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PROCESS AND AGENCY IN USING A DATASET FOR SOUND ART AND MUSIC COMPOSITION

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This paper discusses the issues of process and agency in generating data, sound art and music compositions in the context of Composing [De]Composition[2], a BioArt installation/laboratory that explores the creative potential in sonifying compost temperature. The project was first presented at University of California Riverside's Sweeney Art Gallery in 2015, and the second iteration of it is presented as part of the 7th Computer Art Exhibition hosted by Brasilia's National Museum of the Republic. After first describing the project and defining key terms for the reader, I share my three-tiered process of working with compost, transforming, and translating its temperature data for digital sound art and acoustic music. Finally, I will delve into the issues of agency in sharing my creative role with the biota and in using datasets in my creative process.

Keywords: Process, Agency, Data Sonification, BioArt, Sound Art

1. SPREADING THE SEEDS: Art, Technology, Process, and Agency

In the 1969 essay, "Art and Technology" American composer and visionary John Cage (1912-2000) states, The purpose of art is not separate from the purpose of technology... (They) bring people together (world people), people and their energies and the world's material resources, energies and facilities together in a way that welcomes... discovery and takes advantage of synergy, an energy greater than the sum of the several energies had they not been brought together.[3]

Forty years after Cage's above observation, online pioneer Ken Jordan sees the development of digital media as agential in aiding artists to more intuitively engage with the world—by blurring the demarcations between traditional artistic media: Digital media is opening new avenues to intimate personal expression— through the recombining of media elements, and the blurring of distinctions between traditional mediums in a way that reflects our intuitive engagement with the world. The line where art blurs into science is at the forefront of the discovery of new aesthetic experiences... the tools we have at our disposal to make art carry consequences for the art we make... [for example] the link between the notation on a page and the sound a musician makes when reading it is an interaction that blurs the line between mediums, just as digital media makes possible blurring in other ways... while the score provides an approximate transcription of a musical work, it is rough, open to interpretation.[4]

Digital media has afforded artists a similar luxury to a musician navigating through a musical score—the ability to interpret entire systems 'notated' into machine readable data—allowing the artist/player the ability to render and/or interpret that information into whatever artistic medium desired. Composing [De]Composition is a sonification art project that engages the greater community through positioning a living BioArt laboratory in public art galleries and museums.

The lab serves as a platform for introducing visitors to the complexities of compost, the practice of data sonification, and also for highlighting how to increase our

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2 - https://jnoiesparker.wordpress.com/composing-decomposition/

3 - John Cage. John Cage, Writer: Previously Uncollected Pieces, ed. Richard Kostelanetz. (New York: Limelight Editions, 1993), 111.

4 - Ken Jordan. "Stop. Hey. What's that Sound?" in Sound Unbound, ed. Paul Miller (Cambridge: The MIT Press, 2008), 250-251, 263.

ISSN 2238-0272

own day-to-day sustainability efforts through understanding (and hopefully as a result) readjusting personal practices of organic waste disposal. Composing [De] Composition (forthwith C[D]C) employs digital media to blur the line between organic and non-organic processes in art making—combining the natural, organic process of composting with the technologically-mediated practice of data sonification—resulting in a highly process-based art where each phase triggers the next.

In its largest sense, the project brings the idea of vital materiality posited by Jane Bennett in Vibrant Matter: A Political Ecology of Things (2010) into clear focus. Bennett's work deals with unpacking the issues around material agency or " the affectivity of nonhuman or not-quite-human things".[5] Bennett equates affect with materiality, rather than posit[ing] a separate force that can enter and animate a physical body... theorizing a vitality intrinsic to materiality as such, and... detach[ing] materiality from the figures of passive, mechanistic... natural bodies and technological artifacts.[6]

Compost and the dataset it generates during the exhibition period form the main nonhuman agencies of Composing [De]Composition. This paper discusses my layered artistic process and the issue of sharing creative agency in with the compost and its data in generating sound art and music compositions.

