B O W   W O W

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The interactive violin bow: its history, role, and potential in improvised music—a personal perspective.

Abstract. Bowed string music has always existed as an aural culture with improvisation considered a prime focus of expression. Even allowing for the aberration known as Western Art music, it is the author's strong belief that experimentation is the natural state of all string music. This paper concentrates on recent history: bows that have incorporated interactive sensor technology. The central narrative deals with the author's own experiments and experience at Steim since 1987 (The Hyperstring Project); the contributions of others in the field are also examined. How well have sensors such as Ultra Sound, pressure pads, accelerometers, infra-red, and radio transmission mapped the tactile and inherently flexible characteristics of the many bow strokes (legal and illegal) available to the improvising string player? How reliable and practical is this technology? Are the results worth the trouble? What musical and new media possibilities are available for a violinist through an interactive bow that are not available through the traditional bow? Are there new modes of improvising only possible with an interactive bow?

Grunt Grunt

Sometime after the last Ice Age, a hunter-gatherer returned to his cave and, instead of sharpening his arrows for the next day's sortie, picked up his bow and started to improvise on it—using his fingers, a stick, or a bone. Sometime later, in a stroke of genius, he started to use that weapon to excite the strings of a chordophone, a precursor to the rebab, lira, ravanastron, er-hu, kalumbu, crwth, berimbau, bumbass, chikara, viol, and violin, to name but a few from the long list.

Bows come in a plethora of shapes and sizes, from the colossal arched Vega bow invented through misguided Bach scholarship (1), to the abrupt, serrated, and hairless stick used with the Korean ajaeng (zither). One thing, however, that bows with hair have in common is their stick-slip action. While the bow hair is sticking to the string, motion in one direction is followed by a quick snap back in the opposite direction upon release. This gives rise to the characteristic saw-tooth waveform and consequent sound of the bowed string.

With the invention of the "modern" François Tourte (dates please) violin bow in the 18th century, an aesthetic as well as technical watershed for the violin bow was reached. Up until that time, violin bowing technique maintained the essence of its dance music origins in the *messa di voce* bow stroke—a short, sharp sonic hairpin articulating a rhythmic gesture. The accumulated knowledge of the dancing bow reached its zenith in works such as *L'arte del Arco –The Art of Bowing* by Giuseppe Tartini (1692-1770). Post-*messa*, composers (with the exception of the virtuoso class like Paganini) moved string music ever further away from the rhythmic impulse into a symphonic swirl of massed strings—leading to Mahler and eventually to Mantovani. Nothing wrong with either, but the rise of the symphony orchestra to unchallenged power sped the death of many improvising traditions in European music. The ones that survived, such as church organ music, did not use the violin bow.

Up and downs

The majority of *detaché* violin bow strokes take place at right angles to the string—the legitimate angle of action. Once an improvising musician circumnavigates this straightjacket convention, a number of bent bow strokes can be applied to the string—from the diagonal to the almost parallel. The *lateral* bow stroke (with bow hair moving at 180 degrees up and down the whole fingerboard) is perhaps the most useful, revealing (with variable pressure) a smorgasbord of vibrations and transient noise. The *circular* bow incorporates a loop of lateral (the normal saw tooth action) and longitudinal (à la Ellen Fullman) vibrating options. Between the axis of the straight and unstraight bow stroke lies a broad area of under-utilized bow options—and that's using just the straight, plain vanilla, *detaché* bow stroke.

If we push and pull on through the bow's repertoire of tricks, we find the *martelé,* meaning 'hammered", referring to a percussive on-string stroke produced by an explosive release following heavy pressure—a kind of initial pinching of the string. *Staccato* is basically a series of *martelé* strokes but taken in one bow stroke. Then, we get to the *flying staccato*, probably more hovering than flying, which leads us to the *ricochet* or thrown bow stroke said to have been invented by Paganini in a very bad mood.

Improvisers such as myself have developed variations and combinations of these two killer actions—one of mine is the equivalent of running on the spot for extended durations (it comes with an RSI health warning). Utilizing and extending its basic binary action, the bow will present a full range of sensors with quite an array of readings. (Oh, I forgot to mention the *tremolo*. On no account use this bow stroke! These days it is considered very uncool to do all that light weight rapid up/down stuff. That said, it's a very effective bow stroke that all non-string players want to do when they pick up a violin for the first time, 'cause it looks good and punters think you are really working hard).

