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Musical Ecologies of Persons and Things

DISSERTATION

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by

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ABSTRACT OF THE DISSERTATION

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Doctor of Philosophy in Integrated Composition, Improvisation, and Technology

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This dissertation considers the development of musical form in improvised music performances from a perspective based in embodied and ecological theories of cognition. Here, improvised music refers to a wide range of musical practices which utilize "free" improvisation as a foundational process for structuring musical form. As a temporally extended, embodied, and often cooperative creative practice, improvised music composition and performance may be enriched by a perspective informed by theories of cognition which help explain embodied, dynamic, and distributed cognitive tasks. Drawing primarily on the enactive cognition of Thompson, Varela, and Rosch, as well as James J. Gibson's ecological psychology, I develop a perspective on improvised musical forms as contingent on performers interacting with musical possibilities for action afforded by their environment. Such a perspective suggests that improvised music performances are structured ecologically, as a musical ecology. This has implications for pre-performance organizations of musical form, such as in composition, wherein the musical ecology may be manipulated through a variety of interdisciplinary means, a practice I call *Systems Composition.* Furthermore, improvising performers may adopt the ecological perspective in order to better understand adapting to a musical ecology as improvisational skill, emphasizing openness and attention to musical affordances over physical or technical virtuosity alone. Finally, I explore ways in which I have applied the

enactive and ecological perspectives in my own practice as a composer and improviser, discussing musical works from my dissertation concert, *Musical Ecologies of Persons and Things.*

1 INTRODUCTION

1.1 AN ENACTIVE, EMBODIED, AND ECOLOGICAL APPROACH TO IMPROVISED MUSICAL FORMS

This dissertation draws on enactive and ecological theories of cognition to develop a conceptual framework for improvised music practice that understands improvised musical forms as arising from musicians actively engaged in a distributed cognitive task of musical creativity, as dynamic cognitive ecologies which express properties of self-organization and emergence characteristic of ecological systems. Enactive, ecological, and other embodied theories of cognition broadly emphasize the distributed nature of cognition between an organism's brain and body, but also reaching into the socio-material environment, such as physical implements, tools, and the culturally acquired skills which make them useful to cognitive life. Enactive and ecological theories focus on ongoing engagement between organisms and their environment, and thus provide useful insights for understanding the cognitive task of improvisation as interaction in a musical ecology. As I will argue, this ecological perspective provides insights for composers and improvisers in better understanding and developing a practice in improvised music. Here, improvised music refers to a wide range of musical practices which utilize so-called "free" or "open" improvisation as a foundational process for structuring musical form. Applying these fields of cognitive and philosophical study to improvised music is helpful for describing how improvisers create musical forms by interacting in real time, with the aid of instruments, scores, and each other. Enactive and ecological perspectives offer a language with which to discuss and understand the cognitive phenomenon of improvised music, and have helped in developing my own creative practice as an improviser, composer, and instrument designer. These and other embodied theories of cognition have been usefully

applied to improvised music practice in a variety of contexts in recent years.[1] This body of research has shown that improvised music practice presents a strong case study for the types of dynamic, distributed, and socially situated cognitive tasks emphasized by embodied cognitive theories. As such, contributions of musical practitioners able to synthesize their experience with developing research on the nature of cognition in improvised music may prove useful for musicians and cognitive theorists alike.

Presented as a combination of both research and creative work, this dissertation project is one such contribution. It is the culmination of my work so far in trying to better understand my own practice in improvised music through embodied cognitive theories, and simultaneously produce musical works which are informed by what those theories elucidate about the nature of improvised music. Primarily, I focus my line of inquiry on the notion of musical form and explore how enactive and ecological theories of cognition can help to explain and exploit the *distributed* and *emergent* properties of improvised music, from the perspectives of both composer and improvising performer. These and other terms from embodied cognitive science explored in this document speak to the core features of improvised musical forms which have historically provided challenges and opportunities to composers and performers. Importantly, the questions raised in this line of inquiry regarding the nature of formal organization in improvised music are not new. As I will explore later in this text, theorizing on the organizational dynamics implicit in improvised performance has a long history of activity in the work of musicians in communities of improvisational practice, through musical works and performances, which serve as practice-based and experimental research into how improvising ensembles co-create musical form. By supplementing my musical practice with theories that help explain the organizational dynamics of

[1] Borgo, David. "The Ghost in the Music, or the Perspective of an Improvising Ant." In The Oxford Handbook of Critical Improvisation Studies, Vol. 1, edited by George E. Lewis and Benjamin Piekut, 91-112. Oxford University Press, 2016.; Clutterbuck, Tristan, Tom Mudd, and Dario Sanfilippo. "A Practical and Theoretical Introduction to Chaotic Musical Systems," In Proceedings of the International Conference on Live Interfaces. Brighton, UK 2016.; Duby, Marc, and Jonathan Impett. "Minds, Music, and Motion: Ecologies of Ensemble Performance." Music & Practice 6 (July 2020): 1-19.; Hayes, Lauren, and Juan M Loaiza. "Exploring Attention through Technologically-Mediated Musical Improvisation: An Enactive-Ecological Perspective," In Access and Mediation: Transdisciplinary Perspectives on Attention. Access and Mediation. De Gruyter Saur, 2022.

improvisatory cognition, this project emphasizes the strength of such theories in providing a useful language with which to address long-standing questions.

1.2 CHAPTER OVERVIEW

This text is divided into four main chapters. The first introduces key research themes from enactive, ecological, and other embodied cognitive theories in order to conceive of improvised music practices in ecological terms, and show what this perspective has to offer improvised music practices. A model of improvised music as cognitive ecology provides a conceptual framework for understanding how groups of improvisers collectively self-organize emergent musical forms. These embodied approaches to understanding cognition in action show that the musical forms of improvised performances emerge from adaptive interactions between musicians, their fellow ensemble members, instruments, and scores. As I explore in the first chapter, a number of concepts from embodied cognition help to describe the cognitive task of improvisation both at the individual level and for the musical ecology at large. Though many embodied and broadly connectionist theories of cognition offer insights into musical practice, I focus on enactive and ecological perspectives for their emphasis on *temporally-extended,* or ongoing processes of organisms adapting in response to a dynamic world. In addition, I incorporate some concepts from related connectionist theories, such as cybernetics and dynamical systems theory, which help explain how complex systems, like societies, ecologies, or musical ensembles, self-organize through patterns of interaction and feedback. In unpacking the cognitive process of improvisation, what emerges is a conception of improvised performances as driven by a dynamic structure of musical opportunities and constraints. This structure is held together in its flux through ongoing adaptation between its component parts. In the language of enactive and ecological cognitive theories, performances are structured according to the suite of *musical affordances* perceptible to each performer. Such affordances, or perceived possibilities for musical action, arise from the history of interaction and adaptation between a

musician and their musical ecology, as well as each musician's history of relationship to their instruments, tools, and cultural experience.

The second chapter explores implications of the musical ecologies framework for composers of improvised music. In conceiving of improvised music performance as a musical ecology, the process by which musical forms are constructed can be understood within a frame of musical possibilities perceptible to performers, or musical affordances. These possibilities arise in large part from performers' prior engagements in music making. As such, the system dynamics of an improvised ensemble exist before specific intervention by a composer or system designer, and can't be entirely controlled by outside influence (doing so would be missing the point). However, composers may employ strategies which engage this system of affordances, specifically attending to how the ensemble navigates shared construction of musical form in scores and other pre performance interventions, rather than providing specific sonic outcomes to be enacted. I call this type of compositional activity *Systems Composition,* due to its focus on manipulating conditions under which performers interact, rather than composing sonic events themselves. Importantly, Systems Composition is not a new way of working, but a framework for understanding improvised music compositional practices through embodied and other broadly connectionist theories of cognition. At the end of this chapter, I explore examples of Systems Composition in the work of George Lewis and Derek Bailey.

In the third chapter, I explore what enactive and ecological theories of cognition offer the improvising performer. Continuing to explore the musical ecologies framework, I focus my attention on the notion of skill in improvised music. Because improvisation does not emerge from the faithful reproduction of specific representational musical outcomes, traditional notions of skill based in physical virtuosity and control alone are not sufficiently explanatory as in musical activities which provide clear sonic outcomes for performers. I show that because free improvisation operates according to the principles of affordances and structural coupling, skill in improvisation may be considered as the strength of coupling between a musician and the other members of a musical ecology, which hones their ability to

adapt to a dynamic, chaotic environment. This coupling may be strengthened by active, embodied participation in the development of structural history within the musical ecology, such as instrumental practice, and ensemble rehearsal. Importantly, this work requires developing experience in adaptation and the shared construction of musical forms, and not just the development of technical virtuosity with one's instrument. However, physical ability to manipulate an instrument remains a highly relevant history of experience for engaging in the musical ecology, providing a rich suite of affordances to the skilled player. Instead of prioritizing technical ability alone, I focus on the development of coupling between a performer and their instrument, as well as between ensemble members, and consider ways in which this coupling may be strengthened to enrich improvisational skill.

The last chapter considers an ecological, enactive model of cognition as it relates to my personal musical practice as a composer, improviser, and instrumental systems designer. Through a process of practice-based research, I have found this perspective on cognition useful for both describing the practices of improvised music that I involve myself in, as well as supplying practical opportunities for Systems Composition and performance practice in developing improvised musical performances. I focus on works presented in my dissertation concert, *Musical Ecologies of Persons and Things*, in order to demonstrate how my research has developed in tandem with my creative work.

2 GROUNDWORK: KEY THEMES FROM ENACTIVE AND ECOLOGICAL COGNITIVE THEORIES AND THEIR RELEVANCE TO IMPROVISED MUSIC PRACTICE

2.1 IMPROVISED MUSIC

The musical practice of "free" or "open" improvisation structures sonic events using temporally extended, or "real-time" processes of musical creativity, in which *creative agency* in structuring musical form is distributed between performers as they improvise. Here, creative agency refers to active participation in contributing sonically to a musical performance, either contributing to, manipulating, or otherwise organizing sounds as they emerge or are arranged over time. Such improvised music practices are characterized by the employment of improvisation as the foundational organizing process of a musical form or composition, as opposed to musical practices which are either entirely pre-composed or utilize improvisation in a limited, ornamental fashion, as special effect. As described by musician and scholar George Lewis, employing improvisation as the foundational structure for a musical performance or composition is historically situated in the "Afrological" tradition, and evident in the work of both Black experimentalist composer/improvisers such as John Coltrane and members of the AACM, as well as postwar "Eurological" avant-garde composers like John Cage and Karlheinz Stockhausen.[2] The use of improvisation in this foundational manner has influenced a broad range of techniques and aesthetic styles, including free jazz, open form composition, noise music, interactive computer music systems, game

[2] Lewis, George E. "Improvised Music after 1950: Afrological and Eurological Perspectives." *Black Music Research Journal* 16, no. 1 (1996): 230-231.

pieces, and more. Following Lewis, I will henceforth refer to this historically situated range of practices which utilize free improvisation in structuring a musical composition as "improvised music".

Improvised music contrasts from traditional western composition practices of fully notated music, in which creative agency is centralized to the composer, and is primarily exercised pre-performance. In fully notated music, the structuring of sonic events occurs through score making, a manipulation of symbols which represent a composer's sonic ideal for later recreation by performers. In the case of improvised music practices, organization and development of musical forms are placed in the hands of performers and at the moment of performance to a much greater extent. In other words, in comparison to fully notated music, improvisation exhibits the distribution of creative agency towards performers in the moment and away from individual composers pre-performance as a foundational structural methodology. This moves the craft of musical forms outside the representational domain of notation as symbolic processing for reproduction by performers, and into a methodology of structuring musical forms which embraces the temporally-extended, embodied, and performative nature of improvised music making.[3] Even when some notated element is employed, the distribution of creative agency to performers in an improvised scenario means that the organization of musical forms cannot be explained as totally the work of an individual composer.

2.2 EMBODIED COGNITION

Musical ecology as a framework for understanding the distributed nature of musical creativity and cognition is firmly rooted in developments made in the field of embodied cognition. Broadly, embodied cognition refers to a position which posits that cognition occurs as a distributed phenomenon between brain, body, and the organism's environment. This is in opposition to cognitivist accounts which

[3] This can be seen to somewhat map onto what Andrew Pickering identified as the "representational idiom" (notation) vs the "performative idiom" (improvisation). See Pickering, Andrew. "The Mangle of Practice: Agency and Emergence in the Sociology of Science." *American Journal of Sociology* 99, no. 3 (November 1993): 59–89.

assume cognition to be the result of internal processing on purported mental representations gathered and translated from separate perceptual inputs, in turn to inform the actions of separate effective outputs. Embodied cognition argues against the implicit Cartesian dualism between mind and body expressed by the internalism of the cognitivist account. This computational internal processing model is informed by a history of cognitivist discourse in the field of artificial intelligence, which conceived of human cognition as akin to computational symbol processing. In large part as a response to this cognitivist discourse in AI, various subcategories of research have formed over the years as scholars have "fleshed-out" aspects of the embodied account. These post-cognitivist approaches are commonly known as "4E" cognition, the 'E's' of which are embodied, embedded, enactive, and extended. This is often expanded to include distributed and situated aspects of embodied cognition, with Simon Penny proposing the acronym "SEEED" to account for this lapse.[4] Though lessons from much of embodied cognition may inform an understanding of improvised music practice, my concept of musical ecologies primarily relies on work from embedded, enactive, and distributed approaches. What follows is a brief overview of the most salient themes for my research and their relevance to supporting an ecological understanding of improvised musical performance.

2.3 ENACTIVISM

Enactive cognition is rooted in the work of biologists Humberto Maturana and Francisco Varela. Their original biological work focuses on questions regarding what constitutes a living system, and through this inquiry unfolds a variety of implications for the nature of cognition and being. The enactive approach defines cognition as an ongoing process of sensorimotor engagement between an organism and its environment, and defines living systems in terms of their ability to maintain this process. The term

[4] Penny, Simon, and Tom Fisher. "Twist-Hands and Shuttle-Kissing: Understanding Industrial Craft Skills via Embodied and Distributed Cognition." *FormAkademisk - Forskningstidsskrift for Design Og Designdidaktikk* 14, no. 2 (May 10, 2021). https://doi.org/10.7577/formakademisk.4209.

sensorimotor refers to the entangled nature of perception and action in interacting with the world, emphasizing neither sensing nor acting over the other, but instead a constant recursive experience of both. Founding enactivists Francisco Varela, Evan Thompson, and Eleanor Rosch stress that recurrent sensorimotor coupling with the world, or *structural coupling*, which is necessarily embodied and temporally-extended, is the process by which organisms dynamically self-organize to sustain themselves as independent, or *operationally closed* systems, which are perturbed by outside stimuli but nonetheless maintain an operational boundary which defines both self and world. Such a capacity for self-organization and reproduction in relation to an environment is *autopoiesis*, from Maturana's autopoietic biology, which defines the cognitive nature of living systems. Importantly, the sensorimotor engagement through which organisms bring forth a world explicitly disavows any need for mental representation or information-processing, stressing a firmly subjective ontology of *sense-making* rather than mental interpretation of purportedly objective information. This sense-making activity *is* cognition, which from the enactivist perspective is non-representational and dynamically distributed between brain, body, and environment.

Enactivism holds particular insights for improvisation because of its focus on emergent, temporally-extended cognitive action. Understanding improvisers as cognizing organisms engaged in maintaining their coupling to the musical environment suggests that the musical decisions of improvisers arise from creative adaptations to environmental perturbation, which operate according to the improviser's history of engagement with a musical world and ongoing sensorimotor feedback with the environment. This perspective on improvisatory decision making implies that the sonic forms of improvised music are *structure determined*, in that they are constrained within a framework of interactions available to improvisers as a result of their structural coupling to the environment.

2.4 AUTOPOIESIS AND OPERATIONAL CLOSURE

Maturana's concept of autopoiesis, the self-organizing behavior exhibited by living systems, shows that cognition is a process of sensorimotor engagement in the world, through which a body dynamically adapts its structure to preserve itself in relation to its environment.[5] This is the most fundamental concept of autopoietic biology, which defines a system as living only if it is able to maintain an embodied relationship of interactions with its environment, while preserving the inner dynamics of its own regulatory systems as they adapt to outside perturbation. The enactivist concept of operational closure defines such a successfully preserved distinction between the operational dynamics of self and world. Autopoiesis describes how living systems define this distinction through recursive cycles of perception and action, dynamically self-organizing and self-making in order to preserve operational closure.

2.5 STRUCTURAL COUPLING

The focus on perception and action is essential to the enactivist concept of structural coupling, first described by Maturana and Varela, which grounds cognition in the ongoing and self-organizing history of embodied relationships between an organism and its environment.[6] As articulated by Maturana, structural coupling describes "the dynamics of congruent structural changes that take place spontaneously between systems in recurrent (in fact recursive) interactions, as well as the coherent structural dynamics that result".[7] Structural coupling helps describe how improvisers dynamically adapt to musical events in their environment by altering their activity to achieve musical structures which preserve a coherent relationship between themselves and the musical ecology at large. Later on in this dissertation, I argue

[5] Maturana, "Autopoiesis, Structural Coupling, and Cognition", 30.

[6] Maturana, "Autopoiesis, Structural Coupling and Cognition", 7.

[7] Maturana, "Autopoiesis, Structural Coupling and Cognition", 16.

that structural coupling provides a solid foundation for a developing notion of improvisational skill and success.

2.6 SENSE-MAKING AND EMERGENCE

The enactive approach emphasizes the dynamically coupled interaction between components of autonomous, sense-making cognitive systems. Rather than argue between internality and externality, proponents of enactivism define cognition as a relational process. In this way, the approach denies the input-processing-output model of cognition as proposed by the cognitivist paradigm in favor of one contingent on sensorimotor loops between participants in a cognitive system. Such a sensorimotor coupling is the relationship by which autonomous systems, be they living organisms or extended to include multiple autonomous components, make sense of their world. As noted, this sense-making activity *is* cognition, which from the enactivist perspective is non-representational and dynamically distributed between brain, body, and environment. The implication of the term sense-*making* is that knowledge of the world emerges from embodied interaction by an observer, rather than through correct translation of objective truths through mental representation of symbols.

Emergence is another concept which originates as a critique of symbol-processing models of cognition by the enactivist subfield. Early enactivists Varela, Thompson, and Rosch emphasize "that cognition is not the representation of a pregiven world by a pregiven mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs".[8] This key insight of enactivism stresses the importance of action in perception, that knowing is not symbolic processing but rather an active process of constructing a world in relation to a history of engagement with that world. Furthermore, no knowledge of an objective world is necessary for intelligent and sustainable life, only the constant and contingent relationship between an organism and world

[8] Varela, Francisco J., Evan Thompson, and Eleanor Rosch. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge, MA: MIT Press, 1991. 9.

through sensorimotor coupling. This resonates with improvised music practices, as improvisers co-enact musical form through a simultaneous process of musical action and perception. An improviser's musical decision-making process is mediated through their history of engagement in musical culture, largely defining the musical opportunities perceived in performance. Improvised musical forms are emergent in the sense that a distributed and dynamic network of interaction results in self-organization of musical materials, rather than according to a precomposed plan of highly specific sonic events. Such emergent form is enacted over time and is thus *temporally-extended*, as opposed to the temporally-fixed structure of sonic events as presented by pre-composed representational scores.

2.7 MAKING SENSE OF MUSICAL FORMS

It is important to note that the concept of musical form being explored here, as well as the related issue of musical meaning, differs from more objective ways these ideas are typically employed in notated music. Musical form is defined here as the experience of relationships between musical events over time. It is the experience of making sense of a musical performance as it is heard, seen, or otherwise participated in. This sense-making activity is a perception of relationships between sounds and other musical events over time, which I refer to as musical form. However, musical sense-making also involves relationships between sounds and the sense-maker's own history of engagement in musical practice, enacting a broader experience of musical meaning. These notions often blur together and should not be overstated, but the perspective that improvisation demands a concept of musical form based in active perception of relationships as a performance unfolds is clear when considering what an improviser does in performance.

This experiential concept of musical form and meaning focuses on the processual and active quality of sense-making, rather than temporally-fixed and symbolic forms most common in fully notated music. It is a subject-oriented and action-focused perspective, which, following Christopher Small, understands all engagement in music as *Musicking*, or an active process of making sense of sound as it is

experienced.[9] Small's rhetorical move in emphasizing music as a verb insists that "music is first and foremost action".[10] "Musicking" helps describe how musical performances are made meaningful through a distributed network of participatory sense-making, which includes the contributions of performers, composers, audiences, dancers, and even ticket counters. Importantly, the sense-making activity involved in a musical performance is distributed among everyone actively involved, and is thus participatory. Participatory sense-making, as described by Hanne De Jaegher and Ezequiel Di Paolo, expands the enactivist perspective into socially cognitive contexts, in which "the onus of social understanding… moves away from strictly the individual".[11]

2.8 Ecological Psychology and Affordances

The ecological approach, largely related to the field of cybernetics, Gregory Bateson's "ecology of mind", and Gibson's concept of "affordances", places the embodied mind in context of its material and social embeddedness.[12] The embodied mind is embedded in a larger system of sense-making with the world itself. This depends on a notion of the recursive, inseparable nature of perception and action; not only are an organism's actions dependent on its direct perception of the world, but also its perception of the world is itself dependent upon the suite of actions available to the organism in relation to its environment, as constrained by its bodily capacities. Affordances show that the way we make sense of our

[9] Note: To engage in the creation of musical forms is to create the conditions for such a musical experience, though the musical form intended by a composer may not always be realized in the experience of the listener, as the subjective experience of a listener is under the constraint of greater contingencies than a composer may account for. Such perils related to the translation between two subjectivities are possible in any practice of musical form construction but are not my focus in this document.

[10] Small, Christopher. *Musicking: The Meanings of Performing and Listening.* Middletown, CT: Wesleyan Univ. Press, 2010. 9.

[11] De Jaegher, Hanne, and Ezequiel Di Paolo. "Participatory Sense-Making: An Enactive Approach to Social Cognition." *Phenomenology and the Cognitive Sciences* 6, no. 4 (December 2007): pg 1

[12] Schiavio, Andrea, and Dylan van der Schyff. "4E Music Pedagogy and the Principles of Self-Organization." *Behavioral Sciences* 8, no. 8 (August 9, 2018): 72.; Gibson, *The Ecological Approach to Visual Perception*.; Bateson, Gregory. Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology. Northvale, N.J: Aronson, 1987

external environment is an embodied phenomenon, relying on our brains, bodies, and world. Rather than being simply "in the head", the sense we make of the world is external, and necessarily dependent on our embedded, situated relationship to an environment. Most importantly, Gibson's ecological psychology grounds sense-making in the dance between perception and action, with meaning arising from the structural congruence between an individual and their world. Here we can see a resonance between enactive concepts like structural coupling and sense-making, suggesting that a concept of musical ecologies could benefit from both perspectives.