2. A Brief Description of the Project

Seemingly spontaneously generated out of lifeless vegetal matter, the biota of compost self-organizes in any place there is a scrap of organic (i.e. carbon-based) matter, moisture and a source of oxygen. Use of the word biota underlines the fact that the decomposing mass is a living micro-ecosystem. My use of the terms compost and biota in the context of C[D]C refer to the entire network of biota present during the decomposition process—consisting of decaying vegetal matter, worms, large insects, fungi, and millions of microorganisms. The main observable parameter driving the project is incalescence—the heat generated by the composting process. Temperature changes observed in the compost are caused by decomposition, which is both a biological and a chemical activity simultaneously supporting a myriad of life forms consuming the organic matter and enabling the bioavailability of macronutrients to the soil. The UCR Sweeney Art Gallery was used as an active BioArt research lab (Figures 1, 2) where visitors experienced compost elaborated as: the gallery's soundscape via a spatialized sonification of temperature data; a stop-frame animation of decomposing matter inside the compost container; scanning electron microscope images of the material magnified up to 5000x revealing heat generating microbial life; and an ongoing research wall that exhibited prototypes of compostable sensors, strategies for parameter mapping/data translation into sound and music, soil nutrient information for home composters, and a scientific poster.

Data sonification is defined as the "systematic, data-dependent generation of-sound"[7] and can refer to a number of different techniques. Sonification "seek[s] to translate relationships in data or information into sounds that exploit the auditory perceptual abilities of human beings such that the data relationships are comprehensible".[8]

5 - Jane Bennett, Vibrant Matter: A Political Ecology of Things.(Durham: Duke University Press, 2010), x.

6 - Ibid., xiv.

7 - Bruce Walker & Michael Nees. "Theory of Sonification" in The Sonification Handbook, eds. Thomas Hermann, Andy Hunt, John G. Neuhoff.. (Berlin: Logos Verlag, 2011), 9.

8 - Ibid.

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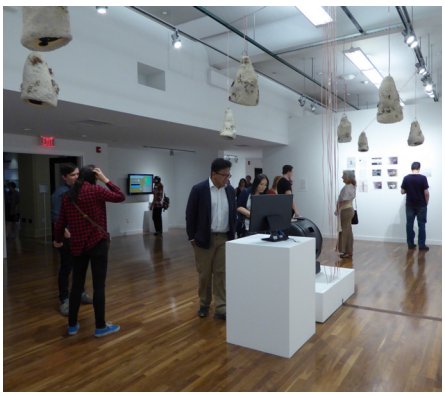

Figures 1, 2. Composing [De]Composition @ University of California Riverside's Sweeney Art Gallery.

In the year leading up to the exhibition period, strategies for the real-time sonification of compost temperatures—known as audification—focused primarily on the development of sensing methods, physical tools, and sound parameter mapping.[9] The development of a compost temperature sensing device with data logging features and the audio display during that period facilitates my ability to create sound art and music compositions in partnership with the biota.

There are two distinct stages of the BioArt lab. Stage one features a period of compost creation, maintenance, and observation; temperature sensing; real-time audification of temperature data; and data collection. During this stage, temperature data sensed from eight distinct areas of the biota is directly converted to Hertz, with the resultant live soundscape projected thorough a biodegradable[10], eight-point audio display mapped to mirror the placement of the temperature sensors inside the compost container. Speakers of the audio display constantly emit individual frequencies ranging between 0.5 and 20 Hertz apart that combine to create a thick, bass-range, subrhythmic, and constantly morphing soundscape resulting from very slow temperature changes and acoustic beating. This texture metaphorically refers to the movements of the uncountable tiny organisms busily at work digesting the compost.