The *reverse* bow requires the string player to remove bow hair from bow by undoing the frog, then replacing hair in said frog, but with the instrument now caught between bow hair and bow stick. This enables the violinist to play all four or more strings at once. Like most string techniques, it has probably been around since the beginning of bowing itself and was standard fare in the fiddling traditions before improvisers took it to their own.

The same goes for super-slow *martelé* bow strokes that slow the sawtooth waveform and pitch down to something more like a chainsaw idling. Most improvisers can control this bowing feature quite well, but Mari Kimura is in a sub-tone class of her own, capable of playing a complete scale *down* from the open G (the lowest string on her violin). These kinds of sub-tones are not achievable through any signal processing that I have heard.

In the classical pedagogy of the last 150 years, the bow has been pacified and straightened out, and the violinist conned into the notion or nonsense of the "endless singing line." The violin was not invented for singing, but dancing! And for dancing, you gotta have rhythm in the bow. Any research directing the bow towards a more radical life armed with sensors needs, I believe, to take this into consideration.

Despite gravity

Once the bow leaves the strings, theatrical space can be accessed, the audience easily following the gesture; away from the violin, the sonic simulacrum of a fly can meet its doom with the swish of the bow stick (2). Apart from the natural swish of the bow (one of the great acoustic gestures), other sonic phenomena lend association, such as the sounds of bird wings flapping, wind blowing, machines whirring, or pre-industrial slashing and hacking. The bow can unleash psycho-drama—the bow is a bit dangerous, you see; you can poke someone's eye out with it. In the hands of Wilbur Hall (Paul Whiteman's trombonist and the most out-there violinist ever recorded on film), the bow becomes truly a magician's wand. The famous armless violinist Carl Unthan was also captured by camera but, alas, there is no movie of him plying his bowing skills with his right foot.

The bow is forever weaving a pattern, like a giant knitting needle noodling with imaginary wool, drawing transitory shapes, creating an abstract gestalt, not quite a synaesthetic condition, but posing intangible relationships. The sign is written in the bow stick as well as by it. The bow drips with its own totemic language. Looking at Youtube classical violinists (and there are many) with the sound turned down, it is possible to pick the piece being rendered (or murdered) as much by looking at the bow as by watching the left hand. The whirl of bow activity is a clear indication of sonic attack, duration, speed, timing, rigor, acoustic projection, and (in non-classical musics) pulse. Amplification can readily confuse that relationship—a volume pedal can transform or reverse that expected expression and function of bow, the lightest toneless bow hair sound becoming as loud as a full on *sforzando* down bow.

No contemporary percussionist worth his sweat leaves home without a bow of some sort. Their use is normally restricted to long tone generation, the revelation of harmonics in a cymbal, gong, or crotales. Let's face it, the bow is a supreme agent at this basic stuff. A few, like Paul Lovens or Gino Robair, go much further and have developed a set of other uses such as a heavily rosined stuttering around the rim of the snare drum.

Hearing the Hair

With a quick rub of that rosin, or colofon, let's move onto the bow hair itself; it's a much under-estimated sonic performer. It's there, embedded in every bow stroke that the 'perfect' Heifetz-type classical violinist ever emitted. It's the noise, the grain, the grit behind any bowed utterance. By itself, a belt of droning broadband noise, but amplified and augmented by pitch shift, the horse can get very frisky with a sound pallet reminiscent of a double bass, Albert Ayler in the tope octave, or a barbed wire fence.

The bow can also play the big switch character. Keith McMillan's K-bow has included gesture recognition software. (Improvements pending: It can get unpredictable when the number of gestures reaches over ten, but as an improvising device, a switch with unstable desires and unknown preferences can also be used to positive improvisational effect.) In terms of embedding a multiplicity of MIDI switches into an improvised language, the selection and isolation of a suitable gesture for each function becomes a key part of the sonic theatre. The gesture must resonate in the subconscious and bubble to the surface almost before it is required, in the same way that many deeper level decisions are made in all instrumental improvised music.

