Collision.
Ryoji Ikeda Meets Whitehead at CERN: Interdisciplinary Experimentation and Evental Aesthetics

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Abstract

Intermedia artist Ryoji Ikeda's 2014–15 residency at CERN, the European Organization for Nuclear Research, and its Large Hadron Collider (LHC) facility raises important issues for evental aesthetics, process thought, and the speculative traversing of the boundaries between art and microphysics. Ikeda has been interested in the sonification and visualization of data and mathematics for two decades, and his observation of the CERN LHC and the ATLAS detector, and his engagement with detector data inspired the creation of his large-scale *micro* | *macro* (*The Planck Universe*) video and sound installation in 2015. This Collision briefly explains some of Ikeda's motivations behind *The Planck Universe* while engaging with some of A. N. Whitehead's ideas about events as well as *event-particles* in the context of process thought. Does Ikeda use microparticle physics outcomes as part of his artistic and creative palette, or, conversely, does he engage with microphysics processes in his intermedial work only on the level of abstraction and through analogy and inspiration? Ikeda does both. Sound "grains," pulses, wavelets, sound quanta, the data visualization of particle clouds, and other evidence of dynamic microparticle interaction from detection data are part of Ikeda's intermedial palette in *The Planck Universe*. The detection data validate that *event-particles* do have microphysical form and a vital materiality.

Keywords

Media arts

Video

Sonification

Microphysics

Process thought

Introduction

Intermedia artist Ryoji Ikeda's one-year residency at the CERN Large Hadron Collider facility raises important issues for evental aesthetics, process thought, and the speculative traversing of the boundaries between art and microphysics. Considering the momentary and ephemeral nature of particle microphysics and its theories of quanta, Ikeda's work draws attention to notions of possibility, infinity, and materiality as also proposed by speculative materialism and related realist ontologies.[1] At CERN, Ikeda engaged and interacted with the science of microparticle collision experimentation, which precipitated in that same year the sound and video installation art, *The Planck Universe.* Does Ikeda use microparticle physics outcomes as part of his artistic and creative palette, or does he engage with microphysics in his intermedial work only on the level of abstraction and through analogy and inspiration? Ikeda does both. This paper exposits some of Ikeda's motivations behind *The Planck Universe* while engaging with some of A. N. Whitehead's ideas about events, and *event-particles* in the context of process thought. It argues that Whitehead's microphysics-influenced ideas about process, realization, creativity, and aesthetics provide context to Ikeda's artistic motivations.

Theoretical Context: Whitehead's Thought and Quantum Mechanics

After a long period of oversight, Whitehead's process thought has returned to the discipline of the philosophy of science and critical theory venues in the English-speaking world. Strongly influenced by twentieth-century developments in quantum physics and mathematics, Whitehead's thought also places emphases on aesthetics as creative action as well as on the continuum of processes of creativity in anticipation of the conceptual arts.[2]

Any discussion of the foundations of Whitehead's process philosophy must focus on his key text, *Process and Reality*, where he lays out the central principles of his theory. Whitehead is refreshing in the way he views subjectivity as a process embedded in the world and an irreducible part of the universe, as opposed to a simple effect of language. Whitehead writes in *Process and Reality* about the discrete yet interconnected forms that contain their own autonomous qualitative patterning derived through process, simplification, and repetition.[3]

For Whitehead, speculative reason is not a function of static ideas, but involves processes of valuation and the fuzzy logic of a quasi-formal mathematics that creates novel constructions. Aesthetic qualities are never located solely in either mind or matter; instead, colors, sounds, scents, tastes, and tactile sensations are pervasive qualities that are situationally located in contextual events and relational arenas. For Whitehead, the *primary qualities* of aesthetics should not be distinguished from *secondary qualities*, such as sight and sound. Aesthetic qualities include measurable properties in physics, such as extension, mass, weight, and velocity, as well as the microparticle qualities of sound quanta and "vibrating electromagnetic fields," such as frequency, resolution, duration, amplitude, and spatial position.[4] Pervasive qualities are consequently diffused throughout the field of environment interactions that would include, for example, the experimental chambers of the Large Hadron Collider (LHC) at CERN.