The sonification of temperature data using a multi-point audio display enables gallery visitors to better grasp the complex ecology of the decomposing heterogeneous mass. Since not all humans have equally developed sensitivity to hear slow, slight changes in pitch—especially in the lower spectrum of our hearing range—the audio display is additionally designed with earcons. Earcons are another type of sonification used to signify a change of status within a system. The C[D]C earcons alert visitors when an increase or decrease of one degree in temperature occurs in any area of the biota—immediately updating visitors of aggregate changes within the pile. Each of the temperature sensors and its corresponding speaker has a distinct gamelan instrument based earcon, thus allowing visitors to perceive changes within the pile spatio-temporally. For example, if speaker number eight's earcon is heard playing forward, it signifies that corresponding area of the biota has reached a one-degree increase in temperature. An earcon heard in reverse indicates a drop of one full degree. Passing the 1 □ threshold tends to occur very gradually, so visitors lucky enough to be present during a transition get an interesting treat.

9 - A deeper discussion of data sonification and sound-mapping strategies is found in Parker, Jennifer. "Sonification as Art: Developing Praxis for Audifying Compost". In Proceedings of the 21st International Conference on Auditory Display (ICAD 2015). Edited by Katharina Vogt, Andreopoulou, A. and Goudarzi, V. Graz (KUG), Austria (2015): Institute of Electronic Music and Acoustics (IEM), University of Music and Performing Arts. 157-164. http://iem.kug.ac.at/fileadmin/media/institut-17/proceedings150707_3.pdf

10 - In an effort toward achieving sustainable sound-art design practices, the speaker housings of the audio display are designed to be fully biodegradable—created out of organic matter, wire, and University of California campus newspapers/local supermarket weekly advertisements.

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For the second stage of the lab, the biota is completely removed, and the resulting dataset is sonified for the remainder of the exhibition period. A 346,000 point dataset was generated during the UCR study, representing a cross section of temperature conditions in the biota over 30 days. The resulting dataset (Figure 3) sonification was then continuously looped through the auditiory display at an increased playback rate—allowing listeners to hear the trajectory of the biota's temperature conditions over 30 days in only 30 minutes.

At the closing of the UCR study, a public "data listening session" was presented. For this event the dataset was re-translated from the original Hertz-based parameter mapping into a microtonal composition for eight virtual electronic pianos. The audience experienced the spatialized 30-minute compost temperature sonification while laying face up on the floor underneath the eight speakers of the audio display (Figure 4). The option of watching a magnified projection of live compost microbes on a nearby wall of the gallery was also available—affording a window into the microscopic world responsible for the creation of the work.

