Real-Time Chance Operations: A Technologically Modern Approach to John Cage's 27'10.554" for a Percussionist

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Abstract

This essay examines the creative freedom of John Cage's work, 27'10.554" for a Percussionist *and offers a strategy for developing future realizations. The author's realization attempts to incorporate variability during performances of* 27'10.554" *using the assistance of modern technology. The score suggests a saturation of different sounds yet only specifies instrument categories, giving the performer freedom to decide on the appropriate instruments and set-up. Given the scope of the preparation, a performer must develop a very strict realization that often does not allow for variability during performance. Another issue arises in logistics: how might one assemble enough instruments, each with a large range in timbre, in order to fulfill the requirement for a seemingly infinite spectrum of sound? Perhaps one solution is the use of technology to help facilitate these difficulties. Most performances of this work that are supplemented with technology use an unwavering recorded playback. In this version, the author has created a realization that gives the computer the capabilities to make decisions and interact with the user. The technology employed here is Pure Data. It is an extremely powerful tool capable of expressing ideas algorithmically, and Pd is used as the major component to the author's realization of* 27'10.554". *With this technology, the author offers a way of interpreting the work that assimilates additional characteristics of Cage's compositional techniques. Additionally, this realization presents a solution to amassing the immense amount of sounds that Cage desires.*

Foundation for Interpretation

Many works that utilize technology will often acknowledge this inclusion by mention in the title. These references can be somewhat vague, or worse, they mention a type of media format that is obsolete. One such piece is Karlheinz Stockhausen's *Solo, für Melodie-Instrument mit Rückkopplung, Nr. 19* (1965), which calls for a performer with assistants to use 114 inches of magnetic tape to create delays with tape loops. Another example is Javier Alvarez's popular *Temazcal* (1984), which specifies the instrumentation as "maracas and tape," yet it is typically performed with audio playback on computer or compact disc instead of magnetic tape. Pieces that specify "with tape" are certainly still performed, but often on a digital format instead of the original analog. One could imagine that, without modern adaptations of the technology, the works themselves might become obsolete.

John Cage's seminal work, *27'10.554" for a Percussionist* (1956), has plausibly experienced reverse obsoletism. In the twenty-first century, advancements in technology have given musicians a vast amount of creative tools to help execute their realization. The music is virtuosic and a feat to perform, and many realizations include audio playback of some of the other parts. The physical demand is not the only difficulty; designing the sounds and set-up require a great deal of experimentation as well. Furthermore, every performance I have seen has included recorded playback; clearly, the technology available in the fifties and sixties would have made this piece unfeasible for most musicians. As technology has developed, more performances of this work are taking place. I am not suggesting that realizations without technological assistance are less convincing, as these are just as valid and acceptable to John Cage's intention. However, I am suggesting that developing a realization supplemented with technology is now more accessible to most musicians, thus opening the door for new directions of creativity with *27'10.554"*.

Cage's Indeterminacy

27'10.554" for a Percussionist is among the first solo percussion works written. Composed in 1956, it came after Cage's early percussion ensemble works that were highly structured and did not make use of chance operations. Cage had begun using chance operations as compositional techniques in the early fifties that included pieces such as *Imaginary Landscape No. 4 (March No. 2)* and *4'33"*. During the late fifties and early sixties, he composed several works that allowed variable instrumentation or duration including *Radio Music*, *Variations I-V*, and *Fontana Mix*. Likewise, *27'10.554"* offers variable instrumentation, with the exception of predetermined categories, by requiring the performer to design a large set-up before ever striking a note. Cage's compositional shift from highly structured scores to heavy indeterminism allows the performer to participate in his exploration of sound and consider the randomness

of the natural world. *27'10.554"* is an example of this shift, and Cage's vehicle for expression through chance was to elicit the imperfections of the manuscript paper on which he composed the score. Each instrumental category is given its own single staff line (which represents *mezzo-forte*), and anything appearing above the line is dynamically louder than anything below the line. Dots represent a *secco* sound while curves/lines represent a controlled, sustained sound, typically by performing a tremolo (see Figure 1). Some dots appearing in the metal category have a tail, which indicates a slow, decaying sound. Each page of the score is one minute and each second within the page is indicated numerically; thus, there are twenty-eight pages with the last page ending at 10.554 seconds.