As early as 1920, Whitehead also proposed the term "event-particle" to describe the momentary, event-like character of microphysical entities in perpetual flux and decay, a premise that Erwin Schrödinger also proposed in 1928 in agreement with quantum mechanics.[5] In Whitehead's aesthetics, the measures and senses, both qualitative and quantitative, emerge from, and are symptomatic of, the processes of actualization and self-realization. Aesthetic values derive from collisions and contrasts surrounding the qualities of entities under conditions of deep intensity and relevance.[6] All determinations regarding the potentials of the universe are resolved in this way: through an 'aesthetics of valuation.'

Whitehead's ideas about self-construction of entities are at the root of his notions of process, endurance, flux, and impermanence. This includes the adjoining and overlapping phases in process of *transition* and *concrescence*, terms that Whitehead employs and redefines repeatedly in *Process and Reality*. These phases are also significant in the workings of the aesthetics of valuation in the construction of the subjective form through the contrast of antecedent and often incompatible objects. As Judith Jones says in her interpretation of this idea, "[t]he natural world is known as a passage of permanences and recurrences knit across a flux of temporal passage."[7] In Part Five of *Process and Reality,* Whitehead discusses and reviews how nature is composed of a multiplicity of atomistic yet interconnected components and elements that are part of the creative process. *Concrescence,* as a genetic concept, is nothing other

than the process of internal constitution that happens at the instance of the actual event itself. Whitehead also borrows the term "two-species of process" from Locke and Hume, whom he suggests never completed their explanation of its workings and determination.[8] He dubs the two phases of the process of concrescence "macroscopic" and "microscopic." Macroscopic transitions move from existent to existent through temporal cycles of creation, change, impermanence and perishing, whereas the microscopic phase passes the single existent through the processes of valuation and attainment.[9]

The question arises whether Whitehead's term *event-particle* is more than just an analogy for a singularity, point of origination, or occurrence. The laws of quantum mechanics, and the notorious impermanence and instability of microphysical particles, render problematic any literal meaning of the *event-particle*, because if and when a dynamic microparticle is detected, the time displacement between emergence and detection requires that the perishing, or short-lived, particle has already altered, been eviscerated, or moved to another position in the chamber. This is evidence of Heisenberg's *uncertainty principle*, an ontological tenet of indeterminacy concerning the position and momentum of electrons, fermions, and other microparticles. Following the rules of quantum mechanics, many CERN experiments have observed that the corresponding operators do not commute, so it should not be possible to know the values of both position and momentum of a microparticle with accuracy, and the increasing accuracy of one value, i.e., its position or momentum, leads to a reciprocal decrease in the other value.[10]

Significantly, quantum theory also posits the complementarity of particles and waves, and so the uncertainty principle necessitates that the phase relations between two sets of waves that are out of step with each other and any possible intermediate state between the two phases can be expressed formally as an amplitude probability, a complex number, or an eigenvalue. Initially, in the 1920s, Arthur Compton provided a quantitative explanation of his observations that electromagnetic radiation carried a particle-like quality, or consisted of quanta, the counterintuitive mixing of states.[11] Louis de Broglie's 1924 doctoral dissertation provided the rudiments of how to translate a stream of particles to waves, asserting that the quantity of persistent motion possessed by a particle is analogously

related to wavelength, using Planck's universal constant as the measure of proportionality.[12]

Under the impact of relativity theory and the theory of quanta, this notion is also expressed metaphysically by Whitehead as the "*fallacy of simple location,"* a correction to Newtonian physics in the form of a premise that an isolated entity is nothing but an artificial abstraction that prevents us from recognizing that each concrete event is inseparable from its context. To ignore the link between particles and their surrounding forces is a basic fallacy of the atomistic thinking of the past.[13] In microphysical worlds, there are few fundamental particles that are everlasting in the Lucretian sense, and even the most stable of protons have momentary and ephemeral lives.