Conceiving of sense-making in terms of functional relationships an environment offers an organism according to its structure or niche is integral to Gibson's theory of *affordances.* In his ecological theory of visual perception, Gibson describes how perception is inextricably linked to bodily action and locomotion, and evolved for success in navigating a world. Gibson shows how organisms may directly perceive the types of actions afforded to them by their environment. For example, humans may directly perceive a congruence between the shape and bend of their legs and the shape of a chair, and know that the chair affords sitting. The same isn't true for flamingos, whose legs bend the opposite direction. This suggests that meaning in the world is both constituted by a functional congruence between an organism and its environment, and also is available to the organism without internal processing of visual information. Penny points out the cognition involved in recognizing an affordance happens "in the eye".[13] Auditory or even tactile perception may also engage affordances, suggesting that cognition in musical performance may be structured from the affordances perceived both from objects in the environment as well as the sonic environment as it is perceived over time. These *musical affordances* are the perception of musical possibilities for action, and arise from performers' embodied relationship to other individuals, sound as it emerges, tools like instruments and scores, and the social history and situatedness of each performer. Musical affordances offer a convenient concept of form as a dynamic framework of musical

[13] Penny, Simon. *Making Sense: Cognition, Computing, Art, and Embodiment*. Cambridge, MA: MIT Press, 2017, 217.

possibilities derived from active perceptual engagement between musicians and the musical environment. Later in this dissertation, I offer further clarification into how and when sound itself may be considered as an affordance.

An action-oriented and distributed concept of musical sense-making can be found in what Mark Reybrouck calls his "experiential" or "ecosemiotic" approach to musical sense-making.[14] Drawing on embodied, enactive, and ecological perspectives on cognition, Reybrouck argues for a concept of music-as-process which provides an "operational terminology for describing both the music as a temporal phenomenon and the process of dealing with the music", something the author cites as missing from music scholarship which focuses on second-order observations of musical symbols.[15] The process of musical sense-making is described by Reybrouck as the "'semiotization' of the sonic world", in which sound is experienced according to functional relationships between the musicking organism and its environment.[16] These functional relationships may be conceived of as musical possibilities for action, which are "not totally arbitrary, but ecologically constrained", contingent on the dynamic structure of an organism-environment system.[17]

Reybrouck has explored the nature of affordances within musical improvisation in depth. In doing so, he lays out a number of sources for musical affordances.[18] These include both "productive aspects" of musical affordances, which refer to "the raw material and what it affords for musical sound production"

[14] Reybrouck, Mark. "Musical Sense-Making and the Concept of Affordance: An Ecosemiotic and Experiential Approach." *Biosemiotics* 5, no. 3 (December 2012): 3

[15] Ibid, 3.

[16] Ibid, 3.

[17] Ibid, 3.

[18] Reybrouck, "Musical Sense-Making and the Concept of Affordance", 12. It should be noted that Reybrouck employs a *biosemiotics* perspective in his description of musical sense-making, which is distinct from the field of *semiotics.* Biosemiotics is generally less concerned with meaning as derived from linguistic symbols, but rather as immediately available to an embodied organism (though there are quasi-linguistic biosemiotics approaches as well).

as well as affordances on the "receptive level", which "embrace perceptual qualities, mood induction qualities and socio-communicative qualities, invoking aspects of sense-making, emotional experience, aesthetic experience, entrainment and judgments of value".[19] In total, these affordances represent constraints and possibilities in musical instrument design, personal playing practice, sound modulation capabilities, and the sense-making which occurs as performers listen to and adapt to a dynamic sonic environment. Following Alva Noë, Reybrouck situates listening in bodily movement, showing how perception of sound is grounded in the perception of motor possibilities, or in a word: affordances. These musical affordances construct a frame within which musical improvisation occurs, and thereby suggest implicit form within improvised performances.

A concept of musical form based on affordances and music-as-action emphasizes the temporally-extended, sensorimotor engagement with a musical environment which serves as the foundational process of constructing emergent form in improvised music performance. As I will explain in the following chapters, embodied theories of cognition, particularly its enactive, distributed, and embedded or ecological approaches, provide useful frameworks for understanding how improvised musical forms emerge through a process of distributed sensorimotor engagement in a musical environment. I show that in improvised music, musical form is arrived at through a distributed and temporally-extended process of musicians acting on affordances or musical possibilities for action perceived in a dynamic musical environment.

2.9 DISTRIBUTED COGNITION

Distributed cognition was pioneered by anthropologist Edwin Hutchins, as well as cognitive scientist David Kirsch. Hutchin's classic analysis of cognition between members of a ship's crew describes cognitive phenomena between groups of agents (human and nonhuman) involved in a shared

[19] ibid. 13.

cognitive task, in this case ship navigation.[20] Distributed cognition emphasizes cognitive processes which extend "beyond the body, into tools, structured spaces and social networks".[21] This perspective critiques the cognitivist notion that cognition is explicitly internal, occurring only in the brains of individuals, and thus is at least in part a post-cognitivist position. However, Hutchins retains the computationalist model in his externalism, remaining committed to representationalism and the computer metaphor in his description of cognition in groups as a computational system. Similarly, Hutchins extends the concept of symbolic representations into the world of multimodal perception and action (for instance, representing a navigational orientation by drawing an imaginary line with the hand across navigational charts).[22] My perspective on improvisatory performance as musical ecology generally contrast from this representational computationalist view, insofar as it denies mental representation as integral to the cognitive task of improvisation. Nonetheless, Hutchins' description of distributed cognitive systems is essential to my conception of musical thinking between musicians, their instruments, and each other.

2.10 SYSTEMS

Embodied cognition has close historical and theoretical ties to analytical approaches which use the concept of *systems* as a framework for understanding the emergent organization of individual parts engaged in recursive interactions with one another which produces a common goal, purposive behavior, or expressive tendency. Systems are abstractions of these groups which conceptualize the interactivity of component parts as a larger organizational unit, shifting focus on to analysis of the entire organizational body, or system, as more than the sum of its parts. Components of a system, which may be subsystems themselves, are defined by interactive feedback across narrow bandwidth interfaces with input and output

[20] Hutchins, Edwin. *Cognition in the Wild.* Cambridge, Mass.: MIT Press, 2006. 9-49.

[21] Penny, *Making Sense*, 177.

[22] Hutchins, Edwin. "Imagining the Cognitive Life of Things," In *The Cognitive Life of Things: Recasting the Boundaries of the Mind.* Edited by Lambros Malafouris and Colin Renfrew, 91-102. McDonald Institute Monographs. Cambridge, UK, 2010.

capabilities. While individual subsystems may be complex within their enclosed operative boundaries, relatively simple, or narrow bandwidth interfaces between subsystems allow for a focused observation of salient control variables between components which determine system states. In this way, we can understand the trends in a circulatory system through interaction and exchange of blood between organs with complex inner dynamics; in ecology, understand the distribution of food resources through a diverse collection of flora and fauna; in machines, develop global behaviors of interactivity and regulation between complex components; and perhaps, in improvised music, understand musical form construction as the product of interactivity between musicians and their embedded environment of people and tools.

In this paper, I refer broadly to approaches which utilize systems as a central concept as *systems-theoretical approaches.* These approaches excel in describing how groups of organisms, or organisms and their relevant tools, display emergent behavior and self-organizing capabilities defined by the interactions between component parts. The broadest of these approaches originating in the 1930s is General Systems Theory, or simply Systems Theory, which is an interdisciplinary study of systems, natural and man-made. Cybernetics, most closely related with Norbert Wiener's 1948 text *Cybernetics; or, Control and Communication in the Animal and the Machine,* proposed a systems-theoretical approach which could analyze and implement the control of systems through manipulations in their design.[23] Cyberneticians in a broad variety of fields applied abstract concepts of *feedback*, recursive cycles of action and perception which regulates activity with the system, and *homeostasis,* the state of equilibrium towards which a system tends to move, to better understand the dynamic and self-organizing character of complex systems such as ecologies, social structures, biological systems, and markets. Embodied cognitive thinkers were also influenced by these ideas, for example in the work between Maturana and cybernetic neurologist Warren Sturgis MuCulloch.[24] Enactivism's focus on feedback and control interactions through

[23] Wiener, Norbert, Doug Hill, and Sanjoy K. Mitter. *Cybernetics: Or Control and Communication in the Animal and the Machine*. The MIT Press, 2019.

[24] J. Y. Lettvin, H. R. Maturana, W. S. McCulloch and W. H. Pitts, "What the Frog's Eye Tells the Frog's Brain," in *Proceedings of the IRE*, vol. 47, no. 11, pp. 1940-1951, Nov. 1959.

perception-action couplings echoes the cybernetic concept of negative feedback from Wiener and resonates with a systems-theoretical framework. Likewise, ecological and systems-theoretical approaches highlight the importance of situated, context-specific, embodied activity in cognition described by insights from embedded cognition. Other systems-theoretical approaches, for example dynamical systems theory, which uses mathematics to describe the tendencies of complex dynamic systems, are discussed briefly later in this dissertation.

Importantly, reference to systems within this document should not be taken to reflect any particular systems-theoretical approach, but rather as a general analytical tool for describing the interactivity of groups, in this case improvising musical ensembles, as resulting in emergent organization which exceeds the sum of its parts. While systems provide a useful metaphor for describing musicians and their tools engaged in performance, there are important distinctions which differ between my approach and systems theory. First, if the subsystems identified in a musical improvisation system are to be musicians and instruments, it is not clear that these components interact over narrow bandwidth interfaces. Musicians communicate musical possibilities to one another through a variety of multimodal senses and activities, involving at least sonic, visual, and affective qualities. Similarly, defining clear inputs and outputs is not easy, and the concept of input and output as separated by an internal processor undermines the enactivist reading of recursive, sensorimotor coupling which better explains improvisational practice.

However, describing improvised performance as a system remains useful for emphasizing the emergent, self-organizing character of its musical forms, in that they are the result of interaction between components, and their organization cannot be explained by mere summation of individual sonic contributions. In addition to having incorporated the language of systems thinking from its embedded legacy in embodied cognition, I am drawn to use the concept of systems because it resonates with my perspective on improvised musical forms: that they emerge as products of dynamic, interactive, and distributed systems, and that the structure of such systems allows for playful manipulation of relevant

variables by composers and performers. While these composerly activities result in self-organizing patterns of musical behavior and interactivity, it is more fitting to say a system has been created than a truly autopoietic lifeform. In this way, systems are useful metaphors for describing the emergent, quasi-autopoietic behavior of musicians and their tools engaged in performance.

2.11 DISTRIBUTED MUSICKING

By implementing improvisation in a performance, responsibility for musical decision-making is *distributed* between the composer (if there is one) and the improvising performer(s). Likewise, non-human entities in the performance, such as instruments or scores, provide important opportunities and constraints for improvisational decision making, and can be seen as further components of the distributed system. Distributed and ecological theories of cognition provide a language with which to discuss how ensembles and their tools come together to cognize as a group-in-environment, or *cognitive ecology*. This distribution of creative choice is fundamental to the process by which musical form dynamically emerges over time in improvised performance.

As Small has argued, musical practice is a prime example of this distributed phenomenon of musical creativity. His concept of musical activity as "musicking" places the enactive, dynamic quality of meaning-making at the forefront of musical practice, which is always shared between participants of musical culture, be they performers, composers, or listeners.[25] In the case of musical improvisation, such a distributed, dynamic process of musical sense-making is integral and evident as performers and their instruments create music in real time. This fact shows improvisation is a strong case study for understanding the cognitive phenomenon of enactive and distributed musical creativity, as the "musical ideas" can only be understood through patterns of relationship and adaptation between musical agents in active performance. Here musical agents may include performers as they perceive and act in a musical

[25] Small, *Musicking*, 9.

environment, as well as the instruments and notational technologies which constrain and shape performers' perception-action capacities.[26] From this perspective, musical creativity in improvisation may be understood as the product of a complex system of interdependent agents which dynamically form a self-creating, self-organizing whole through recursive cycles of perception and action. While a performance is not a truly living organism, understanding groups engaged in coordinated activity as similarly autopoietic systems is a useful metaphor for describing the processes of adaptation and emergence evident in assemblages of improving musicians and things.

2.12 Interventions and Implications of Improvisation as Ecology

Two primary interventions into western musical practices become apparent from this ecological perspective. First, it follows that improvised musical performances which operate under an ecological framework are much less concerned with symbolic representation.[27] An embodied cognitive perspective suggests that the phenomenon of musical creativity in improvisation operates without the mental interpretation of symbols.[28] This is due to the dynamic, enactive quality of sense-making, in which meaning is arrived at through sensorimotor adaptation in the world rather than processing internal representations in the head. Traditional western music notation, as I will explore later, carries a symbol-processing model of cognition to the concert stage in ways improvised forms do not. Secondly, musical ecologies suggest that creative cognition is always distributed between agents in the system, and that

[26] Here I use the term "agents" loosely derived from an actor network theory perspective. "Actants" may be a more accurate term in this context, but I have used "agents" for simplicity. For more see Latour, Bruno. "On Actor-Network Theory: A Few Clarifications." Soziale Welt 47, no. 4 (1996): 369–81.

[27] Here and throughout this work I refer to integrated practices which blend both improvisation and composition. Often, I will simply refer to these practices as composition. This is not to underplay the importance of improvisation, design, and other practices under that of composition, but rather to reclaim composerly activity from the purely symbolic, notational, and representational forms. As such, I refer to any practice of intentional organization of the temporally extended form of musical performances, either through specific notated outcomes or by sculpting the conditions under which music is made, as simply composition.

[28] Hayes, Lauren. "Beyond Skill Acquisition: Improvisation, Interdisciplinarity, and Enactive Music Cognition." *Contemporary Music Review* 38, no. 5 (September 3, 2019): 446–62.

musical ideas or norms may be attributable to that system rather than the summation of individual contributions. This eschews the notion of single-authorship characteristic of the strict labor divisions between composers and performers in the western classical model. The observable form of systems in action is defined not by a prescribed structure or additive measurement, but by the constant negotiation between its component parts. From this perspective, it is hard to imagine that the products of cultural practice, its artifacts and performances, could ever be defined or delivered solely by single individuals with clever ideas. Musical improvisation embraces this notion as a compositional methodology. This breaks with the internalist, individualistic notions of musical expression common in traditional western musical practices, namely the hierarchical relationships of creative agency between composers, performers, and audience.[29]

Such a distributed notion of creative activity has informed my own practice as a musician. Especially because I almost always implement some degree of improvisation in my performances and composed works, the origin of musical materials as they emerge in real time is of great interest to me. In the loosely defined genre of free improvisation, with respect to which my musical style can be most usefully discussed, musical materials arise from performer(s) negotiating a shared musical environment, with few to no explicit rules or limitations. Such musical practices often eschew pre-performance formal directives, either represented in standard western classical notation or otherwise. Simply put, improvisational forms such as those found in free improvisation emphasize the distribution of creative agency more equally among performers and contrast the traditional hierarchy of creative agency expressed by the western classical composer/performer dichotomy. In this way, improvisational forms embrace a distributed, autopoietic, and ecological form of musical practice. If improvisation naturally distributes creative agency away from the composer, musicians interested in composerly activities (which may include score-making, collaborative composition, instrument design, etc) must consider the musical

[29] Lewis, "Improvised Music after 1950", 91.

ecology being arranged, and how individual agents affect the interaction dynamics between the group. The focus of composing from this perspective is on creating and constraining the conditions under which musical forms arise, more than specific aesthetic outcomes. In understanding this key component of improvised music, practitioners working with improvised forms may be interested to delve further into how distributed creative systems dynamically organize emergent musical forms.[30] Doing so may offer benefits to those working with integrated composition-improvisation practices, cooperating within collaborative ensembles, and even within the intimate creative relationship between individual performers and their instruments.

From a radically interdisciplinary range of scholarship including neuroscience, anthropology, philosophy, and arts practices, embodied cognition argues for the importance of body and world in complex cognitive tasks. In my view, improvised music is a prime example of such a cognitive task, in which the cognitive load of creativity is dynamically distributed between agents in a performance. The lessons from these fields speak to the nature, origin, and dynamics of human cognition in action, and thus serve as a fitting supportive structure for discussing musical practices in which the exercise of musical agency and the cultural product itself (music) arise simultaneously in the process of a musical performance. From this embodied perspective, the operative nature of improvised musical practices may be elucidated and exploited for musical experimentation. Through exploring these ideas as applied to integrated composition and improvisational musical practice, I will show their efficacy in helping to understand the operational dynamics of improvised music. In turn, this understanding may provide new avenues and perspectives for composers and performers working with improvised music practices.

[30] See Borgo, David. *Sync or Swarm: Improvising Music in a Complex Age.* New York: Continuum, 2005.; Clutterbuck, Mudd, and Sanfilippo, "A Practical and Theoretical Introduction to Chaotic Musical Systems" for examples.

2.13 CONCLUSION

Viewing musical improvisation as a complex, dynamic, and self-organizing cognitive phenomenon, a combination of embodied cognition and systems theoretical approaches offers insight into the organizational character of the products of improvisatory thinking. By developing the concept of musical improvisation as an embodied cognitive ecology, we may better understand how musical form emerges within an improvised performance. This perspective offers a more plausible explanation of emergent form within improvisation than traditional cognitivist notions of mentally represented musical ideas, by speaking to the distributed and emergent character of improvised forms. This is particularly helpful for practitioners working with improvisation, as an enactive, ecological model provides an effective framework for implementing integrated composition-improvisation practices which prioritize the organization of interaction dynamics over specific and prescribed sonic outcomes.

As a distributed and emergent musical activity, improvised musical forms should be understood as products of a musical ecology, a network of multiple individuals and their tools cognizing collectively in music making. From here we may consider improvised musical forms in ecological terms, as an expression of a specific *musical ecology*, with a network of feedback controls that determine its emergent form. Furthermore, engaging this implicit formal structure in the organization of improvised musical forms may inform the development of composition and performance practices in improvised music. Composers and improvisers may focus their attention and practice on the network of control relationships within a musical ecology to better exploit (through composition) and navigate (in performance) improvised musical performances. Dealing with these characteristics of improvisation and the issues they raise regarding authorship, group cognition, and musical structure has historically remained at the center of improvisation discourse, most substantially in the musical contributions of composers and improvisers working in a variety of musical communities since the 1950s. My project is a continuation of this history, through composition, performance, and scholarly research, which seeks to utilize cognitive theory to

elucidate what improvised musical form is, how it comes to be, and how it can be organized to best make use of its structural idiosyncrasies.

3 MUSICAL ECOLOGIES AND SYSTEMS COMPOSITION

3.1 COMPOSING MUSICAL ECOLOGIES

Having introduced a number of concepts from embodied cognition as they relate to improvised music practices, I have conceptualized ensemble improvisation as a musical ecology, and thereby implied that improvised musical forms are determined by the structure of this ecology. This perspective suggests opportunities for composers of improvised music, defined broadly as anyone involved in creating and providing musical materials before performance. Because musical forms emerge as products of the musical ecology, through a network of interactive relationships between its component members and their tools, providing materials such as instruments, scores, computer music software, or other sorts of interventions on the musical ecology become important structuring elements for its resulting musical forms. This is because changes to the musical ecology inherently shifts the suite of musical affordances, or perceived musical possibilities for action, which appear in performance and structure the musical decision making of ensemble members.

In this chapter, I explore the notion of composition from a musical ecology perspective. In what I call *Systems Composition,* composers intervene in the musical ecology in order to affect system dynamics, which in turn shapes the process through which musical form emerges in performance. Composing in this way is not new to improvised music practice, as composers in the tradition have developed modalities for organizing improvised performance without prescribing hyper specific sonic outcomes, as is the case in fully notated music. In proposing the neologism Systems Composition, I intend to draw a frame around this tradition of practice in improvised music, show its resonance with embodied theories of cognition, and ultimately suggest my own music as engaged in this tradition. I do not mean to generalize or reduce *all* improvised music practices under my ecological perspective, but rather to express my own practice through the music and philosophies which inspire it.

First, I explore theoretical contributions on distributed musical creativity, to conceive of ensemble performance as necessarily distributed between individuals and their tools. These perspectives on group cognitive tasks show that the emergent behavior of coordinated groups goes beyond the mere summation of individual contributions and may be analyzed by considering the tendencies expressed by the system at large. After this, I introduce work from systems-theoretical and embodied perspectives which analyzes musical forms found on improvised recordings. This project is a useful case study of how enactive, embodied, and ecological approaches can help explain how improvised ensembles make coherent forms through adaptation to a perturbing environment. Showing that improvised forms can be analyzed using these connectionist perspectives suggests that composers may be able to organize performances by attending to relevant variables in the structure of musical affordances available to improvisers. Such a compositional perspective, Systems Composition, sees composition for improvisation as akin to systems design. I explore how the history of post-cognitivist critique in the artificial intelligence community can explain some of the benefits of designing musical systems using embodied perspectives. Lastly, I explore two examples of Systems Composition in the work of George Lewis and Derek Bailey, to show how this compositional concept has been expressed in the work of celebrated improvised music practitioners.

3.2 MUSICAL CREATIVITY IN GROUPS

Thinking in groups, while not exclusive to human cognition, is a hallmark of our success as a species. Our ability to work together by coordinating actions in the world leads to outcomes which go further than the sum of individual contributions.[31] One particularly exceptional example of this is described by Hutchins's classic ethnography of group thinking between members of a ship's crew.[32] In

[31] Duby and Impett. "Minds, Music, and Motion: Ecologies of Ensemble Performance."; Hagberg, Garry L. "Ensemble Improvisation, Collective Intention, and Group Attention." In *The Oxford Handbook of Critical Improvisation Studies*, Volume 1, edited by George E. Lewis and Benjamin Piekut, 481-499. Oxford University Press, 2016.

[32] Hutchins, *Cognition in the Wild,* 9-49.

this example, a crew of multiple skilled persons, working in conjunction with one another at a distance and according to specific roles, is able to navigate on open water quickly and with impressive accuracy through communicative feedback between individuals and their tools. Charting the interactions between crew members as they use a specialized tool called the "hoey", Hutchins argues for the importance of action in the world in the cognitive system, showing how bodily movement, talk, and communicative gesture are used to generate representations which can be used to calculate the ship's position and course. His example shows how groups thinking with tools may be understood as a unified and inseparable cognitive system, fundamentally different from mere additive combinations of individuals. This system operates by the interaction between perception-action cycles which occur from embodied activity in the world. From an enactivist position, the marginal cognitivism exhibited by Hutchins' insistence on symbol processing and the computational metaphor may be adjusted to a less computational conception while still upholding the fundamental insight of group thinking as a cognitive system or ecology.

Importantly, Hutchins' "cognitive ecology" focuses on cognitive tasks which are distributed between multiple minds as well as the tools those individuals use to accomplish complex tasks.[33] The cognitive ecology of the ship crew would fail to operate by the same conditions without the hoey. Distributed cognition shows that a cognitive ecology can produce outcomes which cannot be described by mere summation of individuals in the group. Musical ensembles provide a particularly fruitful case study of this concept, especially considering that their creative outcomes are arguably more complex and widely-varied than in the task of getting where you're going in a nautical vessel.[34]

[33] ibid.

