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Playing with Numbers

A Digital Instrument Inquisition

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Abstract

Are digital instruments instruments? By investigating the role of digital technology—limited to the realm of music-making—one is offered focused insight into the manners in which digital technology affects not only our musical world, but also our scope for agency within a technology-laden society. "Playing With Numbers" examines digital instruments using the register of *unpredictability* to delineate instrument from machine. In so doing, the paper demonstrates that in order for the truly predictable musical tool to usurp musical composition, predictable humans' co-operation is required. However, by actively confronting our digital tools and embracing the ideal of unpredictability we will not only be able to make a powerful claim for our own agency, but we shall also advance toward compelling musical and social horizons.

Keywords

Digital, analog, agency, technology, synthesizer, acoustics

Andreas Lübeck, *Minimoog*.
Image source.

Introduction

> "As the variety of the environment magnifies in both time and space and as the structures that were thought to describe the operation of the world become progressively more unworkable, other concepts of organization must become current. These concepts will base themselves on the assumption of change rather than stasis and on the assumption of probability rather than certainty."
> —Morse Peckham, Man's Rage for Chaos

For 36 000 years humans have been making musical instruments; one can only imagine music's long history before the advent of musical tools (Hitchcock and Klein 2007, 19). Just as the use of general tools allowed humanity to begin to manipulate and control nature, the introduction and development of musical tools has allowed for a vast expansion in sonic possibilities stretching from the Middle Stone Age right through to today. Throughout this history—for both musical and non-musical tools—continuous refinement has made difficult tasks simpler and has yielded an increase in one's overall range of possibility. The development of more recent tools has also yielded a second significant effect: a decrease in required human involvement. This is especially evident in certain industrial contexts in which human operators have all but disappeared.

While these changes may offer obvious benefits in assembly line applications, they pose unique complexities within the musical realm. Particularly, at what point does a tool cease to be an instrument and begin being a machine? Is the instrument/machine dichotomy valid, or can these changes only be discerned in hindsight? This essay will narrow the scope of this matter to a particularly pressing and contemporary question: are digital instruments indeed instruments?

In order to commence this investigation it will initially be important to pose working definitions for several terms. In the first part of this essay I shall offer a distinction between instrument and machine, and will rely on the criteria of unpredictability suggested in Trevor Pinch and Frank Trocco's Analog Days. In order to avoid confusion and in the interest of consistency, I will use the neutral term 'tool' throughout this essay to refer to an instrument/machine. Building on the importance of unpredictability, I shall call on David Suisman's essay "Sound, Knowledge, and the 'Immanence of Human Failure,'" particularly his discussion of the player-piano which—by way of contrast—exemplifies the importance of the possibility of failure in art. Through this taxonomy I shall demonstrate the significance of regarding predictability as a central criterion for the instrument/machine distinction. This will lead to the essay's second part, a cursory explanation of synthesis, and the ways in which digital synthesizers can be classified with respect to the established distinction. Furthermore, I shall demonstrate the manner in which digital synthesizers as a species exhibit a lower degree of improbability than their analog ancestors, making them potential candidates for the 'machine' category.

In the third part of this essay I will build on the argument that digital music tools in their present incarnations are not instruments by turning to the work of Jonathan Sterne. Sterne will serve as counterpoint in his assertion that all sound media—iPods and stereos as well as computer synthesizers—should be considered instruments. Through my confrontation with his oppositional arguments and by incorporating certain elements, I shall refine my ultimate argument. In the fourth and final part I will draw on literature by several modern composers to demonstrate the broader significance of confronting digital technology both in a literal and metaphorical sense. Through a creative, critical, and active approach to the tools that populate the musical landscape of today, I shall demonstrate the potential that lies in our relationship with future digital tools, and the empowering possibilities of confronting them.

Through this investigation I intend to provide a useful but not overly technical approach to understanding the tools that are responsible for making more and more of our music, and I shall direct this understanding at enabling one to recognize the underlying significance of digital code as such. By doing this I will argue that appropriating the tools of today to our own ends can offer an approach to confronting the codes governing our lives, our culture, and our world. Only through our active appropriation can these devices come into their own as instruments, and can we reclaim our position as their players.

Part One, or: 01010000 01100001 01110010 01110100 00000001

Where do instruments end and machines begin? The answer to this question will vary dramatically based on who is asked, and when. Early on in his lengthy book Synthesizer Performance, Jeff Pressing suggests that “we must look at what we expect a musical instrument to be able to do and what causes musicians to play it and compose music for it. There are perhaps three ideas of central importance here: the versatility, identity, and degree of development of an instrument” (Pressing 1992, 2). Pressing goes on to demonstrate that the synthesizer fails every one of these criteria, simply because it is “unlike any [instrument] that has come before it. It . . . offers a range of sonic possibilities without historical precedent” (Pressing, 4). This statement suggests that the inevitable variability in answers given to the divisive instrument/machine quandary is symptomatic of constantly shifting definitions. These definitions are continually challenged by new technological innovations coupled with the social significance each of them possesses. To take an initial definition from a book devoted to synthesizers is appropriate, as that specific tool has singlehandedly caused the conservative, the curious, and the confused to question the dividing line between the two terms.