The infinite diversity and impermanence of microparticles captured the imagination of Ikeda and his team after his residency at CERN. Sound "grains", pulses, wavelets, and other sound quanta, as well as particle clouds, condensates, and other evidence of dynamic microparticle interaction from detection data, are part of Ikeda's intermedial palette in *The Planck Universe*. Ikeda's engagement with the LHC and its ATLAS detector at CERN also expresses the fact that *event-particles* have microphysical form and a vital materiality.

Process Aesthetics and Sonification

Ryoji Ikeda and Tomonaga Tokuyama have a history of engaging with sonification and corresponding visualization processes deriving from non-audio data. In the construction of video and soundscapes, they engage the processes of sonification developed in the 1990s by Bob Sturm, and also build on some of the experimental music and methods of John Cage, Iannis Xenakis, Gottfried Michael Koenig, Herbert Brün, and Karlheinz Stockhausen from the 1970s and 1980s. Ikeda creates discernible examples of process art by manipulating sound on the level of microparticles. Ikeda's procedures mesh well with Whitehead's event-driven 'valuative' aesthetics of process, simplification, reduction and repetition.

The *process* and *anti-form* artists, influenced by Cage, incorporate chance operations and impermanence into their art. They have taken a radical deviation from mid-twentieth-century modern art in the use of ephemeral and perishable materials to create unpredictable and mutable

results. In a Whiteheadian manner, Robert Smithson and others embraced art in flux and transience as an expression of its performativity and immateriality. Certainly, the trend toward minimalism and the simplification of form in the arts can be traced as an uneven, discontinuous genealogy that creates the conditions for the transformation of the arts, rather than an "endgame" for some arts, such as painting.[14] More implicitly, nonrelational color field painting of the last three decades exhibits as a strategy a simple, neutral mathematics to create an immutable, nonhierarchical organization of form that defies conventional spatial and temporal orderings and uses repetition to decrease the disparity of elements, while the modernist notions of subjective gesture and motif are de-emphasized.[15] Art historian Hal Foster also observes a trend in the arts toward using the mind rather than the senses to understand art, a direction toward event-driven, process arts, and toward a non-perceptual appreciation of the arts.[16] As with the Copernican turn in metaphysics toward an appreciation of the active contribution of the mind interpreting our perceptions, the shift to conceptual art involves a movement away from evaluating art primarily through the senses, or based solely on its material base, and toward art in which ideas and concepts are paramount.[17] Nonetheless, this observed shift in no way undermines the relevance of Whitehead's event-driven, process aesthetics that is both temporal and valuative, and which posits that the concrete event is interpretable only in its context.

The concept and usage of *process* are emblematic of the composition and analysis of experimental music and video art. Process is both produced and expressed through the generative and permutational patterns that permeate creative practice. Whitehead's thought is greatly concerned with the processual nature of reality, its temporal endurance, the repetition of changes in both natural and artificial patterns and forms, and the observed similarities among temporally discrete experiences. These parametric values are pertinent to considerations of sonification and visualization of data. For Whitehead, speculative reason is not a function of static ideas, but involves the fuzzy logic that creates novel constructions.

Sonification and granulation are two non-identical but related techniques used to create microsound, experimental music, and sound-image unit correlations. Sonification is a process that maps and translates data into sound in a systematic way so as to reveal information or to

control aspects and features of the original data. Although it may be a complementary tool to classical analytical methods in sound, e.g., spectral, multivariate, or Fourier analysis, the source data does not need to be auditory at all. Complementarily, microsound is a broad term for the process of building larger sound waves from sound particles, or small wavelets called "grains," infinitesimal units of sound. Sound granulation, or granular synthesis, is the process of sampling and creating units of sound on the level of a micro time scale, and subsequently setting parameters to build up larger sound objects at macro time-scales.[18]