[34] Ship navigation in this sense may be more metaphorically akin to musical ensembles with more explicitly hierarchical role-based structures, such as conducted music.

3.3 MUSICAL ECOLOGY AS SUPERORGANISM

Musician and researcher Marc Duby has explored the application of an embodied and ecological framework to group ensemble performance, with a particular focus on free improvisation as a window into the emergent dynamics of creative thinking in groups. He draws on Jacob Von Uexküll's theory of the "Umwelt", which broadly posits that each living organism has access to an individual world, the conditions of which are defined by the organism's capacity for sensory perception, which in turn are evolutionarily necessitated by actions in the world crucial to the organism's survival.[35] This is further supported by Gibson's ecological psychology and concept of affordances, which are "dependent upon what a particular environment offers to a particular agent".[36] As a thought experiment, Duby likens ensemble creativity to the cognition between the members of a colony of leafcutter ants. These insects have defined roles which, coordinated together, are able to form complex colony structures and adapt to their environment to find food, avoid hazards, and other essential cognitive feats of survival. Though their suite of perception-action couplings are relatively small in scale compared to human cognition, the underlying conditions for cognition being dependent on these couplings remains true for humans and ants alike. Duby goes on to argue that these individuals working together can be considered a type of "superorganism", which can better describe the cognitive load of the entire ant colony system than analyzing individuals alone. Likewise, musical ensembles, particularly those which employ non-hierarchical structures like group free improvisation, may best be analyzed using a systems theory approach, following Duby, as a musical superorganism.[37]

[35] Von Uexküll, Jakob. "A Stroll through the Worlds of Animals and Men: A Picture Book of Invisible Worlds." *Semiotica* 89, no. 4 (1992).

[36] Duby and Impett. "Minds, Music, and Motion: Ecologies of Ensemble Performance." 4.

[37] ibid. 4.

3.4 DISTRIBUTED CREATIVITY

Adam Linson and Eric F. Clarke argue for the importance of embodiment and distributed creativity within an improvising ensemble. This distribution is presented threefold. First, creativity is distributed in such a way that undermines "the simple dividing line between the brain (or brain-bound mind) and the body".[38] As we have explored, this is the most essential critique of cognitivism within embodied literature, which shows it is "no longer tenable to regard the brain as the sole site of cognition and creativity".[39] A second mode of distribution in musical thinking extends the distributed brain-body system into the environment, primarily through the inclusion of tools and other objects used in performance. Tools shape the "possibilities and constraints" of interaction between performers and their instruments.[40] In doing so, musical moves must be understood as the product of distributed thinking between brain, body, and world. Lastly, Linson and Clarke point to a third type of distributed creativity which emphasizes the socially situated nature of musical practice. Musical practice is shaped by a complex history of social interaction, wherein cultural norms are learned, acquired, and opposed. The insight that "an individual's knowledge is fundamentally interconnected with the knowledge of others" is thus important to understanding the musical moves of improvisers.

In each layer of distribution presented by Linson and Clarke, Gibson's affordances play the most fundamental role in shaping the possibilities and constraints imbued into a musical scenario. Perceptive and motor capabilities are, in each case, enabled by the embodied relationship between performers and their environment. These affordances are thereby "in the world" and present themselves to skilled practitioners as musical possibilities for action.

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[38] Clarke, Eric, F., and Adam Linson. "Ecological Theory and Group Improvisation." Essay In *Distributed Creativity: Collaboration and Improvisation in Contemporary Music*, edited by Eric F. Clarke and Mark Doffman 52–69. New York, NY: Oxford University Press, 2017. 55.

[39] ibid. 56.

[40] ibid. 56.

3.5 A MUSICOLOGY OF SYSTEMS

If Duby's view of improvising musical groups as superorganisms is to be accepted, how might this affect an analysis of musical moves over the course of an improvised music performance? If musical cognition within improvising groups can be understood as a distributed phenomenon between agents in a cognitive ecology, the ontological focus of music shifts away from individualist conceptions of authorship and internal representation. Attempting to explain freely improvised music using the tools of traditional western analysis will fail due to such an ontological mismatch. This is because the focus of traditional analytical methods, such as harmonic, rhythmic, and formal analysis, is on the outcomes of musical performances. Non-improvised pieces which are notated in western-classical style provide theorists with a document of symbols which represent the ideal outcome of musical events. Implicit in a fully notated score is a perspective on musical cognition which relies on internal symbol processing, and a hierarchical distribution of creative agency between the minds of composers and the bodies of performers. Crucially, traditional, so-called "fully notated" scores provide a conception of musical form represented in atemporal totality. In the case of improvised performances, theorists at best have access to recordings or the performance itself to analyze how the musical ideas unfold over time. Musical events can therefore only be experienced in temporally-extended listening. Even when these performances are (often painstakingly) transcribed, there is little gained in understanding exactly why musicians play what they play. Linson and Clarke describe how trends in early music psychology took a similar approach in trying to understand jazz improvisations through post-hoc symbol analysis.[41] These analyses prioritize the logical progression of harmonic and melodic sequences, effectively defining musical engagement as "a kind of abstract problem solving".[42] By firmly grounding the experience of listening in the realm of mental representation, the embodied and affective interactions between performers and their instruments

[41] Clarke, Doffman, and Linson. "Ecological Theory and Group Improvisation." 54.

[42] ibid. 54.

are entirely ignored, and their cultural situatedness reduced to symbolic patterns. Free improvisation, as Duby notes, is not outcome-oriented, at least not to the degree exhibited in ensembles playing precomposed, representational forms. To understand and explain the musical moves of improvisers, it is useful to develop a framework for analysis which resonates with the dynamic, temporally extended orientation of improvised forms. A musical ecology approach offers an analytical framework which observes system dynamics rather than documenting an individual listener's experience.

3.6 Finding Order in Chaotic Improvising Systems

David Borgo has explored using systems theoretical approaches to analyze improvised music in his book *Sync or Swarm: Improvising Music in a Complex Age.* Acknowledging the complexity of the interaction dynamics inherent within improvisational ensembles and how that complexity is integral to the structure of improvised performances, he sets out to describe how musical order is derived from chaos. With the help of mathematician collaborators Joseph Goguen and Rolf Bader, Borgo employs phenomenological and computational analyses of improvised performances (selections from Sam Rivers Trio, Peter Brötzmann, Art Ensemble of Chicago, and others) to derive representative charts and graphs of salient transitions, fractal pattern development, and major phase shifts within the music.[43] Fractals, phase shifts, and other mathematical terms relevant to systems theoretical analyses are described in *Sync or Swarm* in digestible detail. Delving into these terms at length is beyond the scope of this paper, but nonetheless Borgo's methodology can be usefully explored in general without employing the full lexicon. What this method seeks to show is how changes in the musical system, such as an instrument entrance, sudden changing of tempo, or increasing harmonic density, increase complexity within the musical environment. This change must be adapted to by the ensemble members as they actively listen and respond to musical affordances, generating an emergent form over time. Like Duby, Borgo shows that the

[43] Borgo, *Sync or Swarm*

characteristics of adaptability and emergence distinguish improvising ensembles as self-organizing systems, regulated by feedback control between perception-action cycles of listening and playing.[44]

Further inquiry into how systems theoretical approaches may inform an understanding of musical creativity has been developed in recent years. Dylan Van der Schyff, Andrea Schiavo et al. describe a 4E perspective of musical creativity which synthesizes post-cognitivist and systems theoretical approaches.[45] Drawing on dynamical systems theory, the authors focus their analysis of musical creativity on patterns of interaction within a cognitive system rather than on explicit musical outcomes, moving toward "a more explicitly social and collaborative direction that aligns with a 4E orientation".[46] They describe an empirical study not unlike Borgo's, undertaken by Walton and colleagues, in which dynamical systems theory techniques are used to analyze improvisations by two pianists in two distinct musical environments (a swing style backing track vs. a simple drone). The study tracked the tendencies of the pianists to coordinate movements between one another (such as in rhythmic coordination). Walton and colleagues found that in the more open and stable droning environment, the two musicians demonstrated a higher degree and frequency of movement coordination. Without a static, non-interacting structure provided by the swing track's harmonic and rhythmic framework, the drone track demanded of the musicians "the co-enactment of higher levels of constraint in their music and movement as they worked together to create and keep time".[47] Participants reported a heightened sense of "freedom" in the drone environment, which Van der Schyff et al. describe as potentially indicative of the importance of the social dimension of musical creativity, in that both pianists experienced a demand for more mutual co-creation of structure. Findings from this study support a conception of musical improvisation as necessarily dependent on a

[44] ibid.

[45] Schyff, Dylan van der, Andrea Schiavio, Ashley Walton, Valerio Velardo, and Anthony Chemero. "Musical Creativity and the Embodied Mind: Exploring the Possibilities of 4E Cognition and Dynamical Systems Theory." Music & Science 1 (January 1, 2018)

[46] ibid. 9.

[47] ibid. 10.

system of co-enacted adaptations between agents in a musical ensemble. They also show that the more improvisation and relationality becomes fundamental to musical structure, the more these musical forms may be understood to arise from the conditions and controls inherent to a musical ecology. Furthermore, Van der Schyff et al. insightfully point out that these findings may have implications for musical practices which intentionally attend to organizing the conditions of an improvising environment, stating that "musical environments that allow musicians to mutually constrain each other's creative production—to obtain a balance between individual expression and group cohesion—may afford more creative opportunities for extended or 'distributed' music-making".[48]

Systems theoretical approaches prove to be promising angles for understanding the tendencies exhibited by cognitive ecologies such as improvising musical ensembles. If these approaches help describe how musical events unfold within improvised settings, they may also provide insight for practitioners working in improvised forms, much like traditional score analysis has helped western classical composers understand the operational dynamics of music they admire. Given that the arrangement of agents in an improvising ensemble may easily include persons, instruments, improvising scores, and artificial intelligences, it seems that under the musical ecology framework the scope of composition may shift from the organization of symbols to nontraditional scores like graphic notation and game pieces, ensemble development and history, coding, and instrument design.

3.7 SYSTEMS COMPOSITION

Having explored the nuances of musical ecologies, their functional characteristics, and relevant component parts, the question arises as to how these principles might be utilized by practitioners, outside of merely providing a convincing language with which to analyze and explain improvisatory performances. How might these theories be applied to musical practices, and what would that mean?

[48] ibid. 10., quoting Linson and Clarke

Because musical ecologies help explain behavior of and within cognitive systems of improvised playing, application in musical practice is akin to systems design. To organize musical performance from a systems perspective is thus, in a sense, designing behavior.[49] The relevant creative choices are focused not on specific musical outcomes, but instead on the conditions under which the cognitive ecology operates. Such interventions may take the form of a variety of musical and technological practices, but each bear a composerly quality, in that they seek to influence the organization of a musical performance. What emerges is a sort of "Systems Composition", which shapes the state of a musical ecology by providing for and constraining various musical affordances.

To compose from this systems-oriented perspective is to organize or otherwise restructure the relationships of a musical ecology, which in turn will affect form as it emerges in performance. The perspective of a composer working in Systems Composition requires abstraction of each performers' musical affordances into a larger system than that of an individual improviser working to develop their craft. Given that affordances are available to individuals in part according to highly individualized personal histories, the implementation of affordances in composition is never exact, but instead experimental or speculative. This doesn't negate the potential for Systems Composition, insofar as it is concerned primarily with expressing the dynamics of complex systems rather than exact musical outcomes. Emergent musical forms which result from this change in structure are often surprising even to the systems designer. As I explore later regarding Lewis's *Artificial Life*, this is often an explicit goal of designing a system with behavior.[50]

[49] 'Designing behavior' and the related concept of 'the aesthetics of behavior' are attributable to Simon Penny's theorization on interaction in art practice. For more, see Penny, *Making Sense.* In my work, designing musical behavior does not imply that behavior is or can be entirely controlled, but rather that the conditions under which behavior takes place are organized in an experimental fashion to provide a wide range of musical possibilities unforeseen by the composer.

[50] Lewis, George E. *Artificial Life 2007* New York: Edition Peters, 2007.

Designing behavior is not in any way new to the world of art practice. Behavior as an aesthetic variable has proved particularly fruitful for visual and performance artists as computing technologies have grown more capable and accessible.[51] Interactive artworks utilize electronic technologies to imbue behavior into a nonhuman entity and are thereby concerned both with the nature of machine cognition as well as the interaction between artwork and viewer. Unsurprisingly, the broader technocultural situation surrounding the emergence of interactive arts practices had a significant impact on the work, often directly engaging contemporary discourse on artificial intelligence technologies. This discursive history provides a groundwork for what has been explored practically and philosophically in regard to designing behavior in artificial cognitive systems. What follows is a brief stroll through the history of AI discourse as it relates post-cognitivist critique. This provides a conceptual foundation for developing arts practices which prioritize designing the conditions under which a cognitive system like a musical ecology operates in lieu of designing specific, prescriptive outcomes.

3.8 Artificial Intelligence and Post-cognitivist Critique

The application of enactive, ecological, and other embodied perspectives on cognition as a critique of computationalism or cognitivism is historically related to critiques of practices within the artificial intelligence field beginning in the late 1980s. Discourse surrounding the philosophy of cognition and technical AI research has a long history. In the eighties, the AI community was shaken by a wave of criticism from philosophers of mind and AI scientists like Hubert Dreyfus, Rodney Brooks, and Philip Agre, who challenged the underlying internalist assumptions of the discipline. This both informed new and promising avenues for technological research in a time of stagnant growth for the field, as well as offering insight into the nature of human cognition which AI was failing to model. For the purposes of informing a practical application of musical ecologies, the key insight from this critique and subsequent

[51] Penny, *Making Sense,* 357.

development is that design philosophies which emphasize the embodied and distributed character of cognition are better able to navigate complex and noisy environments.

The field of artificial intelligence in the 1980s was dominated by symbolic AI, a set of practices which attempts to model human cognition with machines that make decisions based on some representational model of their environment. This representational model is informed by some sensor system, which sends its electronic impulses to a central processor that decides further action to give its end effectors. AI researchers operated from a perspective that cognition which drives action in the world must be akin to the logical reasoning of Boolean operators. The thinking goes that, if an intelligence could create a detailed enough representation of its environment, it could use inferential processes using a database of prior stored knowledge to meaningfully interact and navigate in its environment. This assumption was convenient for a field thoroughly committed to replicating sentience through an application of mathematical reasoning on representational symbols. Symbolic AI researchers had allowed their methodology to run away with their foundational philosophy of practice, as researchers doubled down on representational models of cognition which conveniently reflected the computational technologies they chose to employ. Unfortunately for the artificial intelligence scientists working in the paradigm of symbolic AI, computationalism was a philosophical miscalculation which created unavoidable limits and failures for AI systems.

For example, one pitfall of the period of symbolic AI is *the common sense problem*. This occurs because even when a system has immense capacity to model the world or some aspect of the world, embodied knowledge requires an understanding of context that is nearly impossible to account for. Simon Penny gives an imagined example from a language processing system in his book *Making Sense:*

> "Imagine a reading system confronted with the word *armchair*. If it knew the words *arm* and *chair*, it might deduce that an armchair is a chair shaped like an

> arm or that it is a chair for an arm, but it would be unlikely to arrive at what we commonly mean by *armchair."* [52]

Criticisms of this and other such failures by the internalist approach to AI appeared from a number of directions. Hubert Dreyfus, philosopher, criticized symbolic AI's representationalist conception of perception in his work inspired by the phenomenological insights of Maurice Merleau-Ponty and Martin Heidegger.[53] Roboticist Robert Brooks introduced his concept of subsumption architecture, a type of "bottom-up" robotics which modeled how some animals are able to skillfully navigate noisy environments using only simple reactive strategies which tightly coupled perception and action, rather than the extensive process of top-down sensing, mapping, planning, and acting.[54] Philip Agre and his collaborator David Chapman, both of whom worked under Brooks on their PhD research at the MIT AI lab, challenged the notion that cognition required some capability of panopticism in the pursuit of detailed mental representation, instead arguing for simple interfaces capable of adapting to novel situations.[55] Agre understood that to create an intelligence was to engage in cultural and social practice, and advocated for a "critical technical practice" which Penny points out is closely related to the practice of critical making already long adopted in interactive art practices.[56]

Contemporary AI is radically different than the sense-map-plan-act implementations of the 1980s, instead employing more bottom-up approaches like neural networks and machine learning. Today, recent developments into Bayesian predictive coding in artificial intelligence systems may present an

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[52] Penny, *Making Sense*, 114.

[53] Dreyfus, Stuart E., and Hubert L. Dreyfus "The Five-Stage Model of Adult Skill Acquisition." *Bulletin of Science, Technology & Society* 24, no. 3 (June 2004): 177–181.

[54] Penny, *Making Sense*, 118.

[55] ibid. 122.

[56] ibid. 123.

opportunity for AI to inform the design of musical ecologies. Put quite reductively, Bayesian models are systems which continuously update internal, probabilistic inferences about the world. They operate by interacting with the world and analyzing the real outcome of actions as compared to the model's predicted outcome to decrease the degree of error between the two. By modeling a system which acts much like the constant feedback between perception and action described by enactive cognition, Bayesian models may provide strategies for coding decision making behavior into technological artifacts that participate actively in their environment. However, as Nico Orlandi points out, Bayesian perception must not be thought of as representational cognition.[57] Orlandi offers a conception of Bayesian perception which is more akin to Gibson's ecological models of perception. This insight defines Bayesian perception as not true inferences, and thus not reliant on a process involving representational cognition. Instead, perception is a direct relation to a cognizer's environment, as in Gibson's models. If such a nonrepresentational approach to modeling cognition is maintained, the principles of Bayesian coding may provide new avenues for modeling cognition in enactive and interactive systems for composition, improvisation, and performance. This may pose a sort of synthesis between internalist and externalist paradigms, as Bayesian systems are technically processing predictions based on internal representation, but nonetheless operate with the sort of constantly updating, emergent, and adaptive behavior of truly enactive and embodied cognitive systems.

These lessons from the discourse surrounding AI provide new vocabularies for artists to describe their work outside of a representational paradigm of cognition and instead with an embodied approach. This approach more accurately describes the types of emergent experiences of meaning making available

[57] Orlandi, Nico and University of Arkansas Press. "Bayesian Perception Is Ecological Perception:" *Philosophical Topics* 44, no. 2 (2016): 327–351.

to improvisers and performers of all types, who are familiar with the tightly coupled nature of perception and action in performative musical creativity.

Furthermore, an enactive, ecological approach to understanding musical creativity and emergent form within improvised music suggests the potential for an applied practice of musical ecologies, designing or otherwise attending to the conditions under which cognition occurs in an improvisatory performance. Practices which employ this ecological perspective may take the form of notational composition (such as in an open, improvisatory score), the development of instruments and other musical technologies (such as interactive audio effect programs, embodied robotics, and enactive instruments which exhibit autopoietic behavior), and even in the careful curation of musical ensembles, with each member carrying their individual, socially embedded histories into an expanding territory of the ensemble's shared cognitive ecology. These ideas are not particularly new to the world of improvised music, as practitioners have intentionally engaged the emergent and ecological nature of group improvisation for many decades. My hope is to draw a conceptual frame around these practices under the name *Systems Composition*, to elucidate the efficacy of and further potential for organizing improvisatory performances from a perspective which embraces the embodied, distributed, and ecological nature of improvised creativity.

What follows are two brief case studies of musical works which resonate with the notion of Systems Composition, to exemplify the application of musical ecology in practice. These musical contributions, among others in the history of improvised music communities of practice, have in large part laid the foundation for my concept of musical ecologies and Systems Composition. Rather than merely examples or proofs of my own concept, they are important historical developments in understanding how improvised musical performances result in emergent forms.

3.9 DEREK BAILEY – *COMPANY*

Human participants in a musical ecology bring into the system their individual histories of musicianship and selfhood, and these socially embedded characteristics meld and interact with those of other ensemble members, forming a group identity with its own historical and social embeddedness. An individual musician's historical context is developed by not only their personal relationship and coupling to their instruments through practice, but also their sociopolitical experiences of class, race, gender, sexual orientation, and other salient social histories.[58] Musical practice, of course, is social in ways that are not explicitly musical. Bringing together an ensemble is a manner of constructing the conditions of a musical ecology, and successful ensemble development requires that ensemble members be able to empathetically relate to one another's social situatedness without tending towards a volatility which threatens the stability of the system.[59] Duby outlines the case of British rock supergroup Blind Faith, which despite their individual accomplishments in music, were unable to succeed due to an inability to work together personally and musically.[60] Other cases prove more concerning than a few rockers not getting along, such as the 2004 Guelph Jazz Festival controversy described by Tracy Nicholls, in which a trio by Sainkho Namtchylak, William Parker, and Hamid Drake erupted into turmoil when concert organizers pulled Namtchylak offstage for what they perceived as a critical and uncooperative performance style.[61] (Note that, as Small's concept of musicking suggests, event coordinators, producers,

[58] Treatment of race, gender, and other identities within improvised and experimental music deserves further discussion which is outside the scope of this text. For more detailed discussion of these topics and their relative lack of attention in scholarship, see Iyer, Vijay. "Beneath Improvisation." In *The Oxford Handbook of Critical Concepts in Music Theory*, edited by Alexander Rehding and Steven Rings. 59–80. Oxford University Press, 2020., and Lewis, George E. "Gittin' to Know Y'all: Improvised Music, Interculturalism and the Racial Imagination." *Critical Studies in Improvisation / Études Critiques En Improvisation* 1, no. 1 (September 1, 2004).

[59] Clarke, Eric, Tia DeNora, and Jonna Vuoskoski. "Music, Empathy and Cultural Understanding." *Physics of Life Reviews* 15 (December 2015): 61–88.

[60] Duby and Impett. "Minds, Music, and Motion: Ecologies of Ensemble Performance." 10.

[61] Nicholls, Tracey. "Speaking Justice, Performing Reconciliation: Twin Challenges for a Postcolonial Ethics." Critical Studies in Improvisation / Études Critiques En Improvisation 6, no. 1 (May 1, 2010).

and audience members are relevant components of a musical ecology). Despite many such cases in which a musical ecology fails to adapt between the social and cultural differences of ensembles, producers, and audience, the dynamics created between ensemble members according to their social situatedness are capable of very productive outcomes. Curation of ensembles with an intention towards the generative effects of cultural combination has proved valuable for a number of artists, with some taking this idea as a key methodology of organization.