Cage's aesthetic connected philosophy with indeterminacy. Much of his music compels the performer to take a heuristic approach and *27'10.554"* is no exception. He continued to seek out ways to remove ego from the self in order to let the compositional process happen non-discriminately.[1] To enable this, he laid out a design for using chance operations in many of his works. These designs were often implemented in several different ways:

1) Changes[2]
   : chance operations are executed before the work is created. The results create the parameters for performance. Example: *Music for Piano*, similar to *27'10.554"* where imperfections of the paper were used.
2) Indeterminacy[3]
   : chance operations take place during the performance. This is used in some works and is often dependent on the performance space and the members of the audience. Also, this is the most difficult to rehearse so certain parameters are substituted to facilitate preparation. Example: *Fontana Mix.*
3) Communication[4]
   : chance operations are executed by the performer but before the performance. The results create the parameters for performance. Examples: *c¢omposed Improvisation (for Snare Drum Alone)* and *Child of Tree*.

Evidently, *27'10.554"* was composed using chance operations during the process of creating the work. To embody Cage's other designs for alea and to create performance-based chance operations, I decided to implement this concept into my patch.

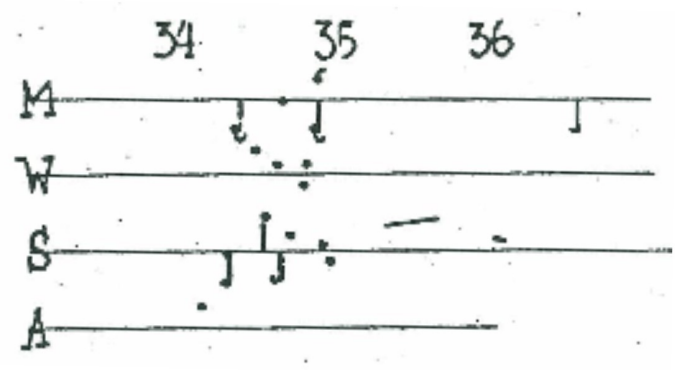

Figure 1. John Cage, *27'10.554" for a Percussionist*, page 3, 34th second.

Designing the Interpretation

One of the biggest challenges of *27'10.554"* is finding a large enough sonic palette to produce a compelling realization. The score indicates four instrument categories of *Metal*, *Wood*, *Skin*, and *Anything* but shifts responsibility to the performer to decide what and how many instruments will satisfy these rules. The *Anything* category allows for literally anything other than the previous three categories: whistles, radios, blenders, etc. Cage explains, "A virtuoso performance will include a wide variety of instruments, beaters, sliding tones, and an exhaustive rather than conventional use of the instruments employed."[5] This presents some limitations, however small they may seem. In order to attain an exhaustive use of instruments, it would benefit the performer to find instruments that have a

1 Christopher Shultis, *Silencing the Sounded Self: John Cage and the American Experimental Tradition* (Boston: Northeastern University Press, 1998), 94.
2 John Cage, *Silence: Lectures and Writings* (Middletown, CT: Wesleyan University Press, 1961), 18.
3 Ibid., 35.
4 Ibid., 41.
5 John Cage, 27'10.554" *for a Percussionist* (New York, NY: Edition Peters, 1960).

large timbral spectrum and respond with a variety of sounds when using various types of beaters. Moreover, one is limited to instruments that are within physical reach and to acoustic sounds that can be produced from these instruments. In *27'10.554"*, Cage seems to have opened the door to endless possibilities of sound for a solo percussionist, whereas in his earlier percussion ensemble works from the late 1930s and 1940s, he explicitly directed the types of instruments to be used rather than specifying only general categories.

Mercifully, Cage offers additional instructions: "This piece may be performed as a recording or with the aid of a recording."[6] Perhaps sensing the quickly changing landscape of technology but also being open to new interpretations of his work, he included this possibility in the score. He wisely avoids mentioning any type of medium (e.g. tape) that would negate variability in later performance practice as technology developed. Interpreting this statement is crucial to how I solve the problem of exhausting sonic possibilities. Rather than using a fixed playback that is the same for each performance, I created a version that uses real-time chance operations to determine sound and incorporates user input to mutate the sounds during live performance. I decided to use a limited set of instruments that allow for reasonable portability. These instruments become the foundation for all acoustic properties for my realization. I sampled each instrument and digitally manipulated the harmonic content to create a large spectrum of sounds, which become extensions of my acoustic instruments. During a performance, I acoustically manipulate my instruments by using many different sticks, mallets, and beaters to create a variety of sounds, much like I did to create their digital counterparts. The end result is that both my acoustic sounds and digitally-manipulated sounds share the same sonic foundation.

