

# HARNESSING THE PIANO'S VOLTAGE

BY

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The piano is a masterpiece uniting science, engineering, physics, craftsmanship, and art in purpose. However, the piano as an instrument reached its apex over 100 years ago, and as composers entered the 20<sup>th</sup> c., the piano's strengths became constricting limitations. The triumph of equal temperament became a fixed black and white set of 88 distinct pitches, and the piano's timbre was unique but limited to the felt hammers initiating its characteristic sound. The piano had been collectively explored and exploited, and modern composers looked to new means to develop a unique voice.<sup>1 2</sup> The intersection of piano and computer was inevitable as the rapidly developing technologically influenced culture.<sup>3</sup> The merging of digital technology and the piano has brought technicians, sound designers, and inventors together to innovatively serve composers' new visions and needs.

The majority of contemporary pianists trained in Western European music traditions find computer music overwhelming and intimidating<sup>4</sup>. In this essay, *Harnessing the Piano's Voltage*, I examine the methods in which technology has been applied to extend the piano's traditional sound to creatively fulfill its musical goals. In introducing how amplitude and pitch tracking, along with MIDI pedal, are used to

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<sup>1</sup> Ludger Brümmer writes "The idea of extending an instrument is crucial in the current situation of contemporary music since [western] instruments reached a point of optimization." Ludger Brümmer, "Extending the Piano," *Keyboards + Live Electronics: The Performer's Perspective / Claviers + <live electronics>: La perspective de l'interprète* 13.2 (April 2011), [http://cec.sonus.ca/econtact/13\\_2/bruemmer\\_extending.html](http://cec.sonus.ca/econtact/13_2/bruemmer_extending.html) (accessed May 24, 2011).

<sup>2</sup> Composer Annea Lockwood (b. 1939) responded with *Piano Burning* (1968), setting ablaze an old upright piano, that is performed upon until the flames are unbearably hot. Annea Lockwood, "Scores for Piano Transplants," [http://www.annealockwood.com/downloads/piano\\_transplant\\_scores.pdf](http://www.annealockwood.com/downloads/piano_transplant_scores.pdf) (accessed January 18, 2014).

<sup>3</sup> Brümmer.

<sup>4</sup> Sebastian Berweck writes that given a survey of "classically trained instrumentalists, ... relatively few musicians specialize in the performance of music with electronics ... A minority [of Graduates from Music Conservatories specialize] in 20th century music and still a minority of those [play] ... with electronics ... [most performers at the forefront of electroacoustic piano performance] did not receive training in playing with electronics while studying [at school]." Sebastian Berweck, "It worked yesterday: *on (re-) performing electronic music*." PhD diss., University of Huddersfield, 2012. <http://www.sebastianberweck.de/media/PhD/Berweck%20-%20It%20worked%20yesterday.pdf> (accessed July 23, 2013).

connect the piano (and pianist) with Live Electronics, I explore innovative ways the piano's timbre is sustained and extended into exciting realms, such as the illusion of multiple tunings or completely new sonorities with the use of electromagnets. I also introduce the concept of distributing sound through space, and the enhancement of drama with the addition of video and motion sensors, and I conclude the essay with a survey of the difficulties pianists and composers may encounter with performing this genre. I have assessed a wide variety of contemporary electroacoustic piano repertoire and chosen examples I feel are strong representations of this genre. I draw upon my own extensive training as a concert pianist and as a computer music composer and programmer, for I have also designed and worked with software.<sup>5</sup> Additionally, I have worked alongside composers, having commissioned and performed works for piano and computer that have been performed with success throughout the United States.<sup>6</sup> I have consulted a wide array of resources, including writings by composers, computer technicians, performers, critics, and philosophers, in addition to scores and recordings. In this essay, I aim to create a bridge between pianists and the electroacoustic community, to open electroacoustic piano repertoire to curious pianists, and also for pianist's needs and perspectives to be recognized by computer music composers writing in this genre.

The most basic technological intervention in the piano repertoire is the simple act of amplification and recording. Composer Mario Davidovsky (b. 1934) held the opinion that "the ability to record sound was ... the single most important technical breakthrough

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<sup>5</sup> I am completing a Doctorate in Piano Performance at Indiana University, with a Minor Field in Computer Music.

<sup>6</sup> Two works I commissioned were selected to appear on SEAMUS (*Society for Electro Acoustic Music in United States*) annual conferences; they were also selected for the Annual SEAMUS CD: John Gibson's *Blue Traces* (2009) and Jeffrey Hass's *Three Etudes for Piano and Computer* (2013).

of the 20<sup>th</sup> century.”<sup>7</sup> Composer Giacinto Scelsi (1905-1988) recorded his improvisations that were later transcribed by assistants under his supervision, for example in *Aitsi* (1974), for amplified piano.<sup>8</sup> For Scelsi, music was discovered in a “quasi-meditative state” and “passed *through* him,” and recording technology allowed him greater expressive freedom for music to stream through him.<sup>9</sup> For Annea Lockwood (b. 1939) amplified piano allowed for ever greater sensitivity to sonic nuance. Her composition *Ear-Walking Woman* (1996), for amplified prepared piano, is an entrance to meditative deep listening.<sup>10</sup> Through exploring extended techniques inside the piano, responding to the subtleties and nuances of different gestures, she writes that the work is an “open-ended exploration ... [in which] the pianist is asked to listen closely to the sounds created by each action, and to explore further the variants which arise [from more exploration].”<sup>11</sup>

Early experiments with computers and piano resulted in the development of electroacoustic ‘tape’ music (also called ‘fixed’ media).<sup>12</sup> The computer forms a polyphonic chamber music complement to the pianist, and vice versa. An outstanding example is Luigi Nono’s *sofferte onde serene...* (1974-77) for piano and tape. Nono was inspired by the sensitivity of touch that could be heard in Maurizio Pollini’s piano playing, with “certain nuances of [his] touch that can barely be perceived in the concert

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<sup>7</sup> Noel B. Zahler. “Davidovsky, Mario,” *Grove Music Online. Oxford Music Online*. Oxford University Press. <http://www.oxfordmusiconline.com/subscriber/article/grove/music/07281> (accessed January 26, 2014).

<sup>8</sup> Christopher Fox and David Osmond-Smith, “Scelsi, Giacinto,” *Grove Music Online. Oxford Music Online*. Oxford University Press. <http://www.oxfordmusiconline.com/subscriber/article/grove/music/24720> (accessed February 4, 2014).

<sup>9</sup> Fox and Osmond-Smith.

<sup>10</sup> Annea Lockwood. “Ear-Walking Woman (1996),” <http://iresound.umbc.edu/index.php/home/40-ear-walking-woman> (accessed January 27, 2014).

<sup>11</sup> Ibid.

<sup>12</sup> Barry Schrader and Marc Battier, “Electroacoustic music,” *Grove Music Online. Oxford Music Online*. Oxford University Press. <http://www.oxfordmusiconline.com/subscriber/article/grove/music/A2249352> (accessed January 22, 2014).

hall. With the aid of microphones, these unusual but barely noticeable details could be amplified and projected in a completely new dimension .... [creating] a kind of timeless resonance.”<sup>13</sup> <sup>14</sup>This composition, whose title translates as ‘serene waves endured ...,’ marked the occasion of deaths in both Nono’s family and in (his friend’s) Pollini’s family.<sup>15</sup> The composition developed collaboratively between them, Nono selecting excerpts of recorded improvisations by Pollini, which were subsequently treated in computer software by Nono and studio technician Marino Zuccheri, forming the fixed media component. The piano is shadowed by a dense tape track, which sounds into an infinite dark space, like a sonic resonance of the deep inner emotional landscape. The piano and electronics fuse into “ambiguous sonorities that come sometimes from the piano, sometimes from the tape,”<sup>16</sup> creating “natural environment-like timbres.”<sup>17</sup> The vague ethereal sonorities are “enhanced by relatively free time relations between piano-live and tape,”<sup>18</sup> building to a violent climax with jagged cluster chords.

The use of free timing is unusual in electroacoustic tape pieces. It is more common to use a time monitor, either a click track, stop watch, visual cues on the computer monitor interface, specifically articulated audio cues in the electronic track, to align the pianist with the electronic component. The composer must thoughtfully consider these cues for the performer’s reliability in performance. In Jeffrey Hass’s *Three Etudes for Piano and Computer* (2013), the pianist follows a click track playing in their headset.