British guitarist Derek Bailey was one such artist, whose work in curating ensembles for group improvisation is the fundamental compositional concept for his improvisation collective, *Company.* Bailey is also the author of *Improvisation: Its Nature and Practice in Music,* a foundational text on musical improvisation studies which contains, among a wealth of other interviews and essays, a personal ethnography of his work and intentions with *Company.* A short description of the groups musical practice is described in a program note for Company Week, an annual festival devoted to performances by the group: "It is a pool of musicians of changing personnel whose membership reflects a variety of improvising styles and attitudes. The size and personnel of the groups will be decided by the musicians each night immediately prior to the performance."[62] The inspiration to develop an approach which prioritized a constantly shifting and ad-hoc ensemble comes from Bailey's interest and satisfaction with "the early stages of a group's development", which in his view, avoids the concretizing effect on musical style created by a long and developed shared history within an ensemble.[63] Once ensembles had become well-rehearsed and their shared identity clearly formed, musical moves were "less dependent on improvisation".[64] Members included international artists already established in free improvisatory practices, as well as those less experienced in the scene's situated history, such as concert and symphonic

[62] Bailey, Derek. *Improvisation: Its Nature and Practice in Music*. New York: Da Capo Press, 1993. 134

[63] ibid. 133

[64] ibid. 133

musicians. By organizing the musical ensemble by a process of constant ad-hoc reformation, Bailey intended to preserve the specific dynamics inherent to an ensemble with little to no shared history of performance.

Bailey claims that this process was developed "to elevate the method of music-making above its various stylistic results", which resonates with Systems Composition's focus on organizing the conditions for musical creativity over specific musical outcomes.[65] From this perspective, *Company* can be understood not as merely a collective of individuals, but as a compositional methodology. As a form of Systems Composition, *Company* takes as its primary variable the negotiation between each individual's cultural situatedness, and how they dynamically interact with one another to navigate a shared space of empathetic, distributed creativity.

3.10 George Lewis - Artificial Life 2007

As I have discussed, improvised musical works eschew explicit, pre-performance symbolic representation of sonic outcomes by employing distributed and real-time decision making in the development of musical form. This differs from western classical notation practices, which strive to accurately represent explicit sonic outcomes in musical scores, both for performance instruction and scholarly analysis. However, it should not be ignored that composers working with improvised forms often employ notational technologies in the organization of their performances. Despite containing symbols and representations, the use of scores for improvisation operates in a manner fundamentally different from simple delivery of specific instructions for physically reproducing a composer's expressive intentions. Instead, improvisatory notational technologies require that the musician maintains a situated engagement with the ongoing sonic environment created in performance as they make decisions according to what that environment affords, choices which are further limited and enabled by information

[65] ibid. 134

represented in symbolic form. The creative relationship between scores and their human counterparts is thus embodied, situated, and distributed. A score rearranges the suite of affordances available to improvisers as they perform. Much like the navigational charts utilized by Hutchins' ship crew, notational scores become part of the improvising musician's cognitive ecology.

Score-making in integrated improvisation-composition practices has a rich history of development. Important examples from this history of improvised musical practices are abundant in the catalog of works from members of the Association for the Advancement of Creative Musicians (AACM), a Chicago-based collective of composer-improvisers of which George Lewis has been and remains a foundational creative voice. Lewis' work as a trombonist, composer, and music technologist engages questions of freedom and agency within improvised music. One notable example of this work is his development of the Voyager music system, a computational, artificial musical intelligence capable of improvising alongside human counterparts. In his description of Voyager, Lewis shows an understanding of the ecological character of improvised musical forms, claiming that the work is "not only an environment, but… a 'program', a 'system', and a 'composition'".[66] This unstable identity lends power to the work's ability to help performers and listeners "recognize the inherent instability of such taxonomies".[67]

Lewis's prolific output as a researcher and scholar has followed a similar angle of destabilizing and critiquing boundaries within musical practices, perhaps most famously in his essay "Improvised Music after 1950". In the text, Lewis describes improvisation in musical practices of the mid-20th century within both "experimental" and "jazz" practices, his paradigmatic examples being John Cage and Charlie Parker, revealing in Parker's case a history of highly racialized musical identity which informed musical practice. He contrasts the "Afrological" aesthetics of complexity, emergence, and nonhierarchical

[66] Lewis, George E. "Too Many Notes: Computers, Complexity and Culture in Voyager." *Leonardo Music Journal* 10 (2000): 33–39.

[67] ibid. 33

structures (both social and sonic) with those of the "Eurological". In Lewis's strong distinction, Eurological aesthetics are concerned with characteristics like clarity of form, single-authorship, and hierarchical organization. Surveying a range of musicians who after 1950 explored the use of improvisation as a way to structure musical compositions, Lewis argues that composers from the Eurological tradition frequently disavowed resonances and commonalities with Afrological aesthetics in their improvised works. In documenting how these racialized aesthetics have influenced the values of various improvised music communities after 1950, Lewis demonstrates the richly social dimensions of improvised music practice and history. Furthermore, Lewis's text outlines a tradition of musical practice which synthesizes Eurological and Afrological aesthetics through composing improvised works. Thinking of improvised musical performance in ecological terms and employing that perspective through Systems Composition are attempts to engage with this tradition.

One such synthesis can be explored in Lewis's work *Artificial Life 2007.* Composed for the Glasgow Improvisers Orchestra in 2007, its name may derive from the artificial life movement in art and computational technologies, which served as an inspiration for post-cognitivist interventions described earlier in this paper. In the introduction to the score, Lewis claims that the piece "is a situational-form musical composition" which "presents a model of group improvisation as an emergent phenomenon arising from negotiation and local intelligence".[68] This statement resonates strongly with the conception of musical ecologies as presented thus far, highlighting both the emergent and distributed character of the piece's form. The score contains mostly text and none of typical western musical symbols like noteheads, staves, barlines, etc. Divided into two pages, the second of which is picked from a collection of parts for each performer, the score provides no prescriptive outline of specific musical events or their placement in time, but instead constrains patterns of relationship between an individual's musical actions and the

[68] Lewis, George E. *Artificial Life 2007* New York: Edition Peters, 2007.

ongoing sonic environment, whatever it may be at a given time. In addition to text guidelines, there are grids of boxes with cues as to how to relate to the musical affordances of a sonic environment, which the performers move around according to simple orthogonal progressions. Lewis describes this methodology as a "toolbox for producing a range of sounds and forms that will far exceed what the composer would imagine".[69] The move to conceive of the score as a tool erodes the sense that it may ever be some disembodied receptacle for delivering information. Instead, *AL2007* is intended to be used, adapted to, and skillfully wielded in an open and infinitely variable array of musical undertakings.

Artificial Life provides a foundational example of how notational technologies may be designed to influence and direct the interaction dynamics of a musical ecology. As a system for generating improvised performances, it provides the conditions for emergence of form rather than taking specific musical outcomes as its fundamental aesthetic variable. Lewis has shown in this piece the existence of Systems Composition within improvised musical practices, in this example through the employment of notational technologies such as paper scores.

3.11 CONCLUSION

Musical ecology is a framework for understanding the emergent character of musical materials as they unfold in improvisatory performance. Informed by 4E cognition, Gibsonian ecological psychology, and systems theoretical approaches, ecological models of improvisation depend on a conception of musical creativity which is anti-representational, embodied, and radically distributed between agents in a cognitive system, human and nonhuman. By grounding the nature of improvisatory thinking in perception action couplings and not internal symbol processing, the most salient structural variables in an improvisatory performance are those which constrain and enable perception and action possibilities.

[69] Lewis, George E. *Artificial Life 2007* New York: Edition Peters, 2007.

These constraints and possibilities are the musical affordances available to performers as they navigate a process of distributed creativity. In addition to providing a language with which to discuss the enactive, embedded, emergent, and distributed nature of improvisatory forms, these insights have proven valuable for both the analysis of improvised performances post-hoc, as well as for practitioners interested in organizing the conditions for musical improvisation as a compositional methodology. This latter feature I have called Systems Composition to draw a frame around integrated composition-improvisation practices which I and many others before me have engaged in, and yet has not been given proper scholarly treatment as a codified methodology. In describing contemporary trends towards an ecological conception of improvised music in scholarship and a simultaneous history of these ideas applied in musical practice, my hope is to both clarify and promote the importance of this perspective both in understanding and further developing musical improvisation practices.

4 IMPROVISATIONAL SKILL IN A WORLD OF AFFORDANCES

4.1 FROM COMPOSITION TO PERFORMANCE: IMPROVISING IN A MUSICAL ECOLOGY

In the previous chapter, I discussed how affordances limit and enable musical action in improvised music, thereby suggesting implicit, complex formal dynamics within improvised music performances. This perspective presents opportunities for composers working with improvisation to organize works according to affordances which direct the interaction between performers rather than providing instructions for realizing a composer's internal musical models. Because affordances may present themselves from a broad range of environmental sources, such interventions on the musical ecology may be expressed through the mediums of score making, instrument design, ensemble curation and development, or interactive electronic systems. Systems composition presents the manipulation of affordances as a compositional practice for structuring improvised music. This framework for understanding and organizing improvised musical forms articulates an ecological model of music cognition from the perspective of a composer.

But what of the improvising musician? If the ecological model suggests an effective method for pre-performance interventions on emergent musical form, it follows that similar interventions are available to improvisers themselves in the moment of performance. The structure of a musical ecology is embodied and worldly, thus always subject to forces of change from within and outside the system. As an improviser acts in musical performance, they take part in reshaping the affordances available to other agents in the system. Similarly, the possible expressions of a system, its emergent forms, are shaped by the musical affordances available to improvisers. This suggests that the cognitive task of improvising involves both being open and attuned to a rich and dynamic suite of affordances in the environment, as

well as cultivating a sensitivity to the ways in which one's actions may affect system dynamics as a whole.

4.2 Towards an Enactive and Ecological Approach to Improvisational Skill

These embodied aspects of the cognitive task of improvised music describe two fundamental contingencies on which the emergent forms of improvised music rely. First, the cognitive phenomenon of improvisation is structured according to functional relationships between an improviser and their environment. In the language of affordances, this means that an improvising musician must be able to perceive the *usefulness* of a musical environment, or what it affords for musicking. This is an awareness of possibilities for active adaptation to the musical environment, which is mediated through an individual's structured history of musicking, and is thus highly idiosyncratic. Such an awareness involves but is not limited to a physical history of interaction with an instrument, understanding of musical signifiers through training or participation in specific musical cultures or genres, rhythmic entrainment, and the cultivation of shared musical history between ensemble members.[70] Second, emergent form in improvised music is contingent on the ability of improvising performers to take an active role in shaping the musical possibilities afforded by their contribution to a sonic environment. This means improvisers must be attentive to the entire structure of a musical environment in performance, and act in interest of its preservation as a multi-agent system. In performance, this may result in musical actions meant to reinforce the stability of an unfolding musical texture, such as when reinforcing the pulse of a rhythmic pattern by entraining to it, or alternatively introducing material meant to invoke structural change, such as in pursuit of culturally situated aesthetic goals which emphasize development and variation.[71] These two

[70] For further discussion of rhythmic entrainment, see Iyer, Vijay. "Embodied Mind, Situated Cognition, and Expressive Microtiming in African-American Music." *Music Perception* 19, no. 3 (March 1, 2002): 387–414.

[71] Development and variation are not necessarily characteristic aesthetic values of improvised music, for example in the *lowercase* genre, which eschews development and in some cases interaction as an anti-ego aesthetic.

fundamental elements of improvisation, both adeptly dealing with external perturbation by finding usefulness in a musical environment and being a useful source of perturbation oneself, may be understood as qualities which describe improvisational skill.

Skillfulness in improvised music relies on the congruence between interacting agents in a system that results in coherent structural dynamics of adaptation and self-organization (autopoiesis). This resonates with a concept from Maturana and Varela called *structural coupling.*[72] While the two concepts do not map perfectly onto one another, structural coupling and affordances both emphasize embodied relationships between an organism and its environment as the foundational scaffolding which structures cognitive action in the world. Structural coupling and other enactivist concepts help strengthen a perspective on improvised musical form based on affordances, particularly because of the focus on dynamic and temporally-extended processes of adaptation and self-organization evident in improvised music. By working to enrich the structural coupling between oneself and other agents in their musical ecology, an improviser enriches the suite of affordances available to them. In other words, they are able to perceive more usefulness in a musical environment. This increased sensitivity allows the improviser to better adapt within the musical environment to co-enact musical forms.

As Lauren Hayes has argued, traditional notions of physical virtuosity do not adequately explain the skillful ways in which improvisers co-enact musical form.[73] Noting an emphasis on technical virtuosity in the study of improvisational skill, Hayes suggests that this tendency, in addition to an overemphasis on the study of western musical practices, "leads to a narrow conception of the practice, and ultimately excludes numerous valuable contributions from any discussion of its implications or

Even still, emergent form depends on an active engagement in negotiating such culturally situated aesthetics, and the effect that negotiation has on the structural dynamics of the performance at large.

[72] Maturana, "Autopoiesis, Structural Coupling, and Cognition," 11.

[73] Hayes, Lauren. "Beyond Skill Acquisition", 7.

discourses".[74] In my own practice as an improviser, composer of improvised music, and instrument designer working with self-organizing feedback instruments, there are many qualities of skilled musical activity which are not explained by discourses which emphasize technical and physical virtuosity alone. An enactive, ecological model of improvised music performance provides a language with which to discuss improvisational skill beyond notions of instrumental virtuosity and control, instead prioritizing adaptation and openness to affordances in a musical environment. Importantly, this perspective does not deny or attack virtuosity and technical skills as irrelevant, but rather conceives of what virtuosity offers a improvising musician as different than in notated music, and arguably incapable of giving a robust conception of improvisational skill on its own.

4.3 OVERVIEW

This chapter explores such an enactive, ecological understanding of improvisational skill. First, I offer a description of the cognitive task of performing improvised music using the language of embodied cognition, particularly the concepts of affordances and structural coupling. This perspective is informed by my own experience as an improviser, composer, and instrument designer working with improvised music. First, I consider some potential pitfalls for adopting affordances and ecological perception into an analysis of improvised music. In describing improvisation as an embodied and ecological cognitive task, I consider a variety of potential sources of musical affordances available to performers, both materials like instruments and scores, as well as the dynamic and emergent sonic environment. While some musical situations may call for a broader definition of affordances than originally intended by Gibson, I show that affordances still supply a useful framework for describing the challenging environment improvisers must navigate in the shared construction of emergent musical form.

[74] Hayes, Lauren. "Beyond Skill Acquisition", 7.

After this discussion of what Erik Reitveld and Julian Kiverstein call "a rich landscape of affordances", I explore how embodied cognitive research, particularly enactive cognition, helps explain how skilled improvisers dynamically adapt to this challenging performance environment.[75] This helps provide a notion of success in improvised musical performance, and can be used to extrapolate a path towards developing improvisational skill. I show that success in an improvised music performance may be understood as successful structural coupling. This is a process through which a performer and their musical environment are able to adapt to one another through sensorimotor feedback that preserves the autopoiesis of the musical ecology at large.

Lastly, I offer some perspectives on how an enactive, ecological understanding of the cognitive task of improvised music performance may inform the development of skill as in improvised music. In understanding the nature of improvised music cognition and how or when it may be considered successful and skillful, implications arise for practitioners wishing to develop improvisatory skill. The development of this skill means more than simply repetition and rehearsal, requiring active and empathic engagement between musical agents as they epistemically interact with one another in search of new system states. An enactive and ecological perspective on improvisational skill helps explain how technical and physical ability, while undoubtedly relevant for the perception of certain musical affordances, does not fully describe development of skillful adaptation in a musical ecology. This broadened perspective on skill suggests performers and pedagogues of improvised music may attend to the development of structural coupling as an expansion of perceived musical possibilities for action, emphasizing the types of skills in socialization, attention, and interactivity which extend beyond the bounds of a single individual, and into the network of sensorimotor relationships expressed between members of a musical ecology.

Understanding improvised music performance as a cognitive ecology suggests that formal organization of musical materials emerges according to affordances available to performers. As discussed,

[75] Rietveld, Erik, and Julian Kiverstein. "A Rich Landscape of Affordances." *Ecological Psychology* 26, no. 4 (October 2, 2014): 325–352.

musical affordances are the perception of musical possibilities for action, and arise from performers' embodied relationship to other individuals, sound as it emerges, tools like instruments and scores, and the social history and situatedness of each performer. This embodied relationship, through which an agent and its embedded environment are dynamically coupled according to the congruence of their structure, we have called structural coupling. To develop a theory of improvisational skill based in structural coupling, we must explore the nature of musical affordances as they are experienced and attended to by an improviser. Furthermore, we must consider how these affordances come about, and in what ways an improviser might attend to enriching their suite of affordances in performance, to better and more skillfully couple to a dynamic musical environment. In describing the affordances available in an improvised music performance, a territory is charted, and the question of how to best navigate this territory becomes much clearer.

4.4 RETHINKING AFFORDANCES IN SOCIO-CULTURAL PRACTICE

What are the affordances available to improvisers? More precisely, what qualities of a musical environment may be usefully described as affordances in conceiving of dealing with affordances as a fundamental aspect of improvisational skill? The first and most obvious problem encountered by this line of questioning is that so far, as Reybrouck mentions, "most studies in ecological perception have been concerned with visual rather than with auditory stimuli".[76] Complicating matters further, live music performance (like embodied activity generally) is a richly multimodal experience, invoking at least visual, auditory, tactile, and socio-communicative engagement and coupling with the world.[77] Multimodality suggests that not only is embodied activity multisensory, but that these sensory abilities are often "cross-coupled" between one another. For example, in an improvised music performance, improvisers

[76] Reybrouck, "Musical Sense-Making and the Concept of Affordance.", 10.

[77] Armstrong, Newton. *Enactive Approach to Digital Musical Instrument Design*. S.I.: AV Akademikerverlag, 2012., 17.

experience all of the following in cross-coupled relationships: the auditory stimuli of an emergent sonic environment, visual stimuli which attends to the structure of one's instrument and bodily gestures of fellow performers, tactile sensations in interacting physically with an instrument, and awareness of socio-communicative qualities in the environment which suggest proper action according to situation and context, like audience engagement, concert production concerns, and imbalances of socioeconomic power between performers. More empirical research into a multimodal understanding of affordances may help resolve this issue in considering how affordances structure the activity of improvised music and thereby shape its emergent forms. The perspectives of practitioners are particularly helpful here, as their practiced-based knowledge and experience may offer insights into skilled improvisatory practice that theorists and cognitive scientists often miss.

Another potential problem for a theory of musical improvisation as skillful dealing with musical affordances is that Gibson's original concept largely focuses on tactile and motor engagement with the world, according to physical relationships between the structure of an organism and its embedded environment. As described by Reitveld and Kiverstein, these emphasize "motor possibilities the environment offers to a creature such as reaching, grasping, sitting, walking, and so on", and require a congruence of physical form between a creature and world.[78] As such, sound itself as it dynamically emerges in performance may be problematic to define as an affordance in Gibson's original terms. The congruence in structure between an improviser and the sounding environment is likely to be in the domain of socio-cultural practice rather than clearly material relationships evident between, for example, a creature's ambulatory faculties and a surface that affords support and traction for safely walking, but not running. As Reybrouck points out, finding usefulness in a sonic environment is not limited to a "bottom-up approach" for making sense of a "sounding flux", but "can be processed also in a top-down approach,

[78] Rietveld and Kiverstein. "A Rich Landscape of Affordances.", 325.

by applying conceptual knowledge that has been assimilated in the cognitive structure of the music user as the outcome of previous interactions with the sounds".[79]

I will offer an example of this top-down process from my own experience as member of improvised music ensembles. As a doctoral student at UC Irvine, I had the opportunity to play as part of a large, improvised music ensemble under the direction of Nicole Mitchell, acclaimed flutist and composer situated in the AACM and broader creative music scene. As an ensemble, we were working to prepare a concert of music based on open form, scored compositions by the ensemble director. While rehearsing a piece one evening, a young and talented saxophonist perceived an opportunity within the harmonic motion of the ongoing texture to play part of the melody of Horace Silver's jazz standard "Song for my Father", which immediately caused a bit of confusion and laughter in the rest of the ensemble. The saxophonist was clearly acting on the cultural norm of "quoting" in a traditional jazz context, that is not typically employed in the cultural milieu of improvised music. As an undergraduate jazz performance major, this was a relevant socio-cultural history in his musicking experience and training, arguably much more available for application than improvised music contexts, to which he was relatively new. Nicole called for the ensemble to cut off and explained that a rule of hers needed to be clearly established. Quoting was allowed, but if someone played a quote, the ensemble was to immediately create a chaotic and noisy interruptive texture in response before returning to the provided score. Implicit in this rule, in my opinion, may be evidence of the cultural norm in improvised music practice to eschew such tropes from traditional jazz practices. Conversation after rehearsal with friends in the ensemble more familiar with improvised music performance culture reinforced the notion that many of us had, in a sense, already adopted an implicit assumption that quoting was not an apparent musical possibility. The quote had caused a sudden awareness of the subtle imbalances in socio-cultural assumptions and experience between ensemble members. Furthermore, Mitchells's rule allowed for the saxophonist's decision to

[79] Reybrouck "Musical Sense-Making and the Concept of Affordance", 10.

quote to be reinterpreted and adopted into a newly developing socio-cultural history as an ensemble celebrating this imbalance for its compositional utility. At each level of development, the appearance of quoting as a musical possibility for action can only be extrapolated through an improviser's socio-cultural history of embeddedness.

As I've attempted to show in this anecdote, an improviser's situated socio-cultural history of previous interactions with musicking is a crucial factor in enabling and constraining the musical affordances of a sonic environment, and a theory of skill in improvised music based on affordances must account for how these socio-cultural dimensions function as affordances. Reitveld and Kiverstein offer a broadened definition of affordances that accounts for the socio-cultural embeddedness evident in skillful action in the world.[80] Drawing on Gibson's assertion that "affordances include *the whole domain of social significance*", Reitveld and Kiverstein expand the material and morphological categories of "niche" or "species" to include Ludwig Wittgenstein's notion of *forms of life,* that emphasizes "practices and abilities" of the organism rather than material structure as a way of categorizing relationships between an organism and its environment.[81] They conclude that:

> "Affordances are not simply properties of an animal's environment conceived of as a material or physical environment. It is the ecological niche of a particular form of life that is made up of affordances, and each affordance must be understood in relation to the abilities available in a form of life. In the case of humans these abilities are generally acquired through training and experience in sociocultural practices."[82]

Reitveld and Kiverstein's expanded definition of affordances as "relations between aspects of a material environment and abilities available in a form of life" provide a language

[80] Rietveld and Kiverstein. "A Rich Landscape of Affordances.", 325.

[81] ibid. 338.

[82] ibid. 340.

with which to discuss the sorts of socio-culturally embedded abilities and skills that characterize sense-making in improvised music performance, as well as the motor possibilities for musical action directly perceptible from the material environment, as affordances.[83] Such affordances, contingent on socio-cultural embeddedness and acquired experience, may be evident in what Dreyfus called "cultural skills", for example, in the ability to mail letters with mailboxes.[84] This formulation allows for an analysis of musical affordances as musical possibilities for sensorimotor engagement with the world as conceived by both the material environment and socio-cultural embeddedness of a musical ecology. It is important to note that this expansion of affordances from the material and motor dimensions and into socio-cultural abilities does not reify the dualism between so-called "higher" and "lower" cognition, but instead "raises the possibility of accounting for 'higher' cognitive capacities in terms of skillful activities in practices and in terms of the material resources exploited in those practices."[85] Understanding musical ecologies as a "rich landscape of affordances", we may be able to not only analyze and describe the variety of skillful activities evident in improvised music, but may also see how skillfulness may be acquired or shaped by experience or training in musicking.