In conversations with George Lewis about his interactive Voyager project, I remember him saying something to the effect, "Well, I make a pretty good sound on the trombone, why would I want to change that?" Yes, indeed, if the bow is just about the addition of signal processing (let's call them effects!) to the regular violin, is that a worthwhile endeavor? My first effects gadget, purchased in 1969, was a wah-wah pedal—not the kind of thing I wanted an interactive system to bother with 20 years later. Saturated feedback-distortion, however, is a sonic state that I have never grown out of, even 40 years on.

The use of samples became a polemic quest: the simultaneous comparison of the industrial string sample or the self-made string sample to the real string sound. And since I had a garage of homemade string instruments (The Relative Violins), I could explore the contradictions of what constituted fake, real, industrial, and authentic homemade all in real time (3). The convincing and unconvincing illusions of bowed, struck, plucked—once amplified—seemed to hang more on issues of context than anything else. The excitement lay, above all, in the collision of these real and not so real sounding sonic artifacts.

Suitability of sensors: Once upon a time Ultra Sound ruled; then came the reign of the accelerometer. Most sensors are there to model movement, and despite problems of reflection, Ultra Sound did this effectively. As the price of accelerometers dropped throughout the 1990s, the rules of the game were transformed: accelerometers were active, you could play with them, and exploit and exaggerate bow movement. Most experimental interactive bows are now fitted with accelerometers in or on the frog. IRCAM has their clip on controller (4). Diana Young, with her "Hyperbow: A precision Violin Interface," has taken the MIT bow measuring pursuit to another level—but accelerometers do not measure bow movement with "precision." To expect so is a reductive use of their potential. However, Young has inserted a strain gauge into the bridge, an innovative move that must yield useful data on bow pressure (5).

The Holy Horse

The Holy Grail for many scientists is to come up with an algorithm that will model a convincing violin simulacrum in real time. Measuring the complexities of bow action is fundamental in this research. To many non-violinists, the huge data difference between an up-bow and a down-bow may come as a surprise. As I've indicated, I prefer to exploit the gaps and failures of this mission impossible: mine is an improviser's, and not a composer's, worldview. If I want the sound of a real violin, then I can just pick up the instrument and play it. Interestingly, most researchers in this area are also string players themselves; there is almost a religious smell about the quest. How to know the unknowable? It's the "What's in the Stradivarius magic varnish?" syndrome.

Bernd Schoner spent research time in the 1990s analyzing bow movement through oscillators mounted tip and frog, a chain of resistors along the stick, an antenna positioned underneath the violin strings, and another antenna mounted on the bridge; the received signal strength was proportional to the bow position relative to the bridge. The collected data was synthesized into his Marching Cello, a set up that demanded that he play his leg with the bow (6). Let us pause to hear the sound of a leg being played with a cello bow.

What sonic effects might be analogous or amplify what the bow already produces? Probably the most successful results to have been reverse-engineered from bow action deal with timbre; rhythm is a much tougher nut to crack, and I know of no research which deals specifically with its modeling. The bow is capable of filtering the violin strings' twenty-plus harmonics to an extraordinary degree through positions relative to the bridge (*sul ponticello* to *sul tasto*) and by applying a range of pressures and arm weights. Max Mathews experimented with tuning, adding, and removing the characteristic resonances of the violin in the mid 1980s. Earlier attempts would have to include the engaging Peter Beyl and his IT-violin that he showed me in Brussels around 1990.

This has set the stage for further research. Charles Nichols' V-bow and Dan Overholt's Overtone Violin spring immediately to mind. Nichols has taken the lead from bowing-machine maker Chandrasekhara Venkata Raman, who in 1921 created an electric motor-driven prototype to test variations of bow speed and pressure under controlled conditions. (I first read about him in the

Acoustical Cat Gut Magazine, the organ of recently deceased luthier Carleen Hutchins, pioneer of the extraordinary Violin Octet). Under the title “A Four Degrees of Freedom Haptic Musical Controller Human-computer Interface,” Nichols has built a beaut robot, with servomotors, encoders, and cable systems, to sense a fiberglass bow in three dimensions of operation (7). Sadly, the composer limits its function to a data generating/collecting device. I would like to hear what and how it can manipulate in real time by itself or lined up in direct comparison or competition with the human version. I reckon it’s for public consumption in the same way that the Aeolian Company’s Violano was.

