Probability-based Approaches to Modern Music Composition and Production

by
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A thesis presented to the Honors College of Middle Tennessee State University in partial fulfillment of the requirements for graduation from the University Honors College

Fall 2023

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Dedication

To artists who are unafraid to experiment and challenge the status quo. Ensuring a future for the arts means embracing change.

Acknowledgements

I want to firstly thank my family: Mom, Dad, and Delaney. Your endless support enables me to pursue what I love. You inspire me better myself, physically and intellectually, and instilled in me a drive to do so. Thank you for showing me the world and teaching me how to appreciate life.

Next, I'll thank my partner, Keona Masip, and my friends Deklyn Manuel, Logan Davis, and Jacob Seals. I am closer to you four than anyone else in the world, and I am grateful for your daily friendship, love, and affirmation. Thank you for always letting me bounce ideas off you, I'm sure it gets old quickly. I don't know where I'd be without you guys.

Finally, sincere thanks are owed to my thesis advisors. To Misty Jones-Simpson: thank you for cultivating a creative and supportive learning environment. Not only did you sharpen my electronic music-making skills, but you also taught me that it's okay to break the rules and experiment endlessly. I wish health issues didn't cut your involvement on this journey short, but your optimism and perseverance inspire me every day. To Dr. Joseph Akins: Thank you for responding to my email and agreeing to help me finish out this project when you didn't even know who I was. I wouldn't have been able to complete this if you hadn't stepped up.

Abstract

Probability-based Approaches to Modern Music Composition and Production is a creative project that recontextualizes traditional aleatoric and generative music techniques through a modern, digital lens. An overview of the histories of aleatoric and generative music provide a foundation for this project's creative experimentation, as does an analysis of each genre's forms and notable works. This project's outcome consists of three songs that embrace aleatoric and generative principles in different ways. An analysis of each song deconstructs their use of these experimental techniques in an electronic Digital Audio Workstation and what challenges creating modern aleatoric and generative music pose to modern composers.

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List of Terms

Ableton Live. The digital audio workstation that this project will be completed in.

Aleatoric Music. Music that incorporates elements of chance into the composition process.

Arrangement View. A feature in Ableton Live that allows a user to arrange, record, and edit audio and MIDI data from left to right, like drawing notes on a sheet of music.

Clips. Regions of audio or MIDI data in Ableton Live that can be played, recorded, and manipulated.

Delay. A time-based audio effect that repeats echoes of an input signal. The time parameter increases the duration between echoes, and the feedback parameter increases the number of echoes.

Digital Audio Workstation (DAW). Computer software used to create and record music digitally. Examples include Ableton Live, Pro Tools, Logic Pro, and FL Studio. DAWs can interface with analog studio equipment or be used independently.

Follow Actions. In Ableton Live's Session View, decides what action will be taken after a clip is finished playing. Can automatically play the next clip, any other clip, and stop playback among other features.

Generative Music. Music made from a system created by a composer. A hands-off approach to music creation that places importance on the systems that generate music.

Macro. In Ableton Live, allows a user to map multiple parameters to a single knob.

MIDI. A musical binary communication protocol. Stands for Musical Instrument Digital Interface. MIDI signals can be sent physically between instruments and digitally within software.

Phasing. In generative music, a concept used to describe multiple audio loops that initially play together but fall out of sync due to variations in loop length.

Reverb. Short for reverberation, describes a time-based audio effect that simulates a sound's short reflections in an acoustic space. Reverb noticeably occurs naturally in large, reflective spaces (churches, concert halls, etc.)

Session View. The counterpart to Ableton Live's Arrangement View. Allows a user to trigger stored audio and MIDI clips in any order.

Vital. A free virtual synthesizer that reads MIDI information and outputs an audio signal.

I. Introduction

The word "experimental" is apt, providing it is understood not as descriptive of an act to be later judged in terms of success and failure, but simply as of an act the outcome of which is unknown.

– John Cage, *Silence*

Music, as a form of art, manifests itself in different genres and forms and is contextualized by its purpose and intent. Two of these forms, aleatoric and generative music, cross not only in form, but also in composition, aesthetic, and application. The purpose of this project is to marry aleatoric and generative techniques into compositions, or systems, that generate probability and map that probability to tangible elements of a song. This project utilizes the digital audio workstation (DAW) Ableton Live to generate probability variables and create three generative, aleatoric compositions. This project's resultant recordings demonstrate the application of both traditional aleatoric and generative principles inspired by the works of the composers that define the genres.

II. Aleatoric Music

Aleatoric music, simply put, is music that involves randomness or chance in its compositional or performance process. Musicologists Jeongwon Joe and S. Hoon Song state that, "In aleatoric music, the composer deliberately incorporates elements of chance in the process of composition and/or in performance" (263). Traditionally, music is created with familiar, yet distinct sounds selected consciously by the composer, arranged inside a defined harmonic syntax (Hoogerwerf 237, 239). This philosophy is detailed in composer and conductor Igor Stravinsky's *The Poetics of Music*, six lessons in music composition and performance written for Harvard University. A guidebook for modern

composition, *Poetics* treats composition as a cerebral process. Stravinsky notes that the duty of a composer is to invent music (53). He defines this music as "nothing more than a succession of impulses that converge towards a definite point of repose" (35). His compositional process is calculated and controlled. He further writes:

> In truth, I should be hard pressed to cite for you a single fact in the history of art that might be qualified as revolutionary. Art is by essence constructive. Revolution implies a disruption of equilibrium. To speak of revolution is to speak of a temporary chaos. Now art is the contrary of chaos. It never gives itself up to chaos without immediately finding its living works, its very existence, threatened. (Stravinsky 11)

The mere existence of John Cage, the father of indeterminate music, seems to completely refute this classical process. In his words, "One need not fear about the future of music" (*Silence* 8). He argues that one should no longer be concerned with "tonality or atonality," "Schoenberg or Stravinsky," or "consonance and dissonance," rather, one should "allow noises and tones to be just noises and tones" (*Silence* 69). While he never conformed to the aleatoric label, his body of work is aleatoric by nature. His use of complex probability variables not only classifies his work as aleatoric, but also defines a period of colorful, indeterminate art.

Underneath the umbrella of aleatoric music lives indeterminate music, which according to Cage, is music where "the form, the morphology of the continuity, is unpredictable" (38). In a lecture on indeterminate composition, Cage draws a distinction between works *performed* with chance and works *composed* with chance. Of the former, he relates the role of the performer to "someone filling in color where outlines are given,"

and for the latter, the performer acts as “a contractor who, following an architect's blueprint, constructs a building” (*Silence* 9, 35). Both are aleatory, but composing music with chance creates more opportunities to involve aleatoric procedures than performing with chance. The inherent contrast between aleatoric and traditional compositions exists in the emphasis on the creation of the composition as an aspect of the art. Traditionally, the act of music composition is undertaken to achieve an end, a song. However, for aleatoric music, the process of its creation is just as important as the piece itself. Aleatoric music is a context-dependent art, defined not by its result, but by its creative process.

Aleatoric Form

Aside from chance operations and their integration, aleatoric music can be classified into three categories, as defined by author and librettist Paul Griffiths. These classifications further compartmentalize Cage’s distinction between indeterminate performance and indeterminate composition. Griffiths’s first technique is defined as “(i) the use of random procedures in the generation of fixed compositions” (Griffiths 1). Here, he refers to the discrete mapping of chance to musical and compositional variables, how Cage would define aleatoric composition. His second technique outlines “(ii) the allowance of choice to the performer(s) among formal options stipulated by the composer,” and his third details, “(iii) methods of notation which reduce the composer’s control over the sounds in a composition” (Griffiths 1). These second and third techniques delineate two forms of Cage’s aleatoric performance. In technique two, a composer uses traditional notation to offer a choice to the performer, which is to be made

during the performance. Technique three characterizes what one may instinctively imagine is aleatoric or indeterminate composition: indicated sections of expressive freedom for a performer, but instead of using traditional notation, a composer abandons "traditional signs for graphics or texts" (Griffiths 4). These three techniques can be boiled down into two forms, as described by Cage. The first: aleatoric performance, and the second, aleatoric composition.