3. A THREE-TIERED PROCESS

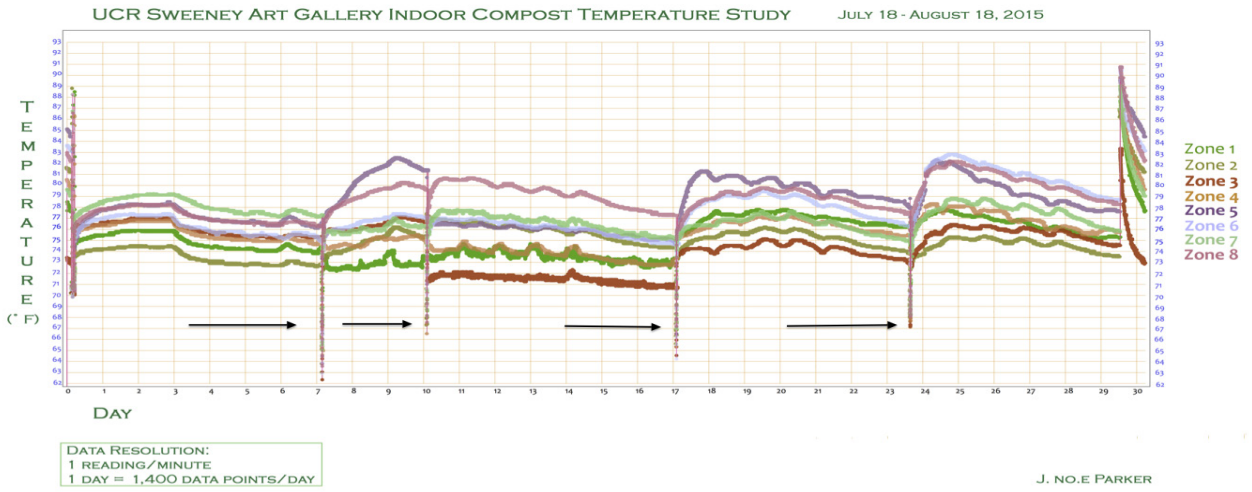

Figure 3: The 30-day Sweeney Gallery study temperature dataset visualization. Black arrows point to removal of the sensors and reflect room temperature of the exhibition space.

Besides sharing credit with the biota in the creation of C[D]C, my main job involved/s the formation of an intricate techno-ecology[11] for the work as a whole—

Figure 4: Visitors at the Sweeney Gallery compost temperature Data Listening Session.

11 - Please refer to Parker, J no.e. "The Techno-Ecology of Composing [De]Composition", forthcoming in Acoustic Space Journal (16). Riga: Center for New Media Culture (RIXC) in collaboration with Art Research Laboratory of Liepaja University.

ISSN 2238-0272

encompassing digital media, technological tools, microbes, data, electronics, human networks, and the surrounding discourses of each. For the initial UCR Sweeney Art Gallery study, sonifying the biota's incalesence consisted of a three-tiered process—

1) Organic: creation and maintenance of an indoor compost pile;
2) Techno-transformative: development of the technological tools required to monitor, collect, and hear the biota's incalescence[12];
3) Techno-translative: parameter mapping to translate and interpret the collected dataset into sound; data audification (real-time); sonification (data playback); and musification (data 'performance').

As the UCR study established C[D]C's techno-transformative framework, the original three-tiered process above has since shifted to focus on its organic and techno-translative aspects in later iterations.

However, as C[D]C is transported to new and different sites, each exhibition depends not only on myself as the artist working with the biota, but also on my close collaboration with members of sponsoring institutions. Each new iteration of the sonification lab requires me to work with museums/galleries/university sponsors to source locally available materials—i.e., the compost used, a suitable composting container, and sometimes hardware for the audio display. Hence, this combined, human tactical effort of manifesting the lab in a new site adds yet another layer of process to the above list.

3.1 Compost: An Organic Process

The choice of compost as a site for exploration stems from a personal 20-year practice of daily food-waste recycling in various internationally based sites. An eventual turn toward the deep integration of this somewhat mundane environmental process into my artistic practice first began during a two-year residency at the Indonesian Art Conservatory in Yogyakarta, Java where I began merging seeds sprouting from my garden compost pile into textile hangings and site-specific installation work. Whereas this previous work integrated plant life borne out of personal food refuse, C[D]C begins an investigation into the actual process of decomposition and harnesses its incalescent properties for the generation of sonification art and music.

Briefly, composting is an aerobic, biological process that occurs when insects, invertebrates and microorganisms "digest" the carbon of the carbohydrates contained in decomposing organic matter. The use of the term aerobic indicates that the organisms involved in this process require oxygen and moisture to live and reproduce. As part and parcel of this carbon- and oxygen-rich "feeding frenzy", the various-sized organisms also generate heat, water vapor and carbon dioxide during the process of respiration.

The human-mediated process of composting requires regular "feeding" and aeration of a compost pile. Feeding consists of adding new organic food and yard waste to it, while aeration consists of turning the pile to mix and expose it to oxygen.
Working with the biota is working at the edge of life and death—what is produced at the end of the human food chain continues on to support millions of smaller life forms who live, eat, reproduce, are eaten, and die at a timescale of a few days or a few months at most—a process transforming nearly all "waste" material into nourishment for future plant life.