Now the V-bow machine has been built with laser precision, so it probably can repeat the same operation without variation. For the Inventionen Festival in Berlin 1989, I built a robotic violin quartet, each instrument with a simple one-dimensional mechanical bowing action (8). Because of my less-than-perfect craftsmanship or less than efficient German motors, the results always guaranteed variation, if not total bow malfunction. This may just demonstrate another difference between the improviser’s brain and that of the composer.

In 2004 I came across Dan Overholt, hunched over a workbench at Steim, busily soldering circuits on his Overtone Violin (9). This is one helluva piece of homemade violin. It comes with fingerboard-tracking sonar sensors, thumb slider, miniature joystick, a heap of pots, infra-red, wireless data transmitter, video camera for media and audio manipulation, and a glove for the bowing hand with (by now) ubiquitous accelerometers and sonar. Unlike the V-bow, this instrument has real strings —in fact, six of them, so you wouldn’t want to be doing complex double-stops often. The name of his violin gives away Overholt’s preoccupations with timbral manipulation, but he states, “The Overtone violin can be viewed… as a traditional electronic violin, and a gestural computer music controller.” The audio-visual composition Sonofusion, available online, shows a number of bow gestures triggering pitch-bend; the influence of the player’s gestures on the video is unclear. The excerpts from the DEAF 04 Festival show off the signal processing better. Rhythm in the bow, there is not. (To lighten the load, I might have taken off some of those switches on the violin and put them on pedals.)

The Pediatric Option

Global volume is probably better accessed through a pedal than on, say, a bow accelerometer or hair pressure. But then again, we could really work at a detailed volume set-up which exaggerates the gain with each clonk of a flying *spiccato* with changes in volume speed not possible with a foot pedal. This is also valuable when used with a noise gate. Depending on how fast our *spiccato* actually flies, we could reach the limits of MIDI processing, a protocol which everybody already complains enough about, so I won’t.

Most violinists who improvise on amplified violin have at some stage engaged with a foot-driven effects or volume pedal. You can spot those who are new to the game; they exhibit a kind of Parkinson’s foot disease. The older hands have developed a pediatric intelligence that takes care of business without the owner (or anyone else) noticing. The first and possibly only law of free improvisation: if you start a sonic action, you should be able stop it immediately.

Around 1999 I was donated a three-dimensional MIDI pedal built at the Sonology Department in The Hague. I utilized it for the basic procedures of volume, panning, and pitch bend. This was a joy to use in conjunction with my interactive bow but a pain to carry, as it was made of heavy gauge industrial steel; as gear, it is now, post 9/11, out of the question for concert tours.

I am going to stay off-message and suggest that fully functional feet can be more than just complimentary to an interactive bow system, particularly in solo improvisation. I do not have many heroes in music, but one would have to be Nicolaus Bruhns. He made quite a reputation as an organist, violinist, and composer at the time of J. S. Bach, but his greatest claim to fame was playing a ground bass on the pedal board of the organ and simultaneously improvising on the violin. In the early 1980s I built a pedalboard to control a string frame and later an amplified two-string pedal board with which to continue his tradition (10). The action was like a clavierchord's, with the pedal cutting each string into two vibrating parts. I initially thought that transferring pedalboard action to the digital realm would involve a chromatic pedalboard of some sort. Then, applying a simple logic, I remembered that I had but two feet, and all I needed were two footswitches with a third switch to change the function of that initial pair. There is something satisfying about stamping away on foot switches that a bow cannot emulate. And the immersive use of the body to demand an idiokinetic relationship with the digital world provided me with a performing rationale more akin to a traps drummer or late 19th century one-man-band straight out of Vaudeville (11).

The necessity to actually do physical work has often led me into jousting with programmers. The argument went something like this. Most programmers were looking for a simple gesture leading to a complex result, often bearing no relationship in scale to the original input. I was happy to have some heavy lifting done by smart programming but not at the expense of scale—the system had to reflect skill, energy, physical human limitations, time spent, and the fact that only one performer was the originator of the music; the potential for artist to morph into an all powerful Nieztsche-style übermensch was not useful. For the first two Hyperstring setups, I also limited my MIDI output to one channel's worth, setting the balance between the monophonic output of violin and digital modeling. The basis for this (to some eccentric) *modus operandi* was the clear instrumental paradigm that expression is often the result of playing to the edges of the possible—what is a piece of cake on one instrument may lie at the extremities of instrumental chops on another. I wanted a digital interface to replicate that. (My early-enforced stringency has relaxed since then, but I am glad I started out considering the issue).

