Chapter Two

SEVERAL ELECTRIC "VIOLINS"

The Violin as Meta-instrument

Now he hit hard and clean on the notes, the double-stops true, a kind of goatish leap in his playing that had never been there before, that cooked out as a raw and slangy sound. Dolor was getting good music out of the box, rich and competent, despite the bad speakers, a yard ahead of his usual cut. The dancers were pulling the music out of them. People were dancing, bumping the stove, the table, the kitchen floor was undulating, Mrs. Bubbie was washing the dishes and slapping the clean plates into the drain rack, they were dancing through the door and into the backyard, when somebody slammed the refrigerator door and the speaker rolled off, bouncing from Mrs. Bubbie's shoulder into the dishwater where it simultaneously broke, exploded and loosed a savage current that raised the birthday girl's hair in a crest and threw her, staggering, into the crowd of dancers.

from *Accordian Crimes*, by E. Annie Proulx.[1]

A Superclass

At some point in their lives, most violinists are asked a seemingly simple question: what is the difference between a violin and a fiddle?[2] As an electric violinist, I have also been asked: what makes an electric violin a violin? The short answer to both of these questions is the same: the way the instruments are played defines both their differences and their similarities. These questions reflect images of the instruments, their music, and their social contexts. The three (unscaled) pictures below, of a "Classical" violin, a "fiddle," and an electric "violin" tell only part of the story:

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[1] E. Annie Proulx, *Accordian Crimes* (New York: Simon and Schuster, 1996), 201.

[2] This question usually refers to some nebulous ill-defined creature that may be Bluegrass, Irish, Gypsy, or any number of other fiddle styles.

Figure 1. A "Classical" violin, a "fiddle" and an electric "violin"[3]

The visual differences between violin and fiddle are hardly obvious. In design they are essentially identical; the primary difference lies in the choice of strings—fiddlers often choose steel strings for greater penetration. The electric violin, on the other hand, is so different that it is not immediately identifiable as a violin. The following pictures, with these instruments in the hands of their players, tell a different story:

Figure 2. Anne Sophie Mutter, Bruce Molsky, and Mark Wood[4]

Put to use, all three become "violins"—of sorts.

The broad visual image of these players defines them all as "violinists" and their instruments as "violins." The details give us an idea of their differences. In this

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[3]Image of "Classical" violin from http://www.silcom.com/~craig/anne-sophie/anne-sophie.html; image of "fiddle" from http://www.tiac.net/users/pleasant/samw/molsky.html; image of electric from http://www.moseisley.com/mw/wvhp.html.

[4]Image of Mutter from http://www.silcom.com/~craig/anne-sophie/anne-sophie.html; image of Molsky from http://www.tiac.net/users/pleasant/samw/molsky.html; image of Wood from http://www.moseisley.com/mw/.

sense, I regard the "violin" as an instrumental archetype—a superclass, or meta-instrument—that specifies little about the instrument and nothing about the music it is used to play (or its sound!). The "violin" is a bowed string instrument. Its strings are 32cm in length, give or take a few centimeters, and the bow is usually about 72cm long. It is held above the (left) shoulder. One hand draws the bow across the strings while the other depresses the strings at certain points. That's about it. One could get picky and imagine an instrument designed to be played upside down yet still satisfying all these criteria, but my archetype is a fuzzy archetype with loose, incomplete criteria, and it includes—indeed, is centered around—the visual image—a physical posture—of how the instrument is played. The three pictures above all satisfy this image, and show that the look of the player is more important than the look of the instrument. One might then argue that I need not specify string and bow length, but these are essential to transparency of technique; anyone with training on any subclass of the violin should be able to bring much of her years of physical training to bear in another subclass—grossly altering either of these lengths can reduce the seasoned professional to near beginner.[5]

The fiddle, then, is a specific subclass of the violin that inherits the properties of the superclass and adds several of its own. Likewise for the "Classical" violin and the electric violin. These include further subclasses, like Corelli's violin, Schubert's violin, and Bartók's violin (for the "Classical" violin), or the Bluegrass fiddle, the Irish fiddle, and the Hardanger fiddle. Each of these subclasses is inherited and brought to life by players, and there may be significant overlap among them. Matt Molsky's violin represents an idiosyncratic instance, a *realized potential*, of the violin, as do those of Anne Sophie Mutter and Mark Wood. To fully describe the differences between a "Classical" violin and a (particular) fiddle would require a critical inquiry similar to that of Chapter 1.

Part of my reason for developing the notion of violin as superclass is to provide a broader context for considering approaches to the electric violin, the "violin's" newest subclass. The violin, both grossly and specifically, is defined by the way it is played. Learning to play any of the particular instances of the violin requires a deep investment in time, energy, and physical training. The things that a violinist teaches his body to do in order to play one kind of violin will, on one level, make it easier to adapt another, but they may also stand in the way. Ask any "Classical" violinist who has decided later in life to learn a fiddle style, and she will tell you about the "retraining" that needs to happen; technique needs to be relearned.[6] A more telling example is the violinist who was trained on a Modern violin (like Schubert's and Bartók's) and decides later to play an "authentic" violin (like Corelli's); although he may be playing the same music, he has to make

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[5]So much of an instrumentalist's training involves teaching the muscles where to put the fingers; it is this kind of training that is so difficult to redo, and also why a violinist will have an easier time picking up viola than cello. The three instruments pictured above have essentially identical string and bow lengths.

[6]This can happen among "Classical" violinists even when they simply switch teachers.

significant adjustments in his technique in order to play the "new" instrument. As I described in Chapter 1, these differences in instrument design intertwine with the expressive nature of the music that is written for them, and by extension, the physical training required by its player; we can see clearly that the music and expressive intents of Mutter and Molsky differ significantly by their pictures alone.

When a violinist of a particular ilk decides to take up different violin, she usually is familiar with, and attracted to, certain aspects of the new violin—its music, its social context—and willing to go through the retraining necessary to play it. Even then, the retraining can sometimes prove more involved than anticipated and discourage the potential convert. For example, after several years of trying, I finally gave up trying to play "jazz" violin, mostly because I was unable to develop a way to "swing" with the bow that was satisfying. Swinging with a bowed instrument is a tough nut to crack, but it has been done—Stephane Grappelli and Stuff Smith are great examples. Absorbing their articulative bow styles is a lifetime endeavor, however, and for a variety of reasons I decided to move on. The problem, however, was with me, not with my violin or with "jazz."

Now, imagine our convert picking up an electric violin. In comparison to any other violin, the electric violin has virtually no music and no social context. This is compounded by the fact that it is physically very different from any other violin. It is a vast reservoir of undeveloped potential, and as a result it lacks the models and traditions that are so rich for other violins. Our convert has no choice but to use her own models as a starting point, and if she is not adventurous and at least as determined as I was to learn jazz, she will be disappointed by the incongruity between her technique and the instrument. "It doesn't feel right," she will say, or "it's not as sensitive as my Guadagnini." She is right, but it's a bit like a violinist picking up a viola and complaining that it's too big and that the strings are tuned all wrong. Just because you can *basically* play the instrument—they both fit the "violin" archetype after all—doesn't mean you can *really* play the instrument. And because there is no Stephane Grapelli of the electric violin, no icon to strive towards, no evidence that the instrument is worth retraining for, she is likely to put it away and label it an inferior instrument.[7]

I believe that the electric violin is one of the most wonderful subclasses of the violin yet to emerge. In the rest of this chapter, I will explore what differentiates the electric violin from other violins. I am particularly interested in discovering those properties of the electric violin that change the way players go about the physical activity of playing. Just as lengthening the neck and increasing the tension of the "Classical" violin in the late 18th-century allowed—indeed, forced—players to engage the instrument with more weight, and hence provided a natural vehicle for Schubert to compose his "weighty" music, amplifying the violin must reinvent the

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[7] This has happened to me several times when I've shown my instruments to other violinists, so this is not hypothetical. Another problem is that, as with acoustic instruments, there is a wide range in electric violin qualities and styles, and it can take years of searching before finding the "right" one.

way the violinist plays. This is in part a *call to action*. The potentials of the violin will never be realized if violinists don't make the effort to look for them. Corelli dedicated his entire compositional career to the violin, and his music continues to demonstrate many of the great strengths of the instrument. As Tracy Silverman (formerly of the Turtle Island String Quartet and one of the current champions of the electric violin) said to me: "We've got to show people what these things can do!"[8]

Deconstructing the Violin:
The Player-Instrument Feedback Loop

The electric violin, as a subclass of the violin, requires but one special property; its sound must be electrically amplified. If the primary motivation for acoustical developments in violin design was to increase volume and projection, it would seem that electrical amplification is the ultimate solution. Indeed, one of the great pleasures of the electric violin is that it allows the player to compete finally with other loud instruments; for so long, violinists have struggled to project over orchestras in large halls, and fiddlers have nearly sawed their instruments in two trying to be heard over drums and dancers. If electrical amplification were a simple extension—a "scaling" mechanism—of the wooden amplifiers (*i.e.*, the resonating bodies) that constitute the violins described in Chapter 1, we would wonder why every concert violinist doesn't plug in when playing the Brahms *Violin Concerto*. It is not so simple, however, and Anne Sophie Mutter continues to rely on her wooden amplifier in Avery Fisher Hall.[9] On the other hand, electrical amplification *has* penetrated virtually every other performance context for the violin, even the "Classical" concert hall with groups such as the Kronos Quartet. How does electrical amplification change the violinist in these contexts? How does it affect our conception, as listeners and composers, of the violin? Which potentials are lost, or gained, and why? How does amplification change the expressive capabilities of the violin?

The first thing a violinist notices when playing electric is that the primary sound source is no longer directly under the ear.[10] This sense of *detachment* can be at once both empowering and distressing. Freed from the limits of the box that fits on our shoulder and projects squarely into our ear, we can turn the volume up and point the amplifier at our electric guitarist friend, deafening him with gruesome *ponticello*. On the other hand, there is a striking loss of intimacy, even with a small amplifier placed nearby. What was once a voice whispering in our ear becomes a

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[8] Personal correspondance.

[9] It is interesting that in the "Classical" guitar world, soloists frequently rely on amplification in concerto and chamber music contexts.

[10] Unless she is playing through headphones, which can be equally disorienting.

remote presence, no longer seeming part of our body.[11] This separation can also be disconcerting for the listener. Part of the voice-like character of the violin is the result of the proximity of the violin's point of projection to the mouth. When we see a violinist pull the bow across the string and hear the sound coming from a speaker (or multiple speakers) that may be many feet from the player, there is a definite sense of disconnectedness. This is the standard mode of operation with the organ, but with the violin, whose voice-like and visual-gestural qualities are so important, it is unfamiliar.