To play back these samples, I built a sequencer using Pure Data (Pd) software. Pd is a graphical programming language used primarily to operate on audio signals and processing sound.[7] A conventional sequencer contains stored information about the timing, pitch, volume, and duration of notes that can be executed autonomously. The sequencer I built follows a similar paradigm, but I added elements of indeterminacy. It keeps a separate folder dedicated to each instrumental category (metal, wood, skin, anything) that stores the information for each page of the score. This information is used to determine the timing and velocity of the note attacks. I also built a representation of the *I Ching* (explained in more detail below) to determine pitch, which in turn makes the decision of which sample to select. Consequently, pitch is mostly ignored from the MIDI files with a few exceptions: deciding whether the note from the score indicates a *secco* sound, resonant sound, or sustained sound. The flowchart in Figure 2 demonstrates the process of a particular instance of sound; this represents how a single note is interpreted from the score. MIDI information is received from the particular instrument and minute and then sent through the various stages of selection until it finally reaches the speaker.

I also have the capability of changing the sound banks in real-time. This feature enables multiple banks of samples to be loaded into the buffer, allowing for an incredibly enormous number of sounds that the computer's RAM cannot support. By taking an adaptive approach to the music, the sounds can evolve throughout the course of the performance. With an analog recording in the fifties, this would never have been possible without assigning an unthinkable amount of assistants to individual tape players. The flexibility of using Pd allows me to easily create new realizations of the piece that provide a framework to orchestrate new ideas. The most interesting and mercurial element of this flowchart is the right half—this is essentially where all of the real-time user and computer decisions take place. Conventionally, the choice of sounds for a sampler is decided in advance, and the pitch is chosen based on the actual note being played. I replaced this step by removing pitch choices and using indeterminacy to decide which sound is heard. Additionally, this patch contains banks of sounds that allow the user to easily change the group of sounds in real-time.

6 Ibid.

7 More information on Pure Data including documentation and downloading can be found here: https://puredata.info.

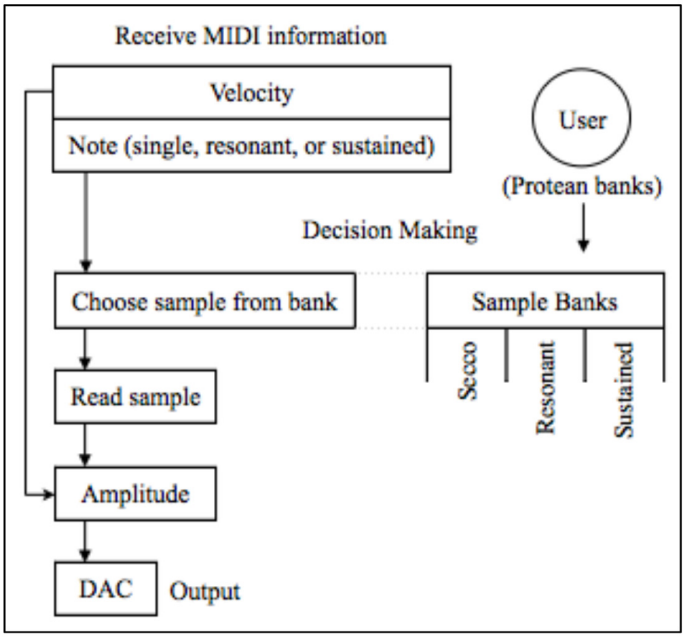

Figure 2. Flowchart of a single instance of a sound. This is the path taken each time a sound is played.

Using the *I Ching*

The actual decision-maker within the patch is a representation of the *I Ching* that I built to choose sounds. The *I Ching*, or *Book of Changes*, is an ancient compilation of Chinese texts containing sixty-four hexagrams. There are several chance methods for obtaining a hexagram from the *I Ching*, but in this case, I will only discuss the Coin Method and how I implemented this. The method involves three coins with heads (*yang* with a given value of two) and tails (*yin* with a given value of three) and a distinctive square hole in the center of the coins, as pictured in Figure 3. With a single toss of these three coins one will derive a single line of the hexagram from the possibilities, also found in Figure 3. Adding the values of the side the coin lands on (two or three) will produce only four possible results: 6, 7, 8, or 9. *Old Yin* is considered to transform into *Young Yang* while *Old Yang* is considered to transform into *Young Yin*, thus finally giving either a continuous or broken line.[8] Repeat this process until a complete hexagram from 1 of 64 possibilities is formed.[9] Each hexagram represents a divinatory meaning; however, Cage often used *I Ching* divination coins as a method for creating a hexagram, to which he then assigned each of the sixty-four to a specific parameter.[10]

This was one of many methods Cage used for chance operations and also one of the most common. Since this was such an important technique for Cage's chance operations, I intentionally decided to build an *I Ching* abstraction in my patch by using Pd's built-in *random* object as the foundation. Arguably, this is perhaps more of an achievement of philosophical accord than an exercise in probability.

