California Institute of the Arts

Accounting for the Transcendent in Technological Art

by

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"I have found what I wanted; to put it all in a phrase: 'Man can embody the truth, but he cannot know it'."

William Butler Yeats

Abstract

This thesis presents several approaches to the creation of technological art that accounts for those aspects of life that seem to transcend attempts of calculability and discretization. The concept presented is firmly situated in the Greek understanding of art as poiesis. A major theme in the works presented is the use of Machine Learning and Biofeedback, both independently and integrated. This thesis illustrates these techniques implemented in several technological art projects to account for the transcendent.

Acknowledgments

I would like to thank my mentor Owen Vallis, without whom this thesis would not have come to fruition. Owen taught an amazing course on Machine Learning in Interim 2012 that sparked my interests in the topic. Furthermore, Owen provided support, advice, encouragement, and valuable philosophical dialogue throughout the completion of this thesis, and in all projects that I've been involved. I also would like to thank Ajay Kapur and Jordan Hochenbaum for their support throughout the completion of this thesis, and their valued contributions to the ideas presented here. Jordan and Ajay contributed significantly to formulation and completion of the Mood and Creativity project, and have endured relentless questioning on everything from coding to writing. I thank David Rosenboom for all of his contributions to the work and ideas presented here. David contributed significantly to the development of several biofeedback projects, including the Digital Organism, and has continued to provide valuable support and advice in my work. Stephen-Wolf Foster, Psy.D, was my psychology professor throughout my undergraduate career and introduced me to existential-phenomenological psychology, and to the philosophy of Martin Heidegger. I met with Stephen in the early stages of developing this thesis and discussed the concepts of poiesis and art. I'd also like to thank Geoffrey Derven, with whom I co-developed the concept of "Participatory Life", and held many valuable conversations on Heideggarian Philosophy. I would also like to thank Lynette Johnson, Aaron Foster Bresley, Jingyin He, and Deepak Gopinath who have been with me throughout this journey and have supported me in all my work. Finally, I thank my parents and family for their continued support of my creative endeavors.

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Chapter 1

Introduction

Art is the unveiling of truth, a concept of immense complexity significant contextual variance (Heidegger 1963). Truth manifests itself differently in the works of different artists, and in the context of different observers; a single truth cannot account for all of the implicit truths existing within a work of art. Modern technology, specifically digital technology, has a tendency to discretize phenomenon; in many cases, reducing or removing qualities and functionalities that cannot be accounted for through calculative methods. This presents an issue when one wants to realize some of the truths of life in art, through the use of such technologies.

This thesis presents several approaches to the creation of technological art that accounts for those aspects of life that seem to transcend attempts of calculability and discretization.

1.1 What does "transcendent" mean in the context of this thesis?

The concept of transcendence, in this thesis, is adopted from an understanding of life in existential phenomenological psychology. Psychiatrist Ludwig Binswinger, inspired by the work of Martin Heidegger (Heidegger 2008), devised the theory that there are three dimensions to human life: the Umwelt, the Mitwelt, and the Eigenwelt.