On the other hand, detachment can minimize the differences in sound that the player and listener perceive. "Classical" violinists are trained to "project" their sound, which can result in the violin sounding harsh and unpleasant under the ear, but strong and full in the back of a large hall. With an electric violin, we have the option of "projecting" by simply placing a speaker in the back of the hall, or in some other configuration between listener and player. Since high frequencies tend to be attenuated more quickly over distance than low frequencies, the listener usually hears some kind of "low-passed" version of the tone the player hears under her ear. Again, in theory we can create identical signals for the player and listener through careful speaker placement.[12]

Ultimately, the electric violinist must decide that detachment is a feature, not a bug, and choose how to work with it. We now have a range of choices. Do we attempt to stay as close to the acoustic violin as possible and use a small amplifier placed nearby (perhaps even on the instrument), do we explore maximum detachment and use a widespread stereo or quadraphonic arrangement, or do we find some place between these extremes? Clearly, what we decide will have a profound impact on the way we play our instrument, and on the music we create. In fact, this choice is perhaps the most significant that we face in inventing our instrument, and is one of the primary parameters for variation in electric violin design. With this understanding, we vividly see that any description of an electric violin must include a clear picture of the amplification setup; an electric violin comprises (at least) a bow, a piece of wood (or some other material) with strings, and a speaker (or two, or more). In a sense, the electric violin is a deconstructed acoustic violin, where the resonating body (*i.e.*, the speaker) has been surgically removed from the neck and placed at the other end of the room, connected only by a sort of umbilical chord.

With this in mind, it is helpful to think of both the violin and violinist as signal processors wired together in a sort of feedback loop:

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[11]Violinists often speak of the vibrations they receive from the violin in their jaw and head; this connection is vital for many players. This kind of connection is known as a *haptic* connection. For an introduction, see Brent Gillespie, "Haptics," in *Music, Cognition, and Computerized Sound*, ed. Perry Cook (Cambridge: MIT Press, 1999).

[12]Although we cannot really compensate for the signal that the violinist receives directly from the instrument, via bone conduction. However, we can place speakers so that their signals are identical, something that is impossible (without undue intimacy) with a conventional violin.

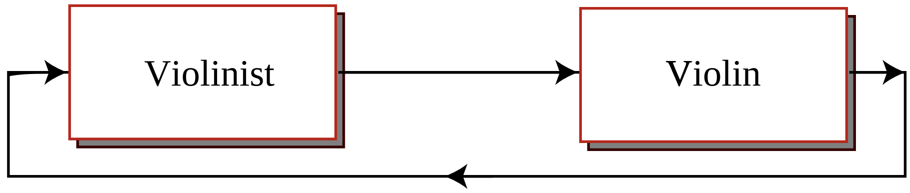

Figure 3. The player-instrument feedback loop

The path from violinist to violin is typically quite short. The return path from acoustic violin to violinist is usually made up of two sub-paths—the path directly from the body to the ear, and the path filtered by the room:

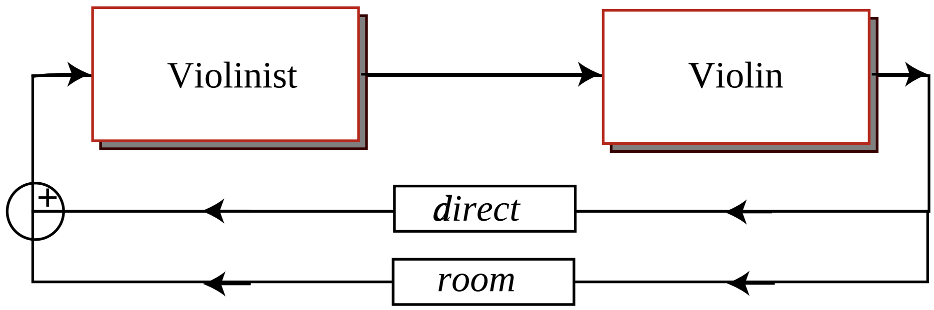

Figure 4. The player-instrument feedback loop, with room and direct filters

In traditional contexts, the violinist hopes to play in a room that enhances but does not interfere with the sound of the violin. However, most violinists have had the pleasure of playing in a bathroom, where the room itself is so reverberant that it, in a sense, becomes part of the instrument; she "plays" the room.[13]

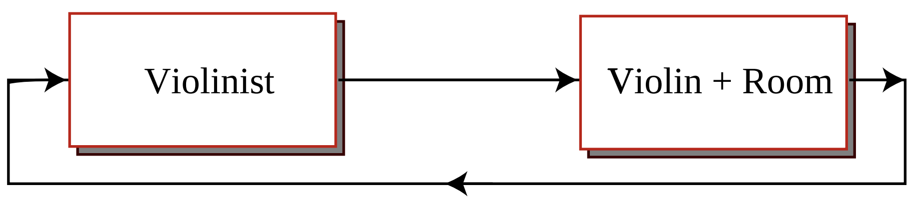

Figure 5. The room becomes part of the instrument

In this case the filter effects of the room overwhelm the direct sound. This can be disillusioning if one leaves the bathroom and goes directly onstage, where the relative dryness of any hall invariably leaves one feeling small and feeble. But it has also been used to great effect; consider Paul Giger's recordings inside the crypt of the cathedral in Chartres, France (Sound Example 13). *Crypt I* could not exist without the crypt. Giger *plays* the crypt, exploring its resonances and making it

[13]Most "Classical" violinists think a lot about "playing the room" in any case, but the bathroom provides an extreme case where the separation between room and violin becomes unclear.

sing. This music is as much about the acoustic qualities of a room as it is about the violin.

What happens to these diagrams when the acoustic violin is replaced with a deconstructed electric violin? First, let's decompose the acoustic violin filter and check out its components:

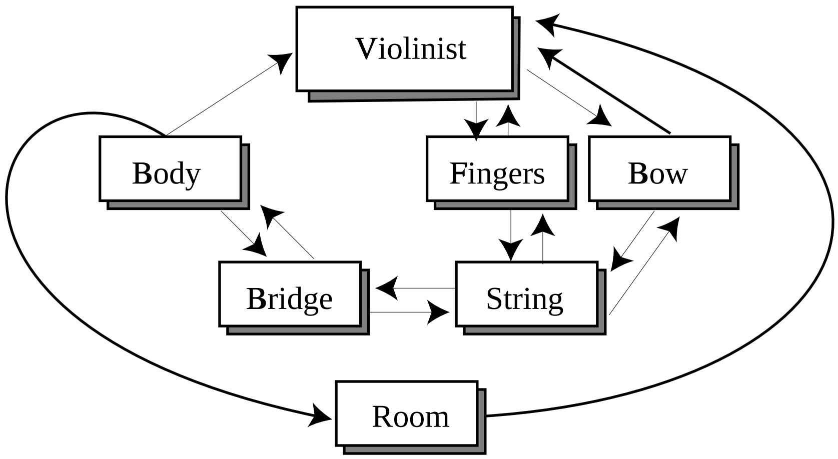

Figure 6. The acoustic violin decomposed

Some of these components have two-way relationships, as indicated with backwards arrows. These can be crucial to the feel and response of the instrument. The feedback from body through bridge, strings, and bow to the player is one path where the differences between Schubert's and Corelli's violins from Chapter 1 are most evident; with Corelli's lower tension violin, the coupling between body and bridge is less significant than with Schubert's, hence this feedback path is less active. The violinist then has three sources of input from the violin—the direct sound, the room sound, and the feedback *feel* of the instrument. Now, consider the following four electric scenarios (Figures 7–10):