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<sup>13</sup> Paolo Petazzi, “Maurizio Pollini Edition Insights,” <http://deutsche Grammophon.com/special/insighttext.Htms?ID=pollini-Edition&DETAIL=12> (accessed February 23, 2012).

<sup>14</sup> MusicExperiment21, “Experimentation versus Interpretation: *Exploring New Paths in Music Performance in the Twenty-First Century*.” <http://musicexperiment21.wordpress.com/artistic-projects/nono/> (accessed January 29, 2014).

<sup>15</sup> “Blue” Gene Tyranny, “Description of ... *sofferte onde serene* ...,” <http://www.allmusic.com/composition/sofferte-onde-serene-for-piano-tape-mc0002354934> (accessed January 23, 2014).

<sup>16</sup> MusicExperiment21.

<sup>17</sup> “Blue” Gene Tyranny.

<sup>18</sup> MusicExperimen21.

In addition, there are several audio cues indicated in the fixed media track to help the pianist align with the electronics. In Etude No. 1, *Fire Drill*, the sound of a beep penetrates the computer texture to anchor the tempo.<sup>19</sup> In Example 1, the bottom stave shows a gestural outline of the computer's fixed media part, with a clear 'beep', indicated on beat 2, that rises above the rest of the texture:



Example 1. Jeffrey Hass, "Fire Drill," from *Three Etudes for Piano and Computer*, m. 44.

The beep is clearly on beat 2, providing a moment for the pianist to align directly with the computer part. I had the privilege of working alongside the composer in the development of this work. At times I found the relentless momentum and virtuosic demands overwhelming, being saturated with dense computer track and rhythmic alignment. I felt the click track needed more distinct cues to anchor the pianist at key structural moments. Hass had the idea of inserting a foreign sound, distinct from the musical environment of the work, into the pianist's headphones. As seen in Example 2, we decided upon the animal cues of dogs barking, pigs oinking, and seals calling. At the end of Etude No. 2, "Frogs," the pianist builds rhythmic palmed cluster chords in the lowest register to a

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<sup>19</sup> In a personal conversation with the composer (October 2013), Hass said that he was having difficulty writing this Étude because the smoke detector kept beeping, because of a low battery. In his annoyance, he got 'even' with it. He recorded it, and wove it into the electronic texture of this piece, thus the title "Fire Drill."

crashing climax. In the fury of the climax it can be easy to get caught counting the number of repetitions. Example 2 shows the rooster’s sounding ‘cock-a-doodle-doo’ in the pianist’s headphones; upon hearing it the pianist gives one final climatic repetition in *fortissimo*.

Example 2. Jeffrey Hass, “Frogs,” from *Three Etudes for Piano and Computer*, mm. 49 –58.

A click track with an imposed tempo is relentless, immovable, and unforgiving. The tempo ‘grid’ was created and secured in a studio far removed from the actual performance venue. This is not always successful for electroacoustic genre for a number of reasons. A concert hall has individual characteristics of resonance, amplification, and refraction based upon its own natural acoustics. A hall with great residual echoes requires a broader musical tempo to allow for the acoustical resonances to clear. Also, each piano’s action is unique, requiring a different touch to achieve the desired sound. For example, a piano with a heavier action, or with the sensation of a softer key bed, requires slightly more time to execute high velocity or louder passages. And finally, each pianist has their own creative interpretive decisions to make, and performances vary depending upon the performer’s decisions in the moment. I personally have felt bound by the click track in fixed media pieces with its narrow margin of mechanical determination. My

focus shifts from following the curves of the sound, the rhythm in my body and the pulse of that particular piano. My mind anchors on the time element, and my piano playing becomes more mechanical. In other words, my awareness shifts from an inner sound, an inner impulse that initiates music, to listening outside of my Self, listening reactively for a cue or alignment with the click track. Other pianists have also felt constricted. At a Round Table discussion at Piano+ Conference 2010, a pianist communicated that the “listening perspective is so radically shifted that [a] ... performer is totally subservient to his/her “knowledge” of his/her role in the production as a whole.”<sup>20</sup> In my experience as an audience member, I feel somewhat strangely at ease during the performance of a fixed media electroacoustic piece, as though I’m passively listening to a predetermined sonic landscape from a removed time and place. The electricity of the musical spontaneity of the moment is lost, thus lacking the conviction of a performance unfolding in real time.

As technology evolved, computers offered more sophisticated means of interaction. Electro-acoustic music with ‘Live’ electronics evolved from fixed media work. Live Electronics implies the use of a computer that is programmed to respond (or ‘listen’) to cues in its environment, and process (or ‘respond’) at that very moment, “without delay.”<sup>21</sup> Natasha Barrett describes live electronics as “tracking systems [that] capture detailed multi-dimensional data, which in turn is used to control real-time sound transformation, mixing and montage of the live audio signal across a range of time domains.”<sup>22</sup> Any number and variety of parameters can be tracked, including, but not limited to, pitch, tempo, dynamics, register, and physical sensors. The computer can be

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<sup>20</sup> Catherine Vickers, “An Innovative Opportunity,” [http://cec.sonus.ca/econtact/13\\_2/vickers\\_innovative.html](http://cec.sonus.ca/econtact/13_2/vickers_innovative.html) (accessed February 10, 2014).

<sup>21</sup> Schrader and Battier.

<sup>22</sup> Natasha Barrett, “Composition and the ‘Live-Electroacoustic’: *sound, time, control and ensemble*.” <http://natashabarrett.org/Live.html> (accessed January 27, 2014).

programmed to respond with a pre-recorded sound, and it can also record and process live sound, by storing the sound in a ‘buffer’ which is then processed in the computer and sent out through loudspeakers in an altered form.

In order to link the piano and the computer, the computer must be synched to the piano. Two common programming tasks are amplitude tracking and pitch tracking. In the former, the computer ‘listens’ for a sudden difference in volume (or *amplitude*) in the piano part. Obvious attacks, such as a loud sharp attack interrupting silence or a *pianissimo* passage, are relatively dependable. However, this method has faults, for the volume levels are measured by the individual pianist, in relation to one another. Performances do vary depending upon the pianist’s sensitivity and control, the strength of resonance of the piano, and also the measurement of the distance of the microphone to the piano. In pitch tracking, the computer listens for and measures a specific pitch (or *frequency*), to trigger its next process. In Alistair Zaldua’s<sup>23</sup> *Contrejours* (2011-2012) for piano and live electronics, the computer is programmed to listen for the piano’s stopped harmonics and to measure their frequency. The computer responds by choosing from a number of sounds, similar in character and pitch to the piano’s,<sup>24</sup> and introduces them into the sonic environment through the loudspeakers. To enable greater variety in performance, the computer has been programmed to randomly select an impulse from a limited selection of pitches and silence,<sup>25</sup> rather than a predictable set response. As a result, the computer’s response will always be slightly different. Because the computer is listening sensitively to the piano for cues, and each pianos’ individual tuning varies, the

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<sup>23</sup> Composer’s birth and death dates are listed when available. Here, no information could be found on Zaldua’s birthdate.

<sup>24</sup> Alistair Zaldua, *Contrejours*, Musical score sent to me by the Composer (August 2013).

<sup>25</sup> Zaldua, page iii.

computer program must be recalibrated to match the pianos' for each performance.<sup>26</sup> To achieve this, Zaldua designed a "tracker-Index.txt file" in the accompanying computer software Max/MSP, that includes specific instructions for the pianist on how to adjust the computer to their piano.<sup>27</sup> To guide the pianist, the accompanying score indicates two staves, one with the piano's fundamental pitch and its desired sounded harmonic, and another staff set above with the electronics' approximate resultant pitch, as can be seen in Example 3.<sup>28</sup>

Example 3. Alistair Zaldua's *Contrejours*, mm. 1 –7.

Although the computer's material is pre-recorded, this piece is 'live' in so far that it is triggered under the full temporal control of the performer. With no click track, the pianist is flexible in deciding the tempo for performance. In the previous example (Example 3), it is also of note that the composition's meter and rhythm is notated in real-time rather than metric time, allowing the pianist freedom within the suggested lengths and "to listen to the sounds themselves and respond."<sup>29</sup> The title *Contrejours* refers to a photographic technique where the camera is pointing directly to into the source of light, so that the main image is almost completely obscured. Similarly, Zaldua creates close overlay

<sup>26</sup> Zaldua, page vi.