8 Stephen Karcher, *How to use the I Ching: A Guide to the Ancient Oracle of Change* (Shaftesbury, Dorset: Element Books Limited, 1998), 34-35.

9 Alfred Huang, *The complete I Ching: the definitive translation* (Rochester, Vt.: Inner Traditions, 1998), 10-11.

10 John Cage, Silence: *Lectures and Writings* (Middletown, CT: Wesleyan University Press, 1961), 57-59.

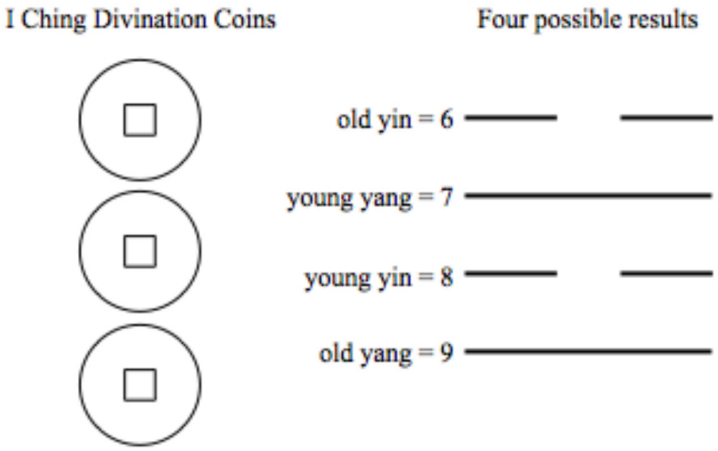

Figure 3. The Coin Method for getting results for a hexagram.

Real-time Chance Operations

Performance-based chance operations are paradoxical in that to rehearse them would reduce the indeterminate aspects, yet under-rehearsing may not subdue the subconscious influence of the performer. As a result of under-rehearsing, the performance would be based on the performer's ego rather than chance; that is, in order to regain a sense of familiarity, the performer may regress to playing comfortable "licks" and nearby instruments instead of exploring new ideas and sounds. The benefit of using a flexible framework for *27'10.554"* is that I can assimilate performance-based chance in the realization.

I constructed the virtual Coin Method by using Pd's built-in *random* object as the main building block. This object outputs a random number based on the parameter set in its creation argument—if set to 10, the object will output any number from 0 to 9. It is worth noting that these are pseudo-random numbers because they are derived from a predetermined sequence loaded at runtime and are not chosen at the time of output. One can easily represent a virtual coin tossing by creating an argument of two, which will output a zero or a one, then adding two so each value will be two or three—representing heads or tails from the coins (Figure 3). Therefore, this connection denotes a single coin, and I group them in threes in order to produce a result of 6, 7, 8, or 9. The results are filtered into a binary output to represent a continuous or broken line (Figure 4). Duplicating this object chain five more times produces a complete hexagram. Using the traditional Coin Method, as Cage did, is a rather time-consuming process, because it involves tossing the coins six different times and recording their results. The patch I built into Pd takes this linear process and compresses it by simultaneously tossing coins in order to produce the results in milliseconds.

Perhaps the most compelling aspect of using the *I Ching* for chance operations is that John Cage mapped the sixty-four possible outcomes to specific parameters. As expected, this is what I do with the results as well. Since the hexagrams are essentially a combination of various continuous and broken lines, or binary results, I can easily represent this in Pd with a zero or one. The output received from the *I Ching* patch controls the sample selection inside the instrument categories, and I reuse the patch to additionally control spatialization—in regard to where the sound occurs in space. While the *I Ching* is used to select sounds, some parameters are taken from the score: the particular instrumental category and the form of attack (*secco*, resonant, and sustained). Therefore I group related sounds so that the *I Ching* may only choose from the given category. With the current technology of available memory in most computers, it is infeasible to actually have sixty-four samples per instrument and their respective sustained sounds. To solve this problem, my patch has the ability to reload multiple sound banks into the buffer during performance. I wanted to maintain a balanced probability for each sample, so I made sure the number of sounds were able to divide evenly into sixty-four. Mapping the panning parameters was quite easy. The sinusoidal curve I use for panning signals can take a much finer grain of detail than the number of samples I use at one time. Thus, I can benefit from using all sixty-four possibilities of hexagrams from the *I Ching* without having to divide them into smaller numbers. The patch can support stereophonic and quadrophonic sound, which both take an input range from 0 to 1 and have the values 0 to 63—from 64 hexagrams—mapped accordingly.