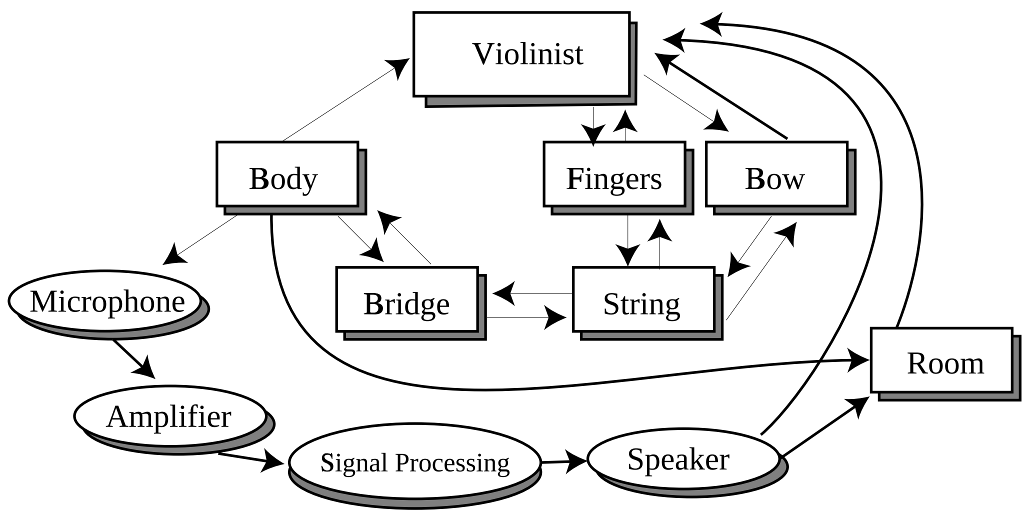

Figure 7. An amplified acoustic instrument

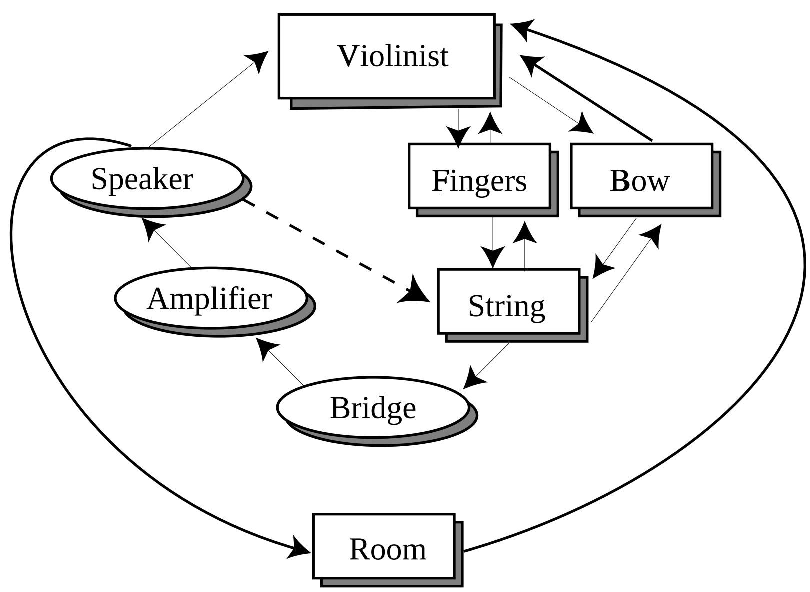

Figure 8. A solid-body electric, with a simple amplification setup

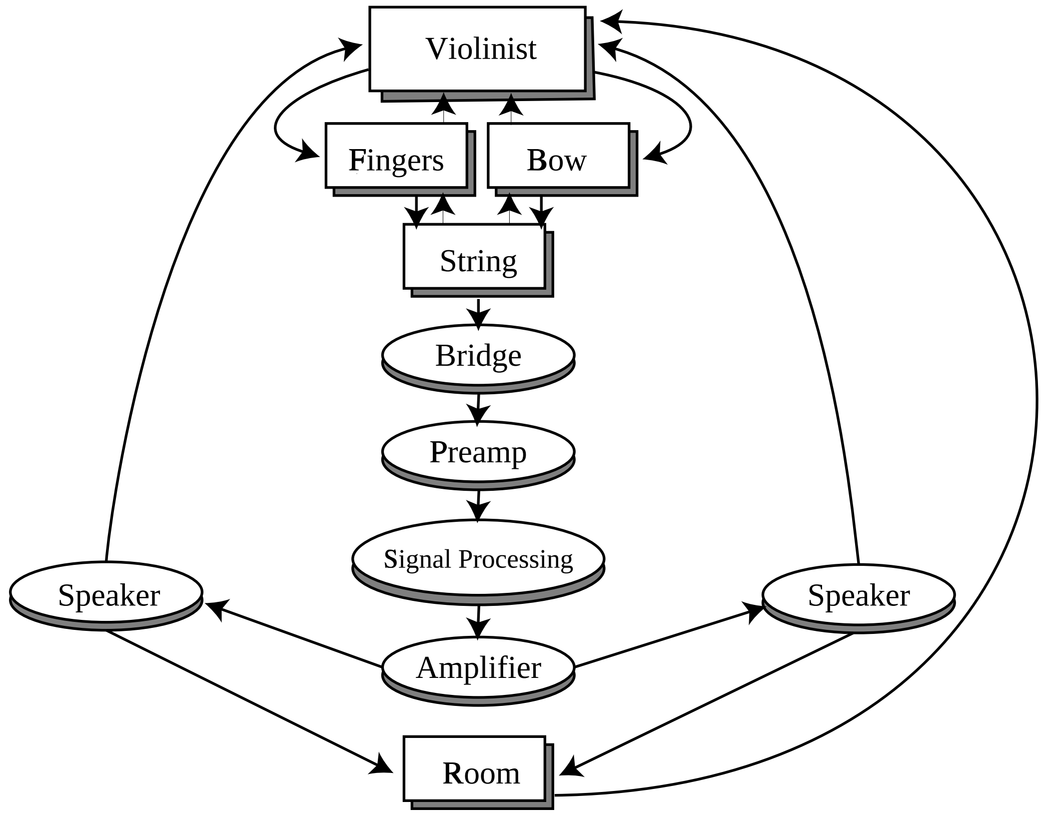

Figure 9. A solid-body electric, with stereo (or N-speaker) amplification

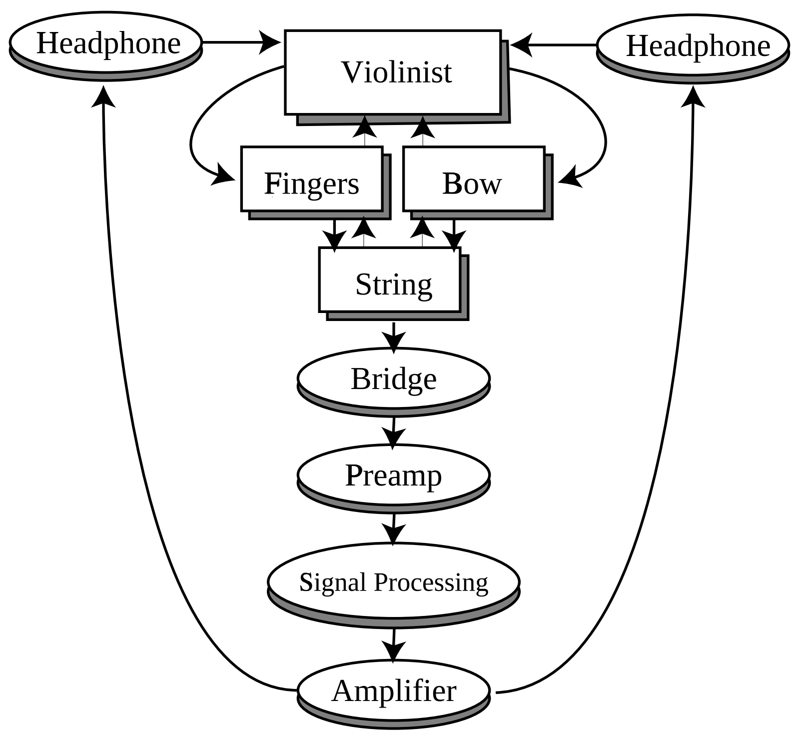

Figure 10. A solid-body electric through headphones

Each represents a different form of detachment and, depending on the instrument, creates different qualities of feel (as represented by the backwards arrows).[14] In the context of the violins discussed in Chapter 1, all of which can be regarded as relatively subtle variations within the signal path of Figure 6, these configurations show how coarse and radically different the issues facing the player and designer of an electric violin can be.

An Electric Acoustic

The most prevalent electric violin is that represented by Figure 7. The primary motivation for playing an acoustic violin into a microphone is simply to make the violin louder so it can mix with electric guitars, saxophones, drums, and other electric instruments. However, it didn't take violinists very long to realize that they could steal some of the toys their electric guitar friends used and stick them between the microphone and the speaker. Jerry Goodman of the Mahavishnu Orchestra was one of the first to be widely heard playing the acoustic violin through an amplifier and effects. In *The Noonward Race* (Sound Example 14), Goodman uses what sounds like a rich chorus with compression. He accomplishes two things with this setup; first, he achieves a volume level comparable to the drum set and electric guitar;[15] second, he brings the violin into an electric sound world, essentially stripping it of most of its "Classical" qualities—this is a penetrating, aggressive violin. In *The Dance of the Maya* (Sound Example 15), Goodman adopts one of the electric guitar icons of the 70's: the wah-wah pedal. In a screeching Blues inflected solo, Goodman takes the violin further from its Classical roots than ever before. It is ironic, however, that with his use of the wah-wah pedal, Goodman creates vivid qualities of speech and song; these are not the voices of 18th-century Italy, though, but of the 20th-century American Rhythm and Blues tradition.[16]

In the feedback loop of Figure 7, Goodman obliterates several significant paths. The high volume of the speaker completely overwhelms the direct sound of the body and makes the qualities of the room irrelevant; the speaker is where the action is:

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[14] This is not an exhaustive set of configurations; there are many possible variations on these diagrams.

[15] The Mahavishnu Orchestra is renowned (or notorious) for being one of the loudest bands ever.

[16] The wah-wah pedal is a sweeping resonance filter which creates an effect similar to the sweeping of formants that occurs in speech. When we change our vocal tract shape to move from one vowel sound to another, we cause the primary resonances (formants) that serve to identify each vowel to sweep. See Perry Cook, "Articulation in Speech and Sound," in *Music, Cognition, and Computerized Sound*, ed. Perry Cook (Cambridge: MIT Press, 1999), 144.

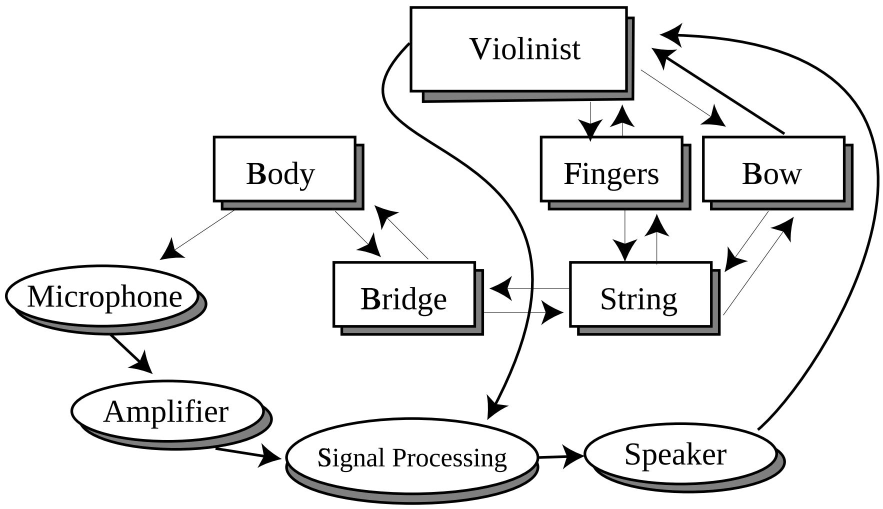

Figure 11. Goodman's violin

Physically, the instrument responds no differently than any acoustic violin (except in the case where the volume is so high that the body or strings begin to feedback with the speaker). But the addition of an electronic component provides an entirely new domain for reinventing the instrument. It is a flexible domain that can be altered from tune to tune (*e.g.,* by plugging in the wah-wah pedal) or within the tune (*e.g.,* by stepping on the wah-wah pedal). In the latter case, modifying the signal processing becomes part of the instrumental performance technique, hence the arrow between player and signal processing objects.

Goodman's violin is about volume and raw, aggressive expression. On the other hand, Iva Bittova uses subtle amplification and signal processing to create a wispy, sustained voice to support her own singing voice. In *Ne Nehledej* (Sound Example 16), Bittova exploits one of the most enticing potentials of the electric violin: *microscopy*. Here, she sets the volume of her amplified violin sound to match the volume of her unamplified voice (and another unamplified violin, *pizzicato*). She plays lightly, allowing the amplification and signal processing to reveal the details in the harmonics that emerge with *ponticello* bowing. This is the expressive polar opposite to Goodman's violin, and reflects one of the wonderful ironies of amplification—in the effort to make the violin louder, we allow it to be softer. Again unlike Goodman's, Bittova's violin does not obliterate the direct sound from violin to violinist or the room sound from Figure 7; in fact, all the connections within the feedback loop are relatively balanced and equally important.

Two groups that fall somewhere between Goodman and Bittova are the Scandinavian band Hedningarna and the American Turtle Island String Quartet. The first tune on the Hedningarna recording, *Kaksi!*, begins with the sounds of drums and an amplified nyckelharpa (Sound Example 17).[17] The gritty quality of the bowed string sets the tone for the tune; similarly, the picture of the instrument on the back of the album provides a sense of what the music is about:

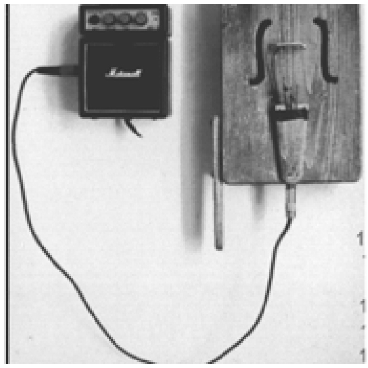

Figure 12. An old *stråkharpa*, plugged into a mini Marshall stack[18]

Although amplification is not essential to a Turtle Island performance, some of their techniques are most effective when given an electrical boost. Their backbeat *scritch*, though audible acoustically, is a better substitute for the high-hat through a speaker (Sound Example 18). Created by forcing the bow into the string, at the frog, in the direction of the strings (rather than the usual perpendicular orientation), the *scritch* is mostly unpitched noise, and can be executed quite rapidly. Unamplified, it has to be done loudly to be heard; amplified, its dynamic range is greatly expanded, allowing for a wider range of articulation.