Granulation since the 1970s has mostly relied on sampling an existing sound, synthesis techniques with synthetic waveforms, and transformation with other particle-based operations.[19] Sound grains, also called sound particles, can have an arbitrary size, and each may comprise a unique identity in terms of frequency, waveform, duration, amplitude, and spatial position.[20] They may function as singularities, or accrue greater timbral significance in larger chains of sequences, clusters, and clouds. For example, Gottfried Michael Koenig's experiments in the 1980s permitted the adjustment and modulation of the tone color of the cloud texture through changes in waveform and grain frequency. Composer Curtis Roads draws attention to computer techniques in the "disintegration and coalescence" of sound textures that are dependent on the particle density of the material. Contemporary sonographic synthesis techniques, such as software airbrush tools, allow composers to "spray sound particles on a time-frequency canvas," or over a sonic spectrum. The composer can then apply displacement maps to warp the shape of sound clouds, creating different kinds of results.[21]

Bob Sturm, composer and scientist, has been pivotal in developing abstract models that map actual particle wave phenomena from quantum mechanical systems to particle-based sound waves based on an analogy of particles and sonification processes. Following De Broglie's (1924) equations, Sturm developed an algorithm that maps microparticles and corresponding matter-waves in motion inside a three-dimensional space in terms of energy, amplitude, and position, and which then converts those properties to parameters that modulate sinusoidal waveforms.[22] If the energy of a particle is sinusoidally varied at high enough rates, frequency modulation synthesis of sound will occur, and visceral and tangible waveforms take shape. Sturm concludes that

musical material can be derived from particles interacting with fields of force, the quantum motion of particles acting within soundwaves.[23]

Ikeda's technique in the creation of *Plank Universe* also involves a one-to-one mapping of particle appearances from the LHC/ATLAS detector's time projection chamber to spatialized audio in a sound environment that accepts raw data similar to Mac OSC data. A data plot exhibiting evidence of the Higgs boson could be an example of such detection data, and real-time particle collision data, or reconstructions of that data, could provide a source for the sonification process. A binary stream of data is mapped in a two-dimensional matrix, and each binary matrix is then numbered. Initially, the detection data, in the form of binary code, is mapped to short micro pulses, clicks, or wavelets, and each elementary waveform represents a single parameter of a discrete data event. A transfer function, or mapping function, translates sets of data features from the data domain to sound synthesis parameters in the auditory domain. The corresponding wavelets and sigmoidal pulses for each binary matrix are also mapped and articulated on a two-dimensional grayscale graph that takes the form of a continuous data stream sonification: square waves and pulse waves that are also used as visual elements on the *micro* | *macro* multichannel video screens. Employing qualitative perceptual effects and aesthetic criteria in the sonification process, Ikeda and his team build rhythmics, frequencies, harmonics, counterpoint, and macro-musical structures into their sound compositions.[24]

Ikeda and Tokuyama have worked together on several sound and video installations during the last decade that employ event-driven processes to build waveforms, visual correspondences, and compositions from elementary microsound and sampled data. Ikeda's residency at CERN provided him the opportunity to expand his sonification processes to generate quasi-musical sequences from the most elementary microparticles in the universe through access to LHC/ATLAS detection data.

Ikeda at CERN

Ikeda's residency at CERN near Geneva in 2014–15 was an important digression from his previous principle directions and interests in the visualization and sonification of data and mathematics. His observation of

the CERN Large Hadron Collider (LHC) and the ATLAS detector, and his engagement with detector data inspired the creation of his monumental *micro | macro* (*The Planck Universe*) video and sound installation that same year. It was commissioned by and produced in cooperation with ZKM | Center for Art and Media Karlsruhe. Peter Weibel and Ikeda himself curated the exhibit at ZKM, which consists of three DLP video projection systems, computers, and an audio surround system. Norimichi Hirakawa and Tomonaga Tokuyama led a small team of computer graphics programmers and artists, who designed and edited the visual elements. The installation traveled to the Vienna Festival and the Carriageworks multi-arts center in Sydney during the spring and summer of 2018.[25]

Ikeda's experience with the LHC followed his interest and training in infinitesimal mathematics, high performance computing, and number theory, and included his encounter with the mathematics of quantum probabilities surrounding dynamic microparticle collisions and their behavior.[26] The LHC's 17-mile apparatus is centered on its accelerator ring of large superconducting electromagnets that are maintained at -271.3°C (1.9K), a temperature colder than outer space. Below a certain temperature, some materials enter a superconducting state and offer no resistance to the passage of electrical current. In the LHC, it is now possible to tune a beam of electrons and positrons for collisions, and to recycle and redistribute most of the energy released from interaction. In one significant experiment at CERN in 1983, collisions between protons and antiprotons, with masses two thousand times that of an electron, led to the discovery of the W and Z bosons of the unified weak forces. Inside the LHC, two particle beams collide at close to the speed of light within ultrahigh vacuums.[27]