Lastly, there is one more danger worth mentioning for conceiving of the sonic environment in improvisation as musical affordances. The sonic environment in performance is temporally-extended, and an analysis which isolates affordances in the temporal flow of embodied activity may undermine the enactive and process-like nature of creativity in improvised music performance. By pairing an ecological concept of improvised music with closely resonating concepts from enactivism, thus stressing the

[83] ibid. 335.

[84] Dreyfus and Dreyfus. "A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition," 2.

[85] Rietveld and Kiverstein. "A Rich Landscape of Affordances.", 346.

temporally extended, sensorimotor engagement in the world that characterizes musical performance, I hope to avoid this pitfall of atemporality.

4.5 CHARTING THE LANDSCAPE OF AFFORDANCES

Reybrouck's breakdown of the possible musical affordances available in his ecological model of musical practice, mentioned in the previous chapter, are a solid foundation to start from in charting the territory of musical affordances in improvised music. His extension of musical affordances to include both "productive" and "receptive" aspects of musical engagement can be seen as similar to Reitveld and Kiverstein's notion of "a landscape of affordances", in that it emphasizes the inclusion of "perceptual qualities, mood induction qualities and socio-communicative qualities" alongside those that fit more evenly into the traditional notion of affordances as motor possibilities for action.[86] Like Small, Reybrouck is motivated to extend a notion of musicking into all sorts of participatory sense-making and "coping with sounds", citing that "Skilled performance… is not the most common way of dealing with music".[87] These insights provide an understanding of the breadth of musical sense-making, but also suggest that skilled performance is a very particular way of dealing with sounds, as mediated through a richly cultivated socio-cultural history of experience and training. An enactive and ecological approach to cognition based on affordances has proved useful for describing skilled practice in improvisation for a growing number of researchers.[88] In the following sections, I will explore sources in the environment of a musical ecology which seem most salient for describing the variety of musical affordances available to improvised music

[86] Rietveld and Kiverstein. "A Rich Landscape of Affordances.", 325; Reybrouck, "Musical Sense-Making and the Concept of Affordance," 12.

[87] Reybrouck, "Musical Sense-Making and the Concept of Affordance.", 2.

[88] Hayes, Lauren, and Juan M Loaiza. "Exploring Attention through Technologically-Mediated Musical Improvisation" 22.; Geeves, Andrew, and John Sutton. "Embodied Cognition, Perception, and Performance in Music." *Empirical Musicology Review* 9, no. 3–4 (January 5, 2015): 247.; Reybrouck, "Musical Sense-Making and the Concept of Affordance."; Schiavio, Andrea, and Dylan van der Schyff. "4E Music Pedagogy and the Principles of Self-Organization." *Behavioral Sciences* 8, no. 8 (August 9, 2018): 72.; Scipio, Agostino Di, and Dario Sanfilippo. "Defining Ecosystemic Agency in Live Performance." *Array.*, 2019, 28–43.

performers, and consider how relationships with these environmental sources for musical possibility are developed through a history of interaction and coupling.

Before proceeding to focus on specific musical affordances as experienced by the improvising performer, it is important to clarify the scope of this analysis in terms of the reality of affordances. For the improviser in performance, musical affordances are apparent. In saying that an improviser may be able to enrich the affordances available to them in a given musical ecology, it is not implying that there exist affordances which are hidden, or imperceptible. Affordances describe how we perceive the environment for its usefulness in acting in the world and are constituted by a congruent relationship between an organism's structure and those of elements in the environment. As such, when focusing our analysis on the actual skilled engagement with improvised music by performers, it may be correct to say that affordances are experienced as context specific and highly subjective phenomenon in an individual, not entirely unlike Von Uexküll's notion of the *ümwelt.*[89] It should be noted however that this does not deny the reality of affordances expressed by Gibson's original conception, as noted by Reitveld and Kiverstein.[90] In describing affordances as related to particular forms of life, the authors uphold that there exist two relevant levels of description for the existence of affordances, both "the form of life and the patterns of behavior that make it up" and "a particular individual's actual skilled engagement with an affordance."[91]

In analyzing a form of life, affordances which describe normative actions and abilities of that form of life may be said to exist independent of particular subjective experience. In musical terms, though a particular sonic texture may be said to afford melodic soloing over a repeating harmonic progression to forms of life with those abilities and socio-cultural norms, the same affordance is not necessarily

[89] Von Uexküll, Jakob. "A Stroll Through the Worlds of Animals and Men"

[90] Rietveld and Kiverstein. "A Rich Landscape of Affordances.", 337.

[91] Ibid, 337.

experientially available to performers with different forms of life. An instrumentalist without the material or socio-cultural tools for melodic soloing must find other sorts of usefulness in the sonic texture to adapt and couple with the musical environment. In improvised music, the interaction of ensemble members with different instrumental and aesthetic abilities is a feature rather than a problem, as cross-cultural exchange and recontextualization serve to guide the self-organization of the musical ecology as improvers perceive and act on various musical affordances.

4.6 What a Musical Ecology Affords: Material, Sound, and Socio-cultural Ability

For the improvised music performer in a musical ecology, we have seen how musical affordances may be perceived in relation to both the material aspects of an environment and aspects derived from the socio-cultural embeddedness that characterizes human cultural practices. Material aspects of the environment may include instruments, the acoustic qualities of a performance space, scores and other materials provided for performance, and the bodies of other performers, all of which are present in the material environment as relatively static entities. Sound itself occupies a special position in the landscape of affordances, both for being structurally dynamic and volatile, and lacking the clear morphological and spatial congruence with an organism's body characteristic of material and motor affordances, such as "a banjo string affords plucking by sufficiently shaped and skilled fingers" or even "a large and properly shaped performance environment affords echoes to sufficiently loud sounds". However, the pressure changes in air molecules we call sound do afford certain material affordances which are strictly relations between a sound and our particular bodily structures, for example, sounds may be loud enough to afford masking other sounds, or not afford being heard at all, on account of purely physical relationships between our ears and a sonic environment. This is to say that in both the material and sonic affordances available in a musical ecology, there exist both the "productive" and "material" dimensions of musicking,

as well as the “receptive” and “socio-cultural” dimensions, which require abilities acquired through embeddedness in a socio-cultural world of practice with material.

In identifying and analyzing some of the most clearly salient sources for musical affordances in an improvised musical ecology, I have divided my focus into three areas. These are the material instruments used by performers, the sonic environment as it emerges in performance, and lastly socio-communicative factors of a performance which are non-auditory, such as notated scores, bodily gesture, and the broader socio-cultural embeddedness of musical ensembles and histories of performance.

4.7 INSTRUMENTAL AFFORDANCES

An improviser’s instrument, whether it be an acoustic medium that is excited, the human voice itself, or the variety of methods for controlling and performing with electronic and computer-generated sound which have emerged in the last century, is perhaps the most clear source of affordances in an improvised musical ecology, at least according to Gibson’s original notion of motor possibilities for action. Instruments obviously afford sound production to forms of life with the proper bodily structure and socio-culturally embedded ability. However, it is true that “affords sound production” alone does not fully describe a musical affordance. In order to say that a potential instrument affords musicking, one must account for the material in terms of a richly embedded socio-cultural practice of music making. For example, piano keys may afford pressing, sitting, and even sound production to a sufficiently curious cat, but it is unlikely that the creature experiences this affordance as a musical one in terms of human cultural practices. Both the material and motor engagement with an instrument as well as the socio-cultural embeddedness it has in musical practice are relevant to providing affordances for an improviser which are musical. In other words, improvisers acquire their ability to skillfully deal with the affordances of an instrument both by extending their physical and motor capabilities in engaging with the material interface, as well as cultivating an understanding and attention to the socio-cultural history of the material as musical tool.

Importantly, the development of these sensorimotor and socio-cultural dimensions of instrumental performance do not occur separately, but rather are bound together in continuous exchange. In learning to perform a snare drum roll, a complex physical task in which the hands and fingers must account for the fulcrum motion of the stick in relation to the tension of the drum head as it bounces multiple times each stroke, the student learns to adapt their physical and motor structures to those of the material interface – a stick and drum – but this adaptation is equally conditioned in response to a socio-culturally embedded practice which finds performing snare drum rolls useful. The intermediate drum roller is likely to learn that simply making a multiple bounce happen is not sufficient for expert performance, as variations in texture, tone, evenness, volume, and speed are called for in different performance contexts, both between different musical cultures or forms of life, and in the needs of specific musical moments within a performance.

This example of the aspiring snare drum roller describes each of the three sorts of "productive" aspects of musical affordances described by Reybrouck; the making of the snare drum and stick themselves to have such a relationship that affords sound production, the particular congruence between the human hand and instrument interface which it was designed to accommodate in bouncing, as well as the modulatory techniques required in further shaping the drum roll's resultant sound.[92] Each of these engagements in musicking with an instrument, both in training and in performance application, also shows certain "receptive" qualities of socio-communicative and aesthetic judgement, by way of being situated in a cultural world. The ability to use a drum roll in musicking is dependent on both a structured history of adapting to the physical demands of the material, as well as experience in a cultural world which determines its usefulness as a musical gesture. In developing a concept of improvisational skill with instruments based in openness and attention to affordances, it is important to recognize that both

[92] Reybrouck, "Musical Sense-Making and the Concept of Affordance.", 12.

these sensorimotor and cultural dimensions of skill exist and overlap in perceiving the musical affordances of instruments.

4.8 WHAT A SOUND AFFORDS

The sensorimotor engagement a performer has with their instrument is multimodal, as the skilled practitioner must attend to both the tactile feedback generated through physical gesture and auditory feedback from the sound produced in gesturing. This engagement fills the musical environment with sound, and in improvised music, provides opportunities for musical interaction, or musical affordances. The sounds produced by an improviser and their fellow ensemble members in improvised performance are rich sources for affordances themselves. As previously discussed, the affordances available in a sonic environment arise from socio-cultural experience or training, a past experience with sounds as embedded in a culture which gives them meaning. In performing improvised music, the instrumentalist must listen to the unfolding sonic environment, and attend to aspects in the music that appear as useful possibilities for action or sense-making. It is important to note that as an enactive approach to cognition suggests, the experience of dealing with musical affordances in performance is not characterized by perception and action as discrete steps in the cognitive process, but rather as a dynamic and recursive *sensorimotor* adaptation to a challenging world. When acting on an affordance, the skilled improviser remains actively perceptive of a dynamic landscape of affordances as it shifts with the structure of an emergent musical environment, paying close attention to how their own actions induce action from other ensemble members.

In performance, the experience of perceiving and acting on a particular sonic environment in terms of what it affords for ensemble members can be widely varied. For example, an ongoing rhythmic looping pattern started by one musician may afford grooving, melodic and linear soloing over the pattern, both, or something entirely different for another performer. Acting on a musical affordance involves a performative inference about the embodied and culturally embedded relationships which structure the

sonic environment. It is a sounding out of one's own experience of musical affordances, but also a speculative experiment in musical sense-making. In adding to the emergent sound, the new material is mediated and recontextualized by the sensorimotor engagement of other ensemble members, through their own material and socio-culturally embedded histories of dealing with affordances. This process of mutual reformation and recontextualization is key to the self-organizing and emergent character of improvised musical forms.

The performative and inferential process of sensorimotor engagement with a sonic affordance has been considered from the embodied and enactive perspectives on cognition as a mental simulation of movement, as induced by the sounding flux in relation to the history of bodily interactions a performer has with sound and material. Mark Reybrouck refers to this sort of imagined motor action as "ideomotor simulation", in which the history of one's material engagement with sound is implemented in perceiving the sound as an affordance or musical possibility for action, even when motor behavior is "manifest only at an ideational level of mental representation"[93] Similar research on such virtual action in music, based on the embodied perceptual theories of Noë and mirror neuron theories, have provided useful ways of conceiving of an improviser's dealing with sonic affordances as an inference or prediction about the unfolding of a sonic texture.[94]

Perhaps the most promising of these theories which may help explain the predictive or inferential nature of improvising is the Free Energy Principle (FEP) and Bayesian Brain theory. This perspective, developed by Karl Friston, broadly claims that the brain evolved to navigate a dynamic world and remain in steady states of equilibrium, and that it does this by minimizing the amount of entropy or surprise it experiences in adaptation with the world. This is done by predictively modeling structural changes in the

[93] Reybrouck, "Musical Sense-Making and the Concept of Affordance", 12.

[94] Acitores, Alicia Peñalba. "'Compensation Movement Hypothesis': A Conceptual Demonstration of Virtual Action Based on O'Regan and Noë's Sensorimotor Contingencies Theory," Paper presented at the Second International Conference on Music and Gesture, RNCM, Manchester, UK, 20-23 July 2006. 11.

environment and comparing the actual outcome to that model, in order to deduce errors that can be used to constantly update and refine internal predictions. Though this presupposes mental representation in cognition through predictive models, the FEP/Bayesian focus on ongoing engagement between a subject and world may make it more compatible with enactivism than other representational models. FEP provides a language with which to understand the ways improvisers may perceive sonic engagement with a landscape of affordances as a linear unfolding through time. Furthermore, it offers insight into how recontextualization and reimagining of sonic affordances as sound emerges in performance acts as a generative space of discovery and development in improvised musical forms. The strengths of this theory are that it is biologically grounded and resonates with enactivist emphasis on dynamic and temporally-extended sensorimotor engagement with the world. Likewise, as Tomasz Korbak notes, the free energy principle represents a sort of "computational enactivism", which much like Reitveld and Kiverstein's broadened concept of affordances, is capable of synthesizing so-called "higher" and "lower" cognition emphasized by either cognitivist or embodied paradigms respectively without reiterating a mind-body dualism.[95]

4.9 Silent Affordances of the Social World

In addition to instruments and sound itself, there exists a third category of sources for musical affordance. At this point, we have seen how the musical affordances of instruments and sound are often cross-adaptive, in that it is hard to arrive at a musical affordance without both considering the material artifacts manipulated in performance as well as the socio-cultural embeddedness which conditions their usefulness as musical tools. As such, it may be more precise to say that this final category of musical affordances isn't isolated "sources", but rather elements which further condition the experience of finding usefulness in the total musical ecology. These are the materials and social abilities in the musical ecology

[95] Korbak, Tomasz. "Computational Enactivism under the Free Energy Principle." *Synthese* 198, no. 3 (March 2021): 743–763.

which do not sound, yet nonetheless serve to structure the affordances available to improvisers. They are the silent affordances of the social world of musicking.

The first example of such conditioning forces are ones we have mentioned throughout this chapter, characterized by the socio-cultural norms and abilities available to a specific musical form of life. These normative dimensions of musical engagement, formed through experience and training in a socio-cultural world of musicking, enable and constrain certain musical possibilities for action according to their perceived congruence to the values and aesthetics understood to be appropriate in a given socially situated context. Most examples of this refer to questions of musical gesture in relation to musical genre, style, or cultural milieu, as in the "quoting" anecdote mentioned earlier. It may also be said that Bailey's *Company* project, discussed in the previous chapter, is "composed" according to the mixing of such musical forms of life to create a musical ecology which emphasizes an ensemble's process of getting to know one another musically. Another example from improvised music practices are the aesthetics of what Lewis calls "multidominance", characterized by "simultaneous multiplicities of available timbres, microtonal pitchsets, rhythms, transposition levels and other elements".[96] Lewis traces the aesthetics of multidominance in his own and other improvised music practices to the African diasporic art tradition, and quoting critic Robert L. Douglas, notes that Eurocentric forms of musical life and training may not "equip its students to hear music with multidominant rhythmic and melodic elements as anything but 'noise,' 'frenzy' or perhaps 'chaos'".[97]

Lewis's discussion of multidominance as an aesthetic of his and other improvised music practices in the African diasporic tradition suggests that among the culturally embedded constraints on purely musical possibilities, there also exist political dimensions of socio-economic power distribution which structures the landscape of affordances. Multidominance can function as a site for celebration of Black

[96] Lewis, "Too Many Notes: Computers, Complexity and Culture in Voyager.", 36.

[97] ibid. 34.

aesthetics in resistance to a society which systemically undervalues Black life, with Lewis giving the example of hip-hop group Public Enemy's critical plea to "Bring the Noise".[98] Improvised music may champion an egalitarian distribution of creative agency in performance, but it is misguided to say that the hierarchical structures of power which underlie the social world at large suddenly disappear or become irrelevant at the moment of a downbeat. A young female improvisor may not experience the same degree of "freedom" in creative agency as older, more established male counterparts with fewer constraints imposed on their musical affordances according to privileges of gender and class status. A growing number of improvised music performer/composer/scholars are giving attention to the social forces of power which condition the musical affordances of an improvised performance environment, including Lewis, Vijay Iyer, and Hayes.[99] A developing concept of improvisational skill should be sure to account for these social dimensions, both in dealing with them as an individual, and fostering ensemble relationships which directly tackle the obstacles to musicking social power imbalances create.

Finally, there exist common examples of such silent affordances in an improvised musical ecology which can be traced to more explicitly material artifacts, for example notational technologies like scores, or in more formalized bodily gestures, such as in conduction or signaling. It is true that these practices to a large degree incorporate representation and symbol processing in shaping the musical possibilities afforded to improvisers, rendering them unavailable to the direct perception implied by Gibson's original concept of affordances. However, viewing these practices in the context of what they provide or constrain for the application of socio-culturally embedded abilities, it is possible to see them as part of the landscape of musical affordances.

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[98] ibid. 34.

[99] Lewis, "Gittin' To Know Y'all: Improvised Music, Interculturalism, and the Racial Imagination"; Hayes, Lauren, and Adnan Marquez-Borbon. "Nuanced and Interrelated Mediations and Exigencies (NIME): Addressing the Prevailing Political and Epistemological Crises." Paper Presented at the International Conference for New Instruments for Musical Expression, Birmingham, UK, December 1, 2020.; Iyer, "Beneath Improvisation."

Improvised music practices have often utilized score making and other representational mediums of organizing improvised performances. As Lewis notes, early composers in improvised music of Europe and America "began to designate salient aspects of a composition as performer-supplied rather than composer specified, thereby renewing an interest in the generation of musical structure in real time as a formal aspect of a composed work."[100] Examples of this practice may include more straightforward text instructions, as in the case of Lewis's *Artificial Life,* or employ graphic notation techniques that play on predefined or openly relational nonlinguistic symbols to evoke improvisational responses and coordination, with paradigmatic examples being Cornelius Cardew's *Treatise* or much of the notated compositions of Anthony Braxton.[101] In both cases, notational symbols may represent modalities of interaction, such as in the Lewis example, or denote specific musical action, as in the Cardew. Mixes of these representational focal points are also possible, but in each case, the artifact is employed as a signifier of agreed-upon values, aesthetics, and constraints imposed by the socio-cultural situatedness of the ensemble.

Though I have focused mostly on musical actions for the sonic affordances they produce, it is important to recognize that each musical action contains both sonic and visual components which may reveal musical affordances for a performer. The movements, bodily tension, and facial expressions of fellow performers can present a great deal of useful constraints and affordances in a musical ecology, providing insight into the experience of other members of the system. In novel performance situations where this modality of bodily interaction is precluded, such as in networked, over-the-internet performances, the loss becomes quite clear, emphasizing the importance of bodily cuing and interaction for coordinated musical performance. Techniques such as Butch Morris's *Conduction,* which systematizes methods for improvisationally leading an ensemble using specialized hand signals and

[100] Lewis, "Improvised Music after 1950," 215.

[101] Lewis, George E. *Artificial Life 2007* New York: Edition Peters, 2007.; Cornelius Cardew, *Treatise Handbook* London: Edition Peters, 1971

traditional conducting, provide even clearer examples of silent musical affordances typical in some improvised music ensembles.[102] As such, it may be possible to understand scores and other representational techniques like conduction or signaling in terms of musical affordances, in that they are material aspects of the environment that, through a richly embedded socio-cultural history of interaction in musical practice, afford particular organizational relationships or musical possibilities in performance.

4.10 NAVIGATING THE LANDSCAPE

Having examined some of the salient aspects of a musical ecology which condition the experience of dealing with musical affordances, what emerges is a rich and varied landscape of affordances. Engagement with this landscape of affordances in temporally extended performance is the process by which improvised music performers cocreate emergent musical forms. As Reitveld and Kiverstein suggest, "when an individual engages adequately with an affordance this is often an exercise of skill."[103] We may now turn to considering how the improviser might increase their ability to engage adequately with a musical affordance, drawing on further concepts from embodied and enactive paradigms, to arrive somewhere closer to a notion of improvisational skill based in enactive and ecological perspectives on cognition.

4.11 SUCCESS AND STRUCTURAL COUPLING

Embodied cognition research has demonstrated a powerful explanatory framework for understanding the importance of bodily and culturally situated knowledge in skilled practice with tools.[104]

[102] Morris, Butch. *The Art of Conduction: A Conduction Workbook*. Edited by Daniela Veronesi. New York: Karma, 2017.

[103] Rietveld and Kiverstein. "A Rich Landscape of Affordances.", 334.

[104] Baber, Chris. "Cognitive Aspects of Tool Use." *Applied Ergonomics* 37, no. 1 (January 2006): 3–15.; Hutchins, "Imagining the Cognitive Life of Things," 9.; Ingold, Tim. "Walking the Plank : Meditations on a process of skill." In *Defining Technological Literacy: Towards an Epistemological Framework.* Edited by John R. Dakers, 65-80. Palgrave-Macmillan, 2006.

These studies show how skilled practitioners incorporate their material and social environments in completing cognitive tasks. Interest in improvised instrumental performance as a case study of embodied skillfulness has grown in recent history, with a number of authors citing the particular insights into cognition provided by improvisational activity.[105] Determining skill in terms of adequate engagement with affordances is a special problem for improvisation, as much of the earlier examples of embodied skill analysis focused on pragmatic tasks which had clear conditions for success, essentially problem solving. Improvisation exhibits relevant differences from tasks like ship navigation, chess, or sawing a plank, (examples proposed by Hutchins, Dreyfus, and Tim Ingold respectively) in that there is much less clarity in what qualifies as a "success condition" in the mutual co-enactment of musical form.[106] This raises questions for a developing notion of improvisational skill, as measuring success in such a cognitive task is not reducible to the achievement of or progression towards zero-sum conditions.

What then, might constitute success in musical improvisation? As I have explored, improvising musical ecologies may be understood as self-organizing systems, which are structure-determined. Following this biological thread inherited from the enactivist tradition, we might consider the success of a musical ecology to depend on successful *structural coupling* among its constituent agents. As members of a musical ecology interact in performance, they are tasked with dynamically maintaining structural coupling with one another, in order to maintain autopoietic organization of the multi-agent system. Here structural coupling should not be understood in terms of logical reasoning or morphological fit, but rather the adequate responsiveness to musical affordances as conditioned by the socio-material environment. As musical possibilities for action become available in the environment, improvisers adapt their behavior by

[105] Hayes, "Beyond Skill Acquisition"; Iyer, "Embodied Mind, Situated Cognition, and Expressive Microtiming in African-American Music."; Schiavio and van der Schyff. "4E Music Pedagogy and the Principles of Self-Organization."