George Crumb's *Black Angels* uses a similar electric violin to create an entirely different effect. In performance, each instrument is amplified through a speaker placed near the player. Artificial reverberation is added, and the speaker volume is set to match the natural volume of the acoustic instrument. Crumb seeks a certain "surrealism" which this configuration provides.[19] On the one hand, the audience is aware of the direct sound of the instruments filling the room. Yet simultaneously, the sound from the speakers, with the reverberation of some other distant space, creates an other-worldly detachment. Although this sense is not as clear on recording, it is still perceivable (or imaginable). In the *Sarabanda de la muerte oscura*, three members of the quartet play their instruments "like viols," bowing between the fingers and the pegs (so the fingering is reversed) (Sound Example 19):

[17]The nyckelharpa is a keyed, bowed fiddle from Uppland, Sweden. It is one of the oldest bowed stringed instruments known.

[18]Reproduced from Hedningarna, *Kaksi*, Northside NSD6007.

[19]George Crumb, from liner notes of the Brodsky Quartet CD, Teldec 9031-76260-2.

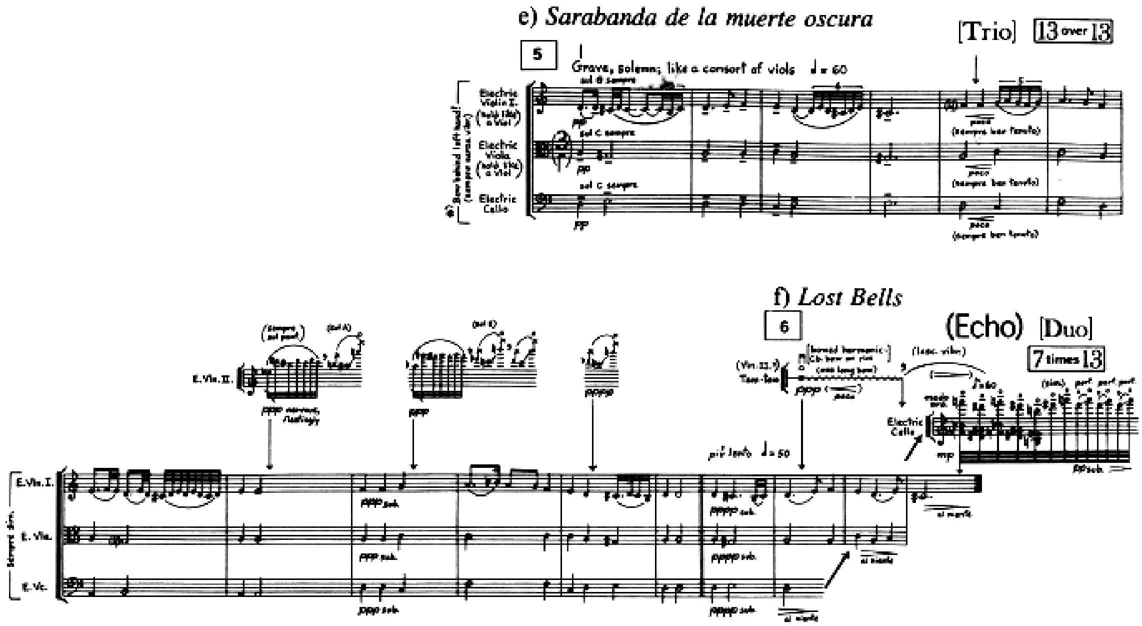

Figure 13. Excerpt from Crumb's *Sarabanda* and *Lost Bells*[20]

Both sonically and musically, this creates a great sense of distance; the instruments are acoustically impaired as the players are technically impaired, and the medieval harmonies (*e.g.,* double-leading-tone cadences) open up broad historical space. From somewhere else, the fourth member plays fleeting *ponticello* and harmonic figures, audible only through the reverberated speaker. This is followed by a set of harmonic *pizzicati*—bells—that again ring through the reverb as if from elsewhere (but not from the same place as the trio).

An Electric with Simple Amplification

Crumb's violin takes advantage of the fact that, with Figure 7, both the regular acoustic sound of the violin and the electrically amplified sound can be mixed in various ways to create different spaces. In Figure 8, however, the wooden resonating body is completely removed, making the speaker the sole source of sound.[21] One of the primary constraints on acoustic violin design is, obviously, acoustics: the body must be of a certain size and shape, the strings a certain length, the bridge and soundpost a certain design, and all put together precisely so as to sound just right. With the resonating body removed, these constraints are severely reduced.

Consider what is perhaps the most radical of electric violin designs:

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[20]From George Crumb, *Black Angels* (New York: C.F. Peters, 1971).

[21]The strings do make some sound, but with any amplification, this is nearly inaudible, even to the player.

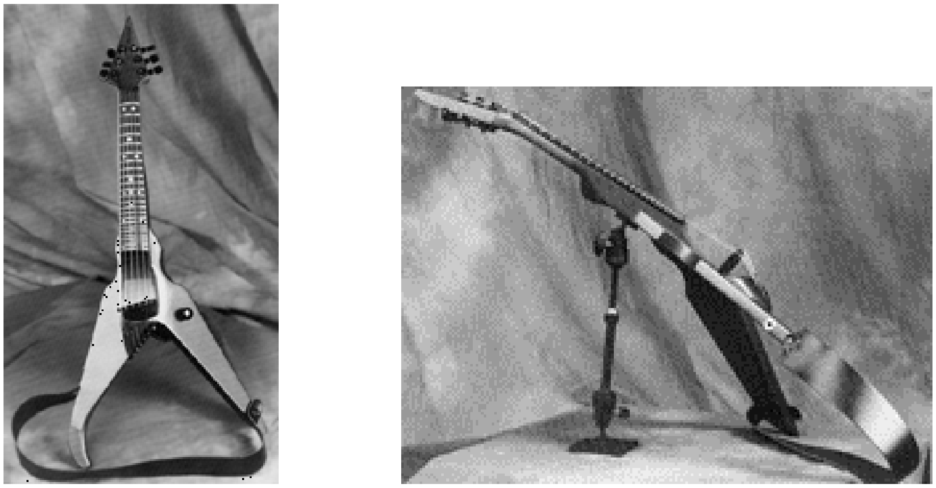

Figure 14. Mark Wood's *Viper*[22]

To start with, Mark Wood's *Viper* is a *solid-body* instrument; the bridge rests on a heavy, solid piece of maple. There is essentially no coupling between bridge and "body;" this relieves the player from the duty of driving a resonating body, which has profound articulative consequences—oddly enough, it is in some ways more like Corelli's lighter, softer violin than Schubert's.[23] The pictured *Viper*, as well as the one that I have played for several years, has six strings; we are no longer limited by the frequency range of a wooden resonating body, and can add lower strings. Typically, these strings are tuned in fifths, giving us C- and F-strings.[24] There are practical limits in string design that make the lower strings, especially the F-string, less responsive than the higher strings, but they nevertheless open up worlds of new musical possibilities.

The *Viper* is usually fitted with a Barbera bridge (made by Rich Barbera) that houses the transducers. Each string has its own piezo pickup mounted directly beneath it, in the bridge. These are separated from one another by cuts in the bridge to isolate the strings as much as possible.[25] These signals are balanced and mixed electrically in the bridge and sent out a single audio jack.[26] This results in a remarkably clean signal that makes a wide range of signal processing more practical than with the rich, complex signal given off by an acoustic instrument.

Mark Wood is the only maker that I know of who makes fretted violins. Having played one for several years, I have come to understand why no one else makes them. They make perfect and variable intonation—skills that violinists spend

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[22]Images from http://www.moseisley.com/mw/.

[23]I will discuss this at length in the last section of this chapter—*Potentials: Discovering the Electric Violin.*

[24]Wood has made a seven-string instrument, going down to B-flat.

[25]With separate pickups, it is important to isolate the strings somewhat to avoid strange phase interactions between strings.

[26]Although it is also possible to have an individual audio line for each string.

years working on—impossible.[27] On the other hand, they don't help approximate intonation much;[28] unlike the guitar, when the violin is bowed it is necessary to place your finger directly on top of the fret—not behind it—and it is possible to be out of tune if it isn't hit just right. Frets can be helpful in finding pitches in the upper positions, and they make improvising in these positions more practical. But for me, the frustrations outweigh the benefits.

The most radical part of Wood's design—the part for which he holds a patent—is the support mechanism. The "body" consists of two wings—a "flying-V"—one of which goes over the left shoulder, the other on the chest. Mounted underneath the fingerboard is an adjustable ball-joint which holds an extendible arm. At the end of the arm is another ball-joint which holds a pad that rests on the chest, suspending the end of the violin. This amounts to a tripod system; the wings are two of the legs, the adjustable arm the third leg. A strap runs from one leg to the other, behind the player's back, keeping the instrument in place.

Wood's violin owes as much to the electric guitar tradition as it does to the violin. His "flying-V" design is inspired by the "flying-V" electric guitar, as are the frets. His music is probably closest to Heavy Metal—an electric guitar music—and his use of effects and distortion make his instrument sound more like an electric guitar than a violin; if you weren't told, you probably wouldn't guess that he is playing a violin, and it is often hard to tell, even if you are listening closely. In *Monkeybats* (Sound Example 20), Wood plays both the lead and rhythm parts on his electric violin. It is difficult not to hear this as electric guitar music, and only occasionally, on close listening, is it possible to hear violin-like inflections. In particular, Wood's use of compression flattens out his articulations and (by definition) dynamics; subtle bow noises are elevated to the same dynamic level as full bow strokes, and bow releases are cut off quickly, as with the electric guitar, leaving the shimmer of reverbs and delays.[29]

Wood's music is distributed by Guitar Recordings, and his instruments most widely advertised in electric guitar magazines. With my own Viper instrument, I have frequently had electric guitarists look at the design and frets, and think they could really play it with a couple hours practice. They are always quickly discouraged. One might wonder why Wood plays the violin when aesthetically it is clear that his heart lies with the electric guitar. The simple answer is that he was trained on the violin and he is an adventurer. He would rather take advantage of his

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[27]By perfect intonation, I mean that it is possible to play intervals perfectly; on the violin, you can play a fourth double-stop precisely, whereas with frets, it is not always possible. By variable intonation, I am referring to the subtle changes that string players make depending on the function of certain intervals; a C# leading tone is likely to be played differently than a C# descending passing tone.