Tail wags Dog

One advantage the violin has over other instruments is that it comes with a full cupboard of iconography. Not a month goes by when the violin's image is not dragged out to sell insurance, banking, real estate, holidays, magazines, lifestyle, and music itself. So, when Tom Demeyer of Steim showed me his pre-Jitter MIDI-to-image program in 1997, I was ready with the entire Rosenberg Archives, from Paganini to Pornography (12). (I once suggested to Tom that if my violin crashed as much as his Mac, I would put it on the bonfire). Mapping bow gesture to violin image is an exciting area, but it is difficult to move into the space beyond the constraints of film music; it's the old maxim of getting beyond the sum of the parts—the eye is so greedy. Much of the time I had to be content with a kind of synaesthetic counterpoint comparable to the way good hörspiel functions except with crossbred medium. My favorite improvisatory moment was the parallel interplay between two waving violin bows and the image of wipers on a dirty car windscreen as it headed outback to the vanishing point. (Since the arrival of Jitter, I see that most artists ignore this challenge, preferring digital abstraction that cannot fail in any context.)

Neal Farwell's interactive project of 2001, even without the play of MIDI-generated imagery, investigates the whole cultural and social baggage of what it means to play *second violin* and not *first*. "My Funny Fiddle project has been dormant for some years. Its aim wasn't to synthesize a string sound (I'd prefer the violin for that), but to make a new interface instrument that could draw on some of the trained technique, visual theatre and audience legibility, traditions of showmanship and real or simulated virtuosity…"(13).

Practice and Theory

I met Michel Waisvisz while on tour in Germany in 1983. He invited me to Steim; this was the same year that I was working on a violin and sampled-violin improvisation project with Martin Wesley-Smith on the Fairlight CMI (the world's first commercial sampler and by then already losing out to cheaper options). In 1985, I went to Amsterdam and got some useful advice from Joel Ryan and George Lewis (on their rebound from IRCAM). By 1987, I had a working MIDI bow using Ultra Sound and a bow hair sensor (a pressure pad taken out of a MIDI keyboard). Other explorations involved bar code, microphone triggers, and putting a sensor actually in the wood of the bow—none really useful in getting a varied and workable data stream.

According to Chris Chafe, who pioneered the Celleto resplendent with Max Mathews pickups, "That early bow was fiberglass with a 1" strain gauge mid-way down the stick (screwed to the top). Like you say, I also didn't like the results, but it was enough for distinguishing articulations. And it had a ribbon cable... interfaced to a Yamaha MIDI controller. There was an accelerometer on the frog." Chris went on to say that when the Don Buchla Lightning came along, he switched to that, using direct position tracking—small infra-red emitters on his wrist. It is easier to handle a bow with a wires coming off a wrist controller than to handle a bow with wires attached to the frog (14).

How to use the bow hair tension as an interactive controller took me a while to figure out. I eventually rationalized it as follows: I broke down violin technique into two basic functions: left hand as primarily *tone manipulator* and right hand as primarily *tone generator* via the bow. The line where each function maintained independence was mobile, of course. I developed a technique that could handle the system's specific difficulties, mainly weight and balance of bows and cables. It was quite a mind-fuck, as the bow, which was the engine of the violin, was also driving the computer system. If I reacted to what the computer did by playing something on the violin, then I automatically changed the state of the bow and its real world input via bow sensors to computer. It was the musical equivalent to Heisenberg's uncertainty principle: by identifying and entering the moment, you changed it.

Added to this conundrum were additional, sometimes uncooperative variants. The pressure sensor on the MIDI bow hair gave different readings depending on room or location humidity, how tight you had turned the screw holding the hair (slightly different every time), how hard you had dug in on the previous bow stroke (a well dug-in stroke might not have returned to non-bowing equilibrium by the time of the next stroke). Initially, I set up the Ultra Sound with a focal length of 5 meters, which lent to theatrical uses of the stage and led to miss-read reflections off objects and surfaces. I could also cheat the system by shielding or interrupting the signal in addition to relying on the violin content provision. In addition, none of the Steim hardware used in the Hyperstring project had any visual feedback information. I took this restriction as a positive feature, as it meant I had to learn the preset options of the entire system using only sound and muscle memory to negotiate the options. At one stage, I also set program changes through random access, which was like driving down a bumpy road: a series of forks kept popping up, and you never knew which one you'd find yourself on… a kind of dysfunctional AI.