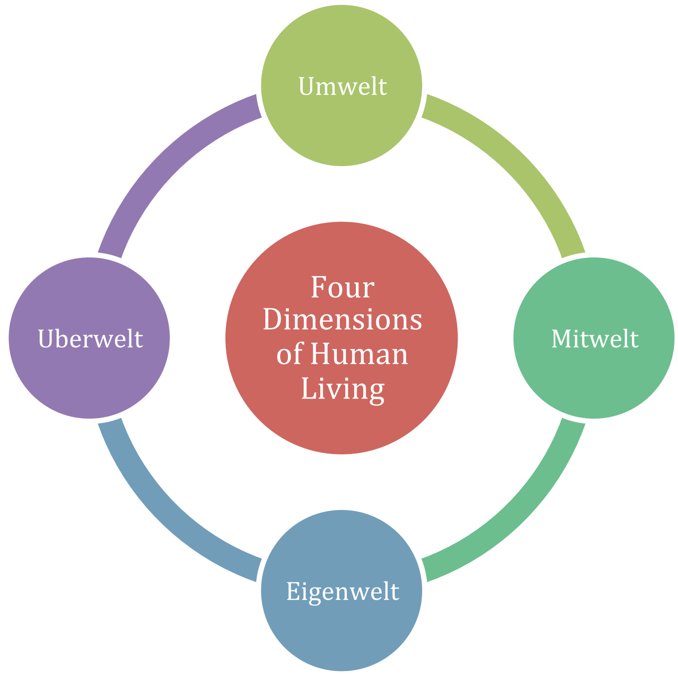

Figure 1: Four Dimensions of Human Living

The Umwelt is the physical world, and consist of human bio-chemical elements: genetics, biological drives, and nature. The Mitwelt is the world of human relations: cultures, social structures, and rules. The Eigenwelt is the world of the personal world of the human, and is the intrapsychic: thoughts, moods, and perceptions.

Many prominent psychiatrist and psychologist, such as Irvin Yalom (Yalom 1980), further developed this theory. Emmy van Deurzen, in 1983, identified a fourth dimension of human life: the Uberwelt (Deurzen-Smith 1984). The Uberwelt is the world of transcendence. In this dimension, exist intentionality and the possibility of learning and choice: it where we make sense of our lives, and where our ideals live. This dimension does not exist as a finite or discrete entity, and unveils itself differently in different context (Chapter 1).

The Uberwelt's influences exist in all of the dimensions of human life, providing elements of transcendence in all aspects of human life. In fact, The four dimensions described in this theory are not viewed as discrete from each other in existential understanding, rather they are all interconnected and happening simultaneously. The understanding of transcendence in this thesis is appropriated from this concept of the Uberwelt. This thesis presents several approached to the creation of technological art that account for the transcendent aspects of life (Uberwelt).

1.2 Overview of thesis

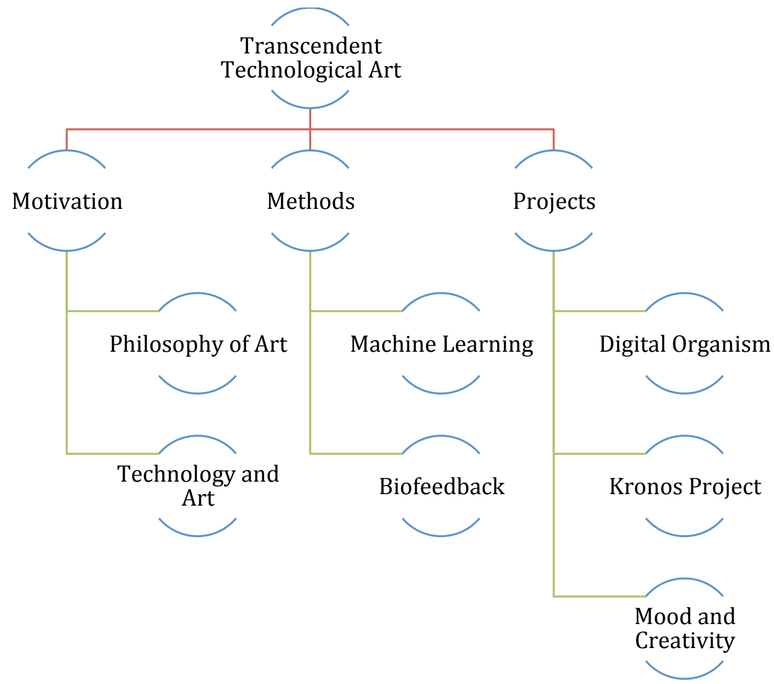

Figure 2: Overview of thesis

This thesis presents 3 projects that account for the transcendent in technological art. These projects incorporate some element of Biofeedback, Machine Learning, or both in their construction. Chapter 2 presents background and motivations for this work, including the philosophies of art that influence this work, algorithms and the programming languages used to realize them and Machine Learning and Biofeedback as methods of implementing the transcendent in technological art. Chapter 3 presents the Digital organism project, which implements the transcendent in a digital representation of life. Chapter 4 presents the Kronos Project, which implements the transcendent in an interactive music system. Chapter 5 presents the Mood and Creativity project, which implements community-driven diffuse biofeedback. Figure 2 shows an overview of the content presented in this thesis. The work presented in this thesis shows how the transcendent can be accounted for in the creation of technological art.