One can immediately appreciate the complexity—and perhaps arbitrariness—of the distinction in light of a statement by historian Jacques Barzun during his regular audience-address before concerts at the Columbia-Princeton Electronic Music Center. In an effort to preemptively confront a predictable concern, Barzun stated that “most people of artistic tastes share the widespread distrust and dislike of machinery and argue that anything pretending to be art cannot come out of a machine . . . the answer is simple: the moment man ceased to make music with his voice alone the art became machine-ridden” (Barzun 1961, 369). The insight of this statement points to the difficulty in assigning any particular tool to the category of either instrument or machine. As we shall see below, by defining one’s tools in these binary terms, one falls prey to the exact forces one must attempt to overcome.

Therefore, in order to proceed sincerely it is important to recognize the murky distinction between instrument and machine; accordingly I shall move forward with this discussion by employing a definition based on a continuum rather than a dichotomy. For our purposes a continuum is a more accurate model than a dichotomy and this continuum will place instrument at one extreme and machine at the other. The criterion connecting the two poles shall be unpredictability, whereby the shift of a tool from the instrumental end toward the mechanical one signifies a heightened degree of predictability. The importance in presenting this distinction as a continuum is that while we might imagine the ‘pure’ instrument as being entirely unpredictable, and the ‘pure’ machine as being thoroughly predictable, the reality is that none of our tools fall into either camp. This continuum shall allow us to proceed with an honest solution to a complex dilemma, and the solution’s very characteristics shall provide an implicit understanding of the difference between analog and digital technology.

Certainly the distinction between instrument and machine can be constructed on criteria other than unpredictability, but I have intentionally selected this criterion as a meaningful testament to the relationship between human involvement and artistic creation. Although the synthesizer and more recent digital tools—AutoTune being a pertinent and obvious example—may have sparked inquiry over the instrument/machine distinction, this debate has occurred throughout history as new innovations have been presented to the musical world—a world whose conservative critics continually reveal their Luddite tendencies. David Suisman highlights this fact by pointing to nearly the same controversy that occurred at the beginning of the twentieth century with the advent of the player-piano in his essay “Sound, Knowledge, and the ‘Immanence of Human Failure.’” As Suisman relates, concerns quickly arose that the player-piano’s mechanization would eliminate human musicians. Tracing these concerns even further back, Suisman points out that “a piano produces eighty-eight regular pitches and only those pitches, and it produces them easily and predictably . . . even the most unskilled operator can walk up to a keyboard and hit a perfect middle C” (Suisman 2010, 21). He goes on to raise the important point that although mechanization is often regarded as an offloading of skill from operator to machine, “mechanization can actually enhance a producer’s skill, not undermine it” (Suisman, 21; emphasis added). Concerns regarding the deskilling that accompanies technological innovation often result from an inability to perceive operator and machine as one. Indeed, new technologies may reduce the necessity for an individual to perform previously-required tasks, and in this way operators may lose old skills. But innovation generally broadens the scope of possibility from what it was before the new technology existed. Only a critical, sober outlook can overcome the myopia that considers the individual apart from her tools.

The significance, then, of the unpredictability factor is outlined by Suisman later on in his essay, in reference to a sign that Oscar Wilde once saw on the wall of a Colorado saloon which read “Please Do Not Shoot the Pianist. He Is Doing His Best.” Suisman’s discussion refers to American author William Gaddis’s belief that “art declined in proportion to the elimination of risk . . . the player-piano, with its predetermined outcomes and detachment from active human involvement, was art’s antithesis” (Suisman, 26-7). If one is to accept the relationship between art and the immanence of failure, then one finds in unpredictability a meaningful criterion to categorize the distinction between instrument and machine. Whilst a trained musician may strive to decrease—to the point of near-elimination—the degree of unpredictability from his relationship with his instrument, one must recognize the irony of this task: the day that unpredictability is entirely removed, the musician ceases to make art. Although the pursuit for the elimination of unpredictability in the human musician will never be realized, we find in the player-piano a working example of the removal of unpredictability which has been realized by mechanized musical tools. Despite vehement fears about the advent of musical machines—well documented in John Philip Sousa’s impassioned 1906 diatribe, The Menace of

Mechanical Music—history has shown that although these fears were understandable, they were generally unwarranted. If Sousa's paranoid visions had manifested, the professional pianist would have long since been eclipsed by his mechanized counterpart. As it stands, in my twenty-six years of life I have never crossed paths with a player-piano.

I have, however, repeatedly come in contact with digital music tools, and it is accordingly important to recognize the ongoing influence of their nearly-forgotten ancestral curios. Refinements in subsequent musical tools as well as in our conceptual frameworks are continually amended based on our steps along successive stones of the technological and cultural path. This then brings us to the more recent fearful music phenomenon, the analog synthesizer and its various digital progeny.