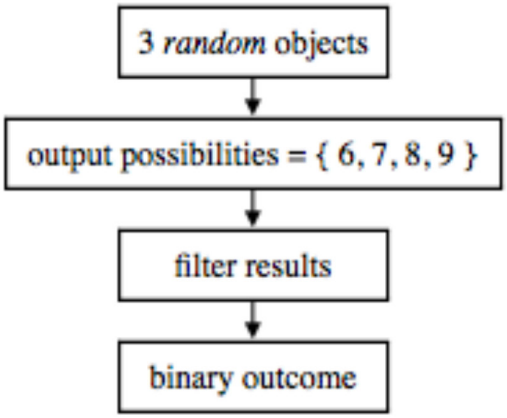

Figure 4. Flowchart for a coin toss in Pd.

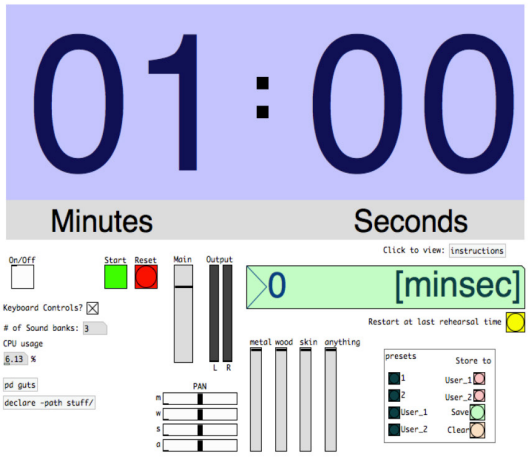

Figure 5. Interface of *27'10.554"* as seen in Pure Data.

This is certainly not a conventional sampler where specific sounds are mapped to specific notes; rather, the sounds are chosen by performing chance operations. The decisions of the computer are made during a performance, thus each execution is, in Cage's words, "virgin."[11] This adds a performance-based chance element to the work, providing a method to incorporate other compositional techniques that Cage used. The end result is that each performance consists of chance operations deciding on a sound and a location of that sound.

Designing a Time-Based Random

Many issues arise when trying to generate randomness inside a computer's memory. The computer can only generate pseudo-random numbers. This becomes somewhat predictable because the computer accesses the same array of numbers, and after rehearsing and using this patch many times, one begins to recognize these patterns. Fortunately, since I am using the same building block for my virtual *I Ching*, I am able to quickly solve this problem by fixing the building block itself—Pd's *random* object. Eventually, I found a solution to this problem by using a white noise generator, seen in Figure 6. White noise contains all frequencies, and in Pd, it is created by a series of random points between 1 and -1. This is similar to the *random* object, except the noise generator operates by continuously sending output. Using the *snapshot* object, I am able to capture the value at any given sample and use it as my random number. This is a huge improvement over the control-rate random object because my new abstraction will change even when I am not using it. This abstraction will not create any predictability that may have been present in the previous version.

11 John Cage, Silence: *Lectures and Writings* (Middletown, CT: Wesleyan University Press, 1961), 36.

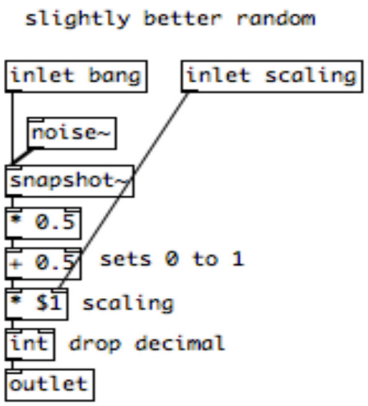

Figure 6. Abstract of the implementation of a better random number generator.