Chapter 2

Background

This chapter defines several approaches to creating technological art that takes into account the transcendent aspects of life. Before presenting these approaches, it will provide context for the relevance of the transcendent in technological art through a brief examination of the philosophical question, "What is art?", which provides a fundamental basis for pursuing the transcendent in technological art. Following this, the chapter will highlight the challenges encountered when attempting to account for the transcendent in technological art. At the conclusion of this chapter, several approaches to producing technological art will be presented.

2.1 Philosophy of Art

As this section shows, questions of "what art is" have been posed philosophical dialogues throughout history. These questions suggests a query of art at the level of essentiality, and seem in part sprung from an inherent difficulty in providing definitions of art based on similar attributes between art objects. Imagine, for instance, the process of producing a definition of art through the analysis of properties in different artist's works. Such an examination may take the course of comparing paintings of Van Gogh and Jan van Eyck and analyzing how those relate to Raphael and Titian, or to Caravaggio and Bernini. Where do the works of Pollock or Pierre Soulages come in? What are the similarities between works of Monet and Debussy and how do those relate to works of Picasso and Stravinsky?

While it may be possible to forge lines of connection between several of the aforementioned artist's works, works such as Duchamp's Fountain or Cage's Silence present a challenge to this methodology. Such works of art, that have no precedence in a given context (e.g. historical), are often not accounted for in definitions of art that are contrived on parallel attributes in art objects.

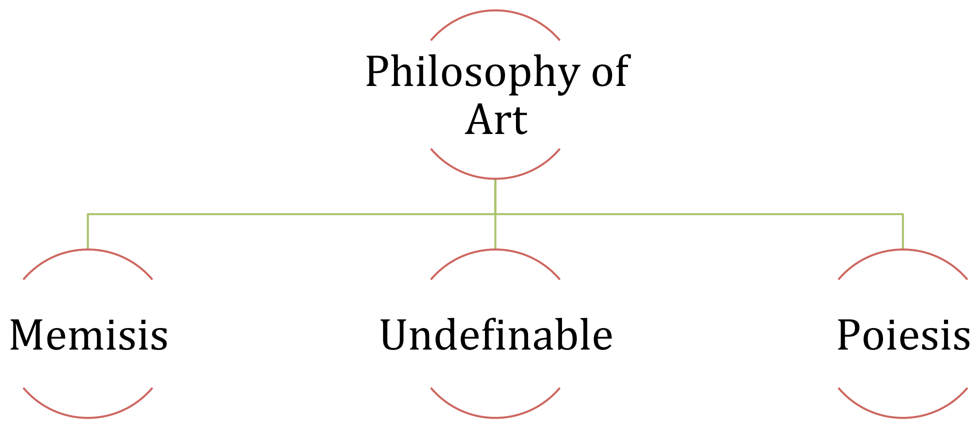

Figure 3: Three Philosophies of Art

There are three major philosophical theories that are important to the formulation of approaches to technological art that accounts for the transcendent presented in this thesis: Mimesis, Indefinability, and Poiesis. Memesis is the idea the art is a reflection of reality. Indefineability is the idea that art cannot be constrained to a definition. Poiesis is the idea that art is the unveiling of truth.

2.1.1 Memesis

Memesis was the philosophy of art held by Plato and Aristotle, and is a Greek word that means imitation or representation. It can be simply understood as the idea that a picture is a picture of something. Memesis asserts that all art is but a representation of a reality, though the understanding of reality manifests itself differently in the philosophies of Plato and Aristotle.

In Plato's theory, he asserts that the highest and most fundamental reality is not that of the physical world, which is known to us through our "sensations", but rather that of perfect, unchanging ideas to which we are an imperfect reflections. He called this the world of Ideal Forms, and art is an imitation of the physical world in which we live (Plato 2012). Aristotle, while agreeing that art was mimesis, held that, "The form and the matter are not separate from the thing" (Aristotle 2004). In his thought, mimesis was both the imitation and perfection of nature. He spoke of catharsis being a purification through Tragedy, stating: "Tragedy is an imitation of an action that is admirable, complete (composed of an introduction, a middle part and an ending), and possesses magnitude; in language made pleasurable, each of its species separated in different parts; performed by actors, not through narration; effecting through pity and fear the purification of such emotions" (Aristotle 1961). Plato and Aristotle both held that art was a representation of their ideal worlds, which alludes to art, in their understanding, being a reflection of the transcendent aspects of life (see 1.1).

