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**“Deep Listening” redux: Early Computational Composition and Its Influence on Algorithmic Aesthetics**

Google engineer Alexander Mordvintsev’s computer vision program DeepDream is known for its uncanny, often nightmare-inducing hallucinogenic aesthetic. Once used to synthesize visual textures, the program popularized the concept of neural network training through image classification algorithms, inspiring visual art interrogating machine learning and the training of proprietary prediction algorithms; though DeepDream has facilitated the production of many mundane examples of surreal computer art, it has also helped to produce some conceptually rich visual investigations, including computational artist Memo Akten’s multi-channel series of films We Are All Connected, and MacArthur Fellow Trevor Paglen’s exhibition *A Study of Invisible Images*. While the significance of trained neural networks is presently considered valuable to computer vision experimentation, a medial archeological investigation of machine learning reveals the fundamental influence early *sonic* experiments in computational music have in its computational and conceptual framework. Early computational music works, such as Lejaren Hiller Jr. and Leonard Isaacson’s *Illiac Suite* (1957), the first score composed by a computer, as well as Hiller and John Cage’s ambitious multimedia performance *HPSCHD* (1969), used stochastic models to automate game-like processes, such as Giovanni Pierluigi da Palestrina’s Renaissance-era polyphonic instruction, as well as the *I Ching* divination process of casting coins or yarrow stalks. Hiller's concerns regarding the historical use of compositional/mathematical gameplay uncovers a conceptual and performative emphasis anticipating the “training” of visual models. Through the adverse reactions of audiences to Hiller’s compositions, written by what the press deemed derogatorily “An electronic brain” in 1957 parallel public reactions to the disturbing mutations of DeepDream, popular participation in the open-source project signals a growing willingness to collaborate creatively with computers to interrogate both computational and cognitive processes.

INTRODUCTION

[FIG 1] In 1988, experimental composer Pauline Oliveros descended 14 feet into the Dan Harpole underground cistern in Port Townsend, Washington, to make a recording.[[1]](#footnote-1) From this experience, Oliveros coined the punny term "deep listening," which would eventually develop into what she described as “an aesthetic based upon principles of improvisation, electronic music, ritual, teaching and meditation.”[[2]](#footnote-2) In a 1998 keynote address, Oliveros further explained:

Forty-five years later I am still doing this meditation as the core of a practice that I call Deep Listening. Sustained listening is quite a task. Though hearing if ears are healthy is a continuous physical phenomenon and happens involuntarily when sound waves enter the ears, listening is intermittent and has to be cultivated voluntarily in its many forms. Though it may be surprising many unenlightened musicians are hearing but not necessarily listening when they perform or compose—at least not to the sound of the music. Listening is processing what we hear—for meaning, understanding and direction or action.[[3]](#footnote-3)

[FIG 2: Dan Harpole cistern music]

Oliveros’ often repeated quote, “Can you imagine listening beyond the edge of your own imagination?” challenges the “deep listener” to shed preconceived notions of the onion-skinned layers of music, sound, and experience and stop passively *hearing*, and start actively *listening*.[[4]](#footnote-4) In Mark Swed’s August 5, 2020 *LA Times* obituary for Oliveros, he noted fondly that she had once told him, “Ear training is nonsense… You can’t train the ear. It can only hear. The brain listens.”[[5]](#footnote-5)

In contrast to “deep listening,” challenging our *visual* imagination is a common and expected occurrence in our “digitally-enhanced” lives: [FIG 3] consider lossy .jpg compression artifacts, the frozen frames of digital streaming services, video game glitches, and moiré patterns and aliasing effects resulting from low-resolution digital scanning. These moments of digital “brokenness” takes us out of flow—one may recall the Heideggerian process by which a tool such as a hammer becomes “present-at-hand,” an object of observation and theorization, when it is broken and no longer serves its intended purpose.[[6]](#footnote-6) Despite our frustration, it’s hard to deny the uncanny, seductive qualities of these digital “mistakes.” More recently, the processed images constructed by trained, image classification neural networks that represent “computer vision” highlight the gulf between biological and mechanical vision; [FIG 4] for example, the deliberate over-processed computer vision images from DeepDream, created by Google engineer Alexander Mordvintsev, produced an international stir on social media with the open source availability of its uncanny, psychobilic aesthetic. When we see these images, we understand them as “post-digital”: the markers of digitality—pixilation, aliasing, clipping—are readily understood as computational aftereffects, produced by systems failing to replicate biological modes of vision. [FIG 5] But rather than reject these images, they have been the subject of fascination by artists—for example, Memo Akten’s Donald Trump and right-wing politician mashups, part of his “Learning to See” series.[[7]](#footnote-7)