The Planck Universe

Ikeda's multiscreen installation *The Planck Universe* explores the universe on the Planck scale, or in other words, contrasts the physical properties of subatomic particles on a microscale with the physical characteristics of cosmological and astrological phenomena on an infinite macroscale. Abstract visualizations of quanta are projected on the floor, and cosmological phenomena and data overflows appear simultaneously on the upright screen, at a 90-degree angle to the floor. Ikeda pushes the experience of the vastness of both worlds, and the sense of awe it inspires in audiences. He identifies physical, mathematical, and quantum-

mechanical things as elements of his palette, so in a sense these creative elements are both minimalist in terms of simplicity, form, and size, and maximalist regarding aspects of velocity, momentum, and numerical quantity.[28]

The screens in *Plank Universe* are projected in tandem. In particular, the two screen projections for the *micro* | *macro* segment are edited and choreographed for synchronicity. Video on the upright screen includes cosmic rays, solar flares, neutrino activity and other cosmological phenomena. The video projection on the floor includes spectral analyses and other measurements of quanta, simulations of particle fields and collisions on curved surfaces, mundane bar codes, streams of square wave and pulse waves data from the sonification process, computational data streams, quantum chromodynamic measurements of fields of quarks and gluons, and other types of particle clouds and condensates detected by experimental dispersive light refraction techniques.[29] From this disconnected data, visualization emerges as an effluent poetic abstraction.[30] However, the raw material for the corresponding sound composition was generated by sonification techniques and detector data (dynamic microparticle interaction) from inside the LHC accelerator.[31] Ikeda and Tokuyama have also collaborated on several sound art installations, performances, and recordings during the past two decades that draw on the algorithmic manipulation of sound grains on the level of microparticles.[32]

Conclusion: Expressing the Microphysical, Infinitesimal, and Mathematical in *The Planck Universe*

Ikeda has long expressed an interest in infinitesimal mathematics and a perfectly ordered, quantitative infinity. Microphysical and quantum-mathematical phenomena are elements in his intermedia compositions, as is particularly evidenced by his *The Planck Universe*. Ikeda's intermedial work is a recognition of the formal structure of a mathematical object, or an "eventual" appreciation of how mathematical form adapts itself to useful apprehension.[33] In Whitehead's terms, as opposed to Kantian epistemological bases, this event is where judgment is eclipsed by aesthetic pleasure as a proposition of potentiality, and is an exploration of the conditions of possibility as disclosed in an appreciation of the content and form. Whitehead's notion of aesthetic attainment, pertaining to the intensity of experience and the affective tone of the object, is interwoven

in the texture of self-construction through which objects become actualized in time. Therefore, it is a short conceptual jump to suggest that Ikeda's objects are an indirect reflection and expression of Whitehead's valuative aesthetics and process thought.[34]

The observer experience of *The Planck Universe* and its sense of infinity is relentlessly unstable and transitory. So, naturally, no two members of Ikeda's audience perceive the multisensory overload in an identical way, even from an identical location in the room. The streams of quantum objects, cosmic exuberances, light, and data points in motion are the balanced articulations of patterns in everchanging galactic phenomena, direct sonification of intermittent detector data, and visualizations of microparticle worlds. Microparticles are so ephemeral that detection is often near impossible. Yet, the continuous detection of these *event-particles* does provide evidence of their vibrant, dynamic materiality.[35]