Within a few years, I realised that this kind of headless "chook" (Australian for "chicken") activity was going to shorten my life, hence the introduction of foot pedal controls, the change over from ultra-sound to accelerometers, and use of the infinitely programmable Steim Sensor Lab (from 1989). With the Perks Badminton project of 1994, based on the Jekyll-and-Hyde mind of Percy Grainger, I got other people to start running around the stage or court. In effect, badminton rackets fulfilled part of the function of bows. Quasi "random" settings of the Spider code (the Sensor Lab software programmed for this project by Frank Balde) were also scaled back, as computers just do not get theatrical moments, and as in Murphy's Law, if there is a chance of misreading a moment, computers will. An accelerometer does not know or care if you just missed the shuttlecock or miss-hit it, or scored a point; even with a video to MIDI tracker, the meaning of a movement is not necessarily decoded into sound.

Oops, No Violin

Eh… let's go back a bit further: what about taking the violin away from the neck? History does not record who had the bright idea to move the violin away from the comfort of a cradling arm to the discomfort of wedging the thing between collarbone and chin. There are certainly advantages in terms of playing higher and faster, but if ever a non-violinist thinks that violin playing is a normal extension of being a *Homo sapiens*, let them stand for half an hour with the left arm held in the correct Carl Flesch posture (a dog's severely twisted hind leg) and feel the pain. The violin playing position is one of self-inflicted perversity. Cello fine. Piano fine. Trumpet fine. All other instruments fine. But the violin…

There is nothing so liberating as using a violin bow, free of a violin. I've got quite a collection of amplified bows, bows with extra strings strung along them, and string instrument homemades that are free standing. You can assault these instruments from all directions with a bow. All can be pitch shifted, scratched, or manipulated in some way by interactive bow-powered MIDI.

Dan Truman has developed this notion of an unattached bow to sophisticated home-made heights with the BoSSA (Bow-Sensor-Speak-Array), a spatial filtering audio diffuser speaker hub (to replace the resonating chamber of the violin) combined with Bonge and Fangerboard, the whole setup set off with his R-bow (two force-sensing-resistors between the stick and hair mounted on foam, plus two accelerometers). I heard and saw most of Truman's gear onstage at the now-defunct Tonic Club in NYC in 2000, and impressive it was, too, in very difficult circumstances (13).

Truman has also identified the composers who want to measure and control the data of a string player without the player actually having to react or change any aspect of his or her playing stick, and those who seek and relish a physical relationship, do not avoid it, and look for some sonic event that will change the moment—I guess we will call them improvisers. Truman clearly has MIT's Tod Machover (and his use of Yo Yo Ma) in his sights… then there's Truman and the rest of us who prefer to jump into the mess (interaction).

Suguru Goto, on the other hand, is seeking the third way, determined to screw up the violinist's back even more by fitting his Superpolm Violin with an interactive pressure-sensored chin rest. If you squeeze down on your chin every time you get or want virtual string excitement, you will be heading to an expensive specialist in your local clinic! To be fair, his non-stringed ersatz violin has some cool touch-strip sensors on the fingerboard, and there does appear to be a reaction when he shakes the Superpolm up and down on his website's video (14). However, the sounds being controlled have such long envelopes, front and back, that it gives away what he thinks a bow or indeed a violin should be about.

When it comes to putting a spanner in the works of the bow's haptic feedback, the British know how. Bennett Hogg submitted an interesting proposal to Steim in 2006; he called his project The Resistant Violin. His trajectory flies as follows: most digital technology is about making music easier and making the performer more powerful for less effort; supposing we reverse that, add technology, make music much more difficult, render the performer powerless if not impotent, and having to work harder and harder. Yes, he's onto something. Love it! The first thing he is going to do is connect the violin bow to a violin with fifteen strong elastic bands triggering strain gauges… I leave the rest to the imagination of the reader.