2.1.2 Undefinable

Wittgenstein and Weitz provide a radically different philosophical understanding of art than that of Memesis. For Wittgenstein and Weitz, art is an indefinable phenomenon, challenging the validity of any attempts at defining art. Wittgenstein held that there is no suitable definition of art, as art by its nature is too diverse for such constraint and would be stifled by any such attempt, stating: "If we actually look and see what it is that we call "art," we will also find no common properties - only strands of similarities. Knowing what art is, is not apprehending some manifest or latent essence but being able to recognize, describe, and explain those things we call "art" in virtue of these similarities" (Weitz 1956).

Weitz, influenced by Wittgenstein, referred to art as an "open concept". In his theory, "a concept is open if its conditions of application are emendable and corrigible; i.e., if a situation or case can be imagined or secured which would call for some sort of decision on our part to extend the use of the concept to cover this, or to close the concept and invent a new one to deal with the new case and its new property" (Weitz 1956). Art being an "open concept" not only transcends attempts of definability, but also alludes to the way in which life unveils itself. The transcendent aspects of life cannot be explicitly defined and discretized in a single definition (see 1.1), and the realization of these aspects through art further solidify this concept.

2.1.3 Poiesis

Heidegger took a step further than Wittgenstein and in his thought of art as Poiesis, Greek for "bringing-forth". Poiesis is of the Greek word Aletheia (the unconcealment or unveiling of). He says, "In the work, the happening of truth is at work", and that the "Essence of art, on which both the artwork and the artist depend, is the setting-into-work of truth". Heidegger goes on to say, "All art, as the letting happen of the advent of truth of beings, is as such, in essence, poetry" (Heidegger 1963).

Art as poiesis grounds each of the previous theories mentioned above. All art in someway seems to attempt to bring-forth truth. This is illustrated in Plato and Aristotle's opposing views of mimesis. Plato's truth lies in the abstract ideal, while Aristotle's in the changing world itself, however, both philosophers saw art as an attempt to "bring-forth" these truths in work. One can envision Wittgenstein and Weitz's recognition of the inability to define art by comparison of common properties in artworks, as a commentary on truths manifesting themselves in different ways for different people. Yet, a deeper understanding still lies in poiesis.

Aletheia, the unconcealing of, in Heideggarian understanding, is a disclosure. A being cannot be encountered, experienced or known without disclosing itself: unconcealing. However, when a being is unconcealing, that being is also concealing. In other words, if a being is presenting itself in a certain context, it is necessarily hiding its ways of being in other contexts. Aletheia then is a presencing that also conceals.

Poiesis, a word of aletheia, is a bringing-forth that is not completely disposed. One recognizes in a poietic understanding, that a being is not completely available to be known, but reveals itself in a way that it reveals itself. In this way, understanding the revealing of truths in terms of poiesis, accounts for truths being transcendent. Art as poiesis is a phenomenon then that in its roots wants to account for transcendence. This suggests that it is possible to account for the transcendent aspects of life in art, through modern technology.

2.2 Technology and Art

In Heidegger's writings on technology, this idea of poiesis is again central. Heidegger identifies the origin of technology in the statement: "The word [technology] stems from the Greek. Technikon means that which belongs to techne. We must observe two things with respect to the meaning of this word. One is that techne is the name not only for the activities and skills of the craftsman, but also for the arts of the mind and the fine arts. Techne belongs to bringing-forth, to poiesis; it is something poietic." (Heidegger 1982a). In another writing, Heidegger states, "The word techne denotes rather a mode of knowing. To know means to have seen, in the widest sense of seeing, which means to apprehend what is present as such. For Greek thought the essence of knowing consists in aletheia, that is, the revealing of being." (Heidegger 1963)

There is an understanding that technology has grounding in poiesis, and is so, inherently connected with art. This connection provides a context to pursue the trancendent in technological art, however, modern technology presents a challenge to this poietic understanding in that its goal has traditionally been the explicit realization of an actuality.