Quantum mechanics postulates that two discrete electrons cannot be in the same place at the same time while in motion.[36] *The Planck Universe* expresses this in its perpetual state of alteration and excitation of the senses, the quantum mixture of possibilities, and the uncertainty of a fixed state. Birkhoff and van Neumann attempted to formalize the three-valued quantum logic in 1936 by including a third "fuzzy state," or the state of superposition, which results in the multiplication of possible states. [37] The fuzzy-logical augmentation of Boolean algebra encompasses the properties of polyvalence, ambivalence, vagueness, and indeterminate choice. As Milic Capek remarks, "[t]he idea of a sharp-edged quantity loses its meaning on the microphysical level … the deeper meaning of the (Heisenberg) indeterminacy principle consists in the fact that our instantaneous snapshots of nature result always in fuzzy pictures."[38] Ikeda's *The Planck Universe* expresses, visually and sonically and in macro terms, the quantum-chaotic motion associated with algorithms with fuzzy logical applications. Different strategies may be performed at different times during varying sets of iterations, or under different weights, or rates; and random generators allow for the selection of random behavior event streams.[39] With quantum logic as another element in his palette, Ikeda presents only a single rendition and merely a small fragment of the potentially inexhaustible microparticle phenomena. The possibilities for future configurations are limitless.

Notes

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2 Steven Shaviro, *Without Criteria: Kant, Whitehead, Deleuze, and Aesthetics* (Cambridge, MA: MIT Press, 2012).

3 Alfred North Whitehead, *Process and Reality* (New York: The Free Press, 1978), 229. See also Judith Jones, *Intensity: An Essay on Whiteheadian Ontology* (Nashville: Vanderbilt University Press, 1998), 14.

4 Whitehead, *The Concept of Nature* (Cambridge: Cambridge University Press, 2015), 146.

5 Erwin Schrödinger, *Collected Papers on Wave Mechanics* (London: Blackie and Son, Ltd., 1928).

6 Whitehead, *Process and Reality*, 112.

7 Jones, *Intensity*, 21.

8 Whitehead, *Process and Reality*, 210.

9 Ibid.

10 James Gillies, *CERN and the Higgs Boson: The Global Quest for the Building Blocks of Reality.* (London: Icon Books, 2018).

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12 Louis de Broglie, "Recherches sur la Théorie des Quanta" (PhD diss., Université de Paris, 1924).

13 Milic Capek, *Bergson and Modern Physics* (Dordrecht, NL: Reidel Publishing, 1971), 231, 309.

14 Yves Alain-Bois, "Painting the Task of Mourning," in *Endgame*, ed. David Joselit and Elizabeth Sussman (Boston, MA: MIT Press and Institute of Contemporary Art, 1987), 43–47.

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20 Ibid., 28.

21 Ibid., 16.

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23 Ibid.

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25 ZKM Karlsruhe. "Ryoji Ikeda: *micro* | *macro*." ZKM Collections and Archives, 2019. https://zkm.de/en/publication/ryoji-ikeda-micro-macro.

26 "Ryoji Ikeda: The Transfinite, House Program," Park Avenue Armory and Forma, 2011, http://www.armoryonpark.org/downloads/Ryoji_Ikeda_House_Program.pdf.

27 Victor Barger, *Collider Physics* (Redwood City, CA: Westview Press, 1997).

28 John McDonald, "Review: Ryoji Ikeda's micro | macro," *The Sydney Morning Herald*, July 13, 2018.

29 "Ryoji Ikeda: *micro* | *macro*," ZKM Collections and Archives, 2019.

30 Ryoji Ikeda Studio, "Ryoji Ikeda: The Planck Universe, June 21–August 9, 2015, ZKM, Karlsruhe, DE," Vimeo video, 9:15, September 1, 2015, https://vimeo.com/134050005.

31 Ewan Hill and Juliana Cherston, "ATLAS Data Sonification: A New Interface for Musical Expression and Public Interaction." *Proceedings in Science* 5 (2016): 1–4.

32 Ryoji Ikeda, *Dataphonics*, 1.

33 "Ryoji Ikeda: The Transfinite," 2011, 1–3.

34 Whitehead, *Process and Reality*, 18–30, 208–15,

35 Juliana Cherston and Ewan Hill, "Sonification Platform for Interaction with Real-Time Particle Collision Data from the ATLAS Detector," in *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. (New York: ACM Digital Archives, 2016), 1647–53.

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