[106] Dreyfus and Dreyfus. "A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition,"; Hutchins, Edwin. "Cognitive Ecology."; Ingold, "Walking the Plank: Meditations on a process of skill."

acting only on possibilities which are most congruent with their own socio-cultural skills, practiced or perceived aesthetic values common to a community of practice, and other relevant material contexts which constrain musical affordances. In this way, improvisers maintain the operational closure of the musical system, preserving internal mechanics of feedback and control amidst a developing and perturbing musical environment. Through iterative practice in this adaptive environment, improvisers may improve their ability to skillfully identify musical possibilities which both maintain system dynamics while providing for dynamic, interesting, and beautiful musical environments.

If a member of the system fails to adapt to the changing musical structure in a way that dissolves their structural coupling to the ecology at large, the system itself is at risk of falling apart. The experience of such a failure in my own history with free improvisation ensembles has often been complex, and not always universally shared among ensemble members. When acting on a perceived musical affordance, the resulting contextualization by the rest of the ensemble can sometimes be shockingly different than expected, causing an incongruence of meaning. This must itself be adapted to and recontextualized, or else threatens the ability for the system to maintain structural coherence. Though challenging, these situations of instability and subsequent recontextualization are fundamental to improvisational success. When structural coupling is especially successful, the experience has been as close as I have felt to transcendent, as the ensemble seems to literally "make sense" together, mutually constructing musical meaning as a unified system.

4.12 Skill Without Expertise

Having proposed a success condition for free improvisation as the maintenance of structural coupling during performance, a notion of adept improvisational skill emerges that is unlike traditional conceptions of instrumental expertise. This concept of skill in improvisation differs from conventional notions of physical virtuosity common in musical practices which emphasize reproducing a composer's mental representations of musical ideas. In contrast, skillful navigation of a musical ecology is enriched

by strengthening the coupling of perception and action between improvisers and their instruments, ensemble companions, and other environmental agents integral to a given performance.

Hayes describes this move away from virtuosity in contrast to Dreyfus's proposed model of skill acquisition, whereby a novice proceeds to process and internalize increasingly complex technical rules of engagement, ultimately achieving expert status when the rules disappear from immediate perception and the expert acts in a state of mindless flow.[107] In the case of musical improvisation, Hayes rejects this model, suggesting that "a discourse that focuses on aspects of technical virtuosity does not adequately account for the dynamic relationships that are reified during musical play".[108] For Hayes, skill in improvisation relies not on physical or technical expertise, but rather "the instantiation of multiple sensitivities of the person as a whole".[109]

If successful improvisation requires the maintenance of structural coupling through dynamic adaptation, then the goal of developing skill in improvisation is the enrichment of one's capacity for such adaptation. From here we may follow Hayes in calling into question whether a novice/expert framework is helpful for a notion of improvisational skill, as adaptation to dynamic structural changes in the musical ecology takes precedence over deployment of physical or technical mastery.[110] This radical recontextualization of improvisational skill as adaptation to the affordances of a musical ecology resonates with the goals of Systems Composition, which are to explore formal dynamics of participatory music making. Furthermore, as Hayes argues, this ecological model of skill invites a reconsideration of "what we can conceive of as complex musical activity, and who is able to participate".[111]

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[107] Dreyfus and Dreyfus. "A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition,"; Hayes, "Beyond Skill Acquisition,"

[108] Hayes, "Beyond Skill Acquisition," 9.

[109] ibid. 9.

[110] Hayes, "Beyond Skill Acquisition," 7.

[111] ibid. 9.

It is not increasingly technical displays of physicality, but rather sensitivity and openness to affordances that characterizes skilled improvisation. By casting aside these traditional notions of expertise, participation is opened to those with little technical faculty, as well as the differently abled, who are often left out of the process of co-enacting musical form. This openness resonates with an ecological model, which strives to display the emergent dynamics of musical ecologies, examining the lives of humans and nonhumans as they mutually express their embodied and social situatedness. However, this is not to say that this concept of improvisational skill leaves no avenue for actively enriching one's capacity to adapt in a musical ecology. Improvisers wishing to develop their improvisational skill may attend to these notions of structural coupling and openness to affordances in their practice, thereby increasing their ability to adapt and maintain autopoiesis of the musical ecology.

4.13 Developing Attention and Habit

One promising perspective for developing openness to affordances and improvisational skill comes from Hayes and Juan M. Loaiza's enactive-ecological exploration of selective attention and habit in technologically-mediated musical improvisation.[112] Drawing on enactivist theory of Anthony Chemero and Reitveld and Kiverstein's landscape of affordances, the authors suggest that the "particular sensitivity" to affordances through selective attention which characterizes skilled practice "is not the result of a general inbuilt cognitive capacity for picking up and filtering stimuli but the effect of the active exercise of bodily habits that are acquired and stabilized through recurring interactions throughout the agent's life."[113] It is this sort of selective openness to affordances which is key to skilled practice, as successfully maintaining structural coupling with the ongoing sonic environment requires that one adequately and appropriately adapt to the material and social relations imposed by a musical ecology. For

[112] Hayes and Loaiza. "Exploring Attention through Technologically-Mediated Musical Improvisation", 1.

[113] Hayes and Loaiza. "Exploring Attention through Technologically-Mediated Musical Improvisation", 7.

the purposes of intentional development of improvisational skill, Hayes and Loaiza's notion of long and slow timescales of attention are most relevant. These relate to the authors' notion of habit, "which affirms the interdependencies between organism and environment as a fundamentally embodied process of identity generation".[114]

It may follow that a practice of developing improvisational skill requires specific attention to the development of one's personal history in musicking, or musical form of life, in enactivist terms of a sensorimotor history of engagement with material. The crucial factor here is that enactive and ecological models of improvisational skill help describe the sorts of culturally embedded histories of engagement which are integral to skilled cultural practice, and that in the case of improvised music, are essential to the enculturated process of co-enacting musical forms.

4.14 Conclusion and Implications for Practice

To perform in improvised music is to engage in a socio-material world of musical affordances and express the process of musical sense making through sound production in real time. These affordances are constituted by what the musical ecology provides, "for good or ill", to an individual and are a relation to the individual's bodily structure, abilities, and socio-cultural history. To act on an affordance requires not only a complementarity between the organism and its environment, but also on that individual's selective attentiveness to salient aspects of that environment according to what a present situation demands. As a group of improvisers attend to and act on affordances during a musical performance, they dynamically and collectively construct a musical form, expressed as sonic activity over time. Such musical structures are often referred to as *emergent forms*.

As such, improvisers interested in developing their skills in improvisation may do so by attending to their ability to recognize and respond to musical affordances. In gaining sufficient skill, a performer

[114] ibid. 9.

may increase the range of affordances a given musical situation presents, but only when a new musical possibility is sufficiently articulated by the structural congruence between an agent and their environment. It is only then that a musical possibility presents itself in the world, as an affordance.

Having reassessed skill in improvisation as an increased openness to affordances in the musical environment, there are a number of implications for improvisation performance and pedagogy. For independent musicians and teachers alike, focusing on strengthening the embodied relationships and selective attention which structure a musical ecology may enrich a pursuit towards improvisational skill. In personal practice and in teaching, an ecological model emphasizes improvisational practice as the building of structured history between agents in a musical ecology. This stresses advancement in the ability to dynamically adapt, or structurally couple, to one's instrument, ensemble members, and the sonic environment, through coordinated practice in the sense making activity of co-creating musical forms.

5 THE DEPARTMENT OF MUSICAL ECOLOGIES: MUSIC FROM AN ENACTIVE, ECOLOGICAL APPROACH TO COMPOSITION, IMPROVISATION, AND TECHNOLOGY

Figure 1.

5.1 MOTIVATIONS OF THEORY AND PRACTICE

So far, this document has presented research from embodied and ecological approaches to cognition to describe how composition and performance practices within improvised music contribute to shaping emergent musical forms. This research derives from questions that arose from my own practice as a composer, instrument builder, and performer working with improvised music. I wanted to know how improvised music worked, and much like my developing practice with DIY and hacked electronic instruments, how I could get under the hood and tinker with its design. In this sense the theoretical work presented in this document has been developed in service of expanding my creative practice, and that my

practical experimentation as a musician has inspired and directed my line of inquiry. Alongside this research, I have presented a concert of my own music that is informed by enactive, ecological perspectives on cognition in improvisation. Created in collaboration with other students in University of California Irvine's Integrated Composition, Improvisation, and Technology program, this concert is the musical product of integrated, collaborative practice-based research.

In this chapter, I describe how my dissertation concert, titled "The Dept. of Musical Ecologies Presents: Musical Ecologies of Persons and Things", presented March 28th, 2021, at UC Irvine, has influenced and been influenced by my developing scholarly research in embodied cognition.[115] While these works provide useful examples for exploring the types of interventions offered to composers and performers by an enactive, ecological perspective on improvised musical form, they are not simply models for demonstrating my theoretical and philosophical positions. I will show in these works evidence of the strength of the enactive, ecological position in organizing and participating in improvised music performances, through score-based composition, ensemble development, self-organizing electroacoustic environments, and the development of improvisational skill with custom electronic instruments designed with enactive properties of self-organization and emergence. I suggest that not only do these perspectives from embodied cognitive research help to explain the complex and dynamic processes involved in improvising musical forms, but they also may serve as useful points of departure for practical application by improvised music practitioners.

5.2 Overview of Themes

The creative work presented in this dissertation concert derives from my developing practice as an improviser, composer, and instrument designer working with percussion and electronics. Each work may be understood as an example of my concept of *Systems Composition*, whereby an improvised music

[115] Video recording of the concert available at https://youtu.be/EU78e8mLkq4

performance is organized according to an enactive and ecological perspective on improvised forms, by providing or constraining the musical affordances available in a musical environment through preperformance interventions. Systems composition is a useful way to frame my own practice, particularly because it is relatively open to technical applications which extend beyond traditional notions of composition as score-making.

The first way in which the works I have presented may describe elements of Systems Composition is in the cultivation and curation of the musical ecology in organizing a musical event, particularly regarding ensemble building. As seen in the previous analysis of Bailey's *Company* projects, the shared socio-material histories and forms of life between ensemble members in improvisation is a fundamental contingency on the landscape of musical affordances present in performance. This is true even when not specifically implemented from the perspective of Systems Composition. While the works presented in my concert do not focus on ensemble curation as strongly as Bailey does in *Company*, the relationships of myself and the other performers, as well as audiences and staff, undoubtedly form part of the socio-material conditions which shape musical affordances in performance. These histories of socio-material engagements with sound in joint action and musical sense-making inform the unfolding of emergent form in the works presented, and in some cases have been cultivated through an extended practice of ensemble building.

My own work in Systems Composition has largely focused on the development of custom analog and digital electronic instrument systems or interactive audio environments, particularly those which display characteristics of self-organization and feedback control characteristic of autopoietic or cybernetic systems.[116] As much recent research has suggested, these *enactive instruments* offer novel ways of interacting with electronic technologies through improvised music practices, and emphasize an enactive

[116] Hayes, Lauren. "Investigating Autopoiesis In Site-Responsive Sonic Art" *Interference Journal* No. 7 (May 2019), 1.

and ecological approach to musical performance and composition.[117] Furthermore, enactive instruments offer insight into the emergent and ecological character of improvised music forms, particularly as they are distributed between nonhuman and human agents in a musical ecology. The three relevant technologies employed in the concert are: my developing practice with the *feedback drumset* which uses transducer feedback and computer software to turn drumheads into a self-organizing drone instrument; a custom software program made in MaxMSP which allows for integration with an analog modular synthesizer as an audio reactive improvising partner; and implementation of Mari Kimura's MUGIC® motion sensor instrument, which using custom software made in MaxMSP, allows for extending the bodily gestures involved in playing acoustic percussion instruments to control real time digital sound processing of the acoustic instrument. In each of these examples, I explore both the design considerations put into the tools developed, as well as the richly cultivated histories of musicking with those tools.

Lastly, I describe my work in developing the game piece *20 More Wolves,* a representational implementation of Systems Composition based in score making practices and the emergent dynamics of tabletop role-playing games. This work represents both a material artifact (in game pieces) as well as a process of socio-cultural engagement with that material. Inspired by both Lewis's *Artificial Life* and John Zorn's game pieces like *Cobra, 20 More Wolves* is a bottom-up approach to organizing emergent forms, largely centered on establishing rules and terms of interaction between ensemble members rather than prescribing specific musical instructions.[118] As a material artifact meant to be manipulated by a group in a process oriented and distributed approach to formal organization, the piece emphasizes an embodied and temporally extended relationship with a score. This eschews notions of the representational artifact as

[117] Armstrong, *An Enactive Approach to Digital Musical Instrument Design*,; Hayes, "Investigating Autopoiesis In Site-Responsive Sonic Art", Rimoldi, Gabriel, and Jônatas Manzolli. "Enactive Framework for Design of Digital Music Interfaces," Paper Presented at the International Conference of New Music Concepts, Treviso, Italy, March 2016, 10.; Clutterbuck, Mudd, and Sanfilippo. "A Practical and Theoretical Introduction to Chaotic Musical Systems," 8.

[118] Brackett, John. "Some Notes on John Zorn's *Cobra*." *American Music* 28, no. 1 (April 1, 2010). To my knowledge, the score for *Cobra* remains unpublished officially. My comments on the piece in this document refer to information in Brackett's well-cited article.; Lewis, George E. *Artificial Life 2007* New York: Edition Peters, 2007.

mere source of symbolic information for internal processing, and encourages a sense of distributed agency among ensemble members in coenacting emergent forms.

5.3 MUSICKING TOGETHER

Before addressing the specific works presented in the concert themselves, it is important to note that as Small's concept of musicking shows, musical performance events such as these are the product of many people coming together "to take part in a ceremony in which their values, which is to say, their feelings about what are right and proper relationships, are affirmed, explored, and celebrated."[119] As such, any thorough analysis of the sense-making processes that contribute to the meaning of the musical performance must account for how each participant in musicking, including composers, performers, audiences, and sound engineers, engage in socio-cultural relation to the environment of an improvised music concert. While this chapter primarily focuses on material and socio-cultural relationships between human and nonhuman agents on stage, the participation of production workers and audience members played a crucial role in establishing the social context in which the music was presented, experienced, and made meaningful. Likewise, the material environment and socio-cultural aspects of the space itself, an American public university music school venue and rehearsal space, with free admission funded by the university, undoubtedly had a part to play in shaping the experience of dealing with affordances that structures the emergent forms presented in the concert.

In organizing the concert, I developed a small theatrical element to suggest that this notion of highly distributed, participatory sense-making was important to the performance. The participating musicians and I were costumed in screen-printed work coveralls, as members of a made-up research institution, *The Department of Musical Ecologies.* As the main member of the department addressing the crowd, I was able to comment on the distributed nature of creativity between improvisers and the

[119] Small, Christopher. *Musicking: The Meanings of Performing and Listening*., 185.

embedded environment in the works presented. In addition to simply amusing me, framing the concert production in this way emphasizes that the musical performances that took place were products of a distributed system of many persons and environmental aspects working together in relation to one another, for a shared goal, rather than a celebration of one composer's clever ideas. A light-hearted gesture, I see this as a form of context-setting for the concert, serving to establish the project presented as socially situated outside of the normative aesthetics of single-authored form expected from a more traditional PhD composition thesis concert.

Figure 2.

The Department of Musical Ecologies has no real history, however the musicians involved in preparing and performing the concert, myself and seven of my colleagues from the ICIT program, have rich histories of musicking together. Because we are all composer/improviser/scholars invested in the same, highly particular academic program, we share both many overlapping forms of life brought together through our personal musical backgrounds, and specific engagements together in a shared history of

musicking. Though the depth of my history with each ensemble member varies to some degree, each of us has performed together in improvised ensembles, shared ideas on improvised music compositions, listened together, and engaged in improvised musical practices through collaborative research and scholarship. This shared history of socio-material engagement with instruments, scores, and sounds in improvised music performance underlies the skillfulness with which the ensemble can make use of musical affordances in performance.

One example of ensemble cultivation evident in the concert is the piece I presented with buzuq performer Jiryis Ballan, titled *Ghosts of Structured Pasts*, explored later in this chapter for its implementation of the MUGIC® motion sensor.[120] This performance represents the longest and most intentionally structured example of ensemble building featured in the concert due to our prior experience in working as a duo in a recent, long term recording project. In our weekly work together rehearsing and discussing, we intentionally cultivated an ensemble identity around exploring the socio-material abilities of our instrumental practices, with myself using a percussion and electronics set up and Ballan playing buzuq with similarly extended electronic sound production capabilities. We established a frame around the contrasting sonic capabilities in our instruments, most notably noise to tone ratio and changes in articulation, using our electronically extended tools to augment and process acoustic sounds. We also found space to explore the ways we could imply characteristics from the musical styles our instrumental practices had developed around, those being noise and improvised music for myself, and more melodic folk and jazz contexts for Ballan. The piece we performed was mostly improvised but followed a loose structure of moving between states of high similarity or contrast between our sonic contributions according to both spectrums of percussive to sustained and noisy to tuneful.

Importantly, the process of ensemble building and co-construction of musical form based in our socio-material histories took place through rehearsal and performance experience together, but also

[120] Video recording of this performance available at https://youtu.be/EU78e8mLkq4?t=1835

through targeted discussion between improvisations which investigated one another's experience of dealing with musical affordances. In my experience with improvised music practices, this is a crucial part of group enskillment, as the experience of structural coupling and adaptivity in an improvisation is highly idiosyncratic and not always mutually apparent for each individual ensemble member. This is an iterative process of sounding out musical possibilities together in performance, then reflecting on when and where there were challenges for maintaining an experience of structural coupling in adaptation to one another. For us it has been highly effective both in increasing our openness and attention to the musical affordances in each other's playing, as well as in charting the landscape of affordances available to us by way of our histories with material. This latter effect has proved useful in cultivating the ensemble as a form of Systems Composition itself, in identifying the affordances most interesting to us for further exploitation and exploration in co-enacting emergent forms.

The loose structure and conceptual frame we used in the performance was developed through a process of iterative collaboration, preparation which was integral to the structure of the music we improvised. Our collaborative methodology was intentional and persistent, and though no formal score was developed as part of this process, the musical ecology involved was developed and structured as a form of Systems Composition. This temporally-extended process of working together, in which musical values and possibilities are discovered through iterative practice and discussion of what works, is common in improvised music communities in which I have engaged. It shows that the emergent qualities of improvised music are not restricted to the emergent behaviors which occur in performance, but rather that the implicit structure of relationships and control which direct emergent behavior is busy forming long before downbeat, in the history of life and musicking of every improviser. This is not meant as a merely poetic gesture, but as a crucial direction of attention towards the fundamental characteristics of improvised musical form.

5.4 ENACTIVE INSTRUMENTS

As discussed by Reybrouck in his analysis of musical affordances, "the whole history of musical instrument building… is one prolonged search for applying craftmanship to raw materials in order to obtain musical sounds."[121] In creating an instrument, one crafts a material artifact which affords musicking in the employ of a skilled user. These affordances, as have been explored, are related to both sensorimotor engagements which afford sound production, as well as the socio-culturally embedded histories of that sensorimotor engagement in musicking. For the acoustic instrument designer, there is very little room for innovation in the motor and sonic couplings in the affordances of an instrument. Much of this coupling is solved by nature, in that an acoustic instrument's sound making capability is intrinsically linked to the forms of motor engagement which excite the resonant body of the instrument. This is not true for electronic and computer instruments, in which the material interface and what it affords for sound production may be decoupled and remapped, providing near limitless potential for novel embodied interactions with sound production and musicking.

The practice of designing novel electronic instrument interfaces, also called NIMEs (new instruments for musical expression) or DMIs (digital musical instruments), presents designers with particular opportunities for shaping the user's embodied relationship to sound. Rimoldi and Manzolli explain in their enactive perspective on DMIs that "as opposed to the more rigidity of action possibilities in acoustical context, DMIs can comprise more flexible and plastic range of action possibilities".[122] This space for design implementation is related to the broader topics of human computer interaction and user-centered design. It offers the potential for exploring the novel affordances presented by DMIs as a site for examining skilled practice in technologically mediated improvisatory performance.[123] Furthermore,

[121] Reybrouck, "Musical Sense-Making and the Concept of Affordance.", 11.

[122] Rimoldi and Manzolli. "Enactive Framework for Design of Digital Music Interfaces," 10.

[123] Hayes and Loaiza. "Exploring Attention through Technologically-Mediated Musical Improvisation", 17.

designing and performing with DMIs may be understood as a type of preperformance intervention on a musical ecology, suggesting an opportunity to study the potential for an implementation of Systems Composition through designing instrumental affordances. This is especially true considering electronic and computer mediated systems are capable of designs which, through the implementation of feedback control mechanisms, exhibit the self-organization and emergence characteristic of living or quasi-living agents.[124] These possibilities describe an approach to the design of DMIs from the perspective of enactive and ecological theories of cognition, and as such, I refer to DMIs that demonstrate such a perspective as *enactive instruments.*

The enactive perspective has been directly applied to electronic musical instrument design by a number of artists, technicians, and theorists in recent years.[125] The contributions of these thinkers have outlined the most salient issues for design of DMIs raised by the enactive approach, both "problems and prospects", that inspire my own research and creative practice.[126] My implementation of the principles of enactivism into electronic musical instrument design seeks to enrich the improvisational experience by emphasizing the distributed nature of musical sense-making for performers and audiences alike. This is in line with a conception of improvisational skill that values situated, attentive, and empathetic relationships to the musical affordances of one's environment in musical co-creation. As explored in the previous chapter, such a conception of skill emphasizes attention and openness to affordances over virtuosic technical or physical capacity. Enactive electronic instruments, particularly those which demonstrate enactive principles of self-organization and emergence, offer opportunities to engage richly with a co-

[124] Clutterbuck, Mudd, and Sanfilippo. "A Practical and Theoretical Introduction to Chaotic Musical Systems,"

[125] Armstrong, *An Enactive Approach to Digital Musical Instrument Design*; Kim, Jin Hyun, and Uwe Seifert. "Embodiment and Agency: Towards an Aesthetics of Interactive Performativity," Paper Presented at Sound and Music Computing Conference, Lefkada, Greece, July 2007. 230-237; Hayes and Loaiza, "Exploring Attention through Technologically-Mediated Musical Improvisation"; Clutterbuck, Mudd, and Sanfilippo. "A Practical and Theoretical Introduction to Chaotic Musical Systems,"

[126] Armstrong, *An Enactive Approach to Digital Musical Instrument Design,* 7.

enacted system of musical meaning making in which this sort of situated, embodied skill is especially important. In addition to this power to enrich improvisational situatedness and adaptivity, enactive instruments provide a perspective on the nature of our musical cognitive systems in improvisation more broadly. This co-enactment model of musical sense-making can help examine an improvisational system to better understand when and how the system succeeds or fails to skillfully adapt to the cognitive actions of its own constituent agents.