However, this primacy of computer vision neglects its sonic precursors, which includes such landmark moments as Pauline Oliveros’ “deep listening,” and the complex of historical computational musicians and composers who inspired, and are inspired by, her practice. A reexamination of the institutional, algorithmic research in computational music composition during the 1950s and 60s reveals a compelling conceptual pretext to contemporary machine learning experimentation.[[8]](#footnote-8) These early stochastic music compositions, painstakingly programmed on supercomputers ill-fitted for musical experimentation, were the result of two converging post-World War II phenomena: the first involved the sudden exuberance toward interdisciplinary art and technology experiments, an aftereffect of wartime scientific guilt. Many of these collaborations were the result of the interdisciplinary nature of computing centers within research institutions before the onset of recent disciplinary rigidity.

The second postwar phenomenon affecting machine learning’s sonic pre-history involved sheer computational limitations: as post-war computers lacked the means to process or store vast quantities of data, speculative arts research in transcribing music for predictive analysis provided one of the few opportunities to craft algorithms pre-dating the training models of machine learning. [FIG 6] Lejaren A. Hiller Jr. and Leonard Isaacson’s 1957 composition *The* *Illiac Suite*, often credited as the first score composed by a computer, was the first of a series of early experimental compositions aimed at exploring music history through computational predictive analysis. Assisted by Isaacson, Hiller developed stochastic models—or, randomly determined probability models—with a conceptual and performative emphasis that investigated computational and human sensory limitations.

Admittedly, the exact technological process relationship between the Markov Chain Monte Carlo stochastic methods of Hiller and those who came after him—composers such as Iannis Xianakis and Pauline Oliveros—and the recursive neural networks like DeepDream is thin at best. However, the conceptual practice of statistical prediction borne from the Manhattan Project and subsequent computational automation methods signal a shift in understanding systems networks, and a much deeper, popular acceptance of cybernetics, artificial intelligence, and the dematerialization of information more generally. A media art historical survey of the development of these technological processes reveals a fundamental shift in conceiving data transformation, representation, and prediction in image and audio consumption. [FIG 7] These present post-digital experiments—from DeepDream image processing to the techno-punk aesthetics of the Glitchcore and Hyperpop genres of Soundcloud/Snapchat/Tiktok music—push the boundaries of what constitutes a comprehendible "image" or "song." Though the resulting aesthetics trend toward chaos, psychedelia, and nightmare, each rely on internal logic and adherence to—and taking advantage of—the digital processes that automate their production. The resulting aesthetics tests the limitations of both computer processing and the human sensorium; anticipating contemporary visual and sonic experiments that exploit these limitations to ascertain the fluctuations in the gulf between computational “learning” and human intelligence, and what we gain or sacrifice in narrowing that gap.

MARKOV CHAIN MONTE CARLO: NASCENT MACHINE LEARNING

Even though the history of computing is one built largely out of wartime necessity, there are moments of idleness, play, and creativity that gave rise to crucial ideas that fundamentally shape how we engage with current computational technologies. It follows, then, that the nature of processes as they relate to machine learning problems become paramount, rather than a simple list of results. [FIG 8] For instance, computer scientist Tom Mitchell’s definition of machine learning concerns operation and performance rather than concepts of “thinking” or “learning”; he transforms Alan Turing's proposal in “Can machines think?” to “Can machines do what we (as thinking entities) can do?”[[9]](#footnote-9) As explained by statistical scientists Christian Robert and George Casella, "we see how the development of this methodology has not only changed our solutions to problems, but has changed the way we think about problems."[[10]](#footnote-10)

