brought in an engineer to see whether what I thought I was doing was what the science would say that I was hearing. He looked at the equations and said, ‘Yeah, that's right.’ It was all very counterintuitive: Not a theoretical discovery, it was an ear discovery.

“But I was deep into the quadraphonic stuff so I put it on the back burner,” he continues. “In 1971, I was thinking about work that Jean-Claude Risset had done in additive synthesis [among Risset's contributions was showing that the harmonic spectrum of natural sounds changes with overall amplitude] and that Max Mathews had done in analysis synthesis, and I realized I could do the same sort of thing by coupling an amplitude envelope to a modulation index.” In other words, by varying the amount of frequency modulation over time, he could control the spectrum of a sound by using just two oscillators. “I realized it was all predictable, and within a few tens of minutes, I had some pretty passable brass tones. So then I wrote an article for the *AES Journal*, which was published in September 1973.”

Like The Beatles being turned down by the first few record companies their manager went to, Chowning's ideas on FM synthesis were rejected by several companies that Stanford's Office of Technology Licensing tried to get interested. Among them were Hammond and Wurlitzer. Chowning says of these companies, “Frankly, I don't think their engineers understood it — they were into analog technology and had no idea what I was talking about.

“But then the office put a Business School graduate student on the project, and he found out that the world's largest manufacturer of musical instruments, even though they didn't have much of a presence in the U.S. at the time, was Yamaha. One of their engineers was visiting their American office, so he came up to Stanford for the day. I guess they had already been working in the digital domain, because in 10 minutes, he understood exactly what I was talking about." The rest, as they say, is history.

Though not exactly linear history. "Of course, the Yamaha patents made a huge difference," says Chowning, "but they didn't begin to pay off for a number of years." And in the meantime, Chowning had lost his job. "Like many universities, at Stanford you teach for seven years and then they either give you tenure or you're out," he says. "No one understood what was going on in computer music so they didn't promote me, and in 1973, I had to leave."

Next month: The answer to my question on the future of instruments, the meaning of the DX7, what musical instrument designers should be working on today and how the professor got his spot back.

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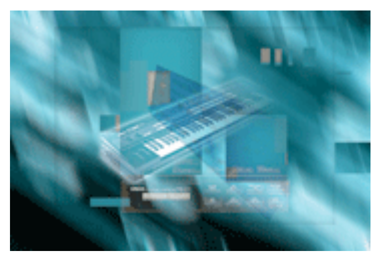
PART II—MAKING ELECTRONICS SING



In last month's "Insider Audio," I began a discussion with legendary composer and music technologist John Chowning, which sprang from a conversation I had with him at last fall's AES conference about the future of electronic musical instruments. When we left off in the story, our hero had invented FM synthesis, gotten Yamaha interested in the idea, published several pioneering papers in the *AES Journal* and founded the Center for Computer Research in Music and Acoustics — the legendary CCRMA — at Stanford University. Oh, yes, and he'd been let go from the Stanford faculty.

"I understand why they did that," he says now. "Except for Leland Smith, I think it scared the music faculty a little bit: the idea of machines in this deeply humanistic department full of musicologists."

But meanwhile, by the late 1970s, Yamaha began to get very serious about building digital synthesizers using FM technology. The company had put together a couple of prototypes called "MAD" and were working on what was going to be its first commercial FM synth, the fantastically complex (and expensive) GS-1. So Yamaha came back to Stanford looking to extend and make exclusive the license it had bought for the patent that Chowning had created and had signed over to his then-employer. Only Chowning wasn't there: He'd been invited to do an artist-in-residency in Berlin (arranged by famed composer György Ligeti) and was also asked by Pierre Boulez — whose concerts had introduced Chowning to electronic music while he was a graduate student in Paris — to help design the new French government musical research center, IRCAM. It was, no doubt, a bit of an embarrassing moment for the university.

Chowning hadn't completely severed his ties with Stanford, however, and in 1975, had come back to CCRMA as a research associate to work on a piece that IRCAM commissioned. And a couple of years later, he was given an offer to return to academia. But it wasn't from Stanford: The University of California wanted to appoint him as a full professor. Stanford, finally realizing what it had lost, asked him to come back with tenure. "It was the only time they had ever let a junior professor go," he recalls with a laugh, "and then hired him back."