Part Two, or: 01010000 01100001 01110010 01110100 00000010

In their eminently engaging and informative book Analog Days, Trevor Pinch and Frank Trocco provide a detailed history of the synthesizer focusing on the most celebrated of them all, invented and improved by Bob Moog in the 1960s. Considering the way in which the synthesizer is perceived today, Pinch and Trocco provide illuminating insight into the pioneering visions of electronic musical tools, repeatedly echoing the view that the synthesizer's ultimate evolution was not aligned with its developers' hopes and expectations (Pinch and Trocco 2002, 318). Although the synthesizer has developed into a musical tool that is often synonymous with a "keyboard" and can easily be reckoned as a piano on steroids, this was certainly not the path the synthesizer needed to take, and it is only under the shroud of present understanding that its genesis becomes obscured.

If acoustic sound is a disturbance of air molecules generated by a vibrating string, skin, or column of air, and a violinist is said to play strings, electronic music, in its simplest conception, might be thought of as playing electricity. Electronic musical tools generate their sound through circuits called oscillators, which convert an electrical signal into a steady frequency. This 'oscillated' signal is then fed through various filters to arrive at a loudspeaker, which ultimately causes the necessary vibration of air that reaches one's ears; a more detailed explanation of this phenomenon is provided below. The user-interfaces on electronic musical tools are extremely varied, and the earliest electronic musical tools look far more like airplane cockpits than they do pianos, with rows of arcane dials, switches, and cables that would make an early telephone operator far more comfortable than they would a musician.

Unsurprisingly, the musicianship of those who composed with these tools was heatedly debated as their sonic creations were frequently regarded as “noise” for many years to come. Part of the reason for electronic music’s relegation to this controversial, unstable, and politically-charged category was a lack of correspondence in these musical tools to traditional Western instruments with their mathematically-based tuning systems, derived by Pythagoras more than two millennia ago. Unsettling as this new music may have been for traditional music aficionados, the innovation opened the door for many artists to begin producing compositions specifically created around new prospects of sonic design. As related by pioneering electronic composer Karlheinz Stockhausen, “the thought arose of giving up preformed instrumental sounds and composing the sounds themselves for a particular composition: artificially assembling them according to the formal laws of this and no other composition” (Stockhausen 1959, 373). Due to its knobs and dials in place of a discrete, traditional keyboard, the interfaces of early electronic musical tools offered a fluidity and lack of pre-defined structure permitting users to “discover the interesting sounds . . . ‘between the knobs’” (Pinch and Trocco, 319). Stockhausen was one of a number of pioneering composers whose new tools allowed him to approach composition with a distinctly non-traditional method, and the resulting music bore sonic testimony to this unconventional trajectory.

In accord with Stockhausen’s approach was Californian eccentric Don Buchla, whose keyboard-less Buchla Box provided an obvious counterpoint to the more conventional Moog synthesizer. Yet in the end it was the Moog that became synonymous with the synthesizer, and a large part of this success was related to its accessibility. Partially responsible for this accessibility was Moog’s decision to use a keyboard on his synthesizers, allowing many traditionally-trained musicians to approach the cryptic musical tool. Jumping forward to the present, digital synthesizers now generally find themselves with banks of pre-programmed patches; although this step has yielded an even further degree of popular accessibility (and predictability), the inclusion of pre-programmed patches was by no means a necessary evolution based on the synthesizer’s early days. Consider as a glaring counterpoint to this development Stockhausen’s pronouncement that “once the realisation of a piece has been completed, the archived sounds and all intermediate results are erased again; there is therefore no sound catalogue which, after completion of a composition, might perhaps be enriched by some hundred or thousand more sounds 'for general use'" (Stockhausen, 373).

One may validly argue that in 1959 neither Stockhausen nor his cavalier contemporaries would have even been capable of storing sounds had they so desired, due to technological constraints. Yet it appears that the early sentiment of these composers was that the tool was partially defined by its transience, and pre-formed sounds were not part of what made electronic music. Although the early Moog synthesizers—with their countless patch cords and incomprehensible configuration—were far from pre-programmable, Moog's decision to add a keyboard was significant in establishing a standard to which these futuristic sounds could be fixed. I assert that although Moog may not have been aware of it at the time, his decision to incorporate a discretely-tuned interface was a significant step in reducing the unpredictability of the synthesizer.

Indeed, further steps occurred within the analog Shangri-La of Moog's Trumansburg, NY factory which pushed the synthesizer further away from the transient, unpredictable days of the first composers to the pre-programmed state in which they now exist. For the 1969 Jazz in the Garden concert at the MOMA in New York City, Moog engineers designed four synthesizers that would be more conducive to a live performance, each of which contained six pre-programmed sounds. By doing so, the Moog engineers overcame the arduous task that had caused bands like Mother Mallard to have entire rehearsals simply devoted to practicing patch-changes; in building these synthesizers the Moog engineers allowed the musicians at Jazz in the Garden to instantly select between prefabricated sounds. Eloquently and accurately stated, "contingency would turn out, again and again, to be the mother of invention" (Pinch and Trocco, 219). From these four specially-designed synthesizers it took only eight years for the first programmable polyphonic[1] synthesizer to be released by Sequential Circuits. This was only a short stopping point on the road that unfurled in the general direction of simpler and simpler tools with a small selection of pre-programmed sounds, a distant echo of their ancestors' sonic complexity. It seems fitting that one of the most popular of these, released in 1981, was the Casio VL 1: it was originally designed as a calculator (Bates 1988, 26).