What processes, then, manifest these forms? As previously defined, aleatoric music involves chance, applied to any variable, be it compositionally or performantly. Cage's differentiation of indeterminate performance to indeterminate composition is again applicable, as both create valid aleatoric music. Of the former, aleatoric performance casts a wider net, and can be loosely applied to most every genre. Is improvisation aleatoric? Does this definition require an examination of jazz technique? While never explicitly discussed by Cage or his contemporaries, it is easy to infer that yes, jazz, along with other improvised music, is aleatoric, as it most often a composition with clearly indicated sections where performers are to improvise. How a composer notates this intended improvisation is what separates Griffith's second and third types of aleatory music. Of the second technique, where a composer uses traditional notation, the performer is given a choice between passages to play during a performance. For example, Karlheinz Stockhausen's *Klavierstück XI* is composed of musical fragments spread on a page, and the performer decides which fragment to play after completing the current fragment (Griffiths 3). Another example is Morton Feldman's *Intermission 6 (for 1-2 pianos)*, which is composed similarly to *Klavierstück XI*, but instead of musical fragments, single notes and chords fill the page. Feldman's instructions for the piece

allow a performer to begin the composition with any sound and continue to any other (Feldman).

Griffith's third technique defines indeterminate music that abandons traditional notation and opts for text, graphic, or written instruction. Again, citing Karlheinz Stockhausen, the tempos of *Zeitmasse* (1955-6) are dependent on the lung capacity and speed of five woodwind players. Instead of tempos, the piece is notated to be played as fast or slow as possible, or how quickly or slowly the performers can exhale a collection of notes (Chang). Earle Brown's *December 1952* bridges the gap between musical and visual art, representing notes and loudness with bars of various length and thickness (Brown 5). For Brown, this composition is not a set of rules, but instead a guide for inspiration. His instructions for the piece ask a performer to start at a point and move to any other point at any speed, with any instrument, for as long as they want. The piece, according to Brown, is a "poetic relationship to the act of performing" (Brown 6). This technique of aleatory composition and performance is not as much concerned with what the artist is playing, but how they play it.

Finally, Griffith's first technique and Cage's second form: aleatoric composition. This form is the most tangible in terms of aleatoric effect and true chance, as aspects of the creation of the song's score is random, while the other two techniques are technically improvised. Most of Cage's work fits in this category. He frequently utilized coins, the ancient Chinese text *I Ching,* and patterns found in nature to generate his chance (Cage 57-61). Other common chance operations include rolling dice, drawing cards, pulling notes from a hat, assigning notes to vowels and scoring based on a text, and utilizing mathematical ratios found in nature and architecture (Edwards 60; Stévance 153). An

example of this technique is *ST/4*, composed by Iannis Xenakis, utilizing randomness generated by stochastic computer models. Xenakis defined the structure of the piece, then used this chance to determine its smaller variables (Griffiths 3). The performances of such pieces do not invite players into the aleatoric process, but instead require them to reproduce the chance determined in the composition process. Any work is usually never wholly one form or another. Instead, a composer may determine certain elements of chance in the composition process, and then invite the performer to also consider multiple variables in the performance.

Aleatoric History

In relation to music, the term "aleatoric" was not recognized until the mid-20th century, but chance has been implemented in the compositional process as early as the 18th century. The first of such compositions existed as a collection of musical dice games published from 1757 to 1812. These dice games generally consisted of melody fragments mapped to numbers associated with sides on a die. The "composer" was to throw the die, and the resulting number would determine the sequential melody fragment (Hedges 180). Johann Philipp Kirnberger invented the first of these games, but perhaps the most well-known figure associated with the practice is Mozart. However, according to Stephen Hedges for the journal *Music & Letters*, "Mozart's name was used simply to boost sales. But in view of the lack of evidence to support a denial of Mozart's authorship, these games are still being published under his name" (183). While aleatoric in nature, these games never adopted the moniker; they did not possess the longevity to adopt the label,

and their focus was not on the music, but on the mathematical tests involved in their conception. Hedges continues:

> Of the many mathematical theories developed in the eighteenth century, the dice games were based on the principles of permutation (re-arrangement of elements) and combination (addition and/or substitution of selected elements) or *ars combinatoria*, the systematic re-arranging of materials in as many ways as possible under given conditions. (185)

These games were not intended to be experimental or genre defining pieces of art. Dice games were simply chance experimentations that allowed common people to compose their own music. Similar chance operations wouldn't notably be incorporated in the composition of music till nearly 200 years later in the early twentieth century.

Marcel Duchamp, a French artist predominantly regarded for contributions to the Dadaism movement, composed two pieces of music in the early 1900s. The first, *Erratum Musical*, a piece for three voices, and the second, *The Bride Stripped Bare by Her Bachelors, Even/Musical Erratum*, an adaptation of *Erratum Musical* for piano (Stévance 151). These are among the first aleatoric works intended to be aleatoric as an art form. Although the term would not be officially coined for almost half a century, Duchamp paved the way for his predecessors. Perhaps not intended, but still applicable, is Duchamp's 1916 work *With Hidden Noise.* For this piece, Duchamp asked a friend to encase an unknown object in a ball of twine which was then welded between two metal plates (Stévance 152). When shaken, the box generates noise indeterminately from the unknown object. *With Hidden Noise* can loosely be referred to as music, and fits within the rubric of the first form of aleatoric music, chance-based performance. However, his

first music composition, and the subject of this explication, 1913's *Erratum Musical*, explores the second form of aleatoric music, chance-based composition. Sophie Stévance quotes Duchamp's written instructions stating the complete piece should be "repeated 3 times by 3 people, from 3 different scores made up of jumbled notes drawn from out of a hat" (153). Though not followed for another forty or so years, *Musical Erratum* set an example for future composers. Stévance continues that Duchamp called for the "abandon of virtuosity" and "the removal of any musicianship in his accompanying notes," making *Erratum Musical* one of the first pieces of context-dependent and aleatoric music (154). By itself, the piece sounds random and erratic, but with knowledge of its compositional process, the song becomes an impressive examination of chance's influence on the selection of notes.