The economics would soon make the wisdom in Stanford's decision clear. Yamaha's first popular FM synth, the DX7, came out four years later and sold something like 180,000 units, which was an order of magnitude more than any synthesizer had sold before. FM technology remained at the center of the company's electronic keyboard line, including home organs and pianos, through the TX, TG and SY Series for well into the next decade. The royalties received by Stanford for Chowning's patent totaled $22.9 million, making it the third most lucrative patent the university ever licensed. (Number two on that list is the gene-splicing technique for building recombinant DNA, and number one is a text-searching technology dreamed up by two graduate students that is now commonly known as Google.) Even though the patent expired in 1995, FM synthesis is still available as an option on Yamaha's current flagship synth, the Motif.

Those who were around at the time have their own ideas about why the DX7 was so popular — and all of them are right: The instrument was groundbreaking and amazingly useful in many ways. But Chowning's thoughts are a bit different, and they cast an interesting light on what makes for a successful electronic musical instrument.

One of the primary goals of a new instrument, he says, if it is to be successful, is that it be able to sort out the good players from the not-so-good. "Two of the most enduring electronic instruments are the Hammond B3 and the Rhodes," he opines. "That's because they have unusual acoustic attributes: They have instantaneous attacks, which pianos don't. So they offer rhythmic precision that someone like Jimmy Smith can take advantage of. That has real musical consequences and it reveals the deficiencies in lesser performers. The same thing is what was important about the DX7: It gave really good keyboardists expressive control that a keyboard without velocity sensitivity wouldn't have. Velocity is one of the things that pianists spend thousands of hours learning how to control. And when you coupled the velocity sensitivity to the modulation index, it gave a dimension to the timbre, not just the loudness, that was different from earlier synths and which our ears are very sensitive to."

Chowning recalls that soon after the DX7 was introduced, English musician David Bristow, who was one of the primary sound designers for the company (and still is, although his current work is on ring tones), did an experiment that showed how important minute timbral changes could be to a musician. "I was working with him in Paris at the time," Chowning says, "writing our book [*FM Theory and Applications*, a seminal tome published by Yamaha]. He convinced professional keyboard players that he was changing the action and the keyboard sensitivity on a DX7 and getting their reactions. Actually, all he was doing was increasing or decreasing the amount of what he called 'stuff' during the attack: the noise. It was an impression based entirely on acoustic feedback; he did nothing to the keyboard at all.

"The relationship between energy, force, effort and the acoustic result is a part of all musical performance," he continues. "More effort results in greater intensity or spectral complexity. I guess the exception to that is the pipe organ, but then again, in the early days you had this little guy in the back working the bellows. The B3 is a little different because the key velocity doesn't matter, but in that case, the precision of execution really does. So if you have a synth with *both* a sharp attack and velocity sensitivity, good keyboard players can get a high degree of expressive control out of it. So it reveals virtuosity, or lack of it, and separates out the really good performers from others.

"That's also why the WX7 [Yamaha's unique MIDI wind controller, which has been in production for some 18 years] works. It's easy to distinguish between a good player and a bad one.

"Here's what I would consider the ultimate test of expressivity. I proposed this to a concert pianist to get his attention. Now, I don't play the piano, so if I tell him to hit a note and then I try to hit it the same way, it will take me a few times to get the velocity just right. If he plays two tones, it might take me 100 times to replicate it perfectly. If he plays a phrase, just four or five notes, I'm lost. I could never do it. I could never convince a listener that it's him and not me. It's not in my hands, it's not in my training. So we need to look for instruments that expose that kind of technique, that have richness and can reveal virtuosity and expressivity. Those instruments will find users who will be able to highlight some or all of that expressive neural-motor connection."

Chowning doesn't think that breakthroughs in new instruments will look entirely different from what we're familiar with. But he does think that musicians can be encouraged to experiment with new techniques, as long as the encouragement is given in the right way. "Controllers that make use of existing technique ought to be the top issue," he says. "I would look for instruments that play upon instruments we already use. Piano, cello and violin are the three great virtuoso instruments — that's what kids learn to play. If you're looking for a population willing to be experimental, you'll find them in those three groups. And also wind players and horn players.