[28]By approximate intonation, I am referring simply to the tempering that is necessary with any fretted or fixed tuned instrument (*i.e.*, the piano).

[29]Compression is a frequently used signal processing technique where high-level signals are attenuated and low-level signals are boosted. All commercially produced recordings (except for "Classical" recordings) are compressed, as are all music radio signals.

years of practice than learn a new instrument, and he enjoys the challenge of bringing the violin to a new place; in the latter regard, he is undeniably successful.

For most electric violins and violinists, the violin is the starting point, not the electric guitar. The *Classique* from Ithaca Guitar Works retains the visual essence of the acoustic violin:

Figure 15. The *Violect*, from Ithaca Guitar Works[30]

Although it does not produce a loud acoustic sound, it does have a semi-hollow body that interacts with the bridge. Rather than using a thick wooden bridge with piezo transducers under each string, it uses a thin bridge with a single piezo pickup. The signals from each string are then mixed mechanically (by the bridge) rather than electrically (as with the Barbera). This instrument is meant to appeal to the "Classical" violinist who doesn't want to stray too far from the acoustic violin. The thinner bridge and semi-hollow body should make it respond more like an acoustic instrument, and its appearance owes its elegance to the "Classical" design.

The instruments of Eric Jensen and Ned Steinberger have a modernist design; only the essentials remain:

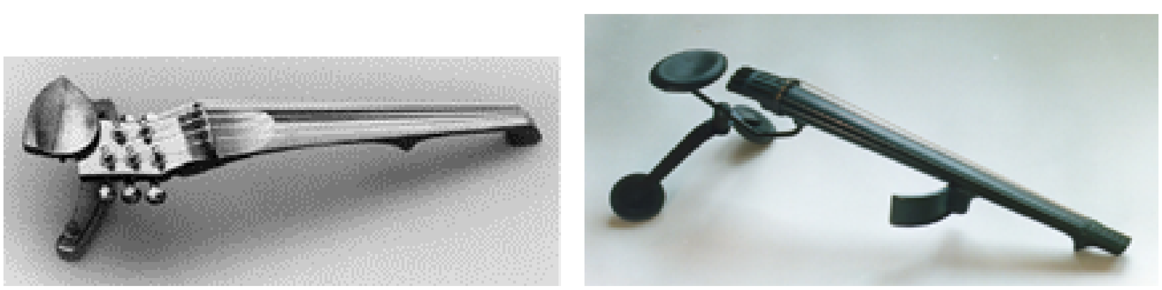

Figure 16. Instruments by Eric Jensen and Ned Steinberger[31]

[30]Image from http://www.ithacastring.com/images/violect.jpg.

Both are solid-body—the Jensen is primarily maple, the Steinberger graphite—and use multi-pickup bridges—Jensen uses Barbera bridges, Steinberger uses Zeta MIDI pickups. The visual imagery of the acoustic violin is abandoned in favor of what is arguably the most natural design for an electric violin; if a resonating body is unnecessary, why continue to mock one. But this brings us to an interesting issue concerning the visual aspect of electric violin design. Now that we have more freedom to make the instrument look the way we want, the design we choose reflects an aesthetic, potentially musical decision. Just as the contrast in the physical techniques of Mutter and Molsky reflects the aesthetic gap that separates them, the designs of the Wood, Jensen, and *Classique* instruments appeal to violinists of particular, distinct musical sensibilities. I initially bought my fretted, glossy black *Viper* when I was playing in a rock band; the strap-on tripod mechanism freed my head so I could easily sing harmonies while playing, and its appearance made for a wonderful stage presence that suited the music and the venues we played. Since then, I have moved towards playing folk influenced music (e-fiddle), electroacoustic improvisations, and concert music; the strap-on design has become cumbersome in these contexts, and the glossy look distracting. My newest instruments are a fretless, wood-finished *Viper*, and a minimalist Jensen.

Solid-Body Music

One fact every new electric violinist encounters is that there is very little music written for the instrument. I have dealt with this in several ways. I began by playing in rock bands, writing and arranging our own tunes, improvising and composing new works for the instrument. I have written several tunes for solo electric violin that are inspired by my experience with the *hardingfele*, but that explore features that are unique to the electric violin. *Sprung* (Sound Example 21) is one of the first of these tunes, and is most indebted to the *hardingfele*. Loosely based on the uneven three-meter of the Norwegian *springar* dance,[32] *Sprung* uses an extended *hardingfele* tuning; the top four strings are tuned to the most common *hardingfele* tuning—E-A-D-A (from the top string down)—while the lower two strings are both tuned to D, separated by an octave (the lowest D is then just a step above the lowest cello string). The low D strings help simulate the effect of the drone strings on the *hardingfele*, and they open up a register previously unavailable to the violin. After the opening which concentrates on the middle four strings (viola range), I open up the high register, and then later the lowest register with a strong quintuple-stop. For me, this extended range is one of the most exciting possibilities of the instrument, as is *scordatura* . The solid-body design makes many different tunings more practical (imagine tuning the lowest strings in octaves on an acoustic violin), again because we don't have the frequency range of a small resonating body

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[31]Image of Jensen from http://www.halcyon.com/jensmus/violinga.htm; image of Steinberger from http://www.digitalrain.net/bowed/steinbur.htm.

[32]There are many variations on the *springar*; the Telemark *springar* (from Telemark, Norway) has three uneven beats—the first is longer than the second, the second longer than the third.

as a constraint. It is also significant, though it may seem trivial, that the tuning machinery on most electrics allow rapid retuning (I have written a suite of e-fiddle tunes which requires that I retune between each piece). In addition, the solid-body does not require a stabilization period after retuning; typically, an acoustic instrument will require some time to "settle," and further adjustment, after first changing the tuning.

In the same tuning, *Duncan* (Sound Example 22) is a song of slow inhales and exhales. The electric violin inspired me to write this tune because with it I have two things that are typically incompatible with an acoustic—volume, and relaxed, almost weightless bowing. The bowed string creates an unpitched "breathing" sound—the soft sound of gritty, rosined friction. This is audible under the ear, but with an electric, it is possible to hear this (through the speaker), play lightly, and simultaneously be bathed in the rather loud sound of the instrument. This is a good example of what I previously referred to as *microscopy*.

In an entirely different tuning (D-A-C-F-D-G, from top to bottom), *Battooota* (Sound Example 23) takes its name from the extended use of *battuta* technique (though not *col legno battuta*—the bow hair hits the strings, not the stick). As an extended technique, *battuta* is traditionally primarily percussive. With the electric and its lower strings, it can be heavily pitched, as *Battooota* illustrates. The low strings ring out after each strike, and the sound of the attack is like a drum stroke. At the end of the piece (Sound Example 24), I take a different approach to these chords, playing them *sul tasto*, three notes at a time. Again, the amplification and solid-body instrument allow me to play these lightly, gliding over the strings with little weight and high speed, and still be heard; triple stops on an acoustic cannot be played as lightly as this.

An Electric with Multiple Speakers

Even though most electric violinists use a single speaker, the standard model for sound reinforcement in most situations is a simple stereo public address system; many electric violins therefore end up fitting into the arrangement of Figure 9, intentionally or not. The musical potential of this spatialization is seldom explored,[33] but its precursors go at least as far back as the split choirs (*cori spezati*) of Giovanni Gabrielli in the 16th-century. In most cases, the stereo field (if it is used at all) is filled by a simple stereo delay or chorus. In Mark Wood's *I Want To Take You Higher* (Sound Example 25), he uses a stereo chorus on the rhythm track and a panning delay on the lead track (which also uses a *talk box*—an effect processor where the sound of the instrument is modulated by another audio signal, usually someone speaking seductive words into a tube).

[33]With the violin, that is. I will not go deeply into the musical issues surrounding spatialization; this is too large a topic in itself.

Spanning nearly nineteen minutes, Alvin Lucier's *Indian Summer*, as recorded by Jeffrey Krieger on electric cello,[34] fills the stereo field in an entirely different way. It is also a wonderful illustration of some of the features I described in the previous section that make the electric bowed instrument unique. Two of the cello's strings are tuned in unison to middle-C. Over the course of the nineteen minutes, the strings are slowly tuned higher, ultimately reaching the F a fourth higher. During this process, various beating patterns emerge. In Krieger's recording, there is a sense of the listener being caught *between* the bow and the string; the amplified sound is coming directly from the string on the bridge, with very little (if any) intervening signal processing. The "breathing" sound that I previously described is clearly present, and combined with the beating patterns, creates an ensemble of wispy, colorful voices. After a few minutes, Krieger begins to work a pedal that slightly detunes his sound in one speaker only, forming a new set of beating patterns that move across the stereo field (Sound Example 26); this is disturbing at first, giving a sense of the instrument being pulled apart as we listen. There is a kind of counterpoint between the excruciatingly slow ascending *glissando* and the rapidly changing beating patterns and spatial movements. In a sense, Kreiger's instrument is no longer primarily about creating a certain pitch with a certain tone, but is both a microscope into a physical process and an atmospheric generator which he fuels and coerces.

A pan pedal—a pedal which allows you to move the instrument signal continuously between two channels—can be used to *play* the stereo field; Sound Example 27 is an example of its use in an improvisation. Just as the wah-wah pedal transformed Goodman's violin (Figure 8), the pan pedal alters the instrument of Figure 9; modulating the signal processing becomes part of the performance technique.[35] Unlike any other aspect of the violin, the pan pedal translates a physical motion directly into a real spatial audio motion, and manipulating this motion becomes a bona-fide musical parameter. It also changes the player's physical involvement with the instrument, requiring the feet to do a kind of dance that may or may not correlate with the activity of pulling the bow across the strings.

Compositionally, the stereo field can be regarded as a kind of canvas upon which sonic objects can be moved around, left to right with a pan pedal or other effect, backwards and forwards with reverbs and volume controls. For *"In 1349...,"* I designed several signal processing patches where panning and depth play crucial roles. Towards the end of the piece (Sound Example 28), delayed and transposed versions of the violinist's sound are strewn about, some louder or softer than others, some panned and transposed. Underneath, two low, sustained (and highly processed) violin tones fill the stereo field, undulating gently. This spatial dimension was on my mind while writing the piece, and so it is really composed for

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[34] Built by Tucker Barrett, using a bridge by Rich Barbera.

[35] I have also used the pan pedal simultaneously with a wah-wah pedal (sitting, of course).

a violin as configured in Figure 9—a stereo violin. It would have become a different piece if the stereo field was not part of the instrument.