Silencing the Self

Much of Cage's music, including *27'10.554"*, is based on an inherent randomness that attempts to remove ego from the creative process. As Cage says, "Chance, to be precise, is a leap, provides a leap out of reach of one's own grasp of oneself."[12] Chance is clearly the edifice used to compose *27'10.554"*, and the randomness of paper imperfections were Cage's compositional technique. He diminished his ego from the compositional process, yet realizations of this work are most likely carefully and methodically planned and rehearsed. Furthermore, because of our intrinsic tendencies, we will subconsciously create overlaying rhythmic structures in order to remember and retain the music. As performers, we risk the danger of becoming complacent by letting the realization begin to gravitate towards a rhythmic *reminiscence*. This reminiscence pulls from deep within our own memories and regurgitates an average of the music buried inside. The beauty of realizing Cage's music is that it forces the musician to understand their own inborn and learned biases. In my realization, I wanted to add more elements of chance that created on-the-spot decisions in order to vary the piece from performance to performance. I am interested in participating in Cage's compositional process in order to have a deeper understanding of his credo. With the aid of technology, my realization has helped maintain this compositional technique by generating unpredictable results over multiple performances. Therefore, a single performance is a snapshot in time never to occur again—the only constant being the constant of change.

This entire concept stems from performances of *27'10.554"* that left me discontented with the number of sounds I used. I felt like this was only a shell of Cage's idea and not a true manifestation of it. Creating a realization of this work requires a great deal of design decisions that place one in the role of composer. However, I wanted to reduce my own bias and give up control to chance. Reducing my influence is achieved with the assistance of technology but the questions still remain: Is the computer really using chance? Is the computer really able to attain randomness? These are certainly debatable, but nevertheless, I have achieved a diminished role of influence during performance, which is another step closer to removing ego.

Limitations and Improvements

The flexibility of the application I developed allows the user to easily create a new realization so that multiple performances can be unique versions. These decisions are all made pre-performance but still encourage mutable realizations that can generate a sizable timbral spectrum not possible in an entirely acoustic performance setting.

After performing this piece many times with the assistance of my patch, I have had time to reflect on the possible limitations of the technology and how it may be improved. One of the biggest shortcomings of the technology is producing true randomness. As I described above, computers can only generate pseudo-random numbers, which are sequences of numbers that are predetermined. I am able to improve on this problem by using a time-based random that is not iterative—meaning the random numbers are generated based on when they are accessed, not by what the next number in the sequence happens to be. However, this does not solve the problem. While even the most attuned ear would most likely never recognize patterns produced from the random number generators, I am still unable to truly give up chance to the universe. However, this can be improved by using outside data—perhaps from stock market prices, weather patterns, etc. The difficulty is to decide whether or not to embed this data into the patch or to try accessing it in real-time. There are disadvantages to both: embedding will produce the same or similar results and accessing data in real-time may be too slow. But certainly these are improvements to consider for future realizations with advancements in technology.

Furthermore, why even try to simulate the *I Ching* at all? I could have easily just skipped using a virtual *I Ching* and simply used

12 John Cage, Silence: *Lectures and Writings* (Middletown, CT: Wesleyan University Press, 1961), 162.

Pd's built-in random capabilities. But developing a realization of Cage's music forces us to look inward and face our own artistic motivations. Why roll the dice or flip the coins at all? It is what we do during the preparation when we are isolated with our own judgment that determines our level of commitment and integrity to the art. Taking a chance to allow oneself to be changed is the only risk here. This is the beauty of the work. In an attempt to incorporate more chance elements, I provided a technological framework for generating unpredictability.

I originally titled my realization, *27'10.554" for a Percussionist and Computer*, but I have since decided against this. At first glance, one will notice that the computer is autonomous, making its own decisions, which lends itself to a performance of two separated entities: human and computer. Much like an adapted performance of this work where multiple performers are contributing various parts of the score (i.e. *27'10.554" for Three Percussionists*), I initially thought the technology should get its own place by mention in the title; I reasoned that it makes decisions, so I should include it as a performer. However, I no longer consider this to be the case. The technology is an extension of my realization, not a separate performer, and it only performs when I am performing. It can only act within the rules and boundaries of the world I gave it; similarly, a performer's realization of *cComposed Improvisation* or *Child of Tree* may have time brackets that set the specific boundary. Cage's *27'10.554"* allows for creativity within his credo, and emerging ideas keep the music in a continuous state of evolvement. New generations of artists play a crucial role in keeping this work in perpetual flux. With my realization of *27'10.554"* and the help of modern technology, I can also maintain the evolution of the work within my own performances.

Media Example 1.
John Cage, *27'10.554" for a Percussionist*, page 4, performed by computer realization in Pure Data.

Media Example 2.
John Cage, *27'10.554" for a Percussionist*, page 4, performed by computer realization in Pure Data.

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