2.2.1 Programming Languages

At the center of modern technology is the algorithm, which can be described as a "Procedure that produces the answer to a question or the solution to a problem in a finite number of steps." [1]. The aim of the computer programmer is to produce optimized and efficient algorithms, reducing the number of computational steps while maximizing result; this process produces a highly reduced and discretized system. The algorithms of modern technology are realized through the use of computer languages; languages designed to communicate instructions to computational machines. Programmer Ellen Ulmann gives a glimpse inside the world of computer programming:

The problem with programming is not that the computer is illogical - the computer is terribly logical, relentlessly literal. It demands that the programmer explain the world on its terms; that is, as an algorithm that must be written down in order, in a specific syntax, in a strange language that is only partially readable by regular human beings. To program is to translate between the chaos of human life and the rational, line-by-line world of computer language. (Ullman 1996)

Andrew Goffey stated in his Essay, Algorithms: "Algorithms do things, and their syntax embodies a command structure to enable this to happen" (Goffey 2008). Computer languages have traditionally been structured to execute logical instruction and explicit commands.

In Heideggers writing on language, he distinguishes between two modes of language: the "calculative" and the "essential (Heidegger 1982b). He asserts that language, if it is to be

[1] Merriam-Webster Dictionary
[2] http://www2.lv.psu.edu/oj.courses.ist-240/reports/spring2001/fa-cb-bc-kf/historyindex.html

grounded in reality, must be indirect and implicit. Heidegger describes the nature of language as saying and showing: "As saying, the nature of language is the appropriating showing which disregards precisely itself, in order to free that which is shown, to its authentic appearance". He suggests a creative (poetic) approach to language, central to his idea is the metaphor.

The syntax of computer languages themselves has evolved from the explicitness of lower-level languages to the metaphorical expressivity of high-level languages.

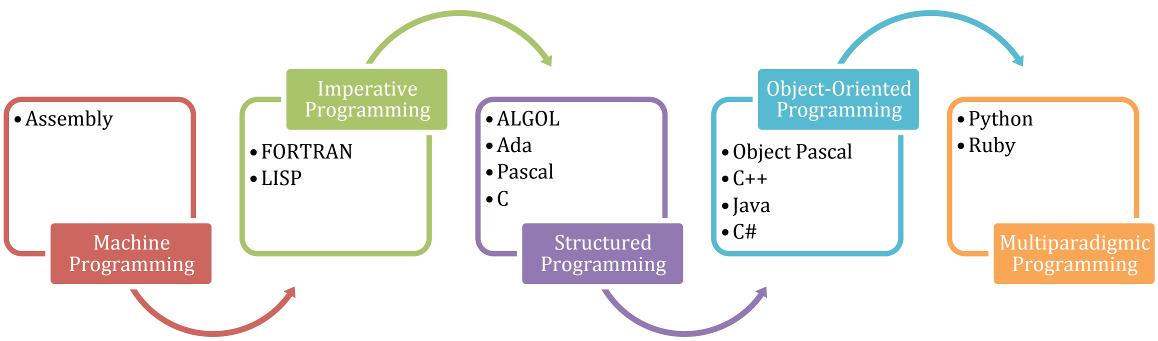

Figure 4: Programming Languages

Assembly language was the first language to translate human readable symbols to machine instruction. It took simple words like "ADD", and translated them to executable machine instruction. This language was highly explicit and logical in its syntax, and didn't have support for the expressivity that exists in human language. However, further attempts to make code more human-readable gave rise to the first Imperative languages, which were written sequentially. Sequential writing brings about the ability to write code similar to the way humans write simple stories or scripts. Statements such as IF, DO, GOTO, TRUE, and FALSE introduced in FORTRAN saw the beginning of higher-level human-type logic and reason in programming. Around the same time, LISP was developed with the goal of producing human-like artificial intelligence through symbolic representation (metaphor). In doing so, it implemented functions and non-deterministic decision processes to mathematical logic.

The aim of structured programming, which arrived shortly thereafter, was to improve clarity, quality, and development time by using subroutines, block structures, as well as FOR and WHILE loops; much the way humans compartmentalize, and generalize for efficiency, but also the way in which human stories are developed (e.g. Plots and subplots).