<sup>27</sup> Zaldua page vii.

<sup>28</sup> Zaldua page i.

<sup>29</sup> Zaldua page i.

between the piano and electronics, treating them as one “singular instrument,” while exploring the “proximities or disconnections” between them.<sup>30</sup> The computer’s sounds are closely related to the piano, both in proximity and timbre. To further assist the blurring of piano and electronics, the displacement of speakers is very important. The piano itself is amplified only slightly, with its sound sent to speakers placed behind the piano.<sup>31</sup> Zaldua indicates that the “levels should be set so that it is difficult for a listener to know where the sound is coming from, i.e. from the pianist or the computer.”<sup>32</sup> All these qualities result in a blurred shadowed auric effect.

The pianist can also trigger Live Electronics by the use of a MIDI pedal. The pedal is pressed by the pianist’s foot (similar to the *Una Corda* pedal), which advances the computer to the next scene or ‘*patch*’. The MIDI pedal affords the pianist the freedom to choose the tempo and control parameters without depending upon specific aural effects. The MIDI pedal offers many advantages to the pianist, given that it is relatively easy to use, employs the feet and not the eyes or hands, and gives a precise on / off information to the computer. However, it also comes with added risks. In composer’s Hans Tutschku’s experience, most pianists tend to forget about the MIDI pedal while in performance. He calls it “the forgotten pedal,”<sup>33</sup> and that it “seems to be in the nature of things and happens time and again – not only in my own composition [*Zellen-Linien* (2007)] but also in performances of other pieces that use a pedal.”<sup>34</sup> Pianist Sebastian Berweck surmises that this must be a common pattern because pianists tend to respond to

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<sup>30</sup> No Room? “Alistair Zaldua – *Contrejours*,” <http://soundartistcollective.bandcamp.com/track/contrejours> (accessed February 10, 2014).

<sup>31</sup> Zaldua, page vi.

<sup>32</sup> Zaldua, page vi.

<sup>33</sup> Hans Tutschku in a personal communication with Berweck, by e-mail on March 26, 2009. As found in: Sebastian Berweck, “It worked yesterday: *On (re)-performing electroacoustic music*.” PhD diss., University of Huddersfield, 2012, 103.

<sup>34</sup> *Ibid.*

somatic information by “hearing and internalizing responses to the mechanical production of the sound,”<sup>35</sup> while the use of the MIDI pedal is different, in that it is (in most instances) a silent or “empty”<sup>36</sup> action. For example, in John Gibson’s (b. 1960) *Blue Traces* (2009), written for piano and electronics, the MIDI pedal is used to trigger the computer to record tones on the piano. The computer records (or *catches*) them, storing the information (in a *buffer*), and subsequently processes the sound and returns it through the speakers. The pedal action does not create an immediately noticeable change. Gibson’s treatment of the electronic sonic environment is deeply sensitively nuanced, and pitches enter with carefully sculpted envelopes, which cradle each end of the processed tones so that they enter and exit gradually and seamlessly. In my own rehearsals and performances of this work, I command my mind to consciously activate my foot to trigger the MIDI pedal. In my experience, it is not an intuitive or a deeply felt musical response guided by the ear, as the damper and *una corda* pedal can be. Berweck suggests that the pianist intentionally practice the manual action of pressing the pedal while rehearsing the piece.<sup>37</sup> Missing a pedal cue, or accidentally depressing a MIDI pedal too early can result in dramatic consequences for the piece. Pressing the pedal at the unintended time can result in launching the preceding section’s material, or one can record an unintentional pitch which is then prolonged throughout the following section. One can also fail to capture any pitch material at all! Solutions to this problem are being

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<sup>35</sup> Berweck, 104.

<sup>36</sup> Ibid.

<sup>37</sup> Berweck, 105.

actively explored, and have included researching the use of a vibrating pedal, that offers immediate feedback to the pianist by generating a vibrating sensation when pressed.<sup>38</sup>

Once the computer receives the piano's live sound, it is capable of altering the sound in many different ways, with infinite combinations. Of the possibilities, perhaps a pianist's greatest frustration is the piano's inability to sustain sound. The piano has a very specific timbre, that is created by the hammer strike to the string, which sets the string into sudden vibration (or *actuation*), followed by a gradual decay gradually returning the string to stasis.<sup>39</sup> Through the use of the computer, it can create the illusion of sustaining a piano's pitch indefinitely, creating *crescendos* and evolving the sound's development through time. The simplest method for a computer to extend a piano's note is by recording it and repeating (or *looping*) it continuously, with programmed amplitude 'envelopes' on either side of the sound file (to ease into and out of a repetition), ensuring a seamless smooth repetition. A common technique to accomplish this is through the process of *granulation*, where the recorded sound of the piano is captured in a *buffer* (which is a sort of recording container with specific time restraints). The buffer is fed through the granulator, which takes the initial sound and divides it into grains, or atoms, so short they are almost imperceptible by themselves. When they are streamed together, like a river of droplets, they reconstruct into what the human ear perceives as a continuous sonority.<sup>40</sup> The parameters of grain duration and the position of the buffer (or where it starts in the recorded material) can be programmed into the computer. This process is very effective in a Live performance, for the "granulation generator creates a

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<sup>38</sup> Berweck continues in stating that "Tychonas Michailidis and Lauren Hayes are currently researching the feasibility of such devices." Berweck, 104.

<sup>39</sup> Brümmer.

<sup>40</sup> Inspired by a private conversation with John Gibson, October 2013.

link between the live action and computer-controlled action,”<sup>41</sup> and the audience can see, hear, and participate in the presence of what is being recorded and processed. In Gibson’s *Blue Traces*, the electronics are built around the principle of granulation. In Example 4, the score indicates the pitches that are captured into the granulator. The numbers above the staff indicate the MIDI pedal cues with their responding rehearsal number (used to align with computer software). Here the pianist holds the chord momentarily while pressing and releasing the MIDI pedal. During that time the computer records the piano’s sound (like a snapshot) and proceeds to granulate it (in Max/MSP).

The image shows a musical score for two staves (Treble and Bass) in G major. A MIDI pedal line is shown below the staves. Rehearsal numbers 33, 34, 35, 36, 37, and 38 are indicated above the staff. Dynamics include pp, f, p, and mp. A bracket under the first two measures is labeled 'Ped'.

Example 4. John Gibson, *Blue Traces*, mm.60 –61.

Gibson sought to capture the “colorful glow cast from bioluminescent plankton,”<sup>42</sup> by the computer creating “gently glowing traces of sound”<sup>43</sup> after what the piano plays. The bridge between the pianist and the computer is strengthened and is very powerful in augmenting the piano’s timbre.

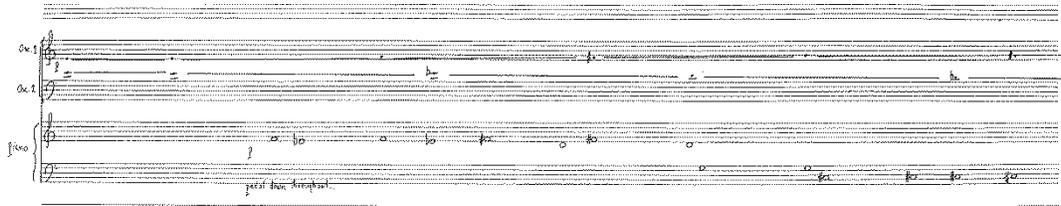
Aside from the piano’s characteristic timbre, another great limiting factor is its fixed 88 keys. Modern explorations of microtuning are impossible to execute without retuning the piano’s pins itself. This time consuming endeavor also influences and limits the other pieces on a concert’s program. However, the computer is able to provide an

<sup>41</sup> Brümmer.

<sup>42</sup> John Gibson, “Blue Traces.” <http://john-gibson.com/pieces/bluetraces.htm> (accessed February 4, 2014).