It is hard to ignore the fact that the evolution of these musical tools was tightly intertwined with general technological development. The shift along the continuum of unpredictability from instrument toward machine was significantly affected by the advent of the micro-processor and digital technology; prior to that, the advent of the analog synthesizer was made possible by the popularization of transistors over vacuum tubes. Tubes were inconvenient and cumbersome, and transistors allowed for complex and relatively inexpensive circuitry that could accomplish a great deal more than its earlier incarnations could. Even in the pre-Moog stage of the earliest transistor-based musical tools, one can observe a push along the continuum from instrument to machine. Likewise with digital technology—vast amounts of information can be stored on a microprocessor that would have required hundreds or even thousands of transistors. The temptation driving synthesizers' digital migration is evident, especially when the analog synthesizers' limitations were regarded as shortcomings and not novelties, as they are today amongst fetishistic collectors of antiquated equipment.

At this point, then, it is useful to introduce a brief discussion on the workings of digital synthesizers. As mentioned earlier, sound is generated by a disturbance in the air; this is only half the story. The air disturbance must come in contact with one's ears for the energy to be converted to sound. This can be easily understood by clapping one's hands. The resulting sound—a sharp, sudden crack—is generated by a sphere of disturbed air traveling outward from the sound-source. In clapping, one compresses air rapidly and this initiates a chain-reaction of colliding air molecules—imagine an expanding bubble emanating from the sound-source: this is how the air disturbance would look if it could be seen. As the sound-bubble moves outward it makes contact with objects in its path, and only when the bubble makes contact with an ear is it "heard"—the air disturbance becomes sound. This all happens very quickly, as the bubble expands outward at a rate of 344 metres per second; while the sphere of air disturbance grows, its energy decreases until it eventually disappears. Understanding this can shed light on the bewildering tree-falling-in-the-forest question: the tree certainly creates an air disturbance, but does not make a sound unless there is an ear present to convert the disturbance.

If one envisions the hand-clap on a graph in which volume is plotted vertically and time horizontally, the graph would show a sudden vertical peak with a slope returning quickly to zero, like a folded umbrella. For pitched instruments the principle works in the same way, but repeatedly instead of only once. The A-string on a guitar, for example, vibrates 110 times per second. This means that the same air disturbance that occurred when one clapped is happening rapidly and repeatedly, from a sound source with a different physical construction than the tissue, skin, blood, and bones of one's hands. The resulting air disturbance, again a growing sphere, can be modeled as a waveform, which plots the 110 air-disturbances-per-second—or Hz—on the graph. If considered in a simplified form, this 110 Hz signal can be represented as 110 successive air-disturbances, which will take the shape of a sinusoidal—or sine—wave. In reality, however, every sound-source has its own sonic signature based on additional vibrations that occur with frequencies that are multiples of the original—or fundamental—vibration. These added complexities, known as the overtone series, are what allow one to easily distinguish between a guitar and a clarinet, although the two instruments may both play a note with the exact same fundamental frequency. Therefore, the overtones must ultimately be considered in the discussion of digital sound, but for the time being it will be simpler to limit ourselves to the differences between an analog and digital sine wave.

In an analog synthesizer, a sine wave is produced by circuits that convert an electrical signal into the aforementioned waveform. With digital synthesizers, however, this works differently. In the case of modern computer-based synthesizers, there is no way in which a real waveform can be stored. A computer operates with simple numbers which only allow it to plot out discrete points. For a CD, a computer takes the 110 Hz wave and analyzes its location 44 100 times per second. Thus, the digital representation of a sine wave is a series of discrete points connected at right angles: it converts a smooth wave with theoretically infinite points into a staircase. As processors improve in power and capacity, the size of these stairs decreases so that the digital waveform may have the semblance of smoothness just as the pixels in a digital photograph cannot be seen unless examined closely—but at the most minuscule level, digital waveforms are a series of discrete points, while an analog signal retains fluidity. Consider the following statement by Brian Eno:

> [Digital] synthesizers are a little bit like formica. If you see it from a distance, it looks great—this big panel of blue or pink or whatever that fits in well with your designer home. But when you get close to the surface of formica, it's not interesting; nothing's going on there. Contrast this with a . . . forest, for instance. You look at it from the air and it's rich, complex, and diverse. You come in closer and look at one tree and it's still rich, complex, and diverse. You look at one leaf, it's rich and

> complicated. . . . [These are] things that allow you to enter them as far as you can imagine going, yet don't suddenly reveal themselves to be composed of paper-thin, synthetic materials. (Eno 1983, 27)

Although not necessarily obvious to the untrained ear, digital and analog audio possess this significant distinction.

Certainly, current state-of-the-art digital technology makes it difficult to talk about analog being better than digital or vice-versa; each has it own properties and sonic character. Most importantly however, for the purposes of this discussion, is that digital audio is far more predictable than its analog counterpart. Despite the differences in each method of digital synthesis (and many modern synthesizers combine methods to make this matter still more complex), the underlying commonality in all their cases is their reliance on digital information, which is converted to sound.