After Duchamp, aleatory form would not be revisited till its climax in the mid 20th century. While loosely visited in the 1900s in compositions by Charles Ives, who invited the performer to make decisions during a piece's performance, the first composer of this period to explicitly include chance operations in his work was Henry Cowell (Griffiths 2). In Cowell's 1934 composition *Mosaic Quartet,* performers are free to assemble the performance in any way they like from provided musical fragments, and in his *Elastic Musics,* performers can choose to negate or improvise bars based on the score's instruction (Cage 71). Seventeen years after Cowell's *Mosaic*, John Cage wrote 1951's *Music of Changes* for piano, perhaps the most influential body of aleatoric work (Griffiths 2). Cage characterizes this era of experimental composition, not only as the composer who defined indeterminate music, but also as one of the first composers to predominantly center his compositional work around chance. However, John Cage is one

among many influential aleatoric composers who include Karlheinz Stockhousen, Morton Feldman, Earle Brown, Pierre Boulez, and Christian Wolff, who predominantly composed pieces that included aleatory in their performance, not composition. Perhaps the important landmark of this period, however, was the formal definition of the term "aleatoric." In 1955, Werner Meyer-Eppler published an entry in the contemporary music periodical *die Reihe* titled "Statistic and Psychologic Problems of Sound," in which he defined aleatoric music, stating:

> A process is said to be aleatoric (from Lat. alea=dice) if its course is determined in general but depends on chance in detail. Calculation of these procedures can be effected by statistical means. Musically, everything which is not 'written in the notes' is within the aleatoric sphere. (Meyer-Eppler 55)

Not only is this definition foundational for the resultant period of experimental music, but it also extended aleatoric's classification to *anything* not written in the notes of the piece. This does not mean that when a performer makes a mistake, a piece immediately becomes aleatoric, but it allows works by Stockhausen, Feldman, and Brown, indeterminate performances, to live under the same umbrella as aleatoric composition. Perhaps the paramount compositions of this period, combining both aleatoric forms, performance and composition, are John Cage's *Music for Piano 21-52.* For these pieces, Cage used a piece of paper's imperfections to determine notes, consulted the ancient Chinese text *I Ching*'s chance operations to determine how many notes a page contains and how those notes are played, and flipped a coin eight times to determine each staff's clef. Finally, time between notes, and those note's dynamics are left to the discretion of

the performer (Cage 60-61). Experimental works during this period frequently combined elements of chance and choice, but none as successfully as those of Cage.

There has not been a period of widespread aleatoric composition since the mid 1900s. After the aleatoric boom, the aforementioned composers returned to linear, traditional, compositions, and the chance-based flame sputtered out. Today, chance-based music exists, but nowhere to the extent of the mid 1900s. Some film scores utilize aleatoric technique such as 1998's *X-Files: Fight the Future*, where composer Mark Snow instructs performers to "play as many notes as humanly possible starting from pianissimo to triple forte" (Karlin and Wright 430). Other notable film composers to incorporate aleatory technique include John Williams and John Corigliano (Karlin and Wright 455). Using samples, or chopped up bits of other songs, can also create unique opportunities for chance-based composition. Composer Graeme Revell re-uses randomly performed crescendos and ramps he has recorded in recontextualized scenarios through the use of modern time stretching (Karlin and Wright 563). Amulets, a multimedia artist, is most known for his work running cassette tape loops of varied lengths through broken Walkmans at the same time, creating indeterminate music through the time relationship of the loops to each other. These examples are few and far-between, though the potential for experimentation is greater than ever thanks to software programs such as Ableton Live that allow probability and chance generation to be mapped to various aspects of the program.

Aleatoric Analysis

Erratum Musical by Marcel Duchamp

Duchamp's *Erratum Musical* is among the first works composed aleatorily. Duchamp wrote the piece for himself and his two sisters, but it can be performed by any three singers. The piece was composed by pulling music notes from a hat, and the performers sing their assigned note together. This song falls into the second form of indeterminate music, aleatoric composition. *Erratum Musical*'s aleatoric quality is the selection of the notes to be performed. The notes themselves are pre-determined, but which artist performs each note and their order is indeterminately selected as the composer pulls notes from a hat. The song does not conform to traditional Western music theory, but as the piece progresses, one's ear begins to find resolution and progression in the note relationships created by chance.

Music for Piano by John Cage

Cage's *Music for Piano* was composed for choreography but can be performed without. Cage detailed its compositional process in *Silence*, a collection of his lectures and writings. For this piece, he used a master score sheet and chance operations from the Chinese text *I-Ching* to determine the number of notes per page. He then marked imperfections on a transparent piece of paper according to the determined number of notes. Next, he placed the transparent paper over the master sheet, and drew notes corresponding to the imperfections. Finally, Cage used coin flips to determine clefs, and more *I-Ching* operations to determine how individual notes are played. *Music for Piano* is aleatoric in composition and performance. The process clearly demonstrates

compositional chance, but its performance is also indeterminate in nature. Cage allows performers to decide what tempo and rhythm in which to fit the notes (Cage 60, 61). Musically, this piece is like Duchamp's *Erratum Musical.* However, this piece focuses on individual notes and how they are played, not necessarily how random notes sound played together.

III. Generative Music

Generative music, not dissimilar to aleatoric music, is an experimental and context-based art form. Its history, use, and classification, however, are not as broad. While aleatoric music evolved over centuries and stagnated, generative music grew quickly and developed exponentially. In a sense, one could see generative music as aleatoric music's successor. Brian Eno, who coined the term generative music, defines the genre as "'machines' and 'systems' that could produce musical and visual experiences" (Eno 330). In the way that aleatoric music is constructed through chance, generative music is created from systems, or anything that generates music. Eno furthers that the point of creating these systems "was to make music with materials and processes I specified, but in combinations and interactions that I did not" (330). At its conception, generative composition was built with physical systems, but as computing power and technology evolved, generative systems became almost completely computer algorithm based. Simply, these algorithms are generative when their output is generally more musical and denser than their input (Wooller et al. 9). When these systems and algorithms create music, the music is generative. Further, much of this music, if not all of it, is aleatoric. A generative composer creates a system with the expectation that the system

will create music that composers could not create themselves. This indeterminacy is inherently aleatoric, combining both of Cage's aleatoric delineations. Combining aleatoric performance and composition, Eno remarks:

> Generative music enjoys some of the benefits of both its ancestors. Like live [performed] music, it is always different. Like recorded [composed] music, it is free of time-and-place limitations - you can hear it when you want and where you want. And it confers one of the other great advantages of the recorded form: it can be composed empirically. By this I mean that you can hear it as you work it out - it doesn't suffer from the long feedback loop characteristic of scored-and-performed music. (Eno 330)

Eno, whether consciously or not, married both aleatoric forms through the creation of generative music. Most generative music is aleatoric, and not all aleatoric music is generative, but the influence that both genres exhibit over the other is evident and irrefutable.

Generative Form

To a common person, the term generative may be more closely associated with AI than music. While different in purpose, the two share similarities in their form, namely the use of algorithms. However, not all generative music is created using algorithms, but instead systems with which composers interact. This collaboration between system and composer builds the foundation for generative music, which can be classified into four sub-categories, summarized by Rene Wooller as Linguistic/Structural, Interactive/Behavioral, Creative/Procedural, and Biological/Emergent. Based on

Chomsky's generative language grammars, Wooller's Linguistic/Structural interpretation utilizes recursion to output infinite (or near infinite) outputs from a finite set of rules. Interactive/Behavioral music results "from a process with no discernable musical inputs" (Wooller et al.). Interactive generative music can be found most commonly in video games, where a nonmusical input, player interaction with the game, creates or changes music (Pasquier and Plut). Wooller's most applicable category, Creative/Procedural generative music, results from "processes set in motion by the composer." This sub-category is arguably the most identifiable, as it is associated with notable composers of the genre, namely Steve Reich and Brian Eno. Wooller's final classification, Biological/Emergent, shares similarities with aleatoric music, in that it is non-deterministic, her example being wind-chimes. While complex, these categories paint a picture of generative music's wide umbrella and define its form.