<sup>43</sup> Ibid.

acoustic backdrop, against which the piano’s corresponding pitches can sound out of tune. Alvin Lucier (b. 1931) employed an acoustical illusion in *Music for Piano with Slow sweep Pure Wave Oscillators* (1992). Here, the pianist’s tones ring out against wide arching glissandi produced by a pure wave oscillator. Example 5 shows the piano part in the bottom two staves, with freely notated pitches over an open damper pedal, and the uppermost staves showing the oscillators glissandi.



Example 5. Alvin Lucier, *Music for Piano with Slow Sweep Pure Wave Oscillators*, m. 1. <sup>44</sup>

Because the pianist’s pitches are relatively stable against the sweeping glissandi, as the oscillator’s frequency moves through the piano’s, the combined (or *resultant*) frequency creates beats that are foreign to the piano’s equal temperament tuning. This creates the illusion that the piano is detuned (or ‘out of tune’).<sup>45</sup> Another striking example of this is Jonathan Harvey’s (1939-2012) *Tombeau de Messiaen* (1994) for solo piano and electronic tape. Written as a tribute to Olivier Messiaen, this piece honors Messiaen’s tonal discoveries and his contribution as a forefather to French Spectralism. To achieve the characteristic effect of detuning, the live piano plays “in unison with an electronically generated piano, but the match is never precise because the latter is tuned utilizing a ‘natural’ harmonic series (involving perfect whole-number ratios: 1:2:3:4:5:6 etc.), while

<sup>44</sup> Alvin Lucier, *Music for Piano with Slow Sweep Pure Wave Oscillators*, Kiel: Material Press, 1992.

<sup>45</sup> Alvin Lucier, “Music for Piano with Slow Sweep Pure Wave Oscillators,” <http://www.youtube.com/watch?v=BboZwwVmAwA> (accessed August 19, 2013).

the live piano is in equal temperament (a “compromised” tuning system invented in the early 18th century to facilitate Western tonal motions).”<sup>46</sup> The detuning that is created through the resultant beats is striking. Julian Johnson describes the piano and computer as “two voices [that seek] ... unison and “in tuneness” with one another, while nevertheless preserving the tensions of their distance”.<sup>47</sup>

The computer can also significantly alter the actual timbre of the piano through a different manipulation of the piano’s sound producing mechanism. Traditionally the piano’s string is excited by the attack of a hammer strike, which is by a series of levers starting with the piano keys. The innovative application of electromagnets to directly resonate (or *actuate*) a piano string is one means to authentically sustain and alter the piano’s natural timbre. Electromagnets were first used on the piano in Germany in 1886, by Richard Eisenmann in *Electrophonisches Klavier*.<sup>48</sup> In 1977 Alvin Lucier furthered this concept, using electromagnets in *Music on a Long Thin Wire*, where a single piano wire, stretched across a large room, is actuated by a large magnet that passes sine waves through a power amplifier.<sup>49</sup> In *Music for Piano with Magnetic Strings* (1995),<sup>50</sup> Lucier continued that development by using EBows. The Ebow is essentially a device that uses an electromagnet (connected to a current) to create a magnetic field. Now commonly

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<sup>46</sup> Julian Johnson, “Music of Jonathan Harvey,” Program Notes. [http://www.sfcmp.org/programnotes/00\\_January\\_Stanford\\_Program\\_Notes.pdf](http://www.sfcmp.org/programnotes/00_January_Stanford_Program_Notes.pdf) (accessed January 26, 2014).

<sup>47</sup> Ibid.

<sup>48</sup> Ajay Kapur, “A History of Robotic Musical Instruments,” *Proceedings of the International Computer Music Conference*, Barcelona, Spain, 2005., as found in Per Bloland, “The Electromagnetically-Prepared Piano and it’s Compositional Implications,” *Proceedings of the Electroacoustic Music Studies Conference, Sforzando!* New York (June 2011). [http://www.ems-network.org/IMG/pdf\\_EMS11\\_Bloland.pdf](http://www.ems-network.org/IMG/pdf_EMS11_Bloland.pdf) (accessed January 27, 2014).

<sup>49</sup> Wikipedia, “Music on a Long Thin Wire,” [http://en.wikipedia.org/wiki/Music\\_On\\_A\\_Long\\_Thin\\_Wire](http://en.wikipedia.org/wiki/Music_On_A_Long_Thin_Wire) (accessed February 12, 2014).

<sup>50</sup> Alvin Lucier, *Music for Piano with Magnetic Strings*. In *Theme* (p. 1) [CD liner notes]. New York: Lovely Music, Ltd. 1999. <http://www.lovely.com/albumnotes/notes5011.html> (accessed February 12, 2014).

used by electric guitarists,<sup>51</sup> when placed over the piano strings they create a haunting resonance capable of being infinitely sustained. While the piano strings themselves are not magnetic (for they are made of steel), they are magnetized towards the electromagnet and then released to a resting position. Repetitions of this pulsation create the sounding resonance of the string.<sup>52</sup> In a mesmerizing composition, Peter Adriaansz (b. 1966), wrote *Waves 1-4* (2007, rev. 2011) for amplified piano and live electronics, and Ebows. The pianist plays the keys in a traditional manner in addition to manipulating the piano strings directly with the Ebow inside the piano harp. By placing the Ebow on different areas of the string, various partials are excited. Requiring a great sensitivity and skill on behalf of the pianist, Adriaansz writes that the Ebows “demand a considerable degree of virtuosity from the pianist, having to co-ordinate, choose and listen all at the same time.”<sup>53</sup> In Example 6, the score of *Waves* demonstrates the Ebows in staves F2 and F3. Their respective sounding pitches are shown in the center staff, under “Pitches.” Along with the manipulation of the Ebows, the pianist is required to pluck, strike, or mute keyboard pitches, shown in the high staff, F 2/3, and the lowest staff, F 3/4. The top three staves, “Sines,” show the approximation of the computer’s part.

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<sup>51</sup> Wikipedia, “EBow.” <http://en.wikipedia.org/wiki/EBow> (accessed February 3, 2014).

<sup>52</sup> Per Bloland, “Basic Principles,” of the Electromagnetically-Prepared Piano. [http://magneticpiano.com/?page\\_id=110](http://magneticpiano.com/?page_id=110) (accessed February 10, 2014).

<sup>53</sup> Peter Adriaansz, “Waves,” Program Notes. <http://www.peteradriaansz.com/works/work34.html> (accessed August 23, 2013).

Example 6. Peter Adriaansz, *Waves 1-4*, m. 1.

While the execution is quite difficult, the sonic result is a beautiful, slowly unfurling meditative stream. A critic compared *Waves 5*'s sonic landscape to “time and sound ... [coagulating] into slowly turning crystals.”<sup>54</sup>

The use of the Ebow evolved into the creation of the Electromagnetically Prepared Piano (EMPP), developed in 2005-06 at Stanford University's Center for Computer Research in Music and Acoustics by Per Bloland, Steven Backer, Ed Berdahl.<sup>55</sup> Designed as a “reappropriation of the traditional instrument,”<sup>56</sup> the EMPP extends the piano by a rack of 12 Electromagnets (which are attached to the piano's cast

<sup>54</sup> De Trouw, Review of “Waves-Peter Adriaansz,” by Ensemble Klang, from March 6, 2010. <http://music.ensembleklang.com/album/waves-peter-adriaansz> (accessed August 26, 2013).

<sup>55</sup> Bloland, “About,” the Electromagnetically-Prepared Piano. [www.magneticpiano.com](http://www.magneticpiano.com) (accessed February 3, 2014).

<sup>56</sup> Private discussion with composer, October 2013.

iron brace), with each magnet “controlled by an arbitrary external audio signal”<sup>57</sup> that actuates the piano strings from a fixed position. No loudspeakers are needed, as the body of the piano amplifies the strings current. In 2012 revisions were made to enhance the power of the signal, with Andrew McPherson designing a new amplifier circuit board,<sup>58</sup> and a new rack and adjustment mechanism designed by the Instrumentation Lab at Miami University.<sup>59</sup> The EMPP differs from the Ebow in that it has a more powerful magnet which is can excite a string at higher volume levels. Additionally, the string’s fundamental can be excited in addition to “any of its first twenty or so partials.”<sup>60</sup> Any current can be sent through the electromagnet to excite the strings. For example, sending the current of white noise through the electromagnets excites the piano string’s various overtones in a shimmering effect, depending upon the sympathetic resonances created.<sup>61</sup> The magnets extend the piano’s timbre in amazing ways, by infinitely sustaining a note, creating crescendos from silence, sounding microtonal intervals, and executing.<sup>62</sup> In Bloland’s composition, *Elsewhere is a Negative Mirror* (2005) written for piano with electromagnets, the electromagnetically amplified pitches are excluded from the notes the pianist plays, so that the performer never strikes a key while its string is being actuated. In Example 8, the score indicates in the bottom two staves the piano’s part. In the uppermost staff, the Electromagnet’s pitches (as activated by the computer) are roughly indicated with dynamic swells. The chord in m. 9 is played silently, held while pressing

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<sup>57</sup> Bloland, “About,” <http://magneticpiano.com/> (accessed February 3, 2014).