The beauty of analog tools, as musician Jon Weiss states, is that "there were . . . certain inaccuracies in the equipment that resulted in wonderful and bizarre events . . . it wasn't a machine. A machine would have created no inaccuracies and I think that's maybe why these computer digital generated sounds are not as interesting as the analog sounds" (Pinch and Trocco, 319). Despite having had a team of expert engineers designing this equipment, there always remained a factor of uncertainty and unpredictability. Weiss relates a story of having been in New York City and hearing Sun Ra playing a prototype Minimoog, stating that "he made sounds like you had never heard in your life" (Pinch and Trocco, 223). For a musician who worked so closely with these synthesizers—Weiss was a studio musician employed at Moog's factory—to be so completely baffled by the sounds one of them created is quite telling of the potential in analog musical tools. The closest traditional comparison might be a musician who helped a luthier build a cello and went to hear a virtuoso use it in concert. Perhaps the musician would be moved by the sounds coaxed from the instrument by the performer, but it seems unlikely that the musician would be surprised or shocked due to having heard the sound of an oboe coming from the cello she helped design. It seems fair, then, to say that Weiss's reaction was of an entirely different order than one might imagine in traditional settings, in hearing unfamiliar sounds emanating from Sun Ra's demented Model B synthesizer. Pinch and Trocco elaborate on this point by stating that "all the best instruments in some sense do not 'work' as they are supposed to. It is the departures from theoretical models of instruments—the unexpected resonances and the like—that make an instrument particularly valued" (Pinch and Trocco, 223).

Although there is only speculation as to how these unexpected sounds occur, the general belief is that ultrasonic frequencies feed back through the synthesizer's signal chain and distort the audible content. Human hearing in its ideal functioning can hear sounds up to 20 000 Hz, and although no known instrument has a fundamental frequency that high, the overtone series stretches far beyond the audible range—theoretically to infinity. It is this set of ultrasonic frequencies which "come back down" and interact with the sounds in the audible range (Pinch and Trocco, 66). This theory is not unreasonable as certain sounds are created in synthesizers by the similar means of introducing inaudible frequencies to produce audible effects. To create vibrato—a subtle pitch manipulation a violinist or guitarist may apply to a sustained note—a low frequency oscillator (LFO) is used to generate a waveform vibrating so slowly that humans cannot hear it. Instead, listeners hear fluctuations in the pitch of the produced sound as the net result of the interaction between the audible signal and the LFO (Bates, 20).

This interaction is significant in the distinction between digital and analog tools. As mentioned above, digital synthesizers do not generate waveforms in the same way as analog synthesizers do; rather, digital synthesizers reproduce waveforms—the combination of fundamental and overtone series. Because human hearing does not extend beyond 20 000 Hz, there is no reason for digital instruments to include ultrasonic overtones. Certainly the overtone series is important in order to give complexity to a sound, but anything inaudible is simply considered wasteful. This attitude is most clearly reflected in "lossy" media formats, the most well-known being the mp3. Within the audible frequency range, humans do not hear all frequencies equally, and because of how the ear functions many frequencies are missed altogether. The mp3 is designed to take advantage of this fact. As Jonathan Sterne explains, it "figures out what you will not hear anyway and [gets] rid of the data for that portion of the sound" (Sterne 2006, 832). Although the approach for mp3s serves a certain purpose—facilitating transfer, storage, and ultimately accumulation—the general principle still applies in the higher-quality digital audio of synthesizers.

Consider how many of our general tools function. A knife, for example, can separate meat from the bone of an animal, or fat from the meat; we use tools to separate nature into what we can use and what we cannot. Accordingly, digital audio is truly a tool, cutting nature's sound-waves into the few usable parts, and discarding the waste. Furthermore, as knives are refined, they allow for more accurate cutting, which permits increasingly precise divisions between that which is useful and that which is not. So it is with improved digital tools, performing complex analyses of what the human ear can apprehend and slicing away wasteful content, trimming ever-closer to the audible "meat." Unfortunately, the seemingly wasteful parts can turn out to be quite useful. One does not need to search far for examples, and the famous opening of Stanley Kubrick's 2001: A Space Odyssey portrays this lucidly as an ape discovers the power of what was previously an overlooked bone.

This being the case, there is a significant shortcoming to digital synthesizers: the predictability that is a byproduct of their efficiency. One might say that while analog synthesizers are alive—in that they generate waveforms just as traditional instruments generate them—in most modern applications digital synthesizers are wax models of waveforms. Even from close proximity they appear quite convincing, but there are no internal organs, nor is there the possibility of movement or action in the same way as there is for a living entity. It must be stated, though, that in the transition period between analog and digital, the first digital synthesizers were in fact hybrids. Using a Digitally-Controlled Oscillator (DCO, instead of the prior Voltage-Controlled Oscillator, or VCO), a stream of binary data would generate complex waveforms. This may be regarded as the ultimate compromise in having taken advantage of computational power while maintaining the inner workings of an analog synthesizer. Today, however, digital synthesizers have extremely advanced methods of simulating an array of instruments, both real and imaginary. Ironically, there now exist virtual Moog synthesizers which model the previously discussed signature distortion. But one must remember that simulated chaos is predictability at a masquerade.