To identify how the particular qualities of enactive systems provide robust opportunities for skilled improvisational practice, it is important to identify what is meant by an "enactive quality". As outlined in chapter two, enactivism stresses the concepts of interactivity, multimodal sensorimotor engagement, and emergence in living, cognitive systems. Skilled musical performers, particularly those using improvisational practices to organize their performances, display embodied, emergent interactions with their instruments in performance. Applying enactivist concepts to new musical instrument design provides opportunities for performers to work with an instrument which takes their embodied, situated, and emergent interactions with a material interface as a central design concept, offering highly person-centered and interactive modes of performance. This prioritizes emergent interactions over strictly controlled parameterization and precomposed automation common in more traditional applications of computers and controllers in musical performance.

Newton Armstrong outlines criteria for qualities of embodied activity provided by enactive instruments (and specifically not the laptop computer interface) in his dissertation on enactive digital musical instrument design:

> 1. *Embodied activity is situated*. Embodiment arises contextually, through an agent's interactions with her environment. The agent must be able to adapt to changes in the environment, and in her relationship to it, without full prior knowledge of the features of the environment, or of its structure and dynamics.
>
> 2. *Embodied activity is timely*. Real world activity involves real-time constraints, and the agent must be able to meet these constraints in a timely manner. This means that it is incumbent on the agent to not disrupt the flow of activity because her capacity for action is too slow.

> 3. *Embodied Activity Multimodal. A* large portion of the agent's total sensorimotor capabilities are galvanised in performance. This involves optimising the use of the body's total available resources for cognition, action and perception, with an emphasis on the concurrent utilisation of distinct sensorimotor modalities, as well as the potential for mutual interaction, or cross-coupling, between those modalities.
>
> 4. *Embodied activity is engaging*. The sense of embodiment arises when the agent is *required* by the task domain. That is, the environment is incomplete without the involvement of the agent, and it presents challenges to the agent that consume a large portion of her attention.
>
> 5. *The sense of embodiment is an emergent phenomenon*. That is, optimal embodied experience arises incrementally over a history of sensorimotor performances within a given environment or phenomenal domain. There is a link between increasing sensorimotor competence within the task domain and the sense of embodiment.[127]

The scheme laid out here by Armstrong allows a clear perspective to assess the embodied activity provided by potentially enactive new instruments for improvisation. What Armstrong describes in his list of qualities centers around a musician's capability to adapt meaningfully to their environment in real time. In the last example, he mentions that "competence", or skill, may be gained from this emergent history of sensorimotor performances. As has been explored in this document, this is related to the enactive principle of structural coupling, whereby an organism recursively adapts to its environment over such an emergent history of interaction, with no ground other than this emergent experience. As seen in Hayes, Reybrouck, and Reitveld and Kiverstein's work, this development of sensorimotor capacity is compatible with a conception of skilled musical meaning-making that includes the sorts of socio-culturally embedded abilities present in improvised musical practice.

What follows is an overview of the enactive instrument technologies employed in my dissertation concert. These include more traditional DMI's like the MUGIC® motion sensor, as well as instruments like the feedback drumset and self-playing synthesizer, which exhibit designs that enable self-organizing and self-generating behaviors characteristic of enactive, autopoietic systems. This latter case provides the most valuable tool for Systems Composition, as instruments and interactive audio software may be

[127] Armstrong, *An Enactive Approach to Digital Musical Instrument Design*, 9-10.

designed to exhibit behavior which substantially shapes the landscape of affordances in an improvised performance.

5.5 Self-organizing Electronic Instrument Systems as Compositional Approach

In the duo improvisation *Ghosts of Structured Pasts* with myself and Jiryis Ballan, I utilized the MUGIC® motion sensor and custom software created in MaxMSP to control a live granular processing effect as an electronic extension of my mixed percussion and feedback set-up. The MUGIC®, developed by violinist, composer, and technologist Mari Kimura, is a wearable, sensor-based controller platform, with a variety of sensory input data related to motion and position available for subsequent mapping to computer audio parameters.[128] Hayes describes this pervasive model of DMI's as derived from "traditional human-computer interaction (HCI) paradigms", in which "a performer will typically use a variety of input gestures that are sensed by a controller or tracking mechanism, in order to affect parameters within digital signal processing (DSP), resulting in changes in sonic output."[129] In this sense, the MUGIC®'s most basic applications are like other digital audio controllers which are pervasive in electronic music performance. My application of the MUGIC® uses a relatively similar model to control a granular processor in MaxMSP, along with additional audio analysis features such as transient detection which aid in gestural control.

[128] Lough, A., Micchelli, M. and Kimura, M. "Gestural Envelopes: Aesthetic considerations for mapping physical gestures using wireless motion sensors." Paper presented at the International Computer Music Conference, Daegu, Korea, August, 2018, pp. 60-64

[129] Hayes, "Investigating Autopoiesis In Site-Responsive Sonic Art", 1.

What sets the MUGIC® apart as an enactive design for electronic sound manipulation is its potential application as an extension of the socio-culturally embedded gestures and abilities an instrumentalist already performs on their instrument. When worn on the hand, the gestures involved in performing on my acoustic percussion instruments may be mapped to control parameters of the signal processing. This causes a recontextualization of my sensorimotor interactions with the instruments, as

Figure 3.

they now may result in both the acoustic sonic result as well as an electronic sound extension. As a performer, this is a challenging experience to adapt to, as it takes time and practice to incorporate the electronically extended sonic environment into a deeply embedded history of socio-material abilities.

My specific application of the MUGIC® in *Ghosts of Structured Pasts* involved a custom MaxMSP patch developed while working together with Ballan as a duo. The goals for the software were to have a sound-processing element to use in improvisation in which I could alter my percussion set-up based on my needs while keeping control scheme relatively constant, allowing me to develop a performance practice with this instrument over a long timescale and in varied contexts. Because the MUGIC® is a wearable motion sensor, my software patch can use acceleration, direction, and velocity data to generate changes in the granular processing effect. In this way, the performative bodily actions I have learned through a history of music-making may be applied directly to a new sonic effect. This

corresponds to the basic controller-mapping paradigm common in DMI performance practices, but in a way that activates a rich variety of musical opportunities in performance through my prior experience and training as a percussionist. Also, amplitude and timbral analysis is implemented to cross-check gestural inputs and provide further layers of control, reducing false triggers from motion data and triggering randomized effect changes when amplitude and timbral criteria are meant. This implementation of rare opportunities for surprise act as structural elements of the performance, as the system changes inspire sudden recontextualization through further improvising. I consider this an example of Systems Composition through musical instrument design, as the design choices in my patch enable an enriched structure of musical possibilities in performance through engagement with my own history as a performer and the introduction of randomness as a source of usefully perturbing myself in performance.

The potential for enactive instrument design to provide novel experiences for improvised music performance goes beyond what I accomplished with the MUGIC® implementation. The capacity for electronic and computer systems to be designed in such a way so as to elicit behaviors of self-organization and emergence suggest that enactive instruments could be not only novel interfaces for controlling sound, but act as structure-determined, quasi-biological subjectivities capable of shaping the affordances of a musical ecology at large according to its own ability to dynamically adapt and couple with the environment in ways humans may perceive as useful for musicking. Hayes characterizes these systems, citing Maturana, as "systems in which behaviour can be triggered by changes in environmental factors, but only the structure of the system itself is responsible for how these external perturbations are dealt with temporally."[130] Examples of such self-organizing musical machine systems are evident in the work of Hayes's *Sounding out Spaces* projects, Dario San Fillippo's work with cybernetic feedback systems, and Lewis's voyager.[131]

[130] Hayes, "Investigating Autopoiesis In Site-Responsive Sonic Art", 1.

[131] Hayes, "Investigating Autopoiesis In Site-Responsive Sonic Art"; Lewis, "Too Many Notes", Clutterbuck, Mudd, and Sanfilippo. "A Practical and Theoretical Introduction to Chaotic Musical Systems,"

One of such systems demonstrated in my concert is a custom software in MaxMSP which allows for integrating with an analog modular synthesizer, using audio interactive techniques like spectral and amplitude analysis to imbue quasi-perceptual capacities into the machine system, which can in turn perceive and adapt to perturbations from outside the system.[132] Influenced by the cybernetic synthesizer designs and the famously self-playing "krell patch" of composers Bebe and Louis Barron, the system uses small amounts of randomness to inject noise into a closed loop of feedback controls which govern the articulation, pitch, timbre, rhythmic precision and density, and other aspects of the voltage-controlled synthesizer voice.[133] I was also inspired by the notion of subsumption architecture from Rodney Brooks in designing the system's ability to interface with the sounds of other performers.[134] I instantiated lower-level processes of perceiving and adapting sonic parameters, such as adjusting filter cutoff in relation to spectral flatness and amplitude, or playing back and reinforcing pitch patterns in the sonic environment through spectral analysis and subsequent memory storage. I also created higher level processes which could "subsume" lower-level musical relations, allowing the system to redirect lower-level processes to respond to larger timescale considerations of variation and development by oscillating semi-autonomously between states of contrast vs. reinforcement, or listening vs. self-generating. Both influences can be traced to Wiener's Cybernetics and theory of negative feedback as the primary driver of self-organization and homeostasis in machine systems.[135]

The control scheme used in the patch has three primary levels: global states which change the tendencies of lower-level processes, lower-level processes which directly control or sequence parameters

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[132] Video documentation of this system used in the performance available at https://youtu.be/EU78e8mLkq4?t=3920

[133] Hayes, "Investigating Autopoiesis In Site-Responsive Sonic Art", 3.

[134] Brooks, Rodney. "A Robust Layered Control System for a Mobile Robot." *IEEE Journal on Robotics and Automation* 2, no. 1 (March 1986): 14–23. https://doi.org/10.1109/JRA.1986.1087032.

[135] Wiener, Hill, and Mitter, *Cybernetics*, 97.

of the analog synthesizer itself, and at the bottom, seeds of random number generation which introduce elements of surprise. Though there is a dense network of controls within the system, the inclusion of randomness is key to developing a system that sounds open, adaptable, and not overtly rule-bound. In both top and bottom level processes, randomness allows the system to change course and enforce musical material on its own terms, similar to how human improvisers might take the lead in introducing new material rather than merely reacting according to preset, if-then rules. I realized in developing the patch that increasing the complexity with further rulesets could only go so far in generating interesting interactions, because the elements of surprise and recontextualization I found important for improvised music were over-programmed away. Interestingly, randomness proved to be a computationally cheap and effective way to introduce this element of surprise, and with some adjustment and scaling according to my own tastes, could result in musical interactions which felt coherent and original.

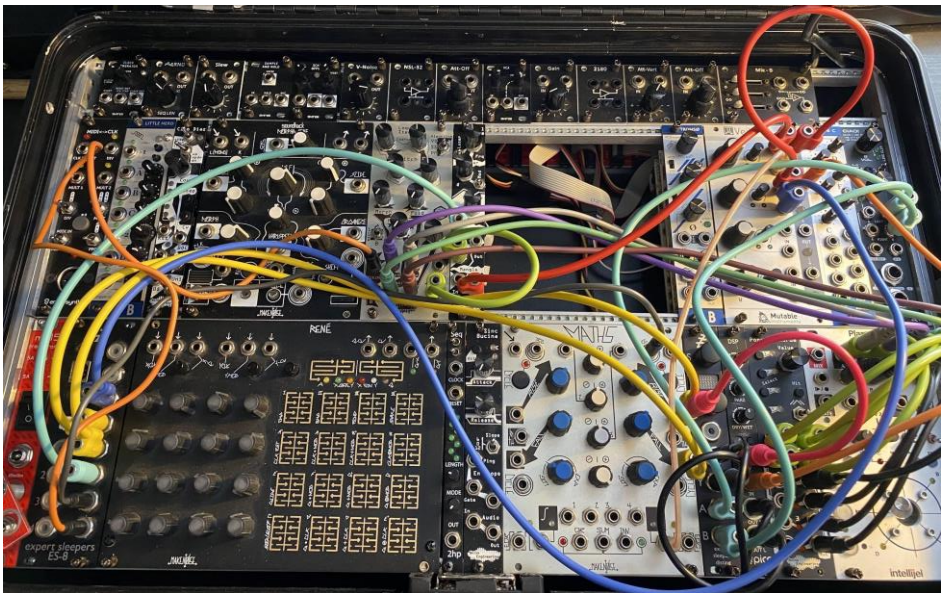

Figure 4.

There are two top level system states in the patch. These define generalized tendencies which push the lower-level processes towards alternating musical conditions. At the highest level, the system switches between states of listening and not-listening, toggling the audio analysis features on or off. This creates occasional, semi-random periods of autonomous material generation from the system, introducing

moments of surprise. Furthermore, the audio analysis system is set up to expect isolated audio from each other performer, so the system can occasionally listen to some performers and not others. Below this is a global state which is only relevant in listening mode, which switches the lower-level processes to prioritize either contrast or similarity with what it analyzes from other player's audio. This simple dialectic is intentionally reductive, providing just enough structure to feel engaging in performance, but not so much that it eschews surprise and spontaneity. Finally, the lower-level processes are a group of computer-controlled voltage sequencers, which control the parameters of oscillator frequency, filter cutoff, timbre, amplitude, and effect settings. In not-listening mode, the sequencers are populated by random values, with some slight scaling to taste. In listening mode, the audio analysis takes over. The frequency sequencer stores a collection of the last eight frequencies (or an octave equivalent) played by the ensemble for use in its melodic material. Importantly, this can pick up both equal-tempered pitches as well as discrete frequencies, allowing congruence with a wide range of instruments and tuning practices. The filter cutoff and timbre are controlled by a spectral flatness analyzer, opening or closing the low-pass filter or adjusting oscillator settings to create a timbral richness that either matches or contrasts with the timbre of the ensemble sound. Amplitude is regulated in relation to the ensemble, prioritizing either an even, blended volume, or a contrasting one. Finally, a granular delay effect is controlled by a randomized sequencer for a bit more timbral variation.

This system shows examples of the principles of negative feedback and homeostasis in controlling an interactive musical system. Negative feedback is implemented through the audio analysis tools. For example, in a listening, contrasting state, the synthesizer voice will gradually decrease its own frequency register when the ensemble begins to play higher and higher material. The implementation of quasi-sensorimotor capabilities which can act and perceive in real time moves the system towards a defined state, granting the system tendency which feigns creative intention through feedback control. This goal-oriented behavior can be seen as the system attempting to maintain homeostasis, resonating with cybernetic theories of machine control. More precisely, the system engages in the maintenance of

homeorhesis, a concept from C. H. Waddington "which connotes the return of a system to a trajectory rather than a state," as there is no specific musical objective outside of continued engagement in specific patterns of interaction, which may take a variety of forms.[136]

The final example of enactive instruments explored in my concert is the *feedback drumset*, which is an instrumental system that uses the principles of audio feedback and matrix mixing, along with custom software created in MaxMSP, which is capable of self-regulating and self-propagating behaviors which push the audio feedback in and out of states of increased complexity and nonlinearity pitch and timbral response.[137] The audio feedback is generated using tactile transducers and contact microphones which turns the resonant properties of a drumhead into a highly performative drone instrument. Presented as a collection of etudes, the pieces explored variations in the performance techniques available to transducer applications, with one being a sound installation in the concert hall.[138] My motivations in isolating the self-organizing behavior of the feedback drumset system as an installation were to demonstrate the semi-autonomous and goal directed patterns of behavior expressed by the system without human intervention,

[136] Penny, *Making Sense*, 153

[137] Video documentation of this performance available at https://youtu.be/EU78e8mLkq4?t=1114

[138] Partial documentation of this installation is available at the start of the performance recording at https://youtu.be/EU78e8mLkq4

as well as provide the audience with opportunities to move around the hall and explore the system from different physical positions and contexts.

Hayes reiterates these goals, stating that in creating "adaptive dynamical systems, the goal is to create audible ecosystems that unfold over time with coherent characteristics which are determined by their internal structures. All this necessarily occurs in strict coupling with the performance space and audience present".[139] In my view, this can be seen as an instantiation in a machine system of the process of generating self-organizing, emergent form characteristic of improvised music. San Filippo describes his music in similar terms, as "an individuality, organicity and expressivity characterising some sort of

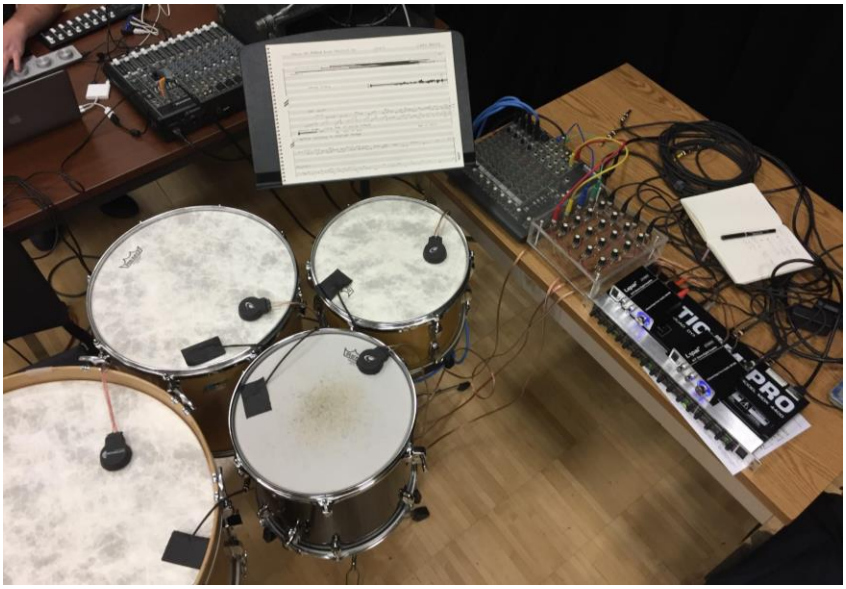

Figure 5.

artificial life form that emerges from networks of recursive and nonlinear interdependencies, for which improvisation is the functional mechanism - aural feedback - that allows the cross-coupling of two entities which simultaneously perturb and adapt to each other."[140] The feedback drumset is perhaps a special case of this phenomenon, because it is also designed for physical manipulation by a performer as an instrument. This positions feedback drumset as a particular type of socio-material engagement with an

[139] Hayes, "Investigating Autopoiesis In Site-Responsive Sonic Art", 5.

[140] Clutterbuck, Mudd, and Sanfilippo. "A Practical and Theoretical Introduction to Chaotic Musical Systems," 8.

interactive system, cross-coupled through sound, physical gesture, and internal system dynamics of relationship and control. As such, performance practice and techniques on the instrument are something closer to contact dance improvisation than strictly instrumental performance or joint ensemble action, as the performer instrument relationship expresses elements of both traditional control-focused DMIs and emergent, autopoietic improvising partners.

Enactive instruments provide a platform for exploring both richly situated, multimodal, and skilled interactions with electronic sounds. Furthermore, design approaches which utilize feedback are capable of exhibiting self-organizing behaviors of emergent musical activity, suggesting a space for the study of improvisational skill between cross-adaptive human and instrument intelligences. Examples from the work of Armstrong, Hayes, and San Filippo have been successful in employing a design approach informed by enactive and ecological concepts of cognition. My work in designing enactive instrument systems follows these successes as an opportunity to explore both the enactive qualities of self-organization and emergent form as instantiated in a machine intelligence, but also as a way of researching complex and skillful human machine interactions in improvised music performance.

5.6 GAME PIECES AS SYSTEMS COMPOSITION

The final implementation of Systems Composition employed in my concert is in the form of a representational artifact, drawing on the tradition of score-use in improvised music to constrain or otherwise organize the improvisational interactions between performers.[141] Inspired by the focus on attention and relational networks of control evident in Lewis's *Artificial Life*, as well as the game structure pieces of Zorn like *Cobra*, my piece *20 More Wolves* is a musical improvisation game inspired by the emergent storytelling dynamics of tabletop role playing games.[142] Its name invokes the idea of

[141] Lewis, "Improvised Music after 1950," 24.

[142] Video documentation of two performances of *20 More Wolves*, with slight organizational variations, are available at https://youtu.be/EU78e8mLkq4?t=2297 and https://youtu.be/EU78e8mLkq4?t=4789; Brackett, "Some Notes on John Zorn's *Cobra*."; Lewis, George E. *Artificial Life 2007* New York: Edition Peters, 2007.

playful tinkering with a simulated animal ecology through the imbalance caused by adding a handful more vicious predators, thereby perturbing the ecological system and exciting structural adaptation and change. The goal of the game is simple, to participate in the shared construction of musical form by improvising in accordance to what the rules of the game help constrain or afford for musicking. Over the course of a round of performance, players navigate individual scores created from a grid of randomly drawn cards. These cards feature text instructions which limit or enable aspects of improvisers' musical contributions, or otherwise alert attention to certain characteristics of the sonic and socio-material environment. For example, when performing a card, players may be tasked with playing slower, lower in pitch, or rhythmically synchronized, and in specific relationship to another ensemble member or groups of members in the performance environment. At any time, players may initiate their individually specific "role cards", which trigger brief group scenarios conditioned by the introduction of new rules or processes before returning to performing the score cards.

The network of relationships created by the game resonate with the structures implicit within the emergent formal dynamics of improvised music. As such, the game provides opportunities for skillful engagement with the socio-culturally embedded history of improvised music practice which largely characterizes the culturally situated position of my ensemble members. Zorn's most famous game piece, *Cobra,* was similarly made with the express intention of providing ensemble members with opportunities

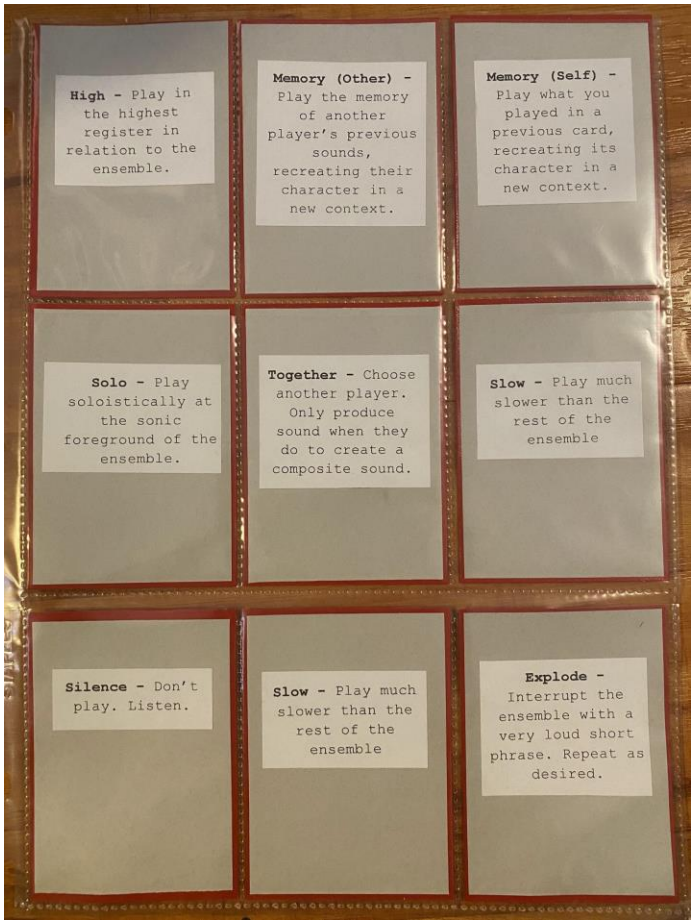

Figure 6.

for skillful engagement in the specific socio-material practice of improvised music. John Brackett, citing Zorn himself, explains that "as with all of Zorn's game pieces, Cobra was 'originally created to harness the personal languages of a new school of improvisers working together in the East Side of Lower Manhattan.'"[143] Both mine and Zorn's piece could be considered examples of Systems Composition,

[143] Brackett, "Some Notes on John Zorn's *Cobra*.": 55.

suggesting the potential for the practice in providing highly person-centered forms of musical organization that provide opportunities for engaging in the enactive and ecological dimensions of improvisational skill.