As implied by the subtitle for Figure 9, there is no reason to limit the instrument to only two speakers. We could easily imagine an Immersive Violin, where we are surrounded by independent speakers and bathed in spatialized sound. To my knowledge, very little has been done with this. At the International Computer Music Conference in 1998, Peter Otto presented a piece (titled *Sprung*) for solo cello and eight channels of audio; he performed the piece from the center of the hall and used a real-time computer-based system to distribute the sound to the speakers:

> "*Sprung* is a study exploring the use of spatialization as a primary compositional concern....The work attempts to establish the physical space of the cellist as a center of gravity, using the centrality of the performer as physical/musical energy source from which spatial music can launch, float, spin, hover, dip, flock, dissipate, contract, expand, snap...spring"[36]

In the Computer Science Department at Princeton University, Professor Perry Cook has built a sixteen-channel audio system to accompany an enormous video wall (a screen that looks somewhat like, and is the size of a movie screen, but has the functionality of a computer monitor—it is driven by several computers running in parallel) and we are exploring the possibility of both composing "tape" pieces for the system and using it as part of electric instruments. With it, we will have the potential to assign different signal processing to each channel and to spatialize sound in three dimensions in real-time.[37]

In contrast, Figure 10 describes a violin which only the violinist can hear. Playing through headphones is a familiar experience for most electric violinists—in fact, this is the way many perform, using a headphone monitoring system on stage—and is, for some, the primary attraction. Yamaha recently released what they call the "Silent Violin," which is advertised as a practice instrument for violinists to use in hotel rooms and apartments.[38] Obviously, composing performance pieces for this instrument would, in a strict sense, be a kind of visual dance piece from the audience's perspective. For me, playing through headphones induces a sort of private (after all, nobody else can hear what I am hearing), meditative state where I

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[36]From Peter Otto, program notes for "Sprung," Program for the *International Computer Music Conference, Thessaloniki, Greece*, 1997, 142.

[37] An extension of this system that the nutty Dr. Cook is proposing would be housed in the new Palmer Stadium at Princeton. Here, the sound will be distributed to a multi-speaker network throughout the stadium. As a performer, I have a wonderful fantasy where I think of myself standing at the 50-yard line, playing through this array, moving my sound through such an enormous space. It is hard to imagine a bigger, grander violin.

[38]They have also created the Silent Trumpet, which is a mute that severely reduces the exterior volume of the trumpet but includes a pickup and headphone jack.

can create my own virtual world. This kind of player-instrument relationship actually has precedents nearly 1000 years old, if not older. For example, the Chinese *hu-ch'in*, a kind of bowed lute, has an ancient tradition where the player explores his relationship with the instrument in a solitary, meditative state.[39] I find this inspiring, and it seems a shame that in our traditional musical training, so much emphasis is placed on performance, and very little on the physical and spiritual experiences one can have playing a musical instrument. In a sense, the violin of Figure 10 forces us to reconsider what it means to play an instrument when the audience is no longer relevant.

A New Approach

I am tremendously motivated by the musical possibilities inherent in all of the various forms of the electric violin. There are, however, frustrations. Two issues in particular—spectral coloration and spatial radiation—have intrigued me, and I have addressed them in a research project—the *NBody* project—in collaboration with Prof. Cook.

The acoustic violin body and bridge are both mixers and equalizers. The bridge mixes the signals from the strings, applies an equalization, translates this to the body which in turn applies its own complex equalization and radiates the sound outwards. Consider the following two curves, the first reflecting the input *impedance* of the bridge, the second the input *admittance* for a Guarneri violin body:[40]

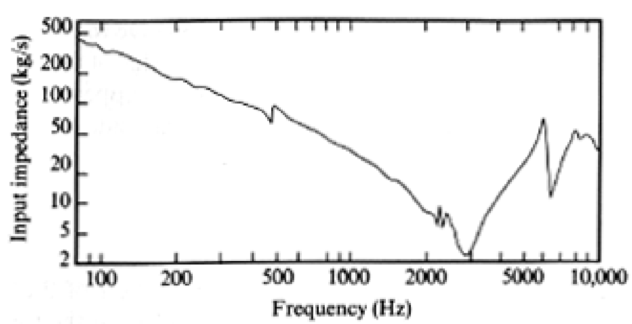

Figure 17: The bridge *impedance*[41]

39For an introduction to the hu-ch'in, see *The New Grove Dictionary of Music and Musicians*, 1980 ed., s.v. "China."

40Impedance reveals what frequencies are attenuated, while admittance is basically the inverse of impedance.

41Reprinted from Fletcher, 256.

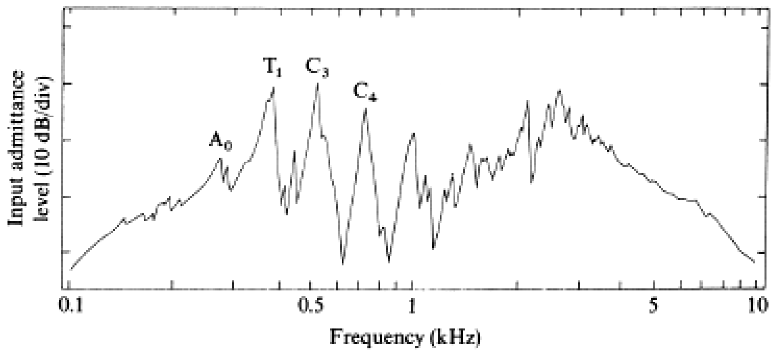

Figure 18: Body *admittances* of a Guarneri violin[42]

The first two vibrational modes of the violin bridge are immediately apparent, at about 3000 Hz and 6000 Hz (because these are impedances, the notches reflect resonances).[43] It is interesting that this first resonance is also in the area of highest hearing sensitivity.[44] The Guarneri body, like most good violins, has several significant resonances below 1000 Hz. The lowest resonance (A_0) is due to air flows in and out of the f-holes. T_1 is from the first mode from the top plate vibrations, and C_2 and C_3 the second and third "body" modes, where the top and bottom flex similarly. These four modes are apparently the most significant of the lower frequency modes in terms of spectral coloration, and together with the bridge form a complex equalizing system.

Above 1000 Hz, there is a "fine structure" in the frequency response of the body that is uncovered in particular by *vibrato* (as discussed in Chapter 1). This was studied closely by Maureen Mellody and Gregory Wakefield of the University of Michigan. They analyzed the amplitude of important partials during *vibrato*, and found that this fine structure creates a complex frequency-dependent amplitude modulation that may be one of the reasons the violin is so prized for its tone.

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[42]Reprinted from Fletcher, 251.

[43]See Fletcher, 1991, for a discussion of vibrational modes.

[44]The ear has variable frequency sensitivity, as most often represented by the so-called Fletcher-Munson (or Equal-Loudness) curves. See John Pierce, "Sound Waves and Sine Waves," in *Music, Cognition, and Computerized Sound*, ed. Perry Cook (Cambridge: MIT Press, 1999).

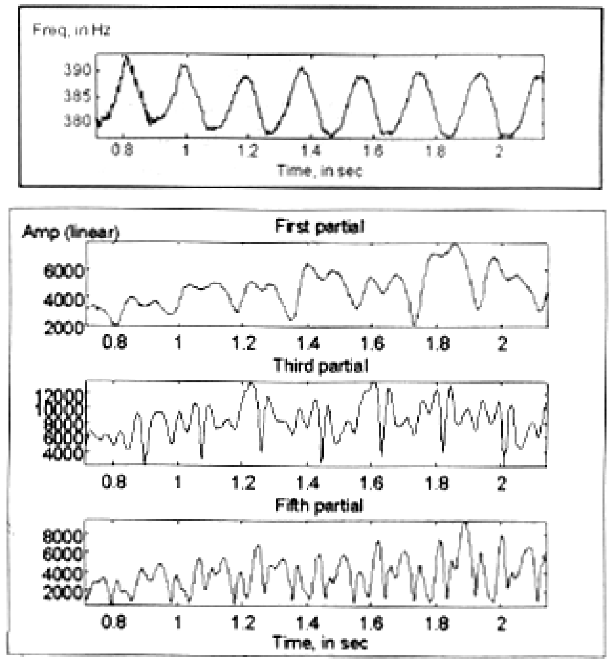

Figure 19. Fine structure as revealed by *vibrato*. The top curve is the oscillating fundamental, the following three curves the amplitude of the first, third and fifth partials. Note how the highly regular periodicity of the fundamental becomes irregular as it is filtered by the finely structured characteristics of the violin body.

In addition, they analyzed the signal coming directly off the bridge pickup of a Zeta electric violin and found that this modulation was non-existent. One criticism I have of the study (and the apparent indictment of the electric violin) is that they did not record the electric violin sound as filtered by a good preamplifier, equalizer and speaker; after all, my definition of an electric violin includes these devices.[45] It is unlikely, however, that a normal speaker would exhibit the rich filtering of a good wooden instrument, though it would make for an interesting study.

There are several ways to determine the spectral coloring qualities of a resonating body and then to apply them to another audio signal. One of the most powerful techniques is to measure the *impulse response* of the body. The idea comes from the theory of signal processing where the nature of a filter is determined by feeding it an infinitesimally short input—the impulse—and looking at the output—the response. With a violin, this is accomplished by striking the top of the bridge with a small hammer and recording the "ring" of the body (the strings are damped, so the ring is unpitched—a thud, with character). This recording,

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[45]Their entire rationale for the modulation is based on body resonance, and if you measure the signal *before* it reaches the "body," how could the explanation be valid? Granted, some of the body resonances are reflected from the body back through the bridge, so they might turn up in bridge measurements of an acoustic instrument, but the detachment of the electric's "body" makes this unlikely with an electric.

typically under 20ms, can then be analyzed and the major peaks applied to an electric violin signal with an electrical equalizer; this also allows the violinist to tweak the peaks, modifying them slightly to suit her tastes. Alternatively, the electric violin signal can be *convolved* with the impulse. Convolution is a fundamental technique in signal processing where, in essence, the spectral qualities of two signals are multiplied.[46] The advantage of this approach is that the high frequency "fine structure" can be applied—this is impossible with a simple equalizer, or with linear predictive coding, another analysis/synthesis tool. The disadvantage is that it is computationally expensive. A third possibility is a combination of the two; the low frequency poles are modeled with simple equalizer filters and the high frequency structure is captured with convolution.[47] This offers both the flexibility and ease of the equalizer approach—we still have knobs that we can turn to alter the resonances—and the richness of the high frequency characteristics.

My inability to create something as effective as the complex equalization produced by an acoustic body and bridge with an electric provided the initial motivation for the *NBody* project.[48] The second motivation stemmed from the highly directional radiative qualities of standard guitar amplifiers.[49] My own Trace Acoustic amplifier—one of the highest quality amplifiers available—produces a beautiful sound directly in front of the speaker. Off axis, the high frequencies become noticeably attenuated and low frequencies boosted. In performance situations, this becomes a serious problem; do I face the amplifier in such a way so that it sounds good to the audience, or do I let them suffer so it sounds good to me? What do I do when I am playing with other musicians? I have found that if I face it towards the audience, I play my instrument quite differently, playing lightly on the low strings and hitting the high strings hard to try to compensate for the darker, thumpy sound in my ears. And even in this case, only the central section of the audience is likely to get a relatively bright tone.