Of the utmost importance is the recognition that digital musical tools are reliant on a code. In their somewhat romantic article pitting records against CDs, academic audiophiles Eric Rothenbuhler and John Durham Peters assert that "the digital storage medium holds numbers—data. . . . Since the numbers, like all such data, are arbitrary—related to their referent only by social convention—it is in principle possible for the consumer to treat them as anything" (Rothenbuhler and Peters 1997, 245). As we shall see in the fourth part of this essay, the apparent weakness of digital media's underlying code may in fact yield an opportunity for empowerment if it is approached critically. For the time being, suffice it to say that the history of musical tools can be understood as a progression from nature (the voice) through technological evolution, and we have arrived at a state of highly advanced code, far removed from the natural order of sound generation but ripe with opportunity when regarded as a social construct.

Part Three, or: 01010000 01100001 01110010 01110100 00000011

The above point will be more clearly articulated by turning to the work of Jonathan Sterne, who has highlighted the significant social formation of many of the taken-for-granted techniques and technologies surrounding sound and music. To Sterne, the instrument/machine distinction is entirely insignificant, and he goes as far as arguing that all sound media are instruments (Sterne, 2007). In his article The mp3 as Cultural Artifact Sterne offers a detailed and helpful explanation of the history of the format along with the procedure—as described above—whereby inaudible frequencies are removed from sound recordings to leave listeners with relatively small files, thousands of which can be packed onto most current cell phones. Through this explanation Sterne concludes that “as a philosophy of audition, the mp3 makes use of the limitations of healthy human hearing. One might even say that the mp3 is a celebration of the limits of auditory perception” (Sterne 2006, 828). By the tight dovetailing of digital sound files to the workings of the ear, Sterne asserts that “the mp3 plays its listener” (Sterne 2006, 835).

This is a significant point. In this model, because of the predictability of the human ear, the mp3 assumes the role of player, and the listener finds himself transformed into a tool brusquely shoved toward the mechanical pole of the predictability continuum. Designers have figured out a very specific model for how human hearing works, and the fact that as of January 2011 Apple has sold nearly 300 million iPods suggests that listeners are not overly perturbed by the discarded frequencies (Apple, 2011).

This raises the question, then, of the distinction between sound production and sound reproduction. Based on the earlier discussion it is clear that—due to their digital nature—not only do mp3s and higher-quality formats fall under the banner of reproduction, but modern digital musical tools do as well. The distinction between sound production and reproduction, however, may not be quite so clear-cut. In an impressive display of intellectual dexterity in his book The Audible Past, Sterne demonstrates that sound production cannot be considered separately from sound reproduction:

> The sonic event is created for the explicit purpose of its reproduction. Therefore, we can no longer argue that copies are debased versions of a more authentic original that exists either outside or prior to the process of reproduction. Both copy and original are products of the process of reproducibility. The original requires as much artifice as the copy. Philosophies of sound reproduction that reference a prior authenticity that is neither reproduced nor reproducible are untenable since their point of reference—an authentic original untainted by reproduction—is at best a false idol. (Sterne 2003, 241)

In pulling the rug out from under audiophiles who continually strive for closer and closer contact with the "religious experience" (Rothenbuhler and Peters, 253) of high fidelity, Sterne argues that copies do not exist solely as extensions of the original; rather, if one hopes to understand the genesis of an "original," one must take into consideration the arrangement that allows for copies to be created. In this way one will recognize that the two are inextricably intertwined. Sterne may then object to the previous discussion by asking, "If the point of digital tools is only for recording, then why does their predictability matter?" After all, recordings—at least as they generally exist as of this writing—are determinate and fixed. Indeed, there is no active genesis of a waveform when one plays an mp3 or a CD; the waveform is frozen and the recording produces an identical waveform each time it is played (Pierce, 292). Furthermore, the most complex ultrasonic overtone series plays no role on a recording that not only cuts frequencies off at 20 000 Hz, but even eliminates a significant amount of information within the range of audibility.

My response to this criticism lies in another dimension of Sterne's argument regarding production and reproduction: aura. In preparing for the aforementioned intellectual somersault, Sterne lays the groundwork by stating that "the very construct of aura is, by and large, retroactive . . . [aura is] the object of a nostalgia that accompanies reproduction" (Sterne 2003, 220). If digital equipment is categorized as a tool of reproduction and this reproduction is—and always has been—devoid of aura, then we are faced with an empowering challenge and opportunity. One of the principal effects of abolishing aura is the removal of an obscuring sheet from the social scaffolding that supports objects and processes previously believed to be governed by universal, natural forces. Thus, one can validly regard digital instruments as reproducing the codes of a society that has bred them into existence. As Walter Benjamin states, the removal of aura has two possibilities: one of them is politicizing art,[2] and in this we find the powerful prospect of confrontation with digital technology (Benjamin 1968, 242).