5.7 CONCLUSION

In this final chapter, I have explored my dissertation concert, *Musical Ecologies of Persons and Things,* and demonstrated some of the ways in which the works and concert production itself resonate with an enactive and ecological approach to cognition in constructing improvised musical forms. As examples of Systems Composition, which may include a variety of social and technologically mediated applications of structuring music according to musical affordances, these works represent experiments in ensemble curation, the design of enactive instruments for improvised performance, and implementation of game structures in a musical score. In each case, Systems Composition provides opportunities for exercising the sorts of materially and socio-culturally embedded practices of relational music making characteristic of improvised musical performance. Likewise, an approach to improvisational skill based in enactive and ecological concepts of structural coupling and affordances offers useful analytical tools for developing composition, performance, and instrument design practices in improvised music.

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APPENDIX 1: CONCERT PROGRAM

THE DEPT OF MUSICAL ECOLOGIES PRESENTS

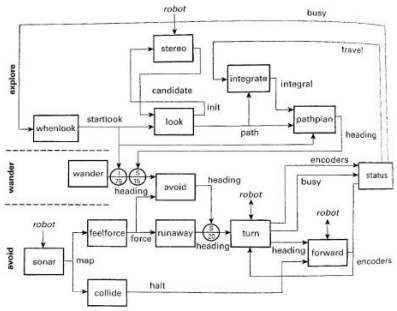
MUSICAL ECOLOGIES OF PERSONS AND THINGS

A DISSERTATION CONCERT BY CHRIS HADLEY

MONDAY MARCH 28TH 7:00PM

UC IRVINE MM 218 (MOCAP)

FREE



Livestreaming at: tinyurl.com/musicalecologies

Etudes for Feedback Drumset

1. *Skin Song 3 (FIFP)* (Installation)
2. *Pulsing (FIDP)*
3. *Pressing (DIFP)*
4. *Chorus (DIDP)*

Chris Hadley, Feedback Drumset

Ghosts of Structured Pasts

Chris Hadley, Percussion/Electronics
Jiryis Ballan, Bizouk/Electronics

20 More Wolves

Isaac Otto, Woodwinds
Atticus Reynolds, Drums/Percussion
Teerath Majumder, Electronics
Antonin Fajt, Keyboard

- Short Intermission -

Something Always With And/Or Without

Corey Fogel, Drums
Adib Ghorbani, Piano

20 More Wolves (Traffic Cop Variation)

Chris Hadley, Traffic Cop
Jiryis Ballan, Bizouk
Isaac Otto, Woodwinds
Atticus Reynolds, Drums/Percussion
Teerath Majumder, Electronics
Antonin Fajt, Keyboard
Corey Fogel, Drums
Adib Ghorbani, Piano

Etudes For Feedback Drumset

These pieces originate in a question I asked myself years ago when I first began to explore using audio feedback to build instruments - how does one learn to play an instrument which has its own behavior independent of the human performer? Audio feedback displays natural tendencies towards the resonant frequencies within a given system-state. "Control" as it is commonly considered must be abandoned. In its place, there remains a playful space of perturbance and skillful adaptation to the resulting chaos and surprise. The etudes are roughly divided according to Alex Lough's description of four possible uses of transducers as instruments, with different permutations of fixed and dynamic input or transducer position. For this performance, I've combined the etudes into a single piece.

Ghosts of Structured Pasts

Improvising ensembles create musical forms in real time according to a complex and dynamic structure of relationships between perception of sound and action on an instrument. These relationships depend on a coupling between human and instrument, as well between performers themselves, which is strengthened through embodied history together. In this piece, Jiryis and I perform using Mugic motion sensor devices (mugicmotion.com) and custom software we have each created and practiced. Much as our developing history with these new interfaces lends to a fluency with which to negotiate an improvised performance, so too does our history with one another as duo members and friends.

20 More Wolves

This piece is a musical improvisation game inspired by the emergent storytelling of table top role playing games. The goal of the game is simple, to participate in the shared construction of musical form. Over the course of a round, players navigate a score created from randomly drawn cards. These cards limit or enable particular aspects of their musical contributions in relation to another performer - slower, lower in pitch, or synchronized, for example. At any time, performers may trigger group scenarios by invoking their "role card", which is specific to each performer. The network of relationships created by the game mirror the structures implicit within a musical improvisation as players relate their musical actions to the perceived sonic environment. This piece will be performed twice on the concert, the last of which features the "traffic cop" variation, in which one performer handles cuing of card changes (helpful for larger ensembles).

Something Always With And/Or Without

Free improvisation demonstrates intelligence independent of symbolic representation. Musicians may have no specific outcomes notated or pre-planned, but rather depend on their ability to negotiate a sonic environment in real time to create meaningful musical forms. Interestingly, developing this capacity for meaningful action without provided symbolic representations was a question for artificial intelligence thinkers like Rodney Brooks, who's *Subsumption Architecture* (diagramed on the cover of this program) showed that a sufficiently robust series of feedback controls, nested together into a hierarchy of higher and lower level processes which could "subsume" or stop one another, could provide a robot an efficient and stable method of meaningfully navigating a world. Taking this approach into a musical scenario, I have created a custom software in Max/Msp which allows my modular synthesizer to selectively "listen" and react to fellow ensemble members in performance.

Special Thanks to:

Michael Dessen
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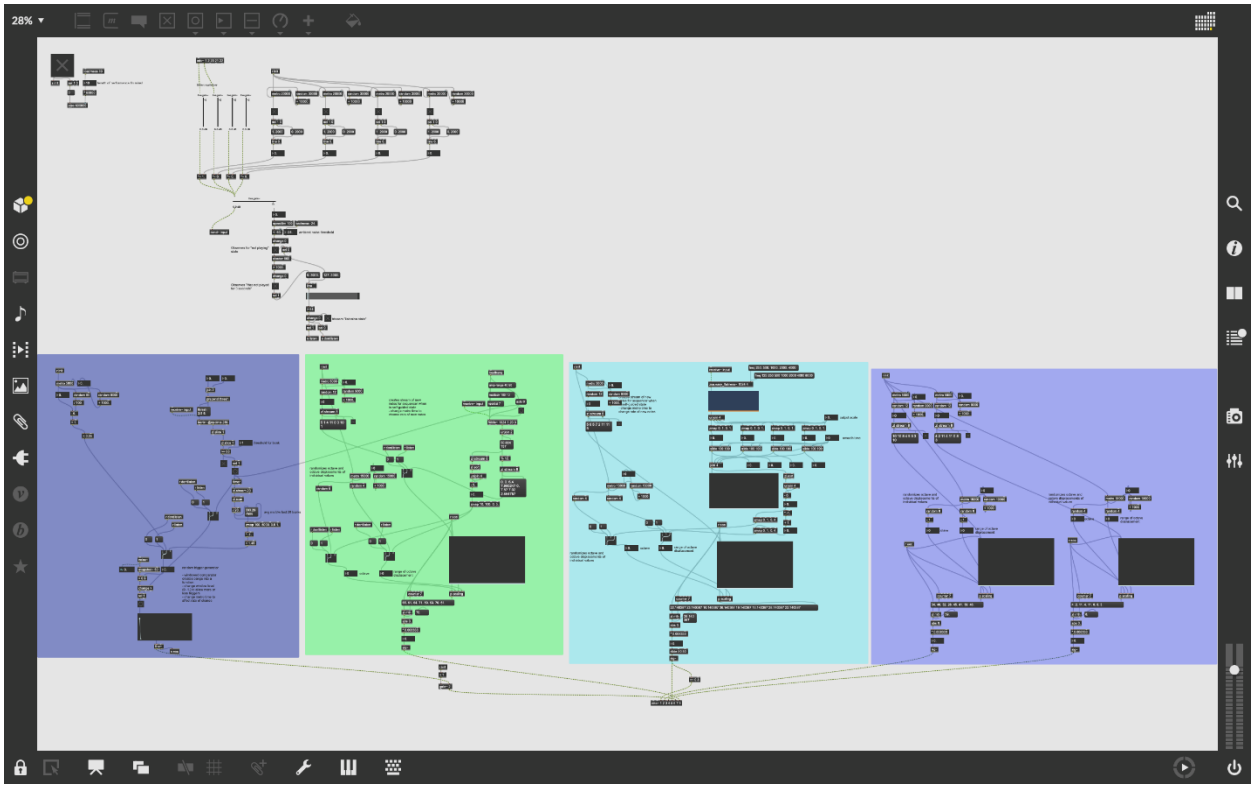
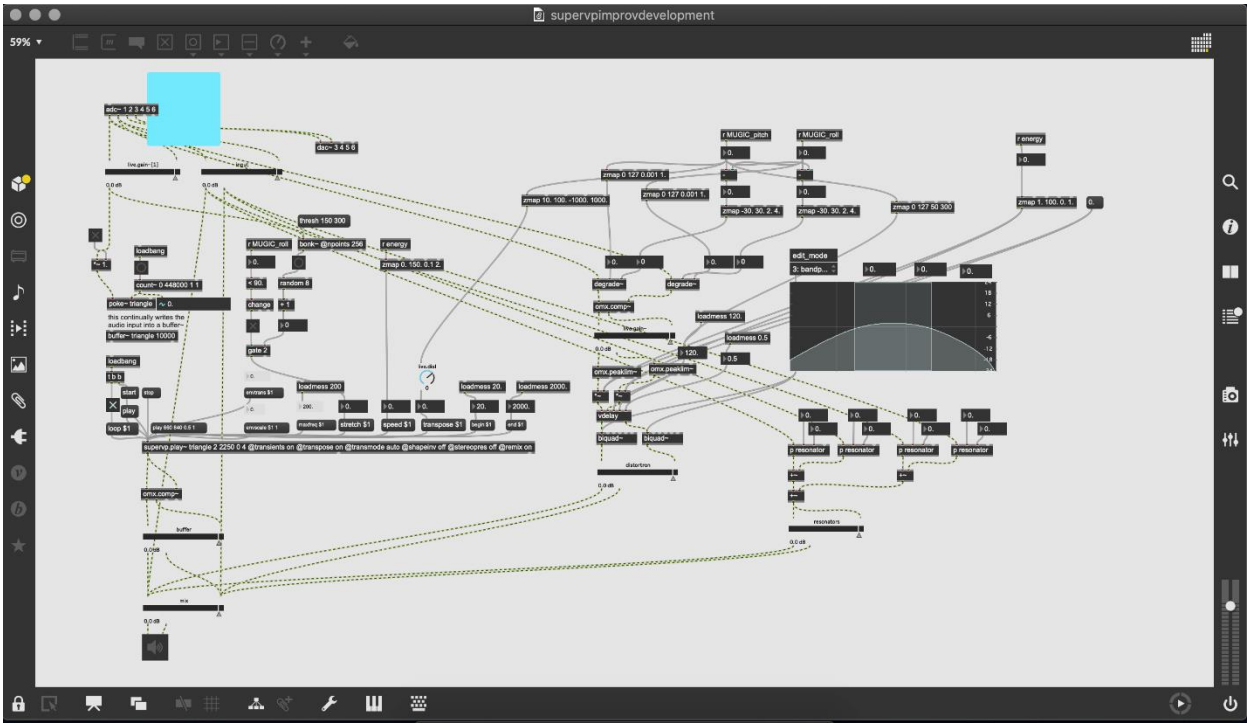
APPENDIX 2: MAXMSP PATCHES: SCREENSHOTS AND LINKS TO CODE

Patch 1: Audio-reactive CV generator for use with a modular synthesizer. Allows for emergent musical interaction between a typical modular synth voice and up to four live improvising musicians. Utilizes audio analysis through the fiddle~ object and zsa.descriptors~ series of objects by Emmanuel Jourdan.



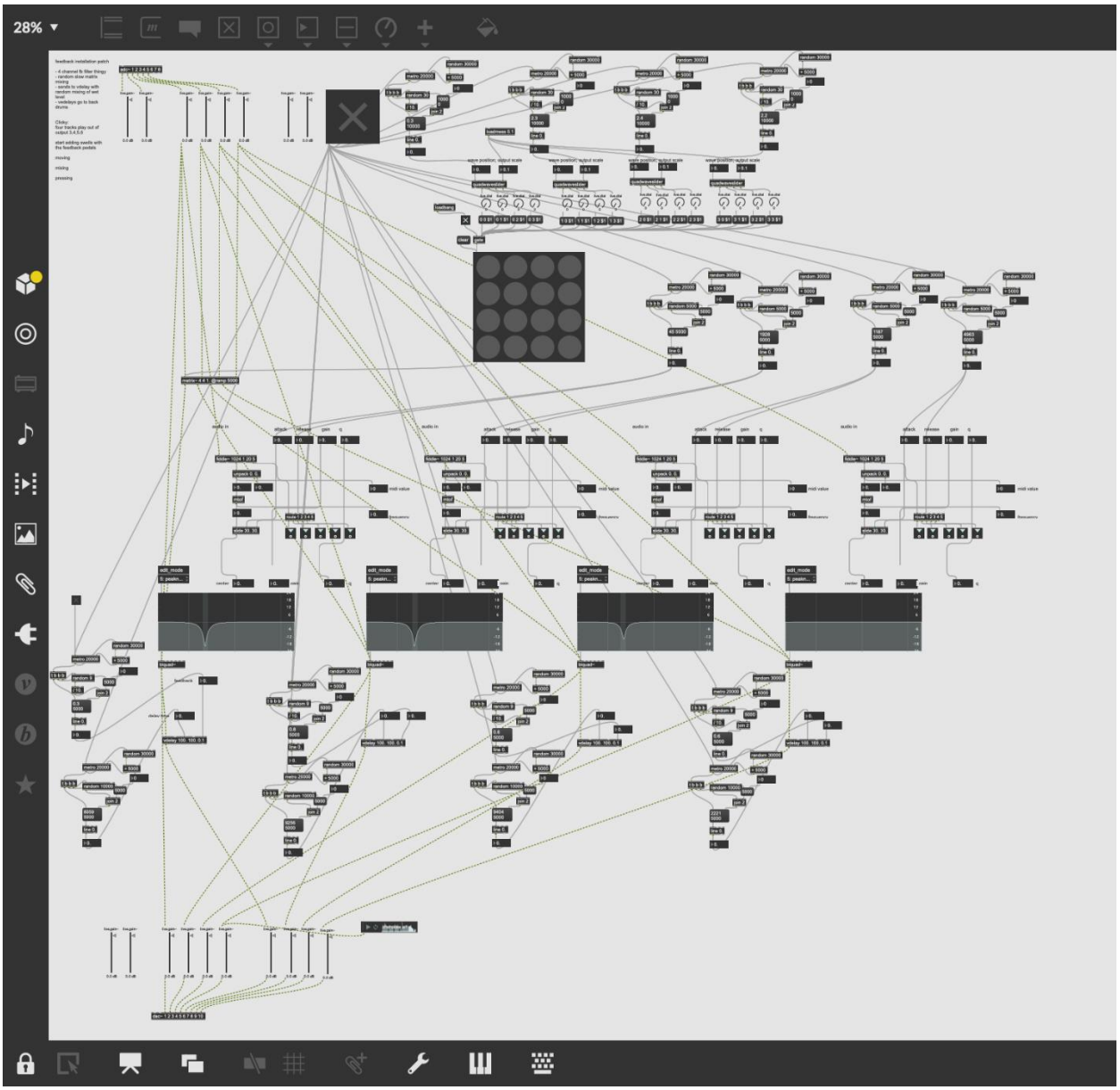
Code available at https://github.com/cchsoundsystems/dissertationmaxpatches/blob/main/modsequencer1.5.maxpat

Patch 2: Live electroacoustic effects, including a circular buffer with granular processing, bitcrusher/distortion, and pingable filter bank. Granular processing is based on the supervp~ object series by IRCAM. Controlled using the MUGIC® motion controller instrument by Mari Kimura for custom gestural control of audio effects. Used in conjunction with an acoustic percussion set up and feedback drums.



Code available at https://github.com/cchsoundsystems/dissertationmaxpatches/blob/main/mugicimprovsetup.maxpat

Patch 3: Feedback Drums, Installation Environment. Self-organizing feedback system for four feedback drums and four additional transducer outputs. Generates metered changes in feedback response through pitch analysis with the fiddle~ object and automated filtering on each channel to perturb the system towards states of rest and instability.



Code available at https://github.com/cchsoundsystems/dissertationmaxpatches/blob/main/FBINSTALLATIONDISSVERSION.maxpat

APPENDIX 3: PERFORMANCE INSTRUCTIONS FOR *20 MORE WOLVES*

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20 More Wolves

By Chris Hadley

Overview:

20 More Wolves is a collaborative musical improvisation game for 3 to 10 players.

The goal of the game is to participate in shared construction of musical form.

This is done by navigating a randomized grid of “score cards” which suggest musical possibilities for action and direct the sonic relationships between improvisers as they play.

Performers start at the top-left corner of this grid, and proceed in any horizontal or vertical direction every 45 seconds - 1 minute, performing each card only once.

Each player may also utilize one “role card”, which grants the ability to trigger one of various musical scenarios which perturbs the ensemble’s progress through their score cards. These scenarios interrupt progression through the score cards for 30 - 45 seconds, after which ensemble members return to playing through the score starting at any unplayed card.

Each round lasts 9-14 minutes.

Set Up:

Each player is dealt nine cards with which to construct a 3x3 grid of cards. Repeat this process for each round the ensemble intends to play.

Once each player has created their score, each player is dealt a role card.

Tip: Players may wish to write down or memorize other players’ role cards for ease of communication in performance. Likewise, ensembles may want to devise a personalized cuing strategy for triggering role cards, such as larger cards for increased visibility, bodily gestures, or other specialized sonic/visual cues.

Variant Rule: Drafting - *Players may elect as a group to "draft" their scores instead of randomly drawing them. To draft, deal a pile of 9 cards to each player. Players take one card from their pile, then pass left to pick another card, repeating this process until all cards have been drawn. Players then may assemble their scores from their drafted cards.*

Variant Rule: Multi-role - *Players may elect as a group to use more than one role card each, so long as cards are divided evenly among players. Similarly, players may elect to use different role cards each round for performances lasting more than one round.*

Playing a round:

Starting:

Once each player is ready, the performance of a round can begin. The round officially starts once the first sound is performed. Any player may be first to play, provided that their top-left starting card allows it (for example, a "silence" or "mimic" card wouldn't permit playing first).

Performing the Score cards:

Once the round officially starts, players begin keeping track of time. This can be done using a stopwatch, or with practice, without.

Starting at the top left, players must attend to what the score card limits or enables in their playing while within the time limit of that card. In addition to performing under the conditions and relationships presented by the current score card, players must be active in listening to the emerging sonic environment from the ensemble. Players must make sure to meaningfully relate their individual contributions to the emergent possibilities and limitations presented both by the music happening at any given time, as well as the score or role card which conditions their musical choices.

There is no obligation to play continuously through each card. Players should always consider the needs of the ongoing sonic environment, both when choosing what to play and whether to play at all. Contrast and development of timbres and textures may serve as a primary aesthetic concern for achieving variability in the emergent form of each round.

Variant Rule: Traffic Cop - *Especially in large ensembles, a leader can be assigned to conduct the movement through score cards. They can do this by cuing individuals or groups to continue on to any new card. Likewise, this leader may facilitate the cuing of role cards by ensemble members.*

Moving between Score Cards:

Each score card is active for 45 seconds - 1 minute. Within that window, players must move horizontally or vertically to another, unplayed card. It is recommended that players stagger their movement between cards. When changing to a new card, players may pause before reentering under the new conditions, change immediately in the middle of a phrase, or create a smooth transition.

Using the Role Cards:

Any player may cue their role card at any time, but may only activate it once per round.

To cue a role card, communicate to the ensemble your cue in whatever manner the ensemble has decided on. Once each member is alerted of the cue, the scenario activated by the role card begins on the first note performed or conducted by the player using the role card. This scenario lasts 30 - 45 seconds, after which players return to progressing through the score cards starting at any other unplayed card.

Ending:

Once a player has played through all their score cards, they must contribute to ending the round. Paying close attention to the ensemble as the round reaches the final moments, players should attempt to find an ending which meaningfully resolves the performance. This may include further sound production which complements the ensemble's final phrases, but can also be accomplished by simply ceasing to play and allowing remaining ensemble members to find an ending.

Score Cards:

Solo - Play soloistically at the sonic foreground of the ensemble.

Starlight - Play short notes with spaces in between to create a pointillistic texture.

Explode - Interrupt the ensemble with a very loud short phrase. Repeat as desired.

Silence - Don't play. Listen.

Dash - Play much faster than the rest of the ensemble

Slow - Play much slower than the rest of the ensemble

High - Play in the highest register in relation to the ensemble.

Low - Play in the lowest register in relation to the ensemble.

Together - Choose another player. Only produce sound when they do to create a composite sound.

Apart - Choose another player. Play whenever they are not playing, to create a trading-off sound.

Memory (Self) - Play what you played in a previous card, recreating its character in a new context.

Memory (Other) - Play the memory of another player's previous sounds, recreating their

character in a new context.

Mimic - Choose another player. Copy their phrases as closely as possible on your instrument.

Role Cards:

Berserker - Each player performs “Explode”.

Silencer - Play as quietly as possible, if at all.

Separator - Each player must try to play, but never at the same time as another player. A chaotic, frustrated hocket.

Loner - The player who cues this card performs an unaccompanied solo.

Groover - Each player must lock in to a tempo or pulse provided by the player who cues this card.

Behemoth - Each player performs the “Together” score card, choosing the player who cues this card. Thus, the player may play the entire ensemble as a super instrument.

Matchmaker - The player who cues this card indicates two players to perform a duo. You can choose yourself.

Jumper - The player who plays this card indicates a number 1-9. Each player then plays “Memory (self)” for whichever card was played on that number sequentially. For example, if the Jumper cues “4”, each player plays whatever they were playing during the fourth card they chose to perform.