This shift in emphasis—from problem to process—is particularly relevant to the development of the statistical analysis methods responsible for the development of the computational models responsible for much of the digital revolution. [FIG 9] In 1946, mathematician Stanislaw Ulam was convalescing, having fallen ill during his tenure at Los Alamos, New Mexico, as part of the Manhattan Project: the United States’ research and development undertaking during World War II that produced the first nuclear weapons. Confined to a hospital bed, he took up hours of Canfield solitaire, idly flipping cards, shuffling, dealing and re-dealing to himself. It occurred to him: how would one compute the chances of the classic Canfield 52 cards solitaire configuration come out successfully? [[11]](#footnote-11) He traded the deck for a pencil and paper, first attempting exhaustive combinatorial calculations. Finally, he decided to go for the more practical approach: he laid out several solitaires at random, and then observed and counted the number of successful plays. This idea of selecting a statistical sample to approximate a hard combinatorial problem by a much simpler problem is at the heart of modern Monte Carlo simulation. Ulam recalled the resultant method:

… I wondered whether a more practical method than ‘abstract thinking’ might not be to lay it out say one hundred times and simply observe and count the number of successful plays. This was already possible to envisage with the beginning of the new era of fast computers, and I immediately thought of problems of neutron diffusion and other questions of mathematical physics, and more generally how to change processes described by certain differential equations into an equivalent form interpretable as a succession of random operations.[[12]](#footnote-12)

The “Monte Carlo” name was a bit of an inside joke; it harkened back to Ulam’s solitaire obsession, apparently a family trait well-known amongst his coworkers. Nicholas Metropolis, his colleague at Los Alamos, later claimed:

The spirit of this method was consistent with Stan's interest in random processes–from the simple to the sublime. He relaxed playing solitaire; he was stimulated by playing poker; he would cite the times he drove into a filled parking lot at the same moment someone was accommodatingly leaving. More seriously, he created the concept of "lucky numbers," whose distribution was much like that of prime numbers; he was intrigued by the theory of branching processes and contributed much to its development, including its application during the war to neutron multiplication in fission devices. For a long time his collection of research interests included pattern development in two-dimensional games played according to very simple rules… It was at that time that I suggested an obvious name for the statistical method-a suggestion not unrelated to the fact that Stan had an uncle who would borrow money from relatives because he "just had to go to Monte Carlo." The name seems to have endured.[[13]](#footnote-13)

Metropolis paints a striking picture of Stanley Ulam. Snapshots of him during this era—scarf thrown over his shoulder, smiling broadly—do nothing to dispel the notion that he was a bright, playful individual with a quick mind and a penchant for games of chance.

At Metropolis’ urging, Ulam discussed this technique with mathematician and Los Alamos consultant John von Neumann. Though Von Neumann did not cut as eccentric a figure as Ulam, by all accounts his very presence was still extraordinary. He was a child prodigy of noble Hungarian extraction; he was never seen publicly in anything less than a three-piece suit. Like Ulam, he also had a penchant for a certain mode of play; friends recounted how Von Neumann was able to memorize telephone directories. He would entertain his friends by asking them to call out random page numbers, and he would then recite the names, addresses, and numbers.[[14]](#footnote-14) He was a man absolutely obsessed with numbers and their applications. In 1946, von Neumann was serving as a consultant to the Manhattan Project, taking frequent train trips to Los Alamos from his position at the Institute for Advanced Study at Princeton, New Jersey. There, he ENIAC, the Electronic Numerical Integrator and Computer, the first programmable, electronic, general-purpose digital computer.[[15]](#footnote-15)

Los Alamos subsequently became so involved with ENIAC that the first test problem run consisted of computations for the hydrogen bomb. The input/output for this test was one million cards. Von Neumann *et. al* recognized that the strength of the Markov chain Monte Carlo method—MCMC for short—was its ability to construct models based on a sampling from a probability distribution; in cases where there are hundreds or thousands of unknown parameters, MCMC could allow for digital computation of large hierarchical models that may be adapted over time. Despite von Neumann’s excitement regarding its usefulness, the realization that MCMC and its various subset methods could be used in a wide variety of situations came over forty years later, as recounted by Robert and Casella:

In the 1982 edition of the *Encyclopedia of Statistical Sciences*, there was no entry for “Metropolis-Hastings algorithm,” “Metropolis,” “Hastings,” or “Markov chain Monte Carlo” (Kotz and Johnson 1982)… J. M. Hammersley and D. C. Handscomb, in their 1964 book Monte Carlo Methods, mentioned the Metropolis method, but they seemingly fail to grasp its great potential. They listed it as a method of solving “problems in equilibrium statistical mechanics”… [and] not as a general way to simulate observations from virtually any distribution.[[16]](#footnote-16)

The relative obscurity of MCMC is thought to be largely due to lack of the computing machinery that made advancements in statistical analysis and machine learning possible. Though MCMC necessitated larger data sets and more computing power than was readily available at the time for data analysis, there was one discipline with abundant mathematical notation data with rigorously plotted methods: music composition.

THE ILLIAC SUITE AND AI

[FIG 10] In the evening of August 9th, 1956, University of Illinois Chemistry Department researchers Lejaren A. Hiller Jr. and Leonard Isaacson debuted the first three movements of the *Illiac Suite: String Quartet No 4* in the Woodward Lounge of the Illini Union [FIG 11]. Though scant documentation of the premiere still exists, secondary sources—for example, the following day’s United Press news release [FIG 12]—describes its “resentful” crowd; the release declares that the *Suite*, “COMPOSED BY AN ELECTRONIC BRAIN” and only “*SPONSORED* BY L.A. HILLER, A CHEMIST-COMPOSER, AND L. M. ISAACSON, A RESEARCH ASSOCIATE,” left the self-described “MUSIC LOVER” in a glum state, lamenting it as a death knell for human creativity.[[17]](#footnote-17) Though Hiller later dismissed the hyperbole as “rather silly,”[[18]](#footnote-18) the *Suite*’s implementation of algorithmic rules describing the history of composition was overshadowed by its novel AI research performed on its namesake, the Illinois Automatic Computer (or, ILLIAC), the first high-speed supercomputing center in a university [FIG 13].

Hiller described the *Suite*—what he called “a bootleg job at night” during his days employed as a researcher in the University of Illinois Chemistry Department—as an exploration of how information theory could be meaningfully applied to music composition.[[19]](#footnote-19) Though his methods paralleled that of others working in the nascent field of AI, his work was largely overshadowed by the more high-profile experiments of dedicated researcher within the cognitive sciences and engineering fields. Foundational artificial intelligence research pioneered by Marvin Minsky and Terry Winogrand at the Massachusetts Institute of Technology (MIT), Arthur Samuel at IBM, Allen Newell, Herbert Simon, and Cliff Shaw at the RAND Corporation and Carnegie Mellon University (CMU) easily found its way into popular culture: Samuel’s experiments with checkers-playing computers (Samuel, 1959), Newell, Simon, and Shaw’s problem-solving *Logic Theorist* program (Newell and Simon, 1956), and Winogrand’s SHRDLU, a natural language understanding program (Winogrand, 1971) garnered both scientific accolades as well as attention from the popular press. Minsky, who also published widely about the philosophy of AI, served as an advisor for Stanley Kubrick’s *2001: A Space Odyssey*.[[20]](#footnote-20)

Hiller was more concerned with the importance of building a conceptual relationship between the content of the information and the method of generating musical scores. In later reflections on the nascent *Suite*, he claimed that he was disappointed by the acoustical analysis that led, in his estimation, to fairly banal and conceptually empty results; the *Suite* began as an attempt to translate statistical analysis to *aesthetic* analysis by applying systems theory to musical historiography.