<sup>58</sup> McPherson redesigned the actuators’ design featuring wound actuators with a new actuator bracket design. MRP page 17.

<sup>59</sup> Bloland, “About,” (accessed February 3, 2014).

<sup>60</sup> Bloland, “About,” (accessed February 3, 2014).

<sup>61</sup> Private conversation with the composer, February 11, 2014.

<sup>62</sup> Andrew McPherson and Y. Kim. 2012, “The Problem of the Second Performer: *Building a Community Around an Augmented Piano*,” *Computer Music Journal* 36, no. 4: 15.

the MIDI pedal which then activates those electromagnets. The change in pitch can be seen in the Electromagnet's staff.

\* order of operations (need not occur at tempo):  
 1 - silently depress chord  
 2 - trigger cue 4 with left foot (releasing ped II)  
 3 - release ped I  
 4 - engage ped II catching chord  
 5 - engage ped I

Example 7. Per Bloland, *Elsewhere is a Negative Mirror*, mm. 8–10.

Aside from the use of the MIDI pedal to advance the ‘scenes’ of the piece, the pianist has no control over the computer and its manipulation of the electromagnets and thus its resultant sound. Therefore, in *Elsewhere*, the piano essentially has “two performers with distinct parts – the human and the computer.”<sup>63</sup>

Andrew McPherson researched and created his own development of the Electromagnetic piano, calling his ‘hybrid acoustic-electronic’ piano<sup>64</sup> a Magnetic Resonator Piano (MRP). In his composition, *Secrets of Antikythera* (2009), the piano is modified using a Moog Piano Bar Sensor that rests above the keys, in addition to a MIDI keyboard that rests on the piano music stand.<sup>65</sup> The MIDI keyboard controls the electromagnets, while the Piano Bar extracts information as to the “continuous key

<sup>63</sup> Private conversation with composer, October 2013.

<sup>64</sup> McPherson, “Magnetic Resonator Piano,” <http://music.ece.drexel.edu/research/mrp> (accessed February 3, 2014).

<sup>65</sup> <http://andrewmcpherson.org/> (accessed February 3, 2014).

position [of the pianist], measured at 600 samples per second per key.”<sup>66</sup> With this sensitivity many parameters are tracked, such as “gradual and partial key presses, taps and sweeps on the key surfaces, pressure into the key-bed, and vibrato gestures.”<sup>67</sup> It is possible to create pitch bends by holding a key (becoming the ‘center’ pitch), and lightly touching a neighboring key, to which the center pitch will ‘bend’ towards.<sup>68</sup> A vibrato gesture, either by holding a key and using a vibrato gesture or a “light tapping or holding the key with thumb and forefinger” has in turn been mapped to control the sounding pitch of the harmonics the magnet excites. The pitch of the harmonic “increases linearly with time at a rate proportional to the vibrato speed,”<sup>69</sup> thus the faster the vibrato, the higher the overtone sounded. While conscious key pressure manipulation and key vibrato are not traditional piano techniques, they open the pianist’s sensitivity to the piano’s physicality,<sup>70 71</sup> and also create sweeping arches that organically move up and down through the overtone series of a given pitch.

Computers have awakened sophisticated use of amplification, leading to new realms of conceptualizing sound. While the traditional piano’s sound originates from the body of the instrument itself, modern technology brought forth the ability for sound to originate anywhere in the room, depending upon speaker placement and sound distribution. Works for ‘Stereo sound’ (2 speakers) opened to 4-channel and now to the

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<sup>66</sup> McPherson and Kim, 19.

<sup>67</sup> Ibid.

<sup>68</sup> Ibid.

<sup>69</sup> Ibid.

<sup>70</sup> A demo illustrating the mechanics and technicalities of execution can be found here: <http://music.ece.drexel.edu/research/mrp> (accessed February 3, 2014).

<sup>71</sup> McPherson’s *Touch Keys*, being developed for future release, will include sensors “on the keyboard [which] report the continuous position of every key. Time and spatial resolution are sufficient to capture detailed data about key press, release, pretouch, aftertouch, and other extended gestures.” From Andrew McPherson. “TouchKeys: polyphonic aftertouch and the CS-80,” <http://andrewmcperson.org/> index.html (accessed February 3, 2014).

performance standard of 8-channel works, with 8 speakers surrounding the audience creating a basic 3-D mapping of sound. This has led to the development of the art and science of *spatialization*, the distribution of sound throughout space. This has resulted in a highly sensitive and specific art, for sound was released from the physical dependency upon a resonating acoustic instrument, becoming “liberated to the point of complete dematerialization, becoming pure vibrations in air.”<sup>72</sup> Because human hearing is capable of perceiving large streams of sonic information only when its polyphonic layers are distributed throughout space,<sup>73</sup> the distribution of sound became very important. If a loud and soft sound are produced at the same time in close proximity, the louder sound tends to conceal the quieter sound. However if both sounds are of equal volume, they would appear to blend together into one sound.<sup>74</sup> But if the sounds “are distributed over a large area, complex sound information [is perceived] ... in a transparent and easily audible manner.”<sup>75</sup> Sophisticated interfaces are being created in order to facilitate complex routing of digital information, designed and used in newly constructed state-of-the-art sound ‘Cathedrals.’ For example, the spatialization software *Zirkonium* was created at the Centre for Art and Media’s (ZKM) “Sound Dome Project” in Karlsruhe, Germany,<sup>76</sup> to enable a flexible mapping of choreographed sound. The ZKM is an auditorium with a spherical arrangement of the speakers, placing the audience in the center, and sound can be manipulated in 3-dimensional ways. In Example 8, a graphic drawing shows the

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<sup>72</sup> Brümmer.

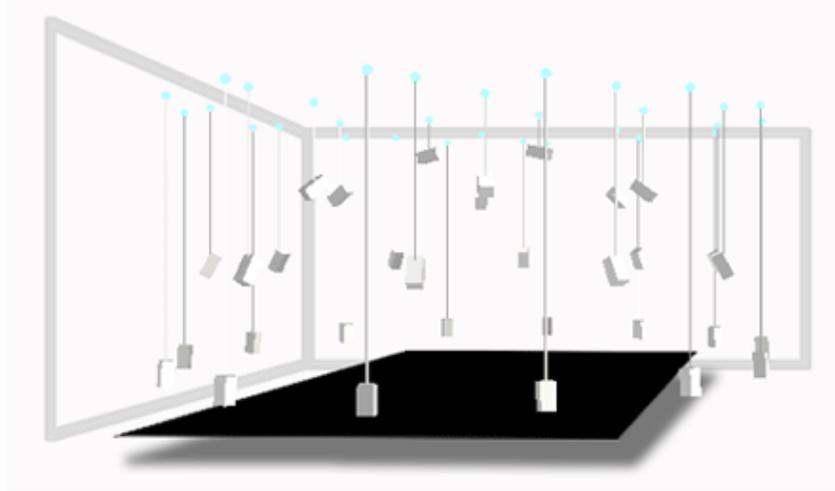
<sup>73</sup> Bregman, Albert S. *auditory Scene Analysis – the perceptual organization of sound*. Cambridge, MA: MIT Press, 1990, page 320.

<sup>74</sup> Brümmer, (accessed January 21, 2014).

<sup>75</sup> Ibid.

<sup>76</sup> Ibid.

distribution of the speakers around the room. Sound can be routed in complex ways to any of the designated speakers.