3.2. Generating Data and its Sonification: A Techno-Transformative Process

Phenomenologist Don Idhe's material hermeneutics serves as a point of departu-

12 - For a detailed discussion, please refer to Parker, Jennifer, "Composing [De]Composition: Data Sonification for Sound Art and Music Composition", PhD diss., University of California, Riverside, August 2016.

ISSN 2238-0272

re in discussing C[D]C's techno-transformative processes—

For science, or art, to be experienced, it must take into account human embodiment... if the phenomenon lies beyond our capacity, then only by being technologically transformed can it come into our range.[13]

As it is impossible for humans to hear temperature directly, it was first necessary to develop tools and methodologies to monitor and transform the heat energy produced by the biota into a machine-readable format manipulatable on the digital realm. Thus, my main role in the project at this stage was facilitator of what Idhe refers to above as the "technological transformation" the biota's incalescence into the range of human perception.

Although the terms translate and transform are generally regarded as synonyms in writing, I will rely on distinct nuances between the terms to demarcate the different thought processes involved in creating the various aspects of the project. The term transform can be defined as to make a thorough or dramatic change in the form, appearance, or character of; while the term translate can be defined in its linguistic sense as, to change text from one language to another.

Thus, changing the active, physical element of heat into static numbers representing it is clearly a transformation. It is only after this initial transformation from a physical to a numerical format that the perceivably silent activity of decomposition can be sonified.

This second tier of the project was a year-long period spent developing hardware and software to monitor, collect and transform the biota's physical heat energy into data, and the data into physical sound. During this time, I conducted research at The Center for New Music and Audio Technology, where I designed, built, and coded three major components of the project: an array-based temperature sensing apparatus to monitor the pile's diverse temperature conditions in multiple areas (Arduino coding by Adrian Freed at CNMAT); MAX/MSP patchers to execute the digitally-based parameter mappings (Hertz, microtonal MIDI note number), record, and visualize the dataset; and the compostable multi-point speaker array to project the dataset into the exhibition space.

3.3 Data > Sound Art > Scored Music Composition: a Techno-Translative Process

Data sonification enables rich, entrainment practices that challenge artists, scientists and engineers in a collaborative process to create practical strategies and robust metaphors for the translation of numerical information into a sonic form understandable to the greater public. To this end, data sonification employs the strategy of parameter mapping for the translation of numerical data into sound.

Using a direct, one-to-one parameter mapping keeps the data closest to its original form, but this only works if the data values fall into the human range of hearing (20-20K). Otherwise, some type of scaling must be performed to produce an audible result. Multiple parameter mappings were performed for C[D]C—two direct and digitally based, and a third hand-scaled and scored for acoustic instruments.

Below, I briefly describe the process of creating the two direct, but differently mapped digital dataset translations. I take my discussion of the third mapping process up later in the section on agency when describing how musification— another type of sonification—brings the act of data translation into the realm of interpretation.

Mapping 1: The gallery's live, data generated soundscape environment is achieved by direct translation of temperature (Fahrenheit) to frequency/Hertz. The resulting soundscape is drone-based—a strategy that prevents the audification from sounding overtly musical. Previous indoor composting has rendered temperatures ran-

13 - Don Idhe. Postphenomenology and Technoscience: The Peking University Lectures. (New York: State University of New York Press, 2009), 78.

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ging between 62 -98F. Translated to a Hertz soundscape, this falls in the low to mid bass frequency range of the sound spectrum. The resulting 8-point soundscape immerses visitors in a constantly throbbing soundbath.

Mapping 2: A microtonal MIDI note number rendition of the dataset was presented at the UCR exhibition closing. MIDI note numbers range between 0-127, with 60 assigned to middle "C" on the piano keyboard (261.6 Hz). This range also directly aligns with the biota's heat profile Changes in fractional values of datapoints could also be heard as microtones. The data was translated to MIDI information with pitched material programmed to emulate keystrokes on eight
grand pianos—one for each speaker of the audio display.