Acoustic violins do not have this problem. They radiate sound in highly directional, frequency dependent patterns, and while the patterns vary significantly with position, the variations are less severe and predictable than with an amplifier.[50]

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[46] So-called Fast Convolution is implemented by multiplying the Fourier Transforms of both signals and resynthesizing an audio signal with an inverse Fourier Transform. Normal convolution uses the impulse response to determine the coefficients of a feedforward (or finite impulse response—FIR) filter. This is significantly more expensive to compute. See Ken Steiglitz, *A Digital Signal Processing Primer* (Menlo Park: Addison Wesley, 1996), for an introduction to digital signal processing and convolution.

[47] By only convolving the higher frequencies, it is possible to shorten the impulse and carry out fewer multiplies, making the convolution less expensive.

[48] I should point out that I am not interested in recreating the qualities of the acoustic violin so much as I am interested in learning how to generalize some of its features and apply them to the electric violin.

[49] Electric violinists are naturally dependent on guitar technology; very little equipment is designed for the electric violin.

[50] See Perry Cook and Dan Trueman, "Spherical Radiation from Stringed Instruments: Measured, Modeled, and Reproduced," in the *Catgut Acoustical Society Journal*, November 1999.

We decided that we would like to be able to use not just the spectral coloring as measured at a single point with respect to the violin, but to be able to model these spatial patterns and apply them to the electric violin.[51] Cook constructed an icosahedral grid (20 faces and 12 vertices) and mounted microphones facing inwards at each vertex.

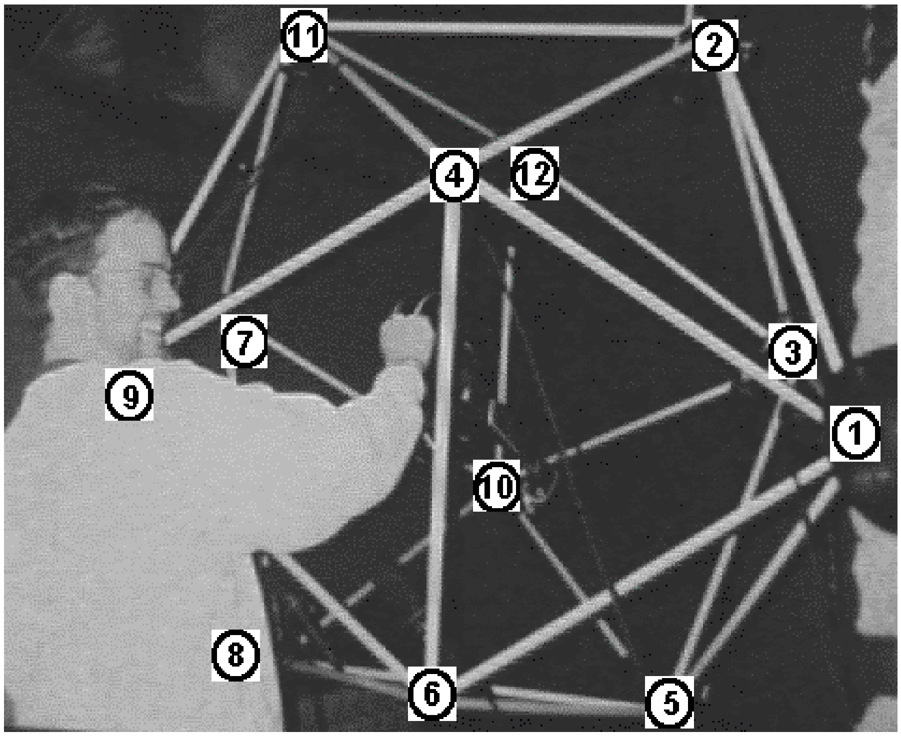

Figure 20. The microphone array, with vertex numbers, of the NBody Project

After suspending the array in a large hall and surrounding it with acoustic foam, we collected directional impulse responses from several instruments, including a "Classical" violin, a *hardingfele*, and three guitars. These were collected both with and without the player holding the instrument, and also with the instrument rotated in various directions.[52] After transferring the impulses to the computer, we analyzed them in various ways. The following curves are spectral representations of the 12 directions for a single impulse (hammer strike):

[51]Or any other input signal: a physical model perhaps.

[52]For a complete technical description of the data collection, see Cook and Trueman.

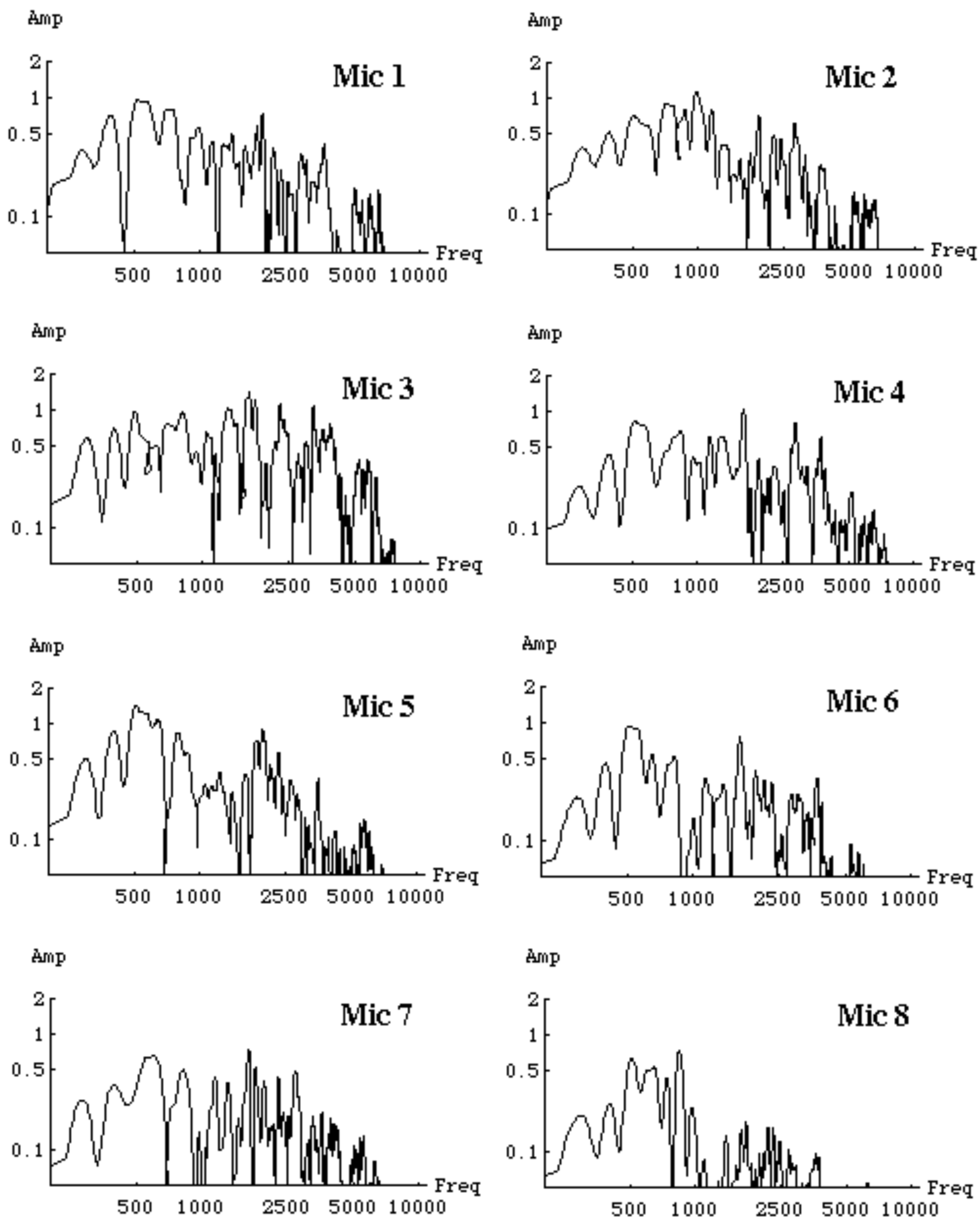

Figure 21. Violin responses for microphones 1–8

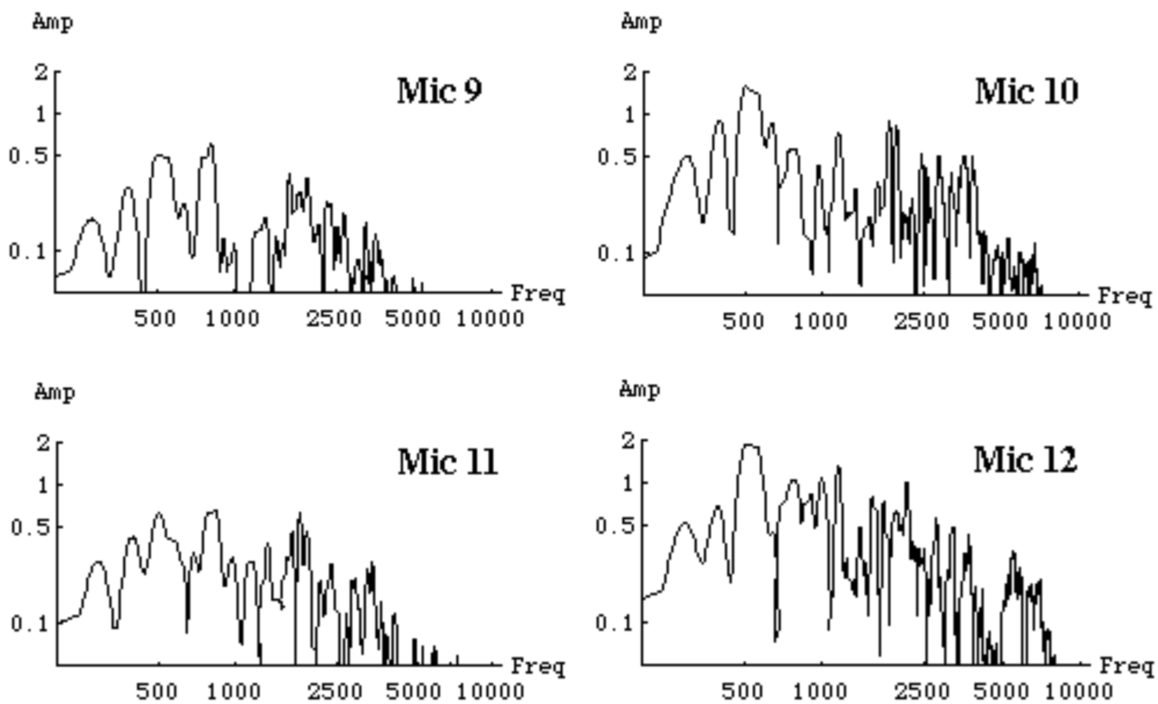

Figure 21 (cont.). Violin responses for microphones 9–12

The variation in both overall amplitude and in the details of the responses is clear, if not predictable. The microphone positions are shown in Figure 19, and the bridge was facing towards microphone 2. Some of the results are to be expected, such as the lower overall amplitude levels of the 7th, 8th, and 9th microphones, which are directly behind the player. Others are not so easy to explain, such as the heavy emphasis on the resonance at about 500Hz in the 10th and 12th microphones, above and below the left side of the violin.