Generative History

Generative music's development occurred more recently than that of aleatoric music. However, similarly to aleatoric music, examples of generative and algorithmic composition exist from before its conception. The earliest recognized example dates to the eleventh century, when Guido d'Arezzo created a chart that assigned pitches to syllables for religious songs (Miranda). This chart fits into Wooller's aforementioned Linguistic/Structural generative structure, as melodies are formed through combinations of non-melodic inputs. A more recent and applicable example of early generative music, however, comes from Steve Reich, whose tape and pattern-based compositions pioneered a compositional concept known as "phasing." Not to be confused with the technical audio

term “phase,” a sound wave’s location in time, according to K. Robert Schwarts, generative phasing occurs when “two or more identical melodic and/or rhythmic patterns very gradually change in their rhythmic relationships to one another during the work. Eventually, as the process progresses, new patterns evolve of their own accord” (384). Reich composed his most popular work, *It’s Gonna Rain*, in 1965 (Schwarts 384). It was composed through phasing and set a foundation for modern generative music. The work was generated from two tape loops of a pastor repeating the phrase “it’s gonna rain.” The loops begin in unison but fall out of sync. Since one is slightly longer than the other, the loops’ rhythmic dissonance creates patterns that change as the piece progresses. Later, Reich introduces more loops of various lengths. This piece exemplifies Wooller’s Creative/Procedural generative form, as the composer chose the phrase, created the loops, and set those loops in motion. The interplay between the tape loops creates indeterminate patterns, generating music.

Despite Guido and Reich’s early innovations, the term “generative” would not be coined until 1995, 30 years after Reich composed *It’s Gonna Rain*. In fact, Eno composed some of his most notable generative works years prior. These works, however, did not expand on Reich’s concept of phasing; they only modernized it. *Discreet Music,* released a decade after *It’s Gonna Rain*, is his first “generative” work. Eno summarizes the composition of the work in his diary, *A Year With Swollen Appendices*, describing a system, “in which two simple melodic cycles of different durations separately repeat and are allowed to overlay each other arbitrarily” (330). Eno created various other works, including notable releases like *Music for Airports,* through similar means, which he calls “automatic systems.” These systems almost identically resembled Reich’s tape machines,

as Eno used cassette and CD players to create his songs. While these songs became successful, recording thirty minutes of phasing melodies to distribute did not satisfy Eno, as the songs replay identically. So, inspired by generative screensavers, Eno sought to utilize computers as a tool to create ever-changing music.

Eno found his solution in 1995. He writes that his computer music "would probably have remained a pipedream were it not for a company called Sseyo who had been thinking on exactly the same lines" (331). In 1994, Sseyo, now called Intermorphic, published a software called Koan Plus, and brought it to Brian Eno's attention in 1995 (Cole). Koan worked by writing instructions for a computer's soundcard, allowing a composer to control nearly 150 parameters. On the program's function, Eno remarked that, "Most of Koan's instructions are probabilistic - so that rather than saying 'Do precisely this' (which is what a musical sequencer does) they say 'Choose what to do from within this range of possibilities'" (331). This allowed Eno to create his theorized ever-changing computer music, save the rules he applied to Koan, and distribute them to anyone with a soundcard in their computer, making experiencing unique generative music easier than ever before.

Nearly three decades later, Eno continues to pioneer the generative music movement. In 2017, he released *Reflection*, a continuation of his mission to bring ever-changing music to the world. The piece was released in two mediums, as a traditional song on streaming services and as a mobile app, available to anyone willing to shell out thirty dollars. While the physical release lasts only fifty-four minutes, the iOS application can conceivably create endless music, given the listener's phone is plugged in. Eno is not the only composer to continue the generative tradition, however. Generative music in the

interactive/behavioral classification is used frequently in the development of video games. Cale Plut and Philippe Pasquier write that, “Generative music can provide endless unique music in a game, and can be adaptive on a much deeper level than composed adaptive music, providing music that is individually tailored to the player’s actions in a game” (2). Similarly, reactive generative music exists in interactive art installations. Artists Grégory Lasserre and Anaïs met den Ancxt, jointly known as Scenocosme, experiment with and create works based on human touch. Their works *Akousmaflore* and *Urban Lights Contacts* explore this touch by converting static energy to sound through human to plant contact and human to human contact respectively. Finally, the explosion of generative AI development has paved the way for new modes of generative music production. In a 2023 Billboard article, Elias Leight analyzed various generative AI music production systems, focusing on the extensive human interaction necessary to create traditionally “musical” music. Leight quotes co-founder and CEO of LifeScore, a generative AI music company, Philip Sheppard, who states that their AI uses “Lego blocks of sound all made in a studio by real musicians playing real instruments through lovely microphones” (Leight). Through music, art, and AI, the development of generative music’s forms shows no signs of slowing down.

Generative Analysis

Pendulum music by Steve Reich

Pendulum Music is a work composed in 1968. Reich’s handwritten notes in his diary *Writings on Music* detail the piece’s inception and execution. The piece is performed by “2, 3, 4 or more microphones” that swing from the ceiling in a pendulum

motion over speakers they are connected to (Reich). The result is a cacophony of feedback that phases against itself, generating a varying rhythm and harmony as the microphones slow down. Initially, as the mics graze over their speakers, blips of feedback pop in and out rhythmically, but as the piece progresses, the feedback gradually draws out, and the tones fight each other, creating dissonant, yet enchanting harmonic interplay. This piece utilizes Reich's generative phasing while simultaneously exhibiting traits of aleatoric, indeterminate performance.

Ambient Walkman Symphony by Amulets

Ambient Walkman Symphony is a YouTube video published by Amulets on May 5th, 2017. This piece was created with four Walkman cassette tape players and tape loops of various lengths, functioning as the "symphony's" generative system. While varied in length, the loops fit in the same key, and the delay and reverb effects blend the loops together. Amulets performed this piece by spontaneously attenuating the volumes of the tape players, sometimes playing machines by themselves, and sometimes playing all four at once, and mostly playing a combination of two. This indeterminate summation of the loops builds a changing, breathing rhythm, reminiscent of Reich's phasing and Eno's *Music for Airports.* However, this song combines both aleatoric performance and generative music, as a system is generating the music while indeterminate human interaction creates an indeterminate aural landscape.

IV. Application of Aleatoric and Generative Compositional Techniques

Before analyzing the compositions created for this project, it is important first to provide an explanation of how digital music creation software can accommodate the marriage of aleatoric and generative music, and what techniques, both traditional and contemporary, I incorporated into my music. The first step in this project's creative process was selecting a digital audio workstation, or DAW, to create this project's compositions in. I decided that Ableton Live, an industry standard software for digital music creation, would be the perfect canvas for my compositions, as it comes with probability-based features not present in many competing DAWs. Additionally, one of Ableton Live's flagship features, Session View, accommodates this unique project well. Ableton functions through two primary interfaces, Arrangement View and Session View. Arrangement View functions linearly like most other DAWs. The playhead, or the point in time where the song is playing, scrolls from left to right and reads audio or MIDI information. This information is stored on clips in tracks. Audio clips store digital audio files recorded or imported into Ableton. MIDI, or Musical Instrument Digital Interface, clips store instructions for devices as binary represented numerically. These devices can interpret the values as note information or modify the values before being interpreted as notes. Essentially, MIDI clips allow a composer/musician to play digital instruments and store their performances with the ability to edit note values after.

Fig. 1. Audio and MIDI clips in Arrangement View

Audio and MIDI clips live on Audio and MIDI tracks, respectively. These tracks also contain devices such as effects that alter a signal's timbre and virtual instruments that interpret MIDI information and output audio. As previously stated, Arrangement View interprets this information from left to right. However, its counterpart and the configuration used for this project, Session View, treats clips less linearly, allowing the user to store multiple clips in a single track, playing them one at a time and queueing the clip that will play next. Tracks play independently of each other in Session View, so while the third clip may be playing in one track, the seventh clip in another track could be playing.