Example 8. *Graphic representation of the Klangdom in the ZKS\_Kubus*<sup>77</sup>

Composer Ludger Brümmer uses *Zirkonium* to map the piano's 88 pitches "into the spatial domain, ... [transforming the scale] into a spatial path, [and] intervals into spatial jumps."<sup>78</sup> Thus "very small movements in pitch can be of a huge dimension in the Sound Dome and large intervals can appear very small."<sup>79</sup> In Brümmer's *Flow* (2009) for MIDI piano and computer, the piano sends MIDI pitch values which the computer translates into "spatial coordinates."<sup>80</sup> This creates large intervallic displacement across the length and width of the Dome, alongside the live piano which is amplified with its own specific speaker placement.<sup>81</sup> <sup>82</sup> With spatialization, composers are able to create vast

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<sup>77</sup> Institut für Musik und Akustik, "Klangdom," <http://on1.zkm.de/zkm/Musik/klangdomen> (accessed February 12, 2014).

<sup>78</sup> Brümmer, (accessed January 21, 2014).

<sup>79</sup> Ibid.

<sup>80</sup> Ibid.

<sup>81</sup> Ibid.

<sup>82</sup> Brümmer suggests a further application, by separating "the polyphonic structures of Glenn Gould's interpretation of the *Goldberg Variations*, ... [to express] it as sound architecture by placing and moving the motive threads in space." Brümmer, (accessed January 21, 2014).

architectural spaces that are fluidly defined and easily manipulated through the distribution of sonic material.

The addition of video to piano and computer music has opened to new vistas of performance art. Simple additions of video have a profound impact, such as the projection onto the inside of the opened grand piano lid in Carolyn Yarnell's *Same Sky* (2010) for piano, soundtrack, and video.<sup>83</sup> Created as a "21<sup>st</sup> Century homage for the paintings and inscriptions found inside harpsichord lids," Yarnell had a deep realization, that "no matter what we may possess in this life, we all share the same sky."<sup>84</sup> This led to a collaboration with videographer Eric Wenger of a powerful journey through clouds, projected alongside Yarnell's compelling and mesmerizing music.<sup>85</sup> Example 9 shows a photograph of the proposed performance setting, with a darkened stage to highlight the projection on the inner lid.

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<sup>83</sup> Carolyn Yarnell, "Same Sky." <http://carolynyarnell.com/mp3s/samesky.mp3> (accessed February 3, 2014).

<sup>84</sup> Ibid.

<sup>85</sup> Carolyn Yarnell, "Same Sky," Performance. <https://myspace.com/clubcontemporaryclassical/video/kathleen-supov-the-same-sky-by-carolyn-yarnell/49397649> (accessed February 3, 2014).



Example 9. Carolyn Yarnell's *Same Sky*, photograph of performance projection.<sup>86</sup>

In David Kim-Boyles' *Shimmer*, the video creates a holographic visual of the produced sound. A hidden loudspeaker's cone contains a small amount of milk, sitting within a thin plastic sheath.<sup>87</sup> As the sound passes through it, the milk creates ever changing shimmering patterns. This is filmed, processed through the computer software, and projected onto a screen. Similarly, the elusive sonority of the resultant piano sounds are created by the unusual placement of microphones, inside wine glasses that are set inside the piano.<sup>88</sup> The glasses act as "acoustic filters,"<sup>89</sup> as "resonant frequencies emphasized by the glasses are then explored and transformed with various techniques of spectral reverberation"<sup>90</sup> in the computer software. The pianist's material is derived from sonorities from Morton Feldman's *Triadic Memories* (1987) for piano,<sup>91</sup> but the sourced reference material is completely transformed through this treatment. At a broader,

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<sup>86</sup> Carolyn Yarnell "Same Sky," Photograph of Piano lid, of Video Projection during performance. <http://carolynyarnell.com/samesky.html> (accessed February 12, 2014).

<sup>87</sup> David Kim Boyle, "Shimmer," <http://www.davidkimboyle.net/Shimmer.html> (accessed February 3, 2014).

<sup>88</sup> Ibid.

<sup>89</sup> David Kim-Boyle, "Musical Image Generation with Max/MSP/Jitter," <http://www.generativeart.com/On/cic/papersGA2004b21.htm> (accessed February 3, 2014).

<sup>90</sup> Kim-Boyle, "Shimmer."

<sup>91</sup> Kim-Boyle, "Musical Image."

“metaphorical/ conceptual level,”<sup>92</sup> the images of the shimmering milk are similarly transformed, as “spectral processing [in sound] is akin to color transformation [in video], reverberation finds its counterpart in visual blurring, and visual magnification is like filtering for resonant tones.”<sup>93</sup> This process of transformation of the audio and visual elements “becomes, in essence, the focus of the work.”<sup>94</sup>

Video can also be used to significantly alter the audience’s perception. A dramatic example is Michael Beil’s *Mach Sieben* (2000, rev. 2012), for piano, computer, and video. Several sections are written in a precise palindrome, being completely symmetrical, forwards and backwards.<sup>95</sup> The performance has specific choreographed gestures, for example a dramatic throw of the arm, but also standing up, adjusting one’s physical appearance, and cued stage entrance and exits. The performance is pre-recorded, in the same concert attire,<sup>96</sup> only to be played forwards and then later, in reverse. In the real performance, the video is projected onto a screen, so that the tail ends of the grand piano and the projected piano touch, the real pianist and the projected pianist facing one another in a mirror image. The performance unfolds with the real pianistic closely following the choreographed filmed version, the result being an eerie other worldly incongruity. Beil’s work is a stunning example of using technology to expand and manipulate the visual and aural expectations. Video can be synchronized to sound, such as in Brümmer’s *Temps du miroir* (2004) and *Move* (2006) for piano, electronics, and video. In both works, the video is synched up with the live piano’s attack, which triggers

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<sup>92</sup> Ibid.

<sup>93</sup> Ibid.

<sup>94</sup> Ibid.

<sup>95</sup> Michael Beil, “Mach Sieben,” Score. <http://www.michael-beil.com/Partituren/Mach%Sieben%202012.pdf> (accessed February 11, 2014).

<sup>96</sup> Rei Nakamura performs Beil’s “Mach Sieben,” <http://vimeo.com/18995526> (accessed February 3, 2014).

the computer, in real-time, to launch sound samples and the process of granulation.<sup>97</sup> Variety is achieved with programming different threshold (maximum amplitude) values aligned with three “independent video streams,” the video can perform “a polyphonic action similar to the samples in the sound domain.”<sup>98</sup> The video and the sound processing are seamlessly connected to the pianist’s free interpretive timing. In Annesley Black’s *4238 de Bullion* (2007), for piano, live electronics and live video, the video camera projects (in real-time) the pianist performing the work. Shuffling from direct synching to sampled images from previous moments “reprocessed,” for example, “in slow motion and projected,”<sup>99</sup> the work is a playful exploration of visual expectations.<sup>100</sup> Pianist Rei Nakamura feels that “movement and sound are independent [and] mutually supportive,” and she seeks to “discover an entirely new type of performance [for pianists], both visually and aurally,”<sup>101</sup> that continues to merge and balance the dynamics of piano and video.

The use of the computer has also opened the door to conceptualizing new ways of notating music. Federico Reuben's *On Violence* (2009), for piano, live electronics, computer display and sensors, features a musical score that combines conventional and experimental notation, displayed on a laptop monitor. The pianist uses Midi pedals to advance through the ‘pages’ of the real-time score, which uses combinations of “chance,

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<sup>97</sup> Brümmer, (accessed January 21, 2014).

<sup>98</sup> Ibid.

<sup>99</sup> Rei Nakamura, “My Cyber Chamber Music Partner: *A Project for Piano, Electronics, and Video*,” *Keyboards + Live Electronics: The Performer’s Perspective / Claviers + <live electronics>: La perspective de l’interprète* 13.2 (April 2011), [http://cec.sonus.ca/econtact/13\\_2/nakamura\\_cyberpartner.html](http://cec.sonus.ca/econtact/13_2/nakamura_cyberpartner.html) (accessed February 11, 2014).

<sup>100</sup> Annesley Black, “4238 De Bullion,” Performance. <http://vimeo.com/18984534> (accessed August 7, 2013).