Using these two different parameter mappings did not alter the data in any way—however it did render two very distinct listening experiences. The constant, immersive, low frequency drone soundscape of Mapping 1 conceptually aligns with the ideas that: a) composting is a relatively slow process (on the human scale), similar to the slow movement of low frequency soundwaves; b) the biota's terranean-based process of soil creation takes place underneath our feet and low frequencies can be felt better than heard; and c) the acoustic beating of the resultant soundscape is much more than the sum of its sonic parts. Contrastingly, experiencing the dataset spatialized and sped up as a "performance" of microtonal pianos in Mapping 2 forced visitors into a focused listening state and enabled close spatio-temporal apprehension of all temperature changes.

4. SHARED AGENCY

The topic of agency comes to the forefront in this next section of mydiscussion. When tackling the issue of 'live' in contemporary electronic music,Simon Emmerson, composer/professor of music technology defines an agent as "an entity (configuration of material, human, animal or environmental) that may execute an action (a change in something, usually involving a transfer of energy)."[14] According to Emmerson, Musicians have for some time used the environment as a source for music generation... the environment finds its way increasingly into music not only via recording and reproduction of sounds... but through simulation of the characteristics of the systems' behaviours and their complexities... the 'live' is also being thrown back from human agency into the (so-called) 'inanimate' world... forming two way relationships [Emmerson's emphasis].[15] C[D]C establishes compost and its network of microbes, fungi, and bacteria as a primary agent in the creation of sound art and music—thus re-contextualizing it from acting as an artistic material to be manipulated into being an active collaborator.

Through this recontextualized role, the material/network of compost is revealed as true energetic force of creation. By harnessing this network's thermal energy and transforming it into sound, the incalescent nature of the biota is expressed, and in turn, it can also be thought of as expressive. This notion returns to Bennett's idea of vital materiality, centered on the idea that "the locus of agency is always a human-nonhuman working group".[16]

4.1 Working with Data

Working toward the purpose of data sonification involves the formation of agential relationships between myself, the biota, and the data. At first, the thought of working with predetermined datasets may seem to leave no room for a composer's own creative agency, however, the act of determining what type of dataset is even worth

14 - Simon Emmerson. Living Electronic Music. (Burlington: Ashgate Publishing Company, 2007), 3.

15 - Ibid., 53.

16 - Bennett, Vibrant Matter, xvii.

ISSN 2238-0272

translating into the sonic realm immediately takes a primary role. While data takes the central role as determining the sonic materials of C[D]C, the fact that I chose to focus on compost temperature data reflects my engagement with issues of personal resource management, global warming—and also my goals as an artist to help create a sustainable future. The challenge of shaping data into sound allows the sonifyer many options that ultimately also determines the type of sonification performed. These options include which aspect(s) of the dataset to focus on; what aspect(s) of sound the data can be used to explore (rhythm, pitch, dynamics, etc.); sonic medium used (digital, acoustic, a combination of both); as well as overall sonic aesthetics (determined by parameter mapping, scaling, transposition, etc.).

Choices made by the composer are all based on the desired end goal of the work. While audification and strict data sonification deal with depicting a dataset as accurately as possible, when translating the data into music—a process called musification—human aesthetics and the physicality of sound making can come strongly into play.

In a musification, "the data is not just auralized as in a sonification, but instead, various constraints are created and applied in order to create a musical performance" of it. [17]These constraints can be subjective and superficially based (so as to make the end result a more 'pleasant' experience), or perhaps physically based—as when a dataset is translated for non-digital instrumentation/performance.

In some instances, forging the conceptual metaphor between mapping data to sound forces the idea of translation further toward the interpretation end of the spectrum. While audification and parameter mapping sonification can produce an extremely high resolution, point-by-point dataset translation, data musification interprets and even distills a dataset in the interest of being musical.