Fig. 2. Ableton's Session View configuration

This allows greater flexibility for those who compose or perform music live. Ableton allows for further flexibility and automation through a feature known as Follow Actions, which, when enabled, determine a clip's behavior when it finishes playing. There are a variety of Follow Actions, but the only two relevant to this project are "Next," which queues the next clip to play, and "Stop," which ends its specific track's playback. Each clip can have two assigned Follow Actions, and a user can choose to assign a percent probability for either option to occur. For example, if I assigned a clip the Follow Actions "Next" and "Stop" and gave each a 50% chance to occur, Ableton would essentially flip a coin when the clip ends, heads the next clip plays, tails it stops.

Fig. 3. Ableton's clip options menu with Follow Action settings on the left

Additionally, I want to explain the devices I used commonly between the three songs. Firstly, and arguably most importantly, I used a variety of devices to create what I call a melody generator, which is essentially a track that creates a random melody from notes in a MIDI clip, shown in Figure 4.

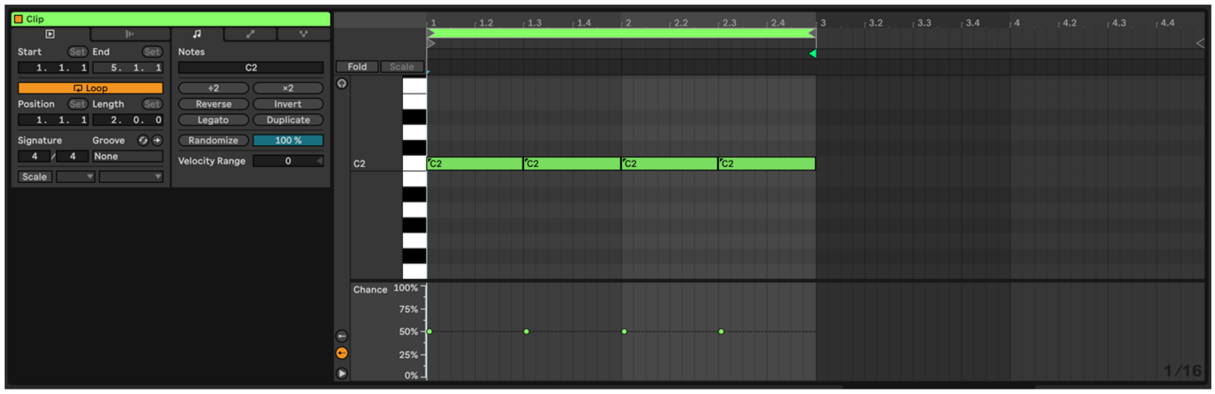

Fig. 4. The melody generator's MIDI clip view

The generator's clip contains notes placed, in this instance, at half note intervals. For the generator to function as intended, I set the probability that each note is played to 50%, a probability I chose to emulate the coin flips John Cage used while composing "Music for Piano." To the left of the note window is the clip options panel, which contains a clip's Follow Action settings. I decided on the Follow Actions "Next" and "Stop," so if "Next"

occurs, the clip will repeat, as it is the only clip in the track, and if "Stop" occurs, the melody will finish generating. I gave "Next" an 83% chance to occur and "Stop" a 17% chance to occur, essentially determining the clip's length through a dice roll, as one has a 16.67% chance to roll any specific number on a dice, mimicking the probability procedures of classical "Dice Music" games. While the clip controls note frequency, two MIDI effects, devices that modify MIDI information before it is interpreted by an instrument, use probability to control note selection. The first MIDI effect I used is called "Random" which adds or subtracts note values from its input. The "Chance" parameter controls the percent chance the device's output note is different from the input, again set to 83% to reference Musical Dice. The "Choices" parameter limits the output of the device to any number of outputs around the input. Using a setting of 12 limits the output to a single octave around the input note. The "Scale" parameter multiples the limit set by the "Choices" value.

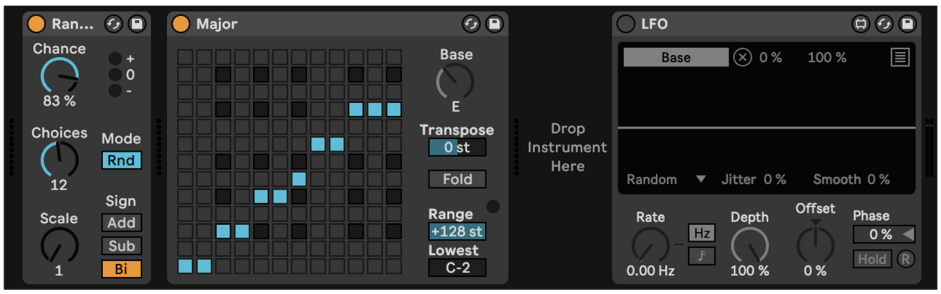

Fig. 5. The melody generator's device view

The second device I utilized is the "Scale" MIDI effect, which conforms any incoming notes to a selected scale. The grid represents incoming notes as columns and the notes they are mapped to as rows. Figure 6 shows a major scale in the device. Essentially, this conforms all the random note values into a scale, so everything sounds decent together. Finally, I added an "LFO," a device whose operation I will explain later, to randomly

select a root for the scale device when enabled. With this combination of devices and probability settings, the only choices left to my control were note length, note octave, and ultimately if I like the composed melody or not.

The next collection of devices I used acts as a randomly generated mixer and consists of a device called "Utility" and multiple instances of the aforementioned "LFO." The devices group together in what is essentially a folder called an "Audio Effects Rack," as seen in Figure 6. The first device in the rack is the "Utility," which allows a user to attenuate an audio signal's gain, adjust its pan, and trim its width in the stereo field.

Fig. 6. Random mixer Effect Rack

In this instance, I only used the "Gain" parameter, as my only goal was to have individual elements flow in and out of audibility randomly. Next in the chain are two LFOs. Essentially, these devices, in Ableton, act as invisible hands that can control any parameter in a track's Device View. The first LFO is set as a sine waveform, and it controls the gain parameter of the Utility plug-in. I limited the amount it can control the gain to 50% of the total parameter, as that represents no change. The second LFO is set to random and mapped to the "Rate" parameter of the first LFO, randomly changing the speed at which the first LFO attenuates the audio signal's volume. This creates a

completely random element of change and ensures that any composition I make that utilizes this randomized mixer is ever-changing and unpredictable.

Methodology

My goal in creating the three songs associated with this thesis was to marry aleatoric and generative form using modern digital audio software. Additionally, while embracing these experimental genres, I wanted to exercise creative control over the probability generated in each song's Ableton session to ensure that each song is listenable and that the three songs fit thematically together for release on streaming services. Choices I made to guarantee that these chance-based variables played nicely with each other were primarily each song's tempo and instrumentation. Additionally, I did not hesitate to keep regenerating melodies until the melody generator created something that I liked.

These songs exhibit aleatoric techniques through not only their randomly generated melodies, but also through random mixing, effects, and instrument timbre. I achieved this through mapping various LFOs to several different parameters in the session. For example, assigning a random LFO to the amount an instrument is sent to a delay effect, and then modulating the time of that delay will result in indeterminate bursts of randomized echoes that fight rhythmically with the instrument's original melody, creating new, random rhythmic tension and dissonance.

Fig. 7. LFOs randomly modulating the delay's feedback and time parameters

The use of generative form in these songs is not as discreet, but generative principals are still identifiable and functional. Phasing, such as that used by Steve Reich in pieces such as "Its Gonna Rain" and Brian Eno in "Music for Airports" is the main generative technique used in these pieces. I achieved this by generating melodies in Ableton and allowing them to loop, creating phasing by altering the lengths of said loops. More loosely, while I am using the melody generator and LFOs aleatorily, the sessions they contribute to fit the definition of generative devices, as I have essentially created systems that generate music. These techniques ensure that not only are these songs generative, but also ever changing. If I were to press play in any three of the sessions these songs were created in, they would theoretically generate unique music eternally. Unfortunately, my laptop will not live forever, so I recorded passages of each composition's session, the details of which I will discuss below.