Influenced by both the work of Warren Weaver as well as his time studying with composer Milton Babbitt at Princeton, Hiller focused on musical structural data to elevate the project from what he considered the banal mimicry he observed in present probability table experiments.[[21]](#footnote-21) His definition of information theory, analyzing the oscillation between “randomness” (or “chance”) and “redundant” (“organized”) data within an entropic system, preceded this compositional process:

[FIG 14] Information theory relates the “information content” of a sequence of symbols (be they letters of the alphabet or musical notes) to the number of possible choices among the symbols. Information content thus resembles entropy or the degree of disorder in a physical system. The most random sequence has the highest information content; the least random (or most redundant) has the lowest.[[22]](#footnote-22)

Rather than treating musical flourish as “noise” and rejecting this data as superfluous, Hiller’s stochastic approach preserved these details as behaviorally relevant and quantifiable. High information content allowing for randomness within the system—a capability only recently achieved through new advancements in probability theory and the use of a supercomputer—would not just allow for musical mimicry, but provide clues as to why aesthetic choices appear as they do throughout history:

The apparent paradox in this statement derives from the definition given the term ‘information’ in the theory. As Warren Weaver has observed, the term ‘relates not so much to what you *do* say as to what you *could* say’... The study of musical structures by information theory should open the way to a deeper understanding of the aesthetic basis of composition. We may be able to respond to Stravinsky’s injunction and cease ‘tormenting (the composer) with the *why* instead of seeking for itself the *how* and thus establish the reasons for his failure or success’.[[23]](#footnote-23)

Many later descriptions summarize the *Illiac Suite* programming process as an attempt to simplify music composition by automating decisions conventionally made by the composer. For example, composer Gerald Strang’s analysis of the *Suite* in the 1969 *Cybernetic Serendipity* exhibition catalog suggests the process was solely an intermediary phase as Hiller explored options in automating music composition; he describes the *Illiac Suite* solely as a first step toward Hiller’s most well-known contribution to computer music, the assistive compositional software/programming language MUSICOMP (MUsic SImulator-Interpreter for COMpositional Procedures).[[24]](#footnote-24)

However, Hiller’s *Illiac Suite* methodology was far more ambitious in its intent and conceptually rigorous in execution: by following Weaver’s insistence that information theory constituted the study of possibility, Hiller constructed probability tables derived from Renaissance and Classical models to contemporary serial compositions to aesthetically “train” each subsequent movement of the Suite. However, Hiller’s interpretive approach diverges most meaningfully from Mitchell's contemporary ML probabilistic model in its historical scope and intentionally limited scale; while contemporary machine learning applications often necessitate that researchers organize many, many more variables in probability distribution tables, Hiller’s more interpretive, experimental scope—attempting to translate statistical analysis to aesthetic analysis—involved a much more intimate and carefully-constructed, historically-contingent set of parameters within the Western classical musical canon.

THE 4 MOVEMENTS OF THE *ILLIAC* *SUITE*

The *Suite’s* movements corresponded to four experiments, each requiring new programs with increasingly complex screening rules exploring historical aesthetics. Hiller constructed the Suite to echo a historical progression from simple to complex melodies: the first mimicked Renaissance counterpoint rules, generating “simple” polyphonic melodies; the second produced four-voice segments within the confines of changing rules. Both the second and third experiments used a random chromatic method, expanding possible tonal values: within the selected interval, no repetition or obvious patterns would be reproduced. The employment of the random chromatic method was meant to explore what Hiller identified as the major aesthetic difference between 17th and 20th century musical styles.[[25]](#footnote-25)

For the third and fourth experiments, Hiller build his own stochastic process translating contemporary compositional rules to algorithmic systems that could represent the mounting complexity of serial compositions, particularly those explored by composer Arnold Schoenberg. Rather than rely on the more interpretive definition of “indeterminacy” espoused by his friend and future collaborator, John Cage, Hiller interpreted indeterminacy through adapting the MCMC methods he previously employed in chemical analysis research. This conceptual transformation of indeterminacy into a stochastic process—stringing randomly generated variables representing the present state to model how current changes affect future states—hinged on its ability to allow for *uncertainty*: the “stochastic” noise present in real-world examples, such as Hiller’s analysis of the structure of music compositions throughout time.[[26]](#footnote-26) This new set of randomly-generated variables disregarded any superfluous states, achieving “memorylessness.” Hiller and Isaacson generated integers sampled from a calculated probability distribution in the computer’s memory until the machine saved a “melody,” designated “complete” after reaching a predetermined numeric length. The melody was printed on perforated tape, then hand-transcribed into conventional musical notation [FIG 15]. In this way, the third and fourth experiments benefitted from MCMC memorylessness, mimicking contemporary compositions by eliminating probability favoring certain tones, automating Schoenberg’s 12-tone technique preventing precedence of any of the 12 notes of the chromatic scale [FIG 16]:

... the machine was first permitted to write entirely random chromatic music (including all sharps and flats)... With the minimal redundancy imposed by feeding in only four of the 14 screening instructions, the character of the composition changed drastically [from Experiment II]. While the wholly random sections resembled the more extreme efforts of avant garde modern composers, the later, more redundant portions recalled passages from, say, a [Bela] Bartok string quartet… The experiment concluded with some exploratory studies in Schonberg’s 12-tone technique and similar compositional devices.[[27]](#footnote-27)

[FIGS 17, 18, 19, 20, SOUND for ILLIAC SUITE]

ASPIRATIONAL ARTIFICIAL INTELLIGENCE

Florian Cramer explains how computer code existed centuries before the invention of the computer in magic and musical composition, analyzing Pythagorean musicology through an arithmetic method of ascertaining the music of the spheres.[[28]](#footnote-28) This kind of aspirational definition of mathematical musicology parallels machine learning researcher Zachary Lipton’s description of AI as an impossibly lofty goal, “... aspirational, a moving target based on those capabilities that humans possess but which machines do not.”[[29]](#footnote-29) While this definition hints at divining a kind of psychological code rather than Pythagoras’ cosmological one, Tom Mitchell’s assertion that ML seeks to “build computer systems that automatically improve with experience” by ascertaining the laws that “govern all learning processes” constitutes a more pragmatic version of divining the secrets of the human psyche instead of the cosmos.[[30]](#footnote-30) Comparisons between such historically and culturally embedded practices and performances such as 17th century counterpoint compositions, Schoenbergian 12-tone experimental music, and the Bayesian methods should not assume a direct material relationship. However, the depth and breadth of the Hiller’s interpretive data sets and probability tables provides insight into the construction of predictive systems not only later computational compositions, but many of the ML algorithms for predictive modelling so commonly used today.

CONCLUSION

The *Suite* is only the first of many stunning experiments in stochastic, computational music exploration; composers and theorists such as Pauline Oliveros and Iannis Xenakis have produced stunning, forceful experiments in sound generation, spatialization, and orchestration. However, despite the nearly logarithmic growth in computing power and access to enormous data sets, Hiller’s attempts to ascertain stylistic meaning within these music composition training methods find no easy musicological research parallels. Hiller’s interest in systems theory and the interrogation of “style” or “aesthetics” still hangs loosely in the air, begging the question of whether stylistic analysis remains too general or banal a notion to concern serious musicological study.

[FIG 23] In 2016, Sony CSL Research Laboratory produced the track “Daddy’s Car,” partially written by AI—the track’s harmonies and lyrics were composed by French musician Benoît Carré—in an attempt to recreate a Beatles-esque chart-topper. The track was produced using Flow Machines, an “augmented creativity” system that learns music styles from a huge database of songs by exploiting unique combinations of “style transfer, optimization and interaction techniques.”[[31]](#footnote-31) [FIG 24] Its GUI system uses patterned blob-like masses that shiver and pulse to differentiate between beat and lick “styles,” ready to be clicked-and-dragged for easy modular music composition. While Flow Machines may present a visually intriguing option for composing novices, its game-ified, pre-defined palettes mix metaphors of visual and sonic style, and greatly reduce the compositional results required by composers interested in the intricacies and complexities of algorithmic music composition offered by older, non-ML-specific real-time audio synthesis programs such as SuperCollider.[[32]](#footnote-32)

If Flow Machines is any indication, employing the machine learning methodologies we so readily use for data analysis in every aspect of contemporary living depends on a slavish adherence to past styles and genres; the mushy soundscapes attempting Beatles soundalikes are not essential listening, but rather an amusing footnote in digital music composition texts.