We have begun using this data in several ways. Cook has developed physical models of all the instruments with these directional radiative characteristics, and a simple software interface for rotating the instruments and hearing how they sound from different vantage points. He has also put together a procedure (as described above) for applying these colors to input audio signals that uses inexpensive filters to model the low frequency peaks and convolution for the higher frequency residual. More directly relevant to the electric violin, we have constructed several spherical speakers as "display" devices for this data. These speakers are essentially inverses of the icosahedral array pictured above, with 12 speakers facing out where there were microphones facing in:

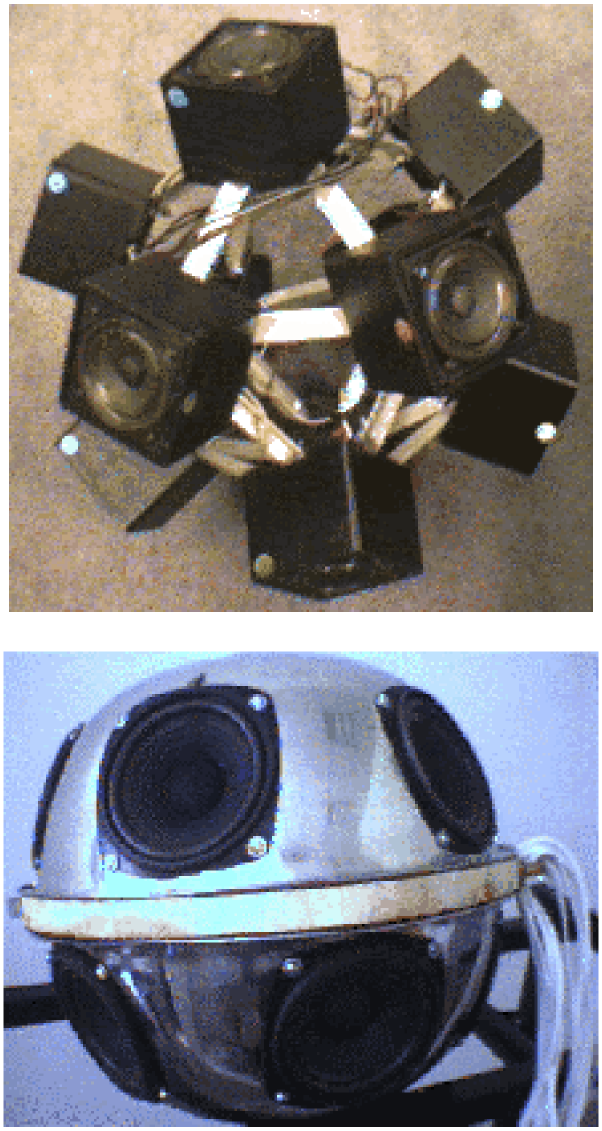

Figure 22. The Boulder and the Bomb: spherical speakers

In the most simple setup, I use these speakers with a set of hardware analog equalizers that are configured employing the data we collected, simulating the basic shape of each response. Using software, it is possible to use the powerful implementation employed with Cook's software in realtime—the primary barrier currently is simply the amount of amplification required to drive 12 individual channels.

The differences between these speakers and traditional guitar speakers are more striking than one might initially think. To begin with, they solve the performance problems I described earlier; the violin sound is radiated in all directions, equally, if I desire. But they do more than this. One thing every electric violinist knows is that in order to sound at all acceptable through a speaker, artificial reverberation must be added. Because of their monodirectionality, conventional speakers do not engage the reverberant qualities of the rooms they fill. Rather, they give the illusion of the sound coming from elsewhere, from some virtual space inside the amplifier, and sound best when the violinist is facing the speaker, listening to the direct sound; reflections from the room (if they are heard at all) are generally annoying because they tend to be dominated by discrete reflections from a single wall—a single delay. Therefore, artificial reverb is often added to make this virtual space seem real, and sound good. With the complex radiative distribution of acoustic instruments—and these spherical speakers—there is a much deeper interaction between room and instrument. Since the instrument (and speaker) radiates in all directions, the violinist hears multiple reflections from all the surfaces in the room. The phases of these signals are scrambled, and the net signal a sum of many signals that reflects the qualities of the room. Psychologically, the violin now sounds like it is in the room with the violinist, not joining the violinist from elsewhere—artificial reverb becomes unnecessary.[53]

These issues come to bear on another problem I have had as an electric violinist. I have found it difficult to play with acoustic instruments in purely acoustic environments (no miking, mixing, or P.A.s) because in general, the sound of an electric violin will not blend well with acoustic instruments. Again, my feeling is that the instruments sound like they are coming from different worlds; the acoustic instrument is in the room with us, the electric instrument is coming from elsewhere.[54] The spherical speakers have changed this situation dramatically, and I now feel much more inclined to play with acoustic musicians and to compose for ensembles that mix acoustic and electric instruments. This is evidenced by two recent works that I have composed—*Ghostwalk*, for Classical guitar and electric violin, and *Machine Language*, for violin, electric violin, cello and percussion. These two pieces mix the electric violin sound with purely acoustic sounds of the other instruments. The results have been encouraging; rather than sounding disconnected, the instruments blend easily to create a rich ensemble sound.

Potentials: discovering the electric violin

The NBody project is a work in progress, and it demonstrates some of my own priorities in attempting to develop potentials of the electric violin. In particular, it reflects my interests in sound quality—tone—and instrumental *presence*. Since I like to play in small halls—chamber music—it is important to me that my instrument fills the space naturally and effectively—I don't want to feel like an alien presence when playing with acoustic instruments.[55] As I argued earlier, the choice

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[53] Although if you are playing in a dry, dull room, reverb can improve the sound.

[54] One of the ironies of this situation is that usually a *recording* of a mixed electric/acoustic ensemble will sound fine, but in a hall the instruments will seem highly detached from one another. Obviously, in this case we hear the recording through speakers, so both the acoustic and electric instruments are coming from some other, now imaginary, space.

[55] On the other hand, I also like to play in big spaces, through big speakers, at high volumes where none of these issues are relevant.

of speaker is one of the most crucial for the electric violinist, and if an appropriate one does not exist, it needs to be created. Because the electric violin is in its early stages of development, the violinist must be both player and instrument designer; for me, this is an exciting combination.

Given then fact that the NBody project seems to be largely concerned with reproducing the tonal and radiative qualities of acoustic violins, one may wonder why I don't just play the acoustic violin. I hope I have made this clear in this chapter. Detachment allows me to explore various distributions of the violin sound, and also encourages insertion of various signal processing devices. By doing away with the wooden resonator, I am able to play instruments with more strings and thus cover a greater range than the acoustic violin.

More importantly, the electric violin changes my physical approach to playing the instrument. One of the themes emerging from my own music as described in this chapter is that of instrumental response. In the Figure 8 feedback loop, the relationship between bow and strings is no longer solely responsible for the volume that is produced. In addition, the player is freed from driving a wooden resonating body, hence there is no feedback from body to player. For me, the resulting instrument is one that feels *more* responsive than an acoustic instrument. Whenever I move back and forth between the acoustic and electric instruments, I am struck by how thick and unresponsive the acoustic feels, and I look forward to returning to the electric where I can delicately draw sound from the instrument and explore the nuances of the bow-string relationship (or of a particular signal processing configuration)—microscopy. The acoustic instrument *asks* me to play forcefully, in a Schubertian sense, and requires me to use the weight of my arm to sink into the wooden amplifier. This is exactly the same issue that I discussed in Chapter 1 concerning the aesthetic tendencies of instrument designs. Corelli's violin encouraged, in a real acoustic sense, the light effortless music that he wrote, while Schubert's violin aligned perfectly with the "weighty" expressive desires of the Romantics. For me, there is an *expressive impedance mismatch* between the modern acoustic violin and my own musical interests—with that instrument in my hands, I am not particularly inspired to compose or improvise.[56] With the electric, however, my creative and performance juices are free to flow.[57]

In his book *Measure for Measure*,[58] Thomas Levenson discusses the difficulties violin makers have had in reproducing the qualities of Stradivari's violins. The mistake, he argues, is to be too scientific about it, attempting to

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[56]From the American Heritage Dictionary: impedance matching is "the use of electric circuits, transmission lines, and other devices to make the impedance of a load equal to the internal impedance of the source of power, thereby making possible the most efficient transfer of power."

[57]Looking sideways (but not backwards), I find Malcolm Bilson's attitude towards using "authentic" pianos fascinating (See Malcolm Bilson, "Why Not Diversity in Sound," *New York Times*, 18 June 1998). He describes how the differences in articulation from piano to piano help him discover different characteristics of music that is usually played on a modern Steinway. He argues for diversity in sound, saying that this is best for a "healthy and vigorous piano life." For him, "standardization may be a good thing for technology, but for art it is ruinous."

[58]Thomas Levenson, *Measure for Measure* (New York: Simon and Schuster, 1995), 225.

reproduce measurements and varnishes precisely. Rather, the maker needs to treat each instrument like a child with its own mind. The wood that one begins with has its own characteristics that the maker must be sensitive to, and over years of developing intuition, a skilled maker should be able make an instrument that sounds as good as the wood can and reflects qualities of both the wood and the maker. Stradivari himself was limited by the quality of his wood. For about eight years between 1710 and 1720, he used a particularly fine piece of maple to create some of his most beautiful and best instruments. Once the supply was gone, he was never able to reproduce their qualities.

This idea can also be applied to the music of the violin. The "poses" of Mutter, Molsky, and Wood from the beginning of this chapter represent three realized potentials of the violin, each with different expressive intent. Just as a good instrument should reflect both its maker and its materials, their musics are collaborations between musician and instrument. The differences in instrument design—subtle for Mutter and Molsky, extreme for Wood—also fit into this equation, alterations being made where they can be to better match expressive intent. It is a complex equation with unpredictable results—nonlinear and chaotic, as Levenson argues—and that is part of its beauty.[59] In order to realize some of the potentials of the electric violin, we need to be sensitive to this relationship, to develop intuitions over long periods of time, to explore, and to build and revise. We may be surprised by what we find.

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[59] In mathematics, chaotic systems are said to exhibit *sensitive dependence on initial condition*. Slight changes in the starting point can create radically different trajectories.