"Composition I (10.11.23)"

Creation

This project's first composition served as the foundation for experimentation and development of techniques used through all three works. Although it is the first of three compositions, it is the last one I finalized and recorded, as I felt its initial iterations did not fit thematically with the other two songs. This track is essentially a single random

melody repeated over three instruments looped at different lengths to create phasing. Initially, I experimented with fully "real" instrumentation, generating a melody by setting the output of the melody generator track to the input of a piano track, and then copying the resulting melody clip to a variety of stringed instruments. I decided against this approach as it felt ingenuine to my stated goal of recontextualizing classical aleatoric and generative techniques electronically. So, I decided on a palette that mixed old and new.

For this song, I used the piano as an anchor point, or the most recognizable song a listener can latch on to, and the instrument that exhibits little to no change. I applied some creative effects to make the piano sound clearer in the mix, and I used two LFOs to randomly modulate the amount the track is sent to a reverb track and delay track to give the song space. I applied these LFOs to all the tracks in this session. I modulated the delay's time and feedback parameters, changing the space of the song as it progresses. The piano also received the MIDI information from the melody generator, so I wanted to preserve the melody as it was generated in the piano's track. I generated fifteen melodies before the melody generator created something I was satisfied with. I then copied the melody from the piano to two other tracks, and I shortened the second loop by three eighth notes and lengthened the third melody by one eighth note. The instrument on the second track is a synth preset from a free virtual instrument called Vital.

Fig. 8. A screenshot of the virtual instrument Vital

I chose this synthesizer because I am familiar with how it operates, it is free, and it has functions called Macros which allow a user to link various parameters to a single control. I found these macros particularly useful because I was able to map LFOs to them, randomizing the synth's timbre. However, the MIDI melody the track is playing loops irregularly because I made it shorter by three eighth notes, so the LFOs randomly modulating the instrument's timbre fall out of sync with the melody as well, as the LFOs change at a set rate. The LFOs are limited to only change the timbral macros by a set amount, so while the instrument changes, generally it retains a plucky, piano-like sound. I added some creative effects to change the synth's timbre and improve its fit in the mix and used the random mixer to bring it in and out of focus throughout the track. My approach with the third instrument was similar to my approach with the synth. I used a multi-sampled vibraphone instead of a synthesizer, and I extended the original MIDI melody by a single eighth note.

Fig. 9. LFOs mapped to the vibraphone's "Articulation" and "Motion" macros

To capture recordings of this session, I routed the outputs of tracks one, two, and three along with the output of the reverb and delay tracks to an audio track labeled "Recording." When I felt ready to capture a take, I would arm the record track and trigger playback of the melody loops in tracks one, two, and three. When I felt like the session had demonstrated its full probabilistic capabilities, I would stop the playback of the three tracks, and then wait for the reverb and delay to die out before stopping the Recording track. In total, I recorded thirteen passes before one was generated that I was happy with. Finally, I inserted a plug-in called a "limiter" to bring the overall loudness of the song up to levels accepted by streaming services.

Analysis

Of the three, this song is the most repetitive, and its melody is the most identifiable through its duration, but this is to be expected, as this piece studies phasing between copies of an identical, randomly generated melody. Tonally, I like the way the three instruments interact with each other; the piano is generally the focal point of the mix, the synth swims in and out of focus and has a low fidelity sound that balances out the clean piano, and the vibraphone glitters in the high end, randomly switching between being bowed and hit with a mallet. I am satisfied with the aleatoric techniques utilized in

this piece. The melody generator, as previously mentioned, uses probability inspired by the dice rolls used in eighteenth-century dice games and the coin flips John Cage used while composing *Music for Piano.* Additionally, the use of randomized LFOs mapped to the synth and vibraphone's timbres and amplitudes induces more probability into the session. This probability, alongside each track's randomized send to a reverb and delay, make the session output unique music every time it is played.

"Composition I (10.11.23)" also utilizes various generative techniques, the most obvious of which being phasing. Being a work that uses same-melody phasing, this song resembles Steve Reich's *It's Gonna Rain* in form. While this piece does not use a voice recording, as *It's Gonna Rain* does, both pieces create ever-changing rhythmic variation by playing identical loops over each other and varying their length. Additionally, this piece exhibits Rene Wooller's Creative/Procedural generative form, as processes I create rules for and set in motion generate the music heard in the session's playback and subsequent recording. Finally, this piece builds on the improvisational live mixing Amulets utilized in his *Ambient Walkman Symphony* by using random, automatic mixers.

This song contains various distinct moments that highlight this song's aleatoric and generative techniques. A listener can identify the melody that's repeated through the song's duration in the first seventeen seconds of the song, the only time the melody plays in sync through the whole recording. Once the melody plays for the first time, the synth repeats first, as its loop duration is the shortest. The piano then loops, and finally the vibraphone loops. According to Brian Eno, the way to calculate the time it will take for loops that are out of sync to play together again is to multiply their length in seconds together (Eno 330). I did not test this postulation, but assuming its true, the loops I

created will play together at their start, and then come together once every four hours and forty-five minutes. A distinct moment that emphasizes aleatoric chance aside from the randomly generated melody and randomized instrument mixing and timbre occurs around six minutes and twenty-three seconds into the composition, near the end of the recording. This moment captures dramatic change in the delay time and feedback parameters, causing notes to echo randomly for a small amount of time. After much experimentation, I think this composition's resultant recording is a success, as it captures my intent well.

"Composition II (10.08.23)"

Creation

This project's longest song, "Composition II (10.08.23)" is subjectively my favorite, as I find it the easiest to listen to and the most fascinating through its duration. Similar in function to "Composition I (10.11.23)," this song again utilizes random melody generation for its primary aleatoric form, and phasing as its main generative process. However, this song's instrumentation varies from the first song's instrumentation, as does its melody generation. Instead of a single melody generator creating one melody that I copy to three tracks, for this composition, I built three generators that feed three individual tracks. This allowed me to generate three unique melodies at once.

Fig. 10. Composition two's Session View

In Figure 9, the generators are visible in green on the left, and their associated tracks are pink near the center. Each generator's MIDI clip held only two whole notes, increasing the probability that the melodies generated in this piece would be too short. This was a response, however, to having to generate fifteen melodies in my first composition before I heard something I was happy with. This approach seemingly worked, as I had to only generate six clips for tracks one and three and ten clips for track two before I was satisfied with the results, even though the process is ultimately left to chance. My goal for this composition was to generate individual melodies for all three tracks at the same time, but I decided that I liked the sixth melodies generated for tracks one and three too much to regenerate, so I kept them and regenerated melodies for all three until track two was satisfactory. Since all three MIDI clips were generated with whole notes, the piece, as generated, would exhibit little to no tangible rhythmic variation. To remedy this, I

trimmed the end of the second track's clip by a single eighth note and elongated the clip in the third track by one eighth note.

Instead of using a piano as this song's anchor, I used a "pad," or a soft, sustained synthesizer, from Ableton's stock library. The preset I chose exhibits change based on the note played. Additionally, I used an LFO to randomize the sound's timbre. The melody generated for this track is six bars long and covers nearly three octaves of notes. The second track contains the same piano that served as the anchor for the first song, but in this composition, it takes a back seat. Its melody is only four bars long (minus one eighth note), and exhibits very little change, only playing three different notes in its duration.