Haptic Feedback

It is not by chance that there are distinct classes of music instrument. The hit, the plucked, the blown, and the scraped exist because they map distinct physiological traits of our species. Each requires completely different motor skills. I am not an academic, let alone a neurologist, so it might be that in a dark cupboard somewhere, someone has carried out research, comparing brain scans as these classes of instruments undergo a set musical task. I have not, however, come across any controlled study that looks at this issue. My hunch is this. When a pianist, a violinist, a guitarist, a trumpeter, or a flautist of similar ability are asked to play an A 440 at various durations and amplitudes, or a phrase, or a complete piece, the neuron activity in the brains of each performer lights up in different amounts and in different parts of the brain. In the reductionist world of European notated classical music, a note is often a note is often a note. But from an instrumentalist's perspective, and of paramount importance in improvised music, it matters how a note is produced. The haptic feedback and instrument motor skills are fundamentally *other* for the various classes of instrument.

A violin bow comes loaded with cultural baggage to be confirmed, augmented, or undermined. The conventions and inventions associated with a bow are beautiful performance options, not just technical issues to be solved or ignored. The bow at work delivers a complex and subtle narrative, and in the context of improvised music at least, it makes you wonder how keyboard players continue to get away with it.

Apparently at Johns Hopkins University, researchers have fingered the medial prefrontal cortex region of the brain as the happening place that lights up when musicians improvise. This is the bit of the brain that flashes when people say "Well, that's enough about me, what do you think about me?" According to Dr. Limb (is that true?), improvisers simultaneously switch off the dorsolateral prefrontal cortex, where the brain plans careful actions and self-censoring. If only improvising were that simple. There is clearly a long way to go on mapping cognition in music, let alone improvised music (15).

Nirvana?

Can an improvising violinist now buy a commercially available interactive bow? Well, not only a violin bow, but the full set of viola, cello, and double bass bows are now available. Based on thiry years of his own and other's R & D (notably Don Buchla), Keith McMillen's K-bow looks like it will break out of the experimental ghetto and into the hands of any violinist who dares or cares (16). Within the fiberglass bow are two loops of wire acting as an antenna; it gives precise positional information about the bow in relation to an emitter that is tucked under the fingerboard. There is the expected x, y, z axis accelerometer in the frog of the bow. There is a very reliable pressure sensor that measures bow grip and makes an excellent program switch. There is a force sensing resistor that measures bow hair displacement. Altogether, there are seven streams of high quality continuous controller information transmitted via Blue Tooth to a computer. The bow is perfectly balanced and weighs no more than a regular bow (the MIT hyperbow weighs 30% more than a regular carbon fiber bow). Max-based standalone software, written by Barry Threw, allows for signal processing, sampling, looping, and the immersive possibilities of surround-sound. Not bad for a bow.

When Miller Puckette came up with his *fiddle* object in Max, he did not expect that there would ever be a perfect pitch rider for the violin; the signal is just too complicated. There are always octave displacements and odd pitches (the inexplicable sixth is common) occurring, often for no apparent reason—it is just an embedded feature of bowed sound. From a composer's standpoint, this is unacceptable behavior, but from an improvisationary aesthetic, the unexpected is often desired and relished. I set my MIDI note on outcomes from bow pressure in a way that I couldn't predict, but at the same time could feel a sense of pitched shapes and tonalities and where they might morph to. Through the bow it was possible to become aware of what might be described in Chaos Theory as the attractor sensibility. Just recently, at McMillen's studio, I was asked to try and screw up a new pitch tracking code—make it make mistakes. It read *spiccato* passages quite well but could still be tricked by fingered harmonics and *sul ponticello*. This gets better and better for the composer but is not really interesting to the improviser.

Other notions coming out of the McMillen's Beam Foundation preference the possibility of multiple bow interaction. This not only takes care of the quartet and chamber orchestra options but could take the bow(s) into more radical and scary scenarios. One of the Relative Violins from the 1980s was the Double piston, triple neck, wheeling violin—a double-bowed instrument built to measure distance in music (as opposed to time) in Australian outback conditions. Another was a Siamese twin violin that delved into aspects of duality; naturally enough it required a double bow. I later discovered the violin playing Blaûek conjoined sisters, who could have used this instrument if it had been invented back in 1891, when they were exhibited in Paris (17). Moving forward with these examples, we can begin to imagine the digital modeling of two or many bows dueling in previously impossible data worlds: dozens of interactive bows transmitting to a central hub or telematic bow hookups of massed strings swarming on a global scale—it's going to be a Chinese violin factory anyway.