We must then approach our digital media as being a significant embodiment of the codes that spawned them. They are, after all, themselves only codes. For listeners to simply replay these codes as they are is to passively accept condition and circumstance. One does not need to search very far for crowds of people who have plugged their heads up with earbuds, passively awash with a disguised code they have inadvertently spawned. The important step that is implicitly suggested in Sterne's discussion is appropriating digital media to our own ends and using it to generate codes of our own choosing rather than bathing in its lullabies of inert s(t)imulation.

Bearing in mind that digital media is reliant on a stream of information, its acquiescent playback occurs when consumers passively use their equipment as manufacturers intended. Rothenbuhler and Peters reinforce this point when stating that "thinking of digital recording media as storage data rather than music makes it possible to enter into the musical process, to intervene in its playback, to participate in the creation of what it is one has gotten when one buys a CD. So digital technology would seem to invite a participatory stance that analog inhibits" (Rothenbuhler and Peters, 246). The question, then, is not if, but how will we choose to approach these technologies. As I shall argue in part four, our approach to this equipment can have significant consequences in allowing us to claim agency by recognizing—as we have with the mp3—that this technology capitalizes on our predictability and scarily pushes us into the realm of the mechanical. More importantly, if we confront this technology critically and creatively, we can embrace its potential and establish our generation as having been one who played with instruments, and not machines.

Part Four, or: 01010000 01100001 01110010 01110100 00000100

> When a mother can turn on the phonograph with the same ease that she applies to the electric light, will she croon her baby to slumber with sweet lullabies, or will the infant be put to sleep by machinery?

> Children are naturally imitative, and if, in their infancy, they hear only phonographs, will they not sing, if they sing at all, in imitation and finally become simply human phonographs—without soul or expression? (Sousa 1906, 281)

To what extent does technology shape culture? Academic debates spawn furiously over this matter, and without attempting to tackle this question it is safe to suggest that the proliferation of a technology tends to make its initially-shocking presence somewhat benign. While the musical tools of the early twentieth century caused quite a furor—both in the case of the player-piano and the phonograph—these debates have raged more recently with the advent of the synthesizer, and I assert that even if critical voices are not heard as prominently today, the issues we face are equally significant. To what extent will we allow digital technologies to continue to 'play us', and at what point will we begin to play them? More importantly, how can we truly play these technologies, if what we are doing with them right now is not playing them? Lastly, why should we care?

The binary code that underlies our digital world possesses a poetic significance. At the simplest level, the difference between analog and digital is that analog is a continuous, fluid stream, while binary is a series of discrete 1s and 0s. If binary is a light-switch, analog is a dimmer. And it is due to this fundamental difference that the analog paradigm may continue to attract users when ostensibly superior technology exists. For nature does not exist in binary form: from the earth's rotation to the growing of fruit, from the maturing of a child to the thawing of a lake, nature's movement is analog and not digital. With that said, it is a pleasant convenience to divide the world up into discrete segments. As we have it, the "summer" begins on June 21st and ends on September 20th; a "baby" becomes a "child" becomes a "teenager" becomes an "adult." The human relationship with nature can be regarded as the digital representation of a complex analog waveform, rounding off a continuous, incessant stream to the nearest comprehensible point and discarding the vast amount of information beyond the scope of our awareness—and a great deal within that scope, as well. Society, then, regarded as an agglomeration of the humans that compose it, exudes binary characteristics. Man-or-woman, rich-or-poor, black-or-white, mine-or-yours . . . these binaries continue to dominate the world in which we live. Digital technology, then, can be regarded as a technological manifestation of this social propensity.

In an effort to elucidate the significance of his essay's subject matter, Suisman describes the player-piano as having been representative of modernity and late capitalism to the aforementioned William Gaddis. To Gaddis, late capitalism was characterized by the mechanization of art and commerce, as well as the various manners in which the two had become linked (Suisman, 25). Today, we find ourselves in a world with similarly intertwined and complex relationships between art and commerce, and dominated by a form of technology that creates convincing simulations through a code. This, however, is not to lament the proliferation of digital technology, as the benefits are extraordinary. But it is an effort to bring attention to the underlying schema that governs this technology, with a hope to address this situation actively.

Suisman goes on to describe the interesting work of composer Conlon Nancarrow. Instead of lamenting the death of human music as so many others did, Nancarrow approached the player-piano as a compositional tool that could yield music previously unplayable. By composing specifically for the new technology, he

> engaged [it] actively and directly . . . In so doing, [Nancarrow] called attention to the technology and the character of recording itself, setting in relief the normative expectations and prevailing assumptions of manufacturers, marketers, and consumers. Certainly, the player-piano could represent the alienation of human labor, the standardization of aesthetic experience, and the reduction of a kind of human risk essential to the nature of art, but so too could it stand for mechanization's hidden possibilities. (Suisman, 30)

The importance of Nancarrow's work—reflected in his receipt of a MacArthur Award in 1982—lies not only in his musical innovation, but in his symbolic engagement with a system that was feared would blindly mechanize the world. Although technology does play a consequential role in shaping our world, the myopia of critics like Sousa lies in their fatalistic technological determinism. To believe that technology is entirely responsible for the ebb and flow of society is to ignore the ongoing human response to, and engagement with, our newest tools. Indeed, the world moves forward through technology, but that only tells half the story: there is also what we do with these technologies. And it is in this area that I argue our own prospect lies in directly engaging digital technology. As Nancarrow demonstrated, to do so is far more significant than simply creating within a new medium; it is rekindling the human flame that may flicker and occasionally fades but is never extinguished.