"For example, you could work on finding ways to use violin technique," he adds. "Not a 'virtual' violin where there's no physical object there — although we've worked with that and it's interesting — but a real object that lets players slap their fingers down and touch the strings; for example, Chris Chafe's 'celleto.' Some of the controllers we have today a dancer could do much better with than a musician. They have a sense of body movement that musicians aren't trained to have."

One instrument of the future, Chowning thinks, will be a fully programmable piano in which the soundboard and the strings — the heavy, temperature-sensitive part — disappear. "The measure would be if you could take a great pianist and blindfold him and sit him down, and he can't distinguish it from a grand piano. And then you move him to another piano, which is identical or maybe even the same one, but you've changed the key reaction characteristics and the sound quality, and he thinks that he's no longer at a Steinway; now he's at a Baldwin."

Another characteristic that he thinks makes for a useful new instrument is its ability to control large musical parameters, as opposed to minute ones. "The most successful controllers are those like Max Mathews' Radio Baton or Don Buchla's Lightning [which are both systems that track the motion of two wands in space], where a simple gesture can produce a result that has meaning at the highest musical level, such as loudness or tempo. It relieves the performer of dealing with all of the details. Think about an orchestra conductor who doesn't know how to play the violin or the bassoon, but she animates all these well-trained machines — the players, who have spent thousands of hours learning from the masters of their instruments, going back generations. Expressivity in machines has to have this kind of top-level control."

In addition, and this was the surprising answer that Chowning gave at the panel discussion at the AES conference, “For a controller to persist, it needs repertoire. It can be written repertoire or oral, or a tradition of jazz or folk or ethnic music. People who begin to play it have to have models of excellence or know that the music is rich because of a long tradition.” He points again to the B3 organ as an example. “The B3 could never reach the popularity of the piano because it is missing the idea that more effort equals greater volume, but it has a solid tradition in pop and jazz and gospel, and so it persists.”

Commercial manufacturers, although they have been very, very good to Chowning, are not necessarily going to be the ones to produce these instruments, in his opinion. “People like Buchla have different ultimate interests than a company like Yamaha. He senses an opportunity and builds a device that extends the performance capability in ways that performers never asked for. His nose is ahead of the pack. Yamaha, on the other hand, is looking for ways to engage the public. If in doing so they can make a more expressive instrument, that's desirable, but they need to make money. Their grand pianos are their great tradition, and fortunately, they make money with them because if they were marginal, they'd stop making them.”

Chowning is very happy that the state of electronic music technology has reached the point that it has, just at the moment when he is able to retire from teaching and concentrate on composing. “The present is the dream for me,” he says. “It's all software and real time and portable. I sit here with a laptop that has more power than I could ever use. With a laptop Mac or PC and a MOTU 824, it's like I have everything I've ever had in all the labs we've ever built, in all the years at Stanford, in 10 stacks of Samson boxes [refrigerator-sized, computer-controlled synths that were state-of-the-art in the late 1970s] put together. Software synthesis is the take-off point for ultimate freedom. The only hardware devices you need are controllers; there's no real reason anymore to build a synthesizer.

“But we still do need controllers,” he says in conclusion, “and the difficulty is how to put that extra piece, that performance knowledge, into them.” Fortunately, musical expression, according to Chowning, is not an unfathomable art, although we have much to learn. He points to studies done by a scientist at the Royal Institute of Technology in Stockholm named Johann Sundberg, an eminent researcher who, among his many accomplishments, showed why you can hear an operatic soloist over an entire orchestra. “Sundberg did some wonderful work on the voice: how the vocal tract changes, how the timbre changes, how to shape a phrase using little gradations in the intensity and the linkages with pitch glide. That's an area that if we understood more, we could make our machines more expressive. It would be extremely enriching. Because once you understand that, you can apply it to a violin or to any other instrument. After all, the voice is the instrument of instruments."

Paul D. Lehrman teaches a course in electronic musical instrument design at Tufts University, but knows he, too, has a lot to learn.