<sup>101</sup> Nakamura, “My Cyber Chamber Music Partner.”



violence” and its influence in society.<sup>104</sup> This violence is expressed musically by abrupt changes in texture and discordant clashes in this cataclysmic music. At times, the pianist's rhythmic chords are shadowed by sampled metal being hit. The music features samples of Hitler speaking and people screaming. The piano's over-popularized canon is hinted at, by processed recorded excerpts from Wagner's *Parsifal* and *Tristan und Isolde*, Buxtehude's *Praeludium in G Minor*, BuxWV 163, while the pianist hints at phrases from the First movement of Mozart's Piano Concerto No. 21 in C, K. 467. Shifting radio frequencies of Top 12 Radio seep through, as the piano persists with its own agenda. It is as though the piano continues unabated amidst the violence of the present day, or perhaps it represents a strength, a purity, in the midst of chaos. *On Violence*, with its specific and also interpretive score and with the computer's generative material changing for each performance, requires a special pianist capable of “spontaneous reaction and improvisation.”<sup>105</sup>

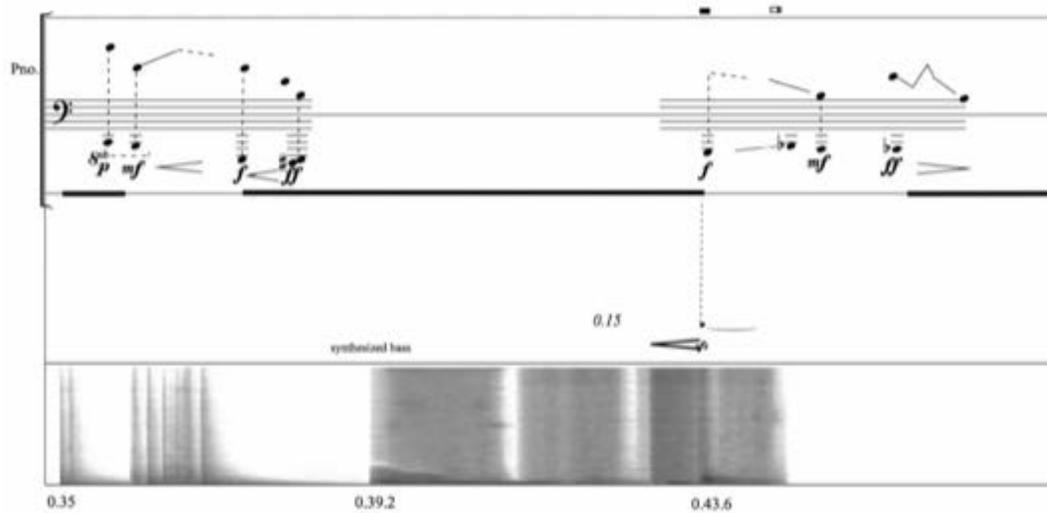
The representation and notation of computer music itself has created additional difficulties. The 21<sup>st</sup> c. electro acoustic chamber music partner (the computer) needs to be accurately represented in the pianist's score. Key aural cues can be notated in an accompanying staff. While more obvious cues rhythmic and pitch oriented cues can be notated, the more complex textures in modern computer music are difficult, if not impossible, to transcribe. There may be no clear melodic line or sound to notate, just massive changes in density or volume. In Lefteris Papadimitriou's *Electric Serpent*, for piano and 4-channel electronics, the electronics are notated as a *spectrogram*, which is a

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<sup>104</sup> Reuben, “On Violence,” Program Notes. <http://www.federicoreuben.com/research/onviolence/Violence-programme-notes/> (accessed February 6, 2014).

<sup>105</sup> Reuben, “On Violence.”

“visual representation of the spectrum of frequencies [and amplitude] in a sound.”<sup>106</sup> The graph unfolds linearly, with the ‘y’ axis representing ‘real’ time, enabling one to interpret the density and length of the graph as the corresponding computer part. In Example 11, the computer frequencies are notated in a Spectrogram underneath the piano score. The piano pitches indicate the strings to be manipulated inside the piano harp.



Example 11. Lefteris Papadimitriou, “*Electric Serpent: Part 1, Serpent on the Edge of an Abyss*,” Section 5: Strife (Saturn in Leo). time 0.35 – 43.6<sup>107</sup>

While composers have experimented with innovative ways to notate computer music, the most effective notation for the pianist is the simplest. There have been efforts made to standardize computer music notation, particularly within a specific computer music instrument. In the *Digital Instrument Magnetic Resonator Piano (MRP) Project*, a hybridized piano (i.e. McPherson’s arrangement of piano with Electromagnets) was made available to a select group of composers. Their compositional process, from

<sup>106</sup> Wikipedia, “Spectrogram,” <http://en.wikipedia.org/wiki/Spectrogram> (accessed February 4, 2014).

<sup>107</sup> Lefteris Papadimitriou, *Electric Serpent*. Photograph of Screenshot, 5:15 mark. <http://www.youtube.com/watch?v=FUM2aWetNnI> (5.15 mark) (accessed February 12, 2014).

conceptualization and experimentation through to actualization was well documented. Composers were encouraged to develop a personal notation system, with the eventual goal to reach a standardized notation based upon commonalities. Attention was paid to notation chosen to represent non-traditional extended piano techniques, for example pitch bends or hairpin dynamics that are executed with the computer. It was found that pitch bends were generally “notated as they *sounded* rather than how they were *played* (a gesture involving two adjacent keys)”<sup>108</sup> Sustained notes were notated differently according to their execution: the term *organ sustain* was assigned to notes sustained with the resonator, and *piano sustain* was assigned to notes that were held in the natural decay of the damper pedal.<sup>109</sup> Additionally, there was attention to how to use notation to distinguish between the keys that the pianist plays as opposed to the pitches activated with the resonators (without hammers). Some composers in the project opted to use regular note heads to represent the notes the resonator plays (*organ sustain*), and triangular noteheads to indicate the pitches played by both the pianist and the resonator.<sup>110</sup> These questions are actively being explored by the computer music community, in order to strengthen the bridge of communication between composers and performers. Additionally, a standardized notation helps to extend the longevity (and performance popularity) of a computer instrument.

There are many additional difficulties that need to be addressed to facilitate a wider performance of electroacoustic music. Ameliorations of older works have led to a revived interest in pioneering works. Luigi Nono’s (1924 – 1990) “... *sofferte onde*

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<sup>108</sup> McPherson and Y. Kim, 21. (*italics added*).

<sup>109</sup> *Ibid*, 22.

<sup>110</sup> *Ibid*.

*serene ...*” (1976) was first published in 1977,<sup>111</sup> including technical set-up instructions that accompany the original reel tape. However, reel-to-reel technology is next to impossible to find in the modern age, and in 1992 a new edition was released,<sup>112</sup> complete with a digitized CD with accompanying *Technical Notes for the Sound Engineer*, by Alvise Vidolin. Revisions have been made in an attempt to improve upon the preciseness of directions and assist the performance viability of this work. Unfortunately the solution is rarely so simple, particularly as software became more sophisticated. The seeming endless variety of computer software available (in addition to idiosyncratic open source software), and the continuous updated versions, can severely restrict the longevity of a work. Software is not (yet) universally adaptable, and certain systems are not compatible with one another. This is compounded by significant differences in technical gear, as cables, cords, monitors, MIDI pedals, interfaces, need to be compatible with one another to function as a whole unit. Pianist Berweck surmises that “only 10-20% of all [electroacoustic] compositions will survive beyond the first concert.”<sup>113</sup> It is difficult to anticipate the changing needs of technology, and there is a growing concern amongst composers in how to prepare electroacoustic compositions that will meet the technological demands of an unknown future.

Additionally, it can prove to be difficult for pianists to rehearse electroacoustic music. Live electronics are at a particular disadvantage because they depend upon the realization of the performance to direct the unfolding of a work. A fixed media piece is easier to rehearse, being aligned with a click track or cues that can be played on accompanying headphones. Most rehearsal facilities lack the technological support, and

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<sup>111</sup> Luigi Nono, 1977. *...sofferte onde serene...*, 1st ed. Milan:Edizione Ricordi.

<sup>112</sup> Luigi Nono, 1992. *...sofferte onde serene...*, 2nd ed. Milan: Edizione Ricordi.