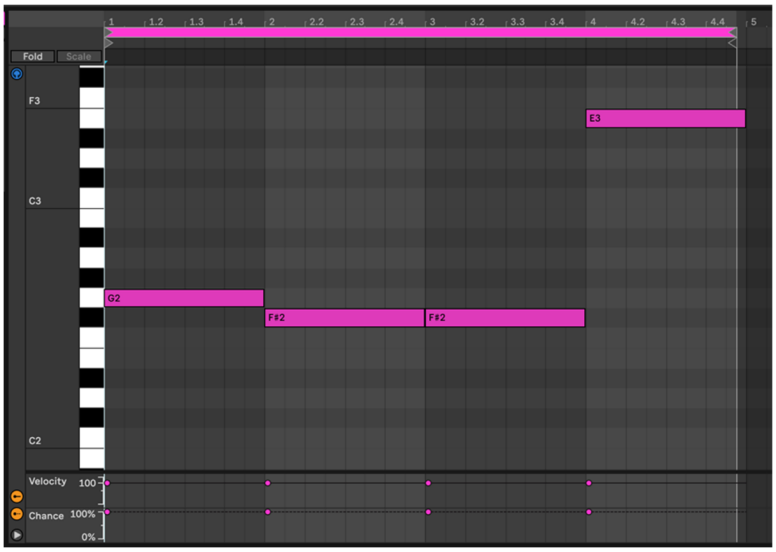

Fig. 11. The MIDI clip generated for the piano in "Composition II (10.08.23)"

The third track also borrows instrumentation from the first song, using the same Vital preset, except I changed the amount the LFOs attenuated the presets macros. This allowed for a more dynamic and unpredictable shift in timbre. The melody generated for track three is eight bars plus one eighth note that I added on. I decided against using the random mixer in this song because I liked how the random LFOs changed the synth and

the pad's timbre. Instead of randomizing the amount each track is sent to the reverb, I left their send amount at 100% meaning each signal is being sent full volume to the reverb track. I did, however keep the random LFOs assigned to each track's delay send as well as the delay's time and feedback parameters. I recorded this track the same way as the first, but I only had to capture eight passes before I was satisfied. I also applied a limiter to normalize this song's volume.

Analysis

Since this song uses non-identical phasing, its repetition is less identifiable. Additionally, its instrumentation is a bit more difficult to discern because the pad and synthesizer blend together. This song follows the same aleatoric and generative principles that the first song does. However, by using different instrumentation, a slower tempo, a different key, and unique melodies generated for each track, "Composition II (10.08.23)" distinguishes itself wholly from its preceding work. It pays homage to the same aleatoric techniques as "Composition I (10.11.23)," but in varying its generative approach, the piece exhibits phasing consistent with Eno's *Music for Airports*, juxtaposing independent loops of different lengths to create ever-changing music.

I prefer the sound and atmosphere created in this composition over the other two created for this project. Though the track is comprised of only three instruments playing loops, I feel that their phasing and aleatoric timbres generate more than enough variety to keep the piece intriguing for its nearly twelve-minute runtime. Interestingly, though the pad was intended to be the "anchor" for this song, the synthesizer seems to take the lead in this track, and the piano sits in the background, occasionally filling empty space. The

pad sits even further underneath the other two elements and makes itself the focal point sparingly.

I decided to record eleven minutes and twenty-six seconds of this composition's output to fully represent its capabilities. I also found myself, in preparing this project, engrossed in this song, replaying it over and over while I work, so I wanted to capture a small fragment, as Brian Eno did, of an ever-changing piece of music. This song's moments that notably exhibit aleatoric and generative traits are like those of the first composition. For example, the three tracks play in sync with each other rhythmically for nineteen seconds, then fall out of sync for the rest of the song, generating unique harmonic and rhythmic interactions for the duration of the piece that are more nuanced than those of the first compositions, as the difference in loop length is much smaller in this composition. The synth audibly changes and morphs through the duration of the song, but what I find more special are moments when the pad peeks its head through the synth and piano's entanglement. This is audible throughout the song, but especially at two minutes and twenty-four seconds. Later, from around nine minutes and twenty-six seconds to the ten-minute mark, the randomized delay latches on to the synth and decides that it wants to take the focal point before fading into the background. Though this piece is like the first composition in its execution, I feel that it is a better representation of aleatoric and generative technique because it is less repetitive. Additionally, while a listener may identify melodic patterns, generative phasing creates interesting harmonic and rhythmic interactions alongside the instruments randomized timbre that keep the piece interesting.

“Composition III (10.09.23)”

Creation

The final song of this project, “Composition III (10.09.23)” is the most conceptually and creatively unique of the three. I wanted to take this song in a completely different direction, as compositions one and two are somewhat similar. For this song, I wanted to experiment with how sounds we experience in our everyday lives and sounds we are familiar with can interact musically. This composition’s only instrumentation is a piano. Instead of the melody generator recording a loop for the piano to play, the generator now randomly creates chords endlessly, no recording necessary. I achieved this by removing the generator’s clip’s follow action, making it loop indefinitely. Additionally, I added three new devices to the generator track’s device chain, as seen in Figure 12. The first of these is called Note Echo, which functions similarly to the delay effect mentioned earlier, except instead of multiplying echoes of an audio signal, the Note Echo device echoes MIDI note information. I used this device to create an indeterminate rhythm for the chords, modulating its “Time” parameter with a random LFO.

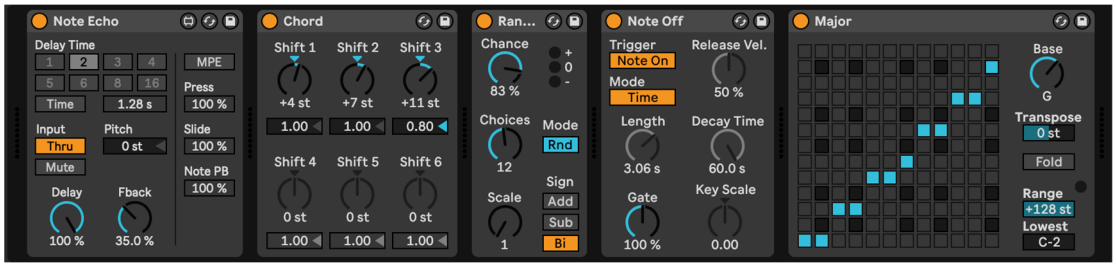

Fig. 12. The melody generator modified to play chords instead of single notes. Not present: LFOs modulating the Note Echo device’s Time parameter and the Note Off device’s Length parameter.

The next device I used to modify the generator is called Chord, and it functions exactly how one might expect, by multiplying and shifting an incoming MIDI signal by a set number of semitones, or notes. I added a major third, a fifth, and a major seventh above the incoming note to create a major seventh chord. This falls apart, however, as the Chord device's output feeds into the Random device, which scrambles the notes. Thus, the function of the Chord device is simply to generate notes that play at the same time as the incoming signal. The output of the Random device is sent to Note Off, a device that simply extends or shortens the duration of an incoming MIDI note. Finally, the Scale device conforms its input to a scale, in this case, G major. The result of these modifications are indeterminate bursts of chords that dance around a major scale.

As interesting as randomized chords are, I felt like this piece needed more, but I did not want to resort to the same techniques used in songs one and two, so I decided to embrace Renee Wooler's Biological/Emergent generative form and explore the musicality of non-musical sounds. To do this, I looped three clips of non-musical audio and applied the random auto-mixer I created in "Composition I (10.11.23)." The first loop I used is a cyclical humming of noise generated by setting the MIDI output of the modified melody generator into a track with a digital instrument called LABS set to a preset called "Locusts." The next audio clip is street ambience recorded in London, also from the instrument LABS, looping every four bars. Finally, I looped an eighteen-second-long clip of vinyl crackle. Each of these ambience tracks statically fed the session's reverb send, while the piano fed the reverb and delay send randomly. I captured nine recordings of this song before I was satisfied with the result, and I normalized its level just as I did with the other two songs.