Hiller later reflected on the overall effect of the *Illiac Suite* in a *Scientific American* report, observing how the *Suite*’s “tonal” and “atonal” movements sounded similar despite their distinct algorithms; he acknowledged that the final movements were audibly indistinguishable from one another even though their computational processes greatly diverged. He proposed that its sound exceeded human perception, stating, “These correspondences suggest that if the structure of a composition exceeds a certain degree of complexity, it may overstep the perceptual capacities of the human ear and mind.”[[33]](#footnote-33) Though listening to the *Suite* proved challenging in its time, even infuriating to some, contemporary audiences of machine learning aesthetics have clearly developed an interest in mining the space between comprehension and complexity: [FIG 25] glitch and dirty new media aesthetics, the fluid animation of Vuk Ćosić’s ASCII characters, and the remixing/modding of internet iconography by artists such as JODI (Joan Heemskerk and Dirk Paesmans) provide a wealth of artistic models of how complexity and human/computing limitations can be exploited to explore the making and deterioration of meaning through technology. Furthermore, the listening experience of the *Illiac Suite* shares some relevant concerns with the “hyperreal” experience of music genres such as industrial, electronic dance, and currently, the social-media popularization of Hyperpop and Glitchcore.

As an introduction to Hyperpop, music critic Spencer Kornhaber describes his social media initiation to the genre:

On TikTok, I recently came across a series of videos in which teens compared how their parents wanted them to dress with how they actually wanted to dress. As preppy sweaters gave way to nose rings and black fishnets, the music flipped from a saccharine sing-along to a harsh digital pounding. The latter sound was like a car alarm outfitted with a subwoofer—but for some reason, it beckoned to be played louder, rather than to be shut off.[[34]](#footnote-34) [FIG 26]

No doubt Hyperpop has punk rock roots, but it’s specifically in its employment of technology to grind out dissonant, abrasive audio that sets its process apart from early genres. In his 2016 book, music critic Ben Ratliff argued that “blast beats” telegraphed the inevitability of a technological landscape of digital audio production as well as digital audio consumption: “They were like the sound of a defective or damaged compact disc in one of the early players, a bodiless slice of digital information on jammed repeat.”[[35]](#footnote-35)

In these cases, however, the hyperreal representations are readily—if not, in the case of Hyperpop, gleefully—flouted as a critique of the already hyperreal genres, doctored or curated images, and overly-produced audio they warp. If the increasing complexity of the Illiac Suite was testing the boundaries of the hyperreal, Hyperpop crashing through those boundaries with hyperactive giddiness. Contrast this with a particularly incisive visual example, MacArthur Genius Grant awardee Trevor Paglen’s installation “A Study of Invisible Images.”[FIG 27] Paglen uses computer vision methods to investigate “the collapsing distinctions between humans, machines and nature.”[[36]](#footnote-36) These images delve into AI suspicion, aligning with Jean Baudrillard’s critique of Hyperrealism and Simulation.

To contrast Hiller’s *Suite*, and subsequent *Computer Music*, as technophilic optimism would be trite at best. Curator Jasia Reichardt’s introduction to the 1968 *Cybernetic Serendipity* exhibition, in which the *Suite* was included, declares that the work included in the show “...deals with possibilities rather than achievements, and in this sense it is prematurely optimistic.”[[37]](#footnote-37) Arguably, this cautious optimism remained despite the embedded struggles these technologists and artists faced—they struggled with the limitations of their technology, the skepticism of both the art world and the more accepted research firms and science disciplines. Lejaren Hiller endured marginalization as a chemist accused of dabbling in music, despite his talent and training. It doesn’t seem like a coincidence that so many Hyperpop artists already self-identify as hybridized outsiders. Aside from the outsider status of the genre-bending, noise-filled cacophony of their compositions, a significant of Hyperpop artists identify as transgender or neuro-atypical.