Strings were never part of a military band going into battle, as they simply could not be heard. But digital bow transmission and amplification place the improvising violinist in contexts that historically have not been considered "in the tradition": violins outside the expected territory (The Relative Violin project also specialized in territorial disputes, such as performances involving the Sydney airport, freeways, beach, explosives, earth diggers, and supermarkets). So, the bow as active improvisational weapon in the digital realm does not necessarily have to transform the sound of a violin with signal processing, control samples or images, or make one violin or cello into a corporation-sized wiz-bang orchestra. The bow can intercede and improvise with any physical phenomena that can be measured, modeled, transformed, or powered by digital data, like traffic, credit cards, player pianos, robots, bulldozers, sports, weather, medical monitoring, or the real time collapsing figures of Wall Street.

To play improvised music with other improvisers these days still tends to be fun but not so challenging, as most aesthetic options have been mapped out, and most improvisers know what to do. It was more exciting thirty-plus years ago when etiquette was unclear and iconoclastic behavior common. An all round improviser on the violin should be able to invent a new solo line for a classical violin concerto, deal with lounge music, and play a counterpoint to an industrial digging machine, but above all engage with the digital age in which we find ourselves.

References:

(1) The Vega bow was inspired by German organist and African colonialist Albert Schweitzer and built by Knud Vestergaard and used in front of my very ears by my last violin teacher, Anthony Saltmarsh, circa 1963. The bow could be used to simultaneously play the all the notes of the four-part chords of J. S. Bach's *Sonatas and Partitas for Unaccompanied Violin*.

(2) Jon Rose performance: *Space Violi*ns with interactive violin bow at Ars Eletronika, Linz, Austria, 1990.

(3) *The Relative Violins* consist of over twenty hacked violins and homemade string instruments built by Jon Rose since 1976. See: http://www.jonroseweb.com/d_picts_relviolins_describe.html.

(4) IRCAM (Serafin, Vergez, and Rodet), Friction and Application to real-time Physical Modeling of a Violin, ICMA, Beijing, 1999.
(5) Diana Young, *Hyperbow: A Precision Violin Interface,* ICMC, University of Michigan, 2002.
(6) Bernd Schoner, Chuck Cooper, Neil Gershenfeld, *Cluster-Weighted Sampling for Synthesis and Cross-Synthesis of Violin Family Instruments,* MIT Media Laboratory, 2000.
(7) Charles Nichols, *A Four Degrees of Freedom Haptic Musical Controller Human-computer Interface*, PhD. dissertation, Stanford University, 2003.
(8) Jon Rose, *Automatic Violin Quartet*, Inventionnen Festival, Berlin, 1989. See: http://www.jonroseweb.com/d_picts_autoquartet.html.
(9) Dan Overholt, *The Overtone Violin: A New Computer Music Instrument*, ICMC, 2005.
(10) Jon Rose, *2 String Pedal Board*. See: http://www.jonroseweb.com/d_picts_2_string_pedal.html
(11) Jon Rose, *Violin Vivisecton*, Bethanien Concert, Berlin, 1986. See: http://www.jonroseweb.com/d_picts_vivisection.html
(12) Jon Rose & Rainer Linz, *Violin Music in the Age of Shopping*, NMA, Melbourne, 1994. See: http://www.jonroseweb.com/g_rosenberg_interactive.html.
(13) Neal Farwell, personal communication.
(14) Chris Chafe, personal communication.
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(16) Suguru Goto, *SuperPolm and Virtualaeri 2*, IRCAM, France, 1997.
(17) Nick Zagorski, “The Science of Improv,” *Peabody Magazine*, John Hopkins University, USA, 2009.
(18) Keith McMillen, *Computer Interface for Stringed Instruments*, ICMC, University of Belfast, 2008.
(19) Dr. Willy Orwig, *The Genetic Tendency in Violin Music*. See: http://www.jonroseweb.com/g_rosenberg_double.html.