Analysis

This piece, to me, is the most challenging to listen to, but it also exhibits the most obvious aleatoric influence through its duration. This piece is also the most unique of the three, differentiating itself from even aleatoric and generative works of the past. Despite these contrasts, the piece still falls under the indeterminate and generative umbrellas, as chance determines not only what notes are played, but also how often they are played and for how long. Additionally, the non-musical loops of audio swim in and out of focus randomly due to the influence of their random mixers. An argument could even be made that, since a majority of the elements in this song are non-musical and thus indeterminate, the inclusion of these ambience loops and their interactions with each other is an act of aleatoric composition. This extends to generative form as well. The obvious generative aspect of this piece is the inclusion of a system, the modified melody generator, that creates ever changing chords that are rhythmically indeterminate. Less obvious, however, is how each element interacts with itself and the track as a whole. Wooler's fourth generative form, Biological/Emergent, emphasizes non-musical auditory interactions having the ability to sound musical, and though her example is of windchimes, I would argue that even less musical objects can still sound musical. Walking through a city or a forest and actively listening to your surroundings can reveal musicality, be it the honking of horns, conversation between strangers, chirping of birds, or rustling of trees. This is the essence of what I tried to capture in "Composition III (10.09.23)." The piano bounces around like chimes through a gust of wind as the chatter of city ambience, rhythmic buzzing, and vinyl crackle swirl around the listener. Though ambitious, I wanted to capture the idea of everyday life being a work of natural aleatoric and generative genius.

To be completely honest, I don't love the entirety of the recording I captured, nor am I satisfied with the non-musical loops I selected for this composition. I considered changing them and capturing more passes, but there are moments of in the final recording I think are too special to toss to the side. Firstly, through chance alone, the piano decides not to play immediately, and instead all three ambience loops fade in slowly to introduce the song. Nine seconds in, the piano introduces itself. The ambience loops fade away and let the piano take a solo, before swelling and almost overtaking the piano. The piece continues this way until a minute and twenty-two seconds in, where the ambience loops fade away and the piano stops playing. This brief intermission is interrupted by the humming, cyclical white noise and an almost angry burst of piano chords.

Something I find fascinating about this piece is my ear's urge to assign familiar musical and harmonic patterns to the chords, despite their randomness. Around two minutes and forty-five seconds, two chords play a common cadence that generally resolves to the root of the scale, but since these chords are randomized, the resolution never comes. This theme continues throughout the piece; for example, the ambience loops fade away and the piano takes a break nearly four minutes into the song, only to furiously return, shattering the listener's expectations formed through listening to traditionally composed and created music. While I may not love the individual non-musical elements of this piece, I think the recording I captured beautifully illustrates aleatoric and generative form as we can perceive it in everyday life.

V. Reflection

This project provided various challenges and opportunities for experimentation regarding modern music composition and production. The two most important questions when considering if this experimentation was successful are firstly: do the systems I created generate tangible degrees of change when put into motion? And secondly: do the resultant creations meet my musical expectations? I argue that the answer to both questions is a resounding yes. Not only do the systems and sessions I created generate probability, but they also pay homage, in form and function, to the aleatoric and generative pieces I studied in the research portion of this project. By researching aleatoric and generative music for this project, I was able not only to enrich my knowledge of experimental music history, but also to contribute a summation of the genre's histories as well three new compositions to the experimental music field.

The research portion of this project challenged me, as I struggled to find academic and reliable sources that corroborate the histories of aleatoric and generative music. However, by digging deeply into the few scholarly articles that exist, I was able to find several primary sources written by the composers I cite throughout this project. Paging through diaries and collections of notes educated me on the history and influences of both aleatoric and generative music and gave me a newfound appreciation of older compositional techniques. Thankfully, I was able to easily locate sources, scholarly and not, that detail forms and techniques found in these genres. I hope that my research and work can spark interest in the genres in others.

Creatively, this project took many forms and entailed more experimentation than I expected when I chose it. I started brainstorming ideas for the creative portion of this

project far before I finished my research, resulting in many of my initial attempts at creating generative aleatoric music either not working or not embracing generative techniques. In the beginning stages of this project, I wanted to create a single session that could produce multiple different songs, simply by pressing play. I found quickly that this approach would require much more knowledge and technical skill than I had, so I decided that three sessions based completely on different types of probability could possibly provide my desired outcome. However, I found that this approach placed too much emphasis on aleatoric form and not enough on generative techniques. After more experimentation and the completion of my research portion, I came up with the approach detailed in this project: three independent sessions that share common techniques while embracing different aleatoric and generative forms. Incorporating chance and generative systems into my creative process yielded results I never could have imagined, and I believe that this approach to aleatoric and generative music creation proves that these genres have applications outside of experimental music.

VI. Final Words

This process changed the way I think about the creation of music and the meaning of art. I have a newfound appreciation for those unafraid to challenge the status quo, experiment, and ask "What if?" To an uninformed listener, the songs I created may sound like sloppy songwriting or lazy production, but in the context of how the works were created, I believe this collection of songs is a continuation of the work aleatoric and generative composers created decades ago. I am satisfied with this project's outcome and

am eager to create and release more music that pushes contemporary compositional boundaries.

Selected Works (10.23), the album that contains the compositions for this project, can be found online, under my name, on all streaming services as of November 3rd, 2023.

Works Cited

Cage, John. *Silence*. Wesleyan University Press, 2016.

Chang, Ed. "Zeitmasze." *Stockhausen: Sounds in Space*, 2015, stockhausenspace.blogspot.com/2015/11/zeitmasze.html.

Cole, Tim, and Pete Cole. "Sseyo Koan (SSEYO)." *Intermorphic Ltd*, intermorphic.com/archive/sseyo/koan/. Accessed 30 Oct. 2023.

Edwards, Michael. "Algorithmic composition." *Communications of the ACM*, vol. 54, no. 7, July 2011, pp. 58–67, https://doi.org/10.1145/1965724.1965742.

Griffiths, Paul. "Aleatory." *Oxford Music Online*, 20 Jan. 2001, https://doi.org/10.1093/gmo/9781561592630.article.00509.

Karlin, Fred, and Rayburn Wright. *On the Track: A Guide to Contemporary Film Scoring*. Routledge , 2004.

Leight, Elias. "It Takes a Lot of People to Create All This AI Music." *Billboard*, 2 Mar. 2023, www.billboard.com/pro/generative-music-ai-creating-millions-of-songs/.

Meyer-Eppler, Werner. "Statistic and Psychologic Problems of Sound." *Die Reihe*, vol. 1, 1955.

Miranda, Eduardo Reck. "Computer-Aided Song Design: Prosody as Scaffolding." *IME/USP Computer Music Group*, 2001,

https://compmus.ime.usp.br/sbcm/2001/researchpapers/sbcm-researchpaper-2001-2.pdf. Accessed 30 Oct. 2023.

Plut, Cale, and Philippe Pasquier. “A Framework for Generative and Adaptive Game Music.” *Game Developer*, 21 Dec. 2022, www.gamedeveloper.com/audio/deep-dive-generative-music-in-video-games.

Plut, Cale, and Philippe Pasquier. “Generative Music in Video Games: State of the art, Challenges, and prospects.” *Entertainment Computing*, vol. 33, 2020, p. 100337, https://doi.org/10.1016/j.entcom.2019.100337.

Reich, Steve. *Writings on Music* . Oxford University Press, 2002.