The prospect of engagement, then, lies in appropriating current tools and technologies to our own ends—ends which neither manufacturers nor marketers prescribed. Through his work, musician Yasunao Tone has provided examples of where possibilities lie within the world of digital technology. For his album Solo for Wounded CD, Tone punctured pieces of Scotch tape with a pin and applied them to CDs. As Rothenbuhler and Peters make clear in their technological diatribe, “when we buy a record we buy music, and when we buy a CD we buy data” (Rothenbuhler and Peters, 246). Accordingly, Tone’s doctored CDs would cause CD players to exhibit unpredictable behaviour—buzzing, beeping, chirping, fuzzing—far from the purposes for which they were designed.

A host of other musicians including Kim Cascone and Christian Marclay work on similar principles, using technology in ways for which it was not originally designed. To stamp out digital technology altogether is to throw away the baby with the bathwater: the power of these tools is tremendous. Yet I argue that as they are being used now we are only experiencing a small fraction of their potential, just as binary social distinctions (man/woman, straight/gay, etc.) limit people to only a tiny fraction of their subjective depth and potential. It is through users’ intentional appropriation of these technologies to their own ends that they may do significant work in establishing their own agency not only in technological encounters, but significantly in non-technological interactions. The opportunities for this sort of transformation present themselves on a daily basis—unsurprising considering the rapidly growing presence of computers in all our lives. Echoing this point, Kim Cascone states that “the data hidden in our perceptual ‘blind spot’ contains worlds waiting to be explored, if we choose to shift our focus there. Today’s digital technology enables artists to explore new territories for content by capturing and examining the area beyond the boundary of ‘normal’ functions and uses of software” (Cascone 2000, 394).

Conclusion

That digital technology has fundamentally altered the world in which we live is not up for debate. The question, however, returns to one of instruments or machines. As we saw with Sterne, it is not necessarily clear who is playing what or what is playing whom. Intuitively we like to believe that we play our tools, but one can understand the circularity of this relationship and the manner in which our tools play us as well. Of great importance, then, is how we choose to use these tools. If we continue to use them as they are intended to be used, the shift toward increased predictability will continue, wherein computers anticipate our behaviour, become smarter and smarter, and shoulder an increasing amount of our intellectual burden. In the best-case scenario of this model, computers will become so smart that they will take over the majority of our mundane efforts so that future music composition will be more like a powerboat, in which the operator simply has to steer a rudder and allow the motor to propel it, whereas traditional composition may have been likened to a rowboat or even swimming.

As things are progressing, this does not seem too far off. The iPhone app LaDiDa allows users to sing into their phones, and using a series of computer algorithms the app analyzes the musical content and creates a backing track around the recorded melody. From the product description: “Can’t sing? Doesn’t matter! *LaDiDa* can automatically tune your voice to the correct notes and add studio-quality vocal effects” (Khush Inc., 2009). Certainly the prospects are fascinating, but with a keen ear, one can hear Sousa’s paranoid prophecies ringing in the background of every AutoTuned voice from Cher to T-Pain. These technologies all function based on an assumed predictability of their users, and thus relegate the passive individual to mechanical purveyor of binary code.

Yet opportunity lies so close to home. By embracing the model of the unpredictable musical tool—Moog’s enigmatic synthesizer with its ultrasonic frequencies that “defy mathematical treatment” (Pinch and Trocco, 66)—we as individuals can approach the digital tools that occupy our musical landscape and recognize in them an opportunity for liberation from mechanical predictability. The incredibly powerful processors at the core of these tools can be manipulated to once again generate unpredictable creations. In his characteristically cryptic style, Marshall McLuhan wrote that we “look at the present through a rear-view mirror. We march backwards into the future” (McLuhan and Fiore 1967, 75), asserting that we approach our current technologies with outdated paradigms. In our digital tools of 2011, we only see the pianos and violins of yesteryear: instruments with fixed, physical parts which had a single way to be played. The revolution in digital technology lies in its open-endedness, its manipulability, its plasticity. To approach our tools as fixed and of a single purpose is to limit ourselves to predictability. Yet in recognizing the inherent power of these technologies, using them to our own ends ushers in the discomfort of unpredictability and importantly calls into question the fixed binaries that govern our world. It is through this action that we can reclaim our tools as instruments, and ourselves as their players.

The windshield, after all, is far larger than the rear-view mirror.

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Endnotes

[1] Meaning multiple notes can be sounded simultaneously, as opposed to Moog's monophonic synthesizers, in which only a single note could be played at once. Analog synthesizers accomplished polyphony by essentially building multiple synthesizers into one unit, each of which was responsible for a single note.
[2] The other possibility involves the aestheticization of politics and in the most extreme cases, the aestheticization of humankind's own destruction.

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