<sup>113</sup> Berweck, “The Game Changer.” (accessed February 9, 2014).

the pianist would then be responsible for setting up and running the technological gear. Equipment can include (but is not limited to) an entire mixing console of speakers, a monitor, microphones and stands, a lap top, cables, and an audio interface, which must be digitally compatible with one another, in addition to being transportable. In my experience, this can take even experienced sound engineers long hours to accomplish. Installing equipment and doing test runs of the piece almost always bring some technical glitch. In my performance of John Gibson's *Blue Traces* (2009) at the Society of Electro Acoustic Music of United States' (SEAMUS) Annual Conference in 2011, we had a one hour sound check to run the ten minute long piece. Unfortunately the production crew did not have the right cable to attach the MIDI pedal to their computer interface. If the pianist cannot operate the MIDI pedal in performance, then Gibson himself, serving as sound engineer, would have to advance the piano's cues from the computer keypad, while monitoring the sound levels. Eventually a cable was found, allowing me a one minute sound check, with computer, for the performance.

It is essential in the performance of the majority of electroacoustic music that an Engineer be present to assist the performance of the work. Tasks can include assisting and testing technical set-up, launching software, monitoring sound levels in performance, and manually assisting the pianist with computer cues when necessary (such as cueing a missed MIDI pedal). The pianist is at an acoustic disadvantage by sitting next to the piano, the generative acoustic sound source, which is usually placed behind the loudspeakers in order to avoid feedback loops (and give the pianist a clear acoustic zone to concentrate upon the piano's sound and their own thoughts). The most accurate acoustic judgments are made sitting towards the center of the concert venue. An engineer

is needed to monitor and adjust the overall acoustic levels. In my performances of Gibson's *Blue Traces*, the precise timing of the MIDI pedal greatly affected the success and ease of each performance. The pedal is used by the pianist to 'capture' the sound, to subsequently be treated in the computer software. If I played the piano too softly (relative to the microphone distance) or deployed the MIDI pedal slightly later in relation to the softer dynamic, there was not enough sound captured in the buffer and thus the sustained granulated tones in the following section were too soft. Alternatively, if I captured the sound (i.e. pressed the MIDI pedal) too soon to the note's sounded actuation, the granulated treatment would be suddenly too loud and abrupt. As a result, Gibson accompanied all my performances of his work, riding the mixing boards with his sensitive ear to 'correct' my human inconsistencies. Additionally, as *Blue Traces* draws its entire electronic component upon the piano's sonority and treats it through granulation, any additional noise picked up in the initial recording compounds into audible artifacts. Gibson found that ambiance from the hall, microphone noise (for example, hissing noise), and the sound of the dampers subduing the vibrating strings, all were compounded and heightened into the granulated sound. Gibson came up with a brilliant solution of using pre-recorded excerpts, which are then triggered by the pianist in Real-time.<sup>114</sup> Thus the generative material is exactly the same, but the means to achieve the end goal are different. The computer still processes the piano sounds, but now they emerge from a pre-recorded buffer. The pianist still controls the tempo with the MIDI pedal triggering the computer's processes. The piece can now be successfully performed by a solo pianist. Composer Hans Tutschku also recognized this difficulty, and experimented with creating an electroacoustic work that can run without the use of

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<sup>114</sup> In a private conversation with the composer, October 2013.

computers, microphones, or loudspeakers. His work, *Irrgärten* (2010), for two pianos and live electronics, uses iPhones (or iPods) that are placed inside the piano along with loudspeaker monitors (that are naturally amplified by the piano's body).<sup>115</sup> The iPhones track the pianos' volume (or *amplitude*) and synchronize the playback of prepared sounds.<sup>116</sup> Additionally, the pianist can easily control the electronics from the piano keyboard,<sup>117</sup> eliminating the need for an engineer.

With computer technology there is always the risk that the computer program will have glitches or will fail in performance. It is all too common for software to malfunction right before, or even during, the critical moment of performance. A pianist must have a performance plan "B" in the event of technological malfunction.<sup>118</sup> It is also necessary that the performer be very adaptable, for when cues or software goes amiss, it is essential that the performer feels comfortable in improvising gestures in order to advance the electronics to another section. In the event that the electronics fail altogether, the pianist must continue the performance in some way, preserving and honoring the concept of the work. As pianist Berweck writes, the "player has to learn the reactions from the computer by playing the piece often."<sup>119</sup> One does not always receive that privileged opportunity!

As more solutions are discovered and absorbed into this genre, electroacoustic music will become more established in the canon. As a shared musical language develops, as concert halls become equipped to facilitate electronics and technological

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<sup>115</sup> Hans Tutschku, *Irrgärten*, "Electronics." <http://tutschku.com/content/works-irrgaerten.en.php> (accessed January 25, 2014).

<sup>116</sup> Ibid.

<sup>117</sup> Ibid.

<sup>118</sup> In computer music performances it is standard protocol that the composer be present, usually stationed behind the computer and mixing console. It is strongly advised to come prepared with several copies of the recorded work, either with CDs or hard drives with the computer file, to substitute in the event of a computer malfunction.

<sup>119</sup> Berweck, "It Worked Yesterday," 102.

demands, and as the technology itself becomes more sophisticated and intuitive, new sonic realms will open to vistas yet unimaginable. New software is being developed that is capable of responding to a pianist's spontaneity. Isaac Schankler and Alexandre François' wrote *Isaac with Mimi* (2010), as an interactive improvisation for pianist and computer. Described as a “*Multi-modal Interaction for Musical Improvisation*” (*Mimi*), it was designed<sup>120</sup> by François (along with Schankler and Elaine Chew), as a “multimodal interactive musical improvisation system that explores the impact of visual feedback in performer-machine interaction.”<sup>121</sup> *Mimi's* interface is created:

through a factor oracle, a data structure for efficient pattern matching ... [which] gives the performer and the audience instantaneous and continuous information on the state of the oracle, its recombination strategy, the music to come, and that recently played. The performer controls when the system starts, stops, and learns, the playback volume, and the recombination rate. *Mimi* is not only an effective improvisation partner, it also provides a platform through which to interrogate the mental models necessary for successful improvisation.<sup>122</sup>

Performers, Composers, and Developers form a collaborative circle to further the evolution of software and its application. The pianist's sensitivity and physical and sonic understanding of the piano are coupled by a composer's limitless imagination, while treating and experimenting with the sounds through Live computer processing. Pianist Rei Nakamura has improvised with electronic music artist Peter Vogel since 2003. Of their exchange, Nakamura writes of “letting the ideas and preconceptions we draw from our respective fields combine and intermingle ... I have learned a lot from him, about

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<sup>120</sup> *Mimi* was designed by François, along with Schankler and Elaine Chew. University of Southern California, Music Computation and Cognition Laboratory, “MIMI – multi-modal interaction for musical improvisation,” <http://www-bcf.usc.edu/~mucoaco/MIMI/> (accessed February 11, 2014).

<sup>121</sup> Ibid.

<sup>122</sup> Ibid.

freeing myself from constraint, letting myself hear afresh.”<sup>123</sup> Catherine Vickers observes that “having the opportunity to react to spontaneous actions by a sound engineer, inspiring the sound engineer to spontaneous actions, omnivorously sponging up the sounds and velocities of which a computer is capable to expand the instrumentalists own capacities — all these individual activities can lead us down roads to places we have not yet visited.”<sup>124</sup>

The piano is being completely re-evaluated as we move into the 21<sup>st</sup> century, combining media and mediums with a wide open palette. Bloland comments how the addition of electronics “forces us to reconsider the piano for what it is ... in all its amazing complexity, rather than rely on our existing conceptions of that which is piano.”<sup>125</sup> As we move forwards into an uncertain future, let us embrace the technologies of the Developed world, to extend and revolutionize our concepts of what the piano is capable of.

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<sup>123</sup> Nakamura, “My Cyber Chamber Music Partner.”

<sup>124</sup> Catherine, Vickers. “An Innovative Opportunity,” *Keyboards + Live Electronics: The Performer’s Perspective / Claviers + <live electronics>: La perspective de l’interprète* 13.2 (April 2011). [http://cec.sonus.ca/econtact/13\\_2/vickers\\_innovative.html](http://cec.sonus.ca/econtact/13_2/vickers_innovative.html) (accessed August 7, 2013).

<sup>125</sup> Private conversation with the composer, October 2013.

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