In the case of C[D]C, quantizing data to conform to a musical scale, and even to MIDI note numbers, much information is lost—this was my reasoning for integrating micro- tones in Mapping 2 above. Mapping the data to be playable by human performers, however, reveals a new set of creative and agential challenges—which is why I now resume my earlier discussion of it now below in this next section.

The thought processes behind creating a one-to-one, high resolution mapping of the digitally-based sonifications and a scored musification for chamber ensemble are markedly different. For example, to achieve the abovementioned, digitally-based Hertz and microtonal mappings heard in the BioArt lab, the utmost priority is that the biota and dataset are given most agency over the sound environment. My role was to devise the clearest metaphor for the data to be heard.

Contrastingly, to produce a chamber ensemble work based on the dataset, I had to further interpret the data according to the physical parameters set forth by the ensemble's instrumentation. Acoustic instruments each have their own unique physical limitations—namely, in/ability to play more than one tone simultaneously and fixed pitch ranges. As a result, I had to become less literal in rendering the dataset and more ontological in nature—forming a system for mapping the data to each instrument individually. Additionally, the 346,000 point dataset contained too much information for human computation/performance, therefore I had to devise a strategy of reducing the amount of data to an appropriate resolution while aligning the resulting work as closely with the dataset as possible. I felt these very physical realities faced during the musification process challenged my agency as "sonifyer", on one hand while also appealing to my agency as "composer" on the other.

5. Conclusion

17 - D. A. Williams and L. G. Wilson, "Evaluating apparatus for musification of P. berghei micro-organism motility with synchronous 3D holography" in Proceedings of the 11th International Symposium on CMMR, ed. M. Aramaki, R. Kronland-Martinet, S. Ystad. (Marseille: The Laboratory of Mechanics and Acoustics, 2015), 570.

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The multifarious processes inherent in developing a project like Composing [De] Composition as sonification art have resulted in a rich entrainment practice in which my own creative agency blended with that of others—both human and non- human. Examination of the larger, techno-ecological processes that exist and support the work—ranging from the biological aspects of compost and the composting process; designing/building the sensor apparatus; computer programming/sound/audio display design; to aestheticizing/re-aestheticizing compost for gallery/acoustic concert settings—has deepened my artistic and intellectual engagement with issues of environmental sustainability, process-based sound art and music composition, and the multivalent aspects of data sonification.

I close this discussion on art, technology, process and agency with a statement made by composer John Cage in reference to the art music of his time: We are living in a period in which many people have changed their minds about what the use of music is or could be for them. Something that doesn't speak or talk like a human being, that doesn't know its definition in the dictionary or its theory in schools, that expresses itself simply by the fact of its vibrations. People paying attention to vibratory activity, not in relation to a fixed ideal performance, but each time attentively to how it happens to be this time, not necessarily two times the same. A music that transports the listener to the moment where he is.[18]

While Cage refers to a new freedom he was agential in attaining for us in the realm of sound and music, data sonification's capacity to synergize art, technology and data as a multimodal experience also enables us to perceive data and sound in a new way—challenging us to engage in an uncharted form of analytical listening in the attempt to gain a new understanding of the world.

Ultimately, data sonification art can be seen as a collaborative, moldable vibration-based technology that clearly can be of aid to society. The opportunity to develop a public, gallery-based sonification research laboratory at major art venues challenges me in my role as an artist/educator to engage exhibition visitors/staff not only with the novel act of listening to compost temperature data, but also to inspire them to try the environmentally green practice in their own daily lives.

Home composting offers one practical method/solution for anyone who eats to actively do their part in reducing methane emissions, which in turn can have a concrete impact on climate change. Whereas the abstraction of the concept of "climate" and the size of the problem of global warming enables people to disengage personally from forming a sustainable solution at an environmentally crucial point in time, home composting offers a personal and small-scale solution toward achieving a sustainable lifestyle.

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18 - Cage. Writer: Previously Uncollected Pieces, 246-247.

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