[FIG 28] Throughout his life and subsequent computer music experiments, Hiller remained more focused on the possibilities computer composition presented as a tool for historical analysis and pedagogy, in the fields of both musicology and information theory, evidenced by his founding of the electro-acoustic research facility Experimental Music Studios (EMS) at the University of Illinois in 1958, and his later research in the groundbreaking music composition programming language MUSICOMP.[[38]](#footnote-38) [FIG 29] Though he called the *Suite* “rather fragmentary,”[[39]](#footnote-39) a re-examination of Hiller’s proto-machine learning compositional analysis methods reveals a rich historical precedent for post-digital art and music, presenting possibilities for contemporary scientists and musicians to critique aesthetic historical music stylistic conventions with the intent to adapt, and ultimately radically defy them.

1. Pauline Oliveros, "Deep Listening: Bridge To Collaboration" Key note address, ArtSci98 seeding collaboration symposium, April 4, 1998, Cooper Union, NYC. [↑](#footnote-ref-1)
2. Ibid. [↑](#footnote-ref-2)
3. Ibid. [↑](#footnote-ref-3)
4. Pauline Oliveros, “Imaginary Meditations, 1979,” in *Anthology of Text Scores* (New York: Deep Listening Publications, 2012), 51. [↑](#footnote-ref-4)
5. Mark Swed, “How gay feminist composer Pauline Oliveros taught us to hear with more than ears ,” LA Times, August 5th, 2020, accessed April 22, 2021, https://www.latimes.com/entertainment-arts/story/2020-08-05/how-to-listen-pauline-oliveros-deep-listening-composer. [↑](#footnote-ref-5)
6. (Ferris, 2003; Dourish, 1999; Dourish, 2001; Martin, 2012; Karlstrom, 2007; Tanenbaum, Antle and Bizzocchi, 2011). Fried, G. and Polt, R. (2014). Translators’ introduction to the second edition. In: Introduction to metaphysics, 2nd ed., by Martin Heidegger. New Haven, CT: Yale University Press.: xii). [↑](#footnote-ref-6)
7. Memo Akten, “Dirty Data,” part of the Learning to See series, accessed April 25, 2021: http://www.memo.tv/works/dirty-data/. [↑](#footnote-ref-7)
8. Though Hiller and Isaacson’s *Illiac Suite* is credited as the first computer-aided algorithmic composition, two additional experimental projects, developed independently in similar circumstances, came to be at approximately the same time: David Caplin and Dietrich Prinz's experiments with adapting Mozart’s *Musikalisches Würfelspiel*, and Sister Harriet Padberg's text-to-pitch mapping procedures (Hiller, 1970, p. 70; Christopher Ariza, 2011, p. 40). Hiller himself made note of Douglas Bolitho and Martin L Klein's *Push Button Bertha* (1956), as well as Richard C. Pinkerton’s “tune maker,” which involved constructing probability tables by averaging the probabilities using data from a collection of nursery tunes (Hiller, 1956, 112). [↑](#footnote-ref-8)
9. Turing, 1950, p. 433 [↑](#footnote-ref-9)
10. Christian Robert and George Casella, Statistical Science 2011, Vol. 26, No. 1, 1. [↑](#footnote-ref-10)
11. Roger Eckhardt, "Stan Ulam, John Von Neumann, and the Monte Carlo Method," Los Alamos Science Special Issue 1987, 131. [↑](#footnote-ref-11)
12. (Eckhardt, 1987, 131). [↑](#footnote-ref-12)
13. N. Metropolis, “The Beginning of the Monte Carlo Method,” Los Alamos Science Special Issue 1987, 127. [↑](#footnote-ref-13)
14. Time, “Passing of a Great Mind,” Blair 1957, p. 90. [↑](#footnote-ref-14)
15. JOHN VON NEUMANN By Norman Macrae. 405 pp. New York: A Cornelia and Michael Bessie Book/ Pantheon Books. [↑](#footnote-ref-15)
16. Hammersley and Handscomb, 1964, pp. 117-121; Robert and Casella, 2011, pp. 245-255. [↑](#footnote-ref-16)
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