With the rise of object-oriented languages in the 1960s, there was the introduction of encapsulation, inheritance and polymorphism. Much the way humans use ready-made tools of language (e.g. cliches) and have implicit understandings in some interrelation contexts (e.g. cultural), object oriented languages brought about the ability to hide and constantly reuse code that is relevant to a context (a program in this case). The introduction of multiparadigmic languages, such as Python and Ruby, brought about the ability to choose between and combine imperative, object-oriented, and functional styles, further expanding the possibilities of metaphor and expressivity in code[2]. A time line of programming languages is shown in Figure 4.

If these computer languages are approached in the traditional sense, as explicit instruction, this limits one to producing only that which can be grasped in calculation, and reproducible in a finite number of logical steps. This approach would seemingly obliterate the possibility of creating a poietically grounded technological art. However, the developments in the syntax of programming languages themselves show that they hold the capacity for human like expression, and could therefore be used accounting for the transcendent in technology based art.

2.2.1.1 Creative Coding

The Perl programming language has become a haven for those who reject the perceived formalism and structuralism of programming languages. The motto "There is more than one way to do it (TIMTOWTDI)" has particular appeal to creators. As creator of Perl, Larry Wall states: "Perl is humble. It doesn't try to tell the programmer how to program. It lets the programmer decide what rules today, and what sucks. It doesn't have any theoretical axes to grind. And where it has theoretical axes, it doesn't grind them" (Wall 1999). Most "Critical Code Studies" writings have some reference to Perl, particularly because of "Perl Poetry".

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[2] http://www2.lv.psu.edu/oj.courses.ist-240/reports/spring2001/fa-cb-bc-kf/historyindex.html

Defying the traditional language structures themselves is a valid and intriguing approach to addressing the rigidity associated with programming, however, it doesn't account for the way we experience code in our everyday lives. Most people do not realize or are not interested in the code that exists behind modern technology: this code is typically hidden from access and seemingly irrelevant to everyday experience and interactions. Technology in its primary existence, presents itself as a tool for the realization of some goal. Even for programmers, cell phones or the microwaves are most often tools for communicating or heating food, not objects to be theoretically deconstructed in each encounter. Heidegger refers to our primary experience of this as the "Ready-to-hand". He points out that it is not until technology malfunctions that it presents itself otherwise: "Unready-to-hand", at such point the technology is seen as conspicuous, obtrusive or obstinate. This understanding has been reinforced in recent Cognitive Science research (Dotov, Nie, and Chemero 2010).

Programming languages have a long lineage in the field of music, finding use in implementation of theoretical music systems, or digital signal processing algorithms. The evolution of musical programming languages also shows transition from explicitness to metaphorical expressivity.

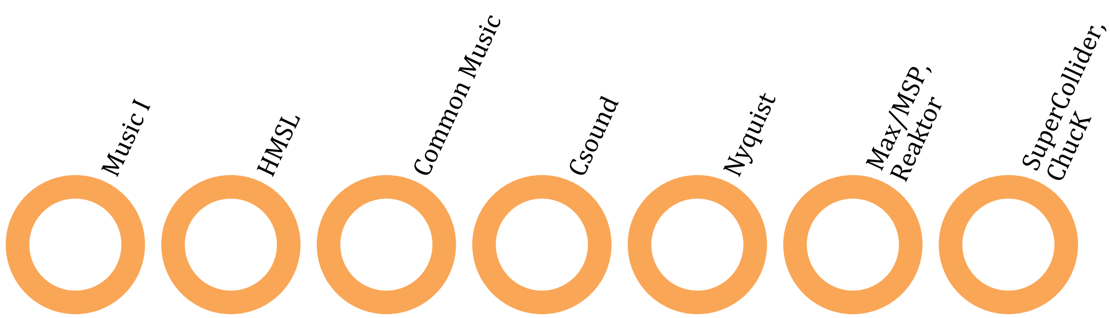


Figure 5: Music Programming Languages

MUSIC I, developed by Max Matthews in 1957, was the first programming environment for the realization of sound synthesis. Early versions of MUSIC relied on the use of assembly code, but in 1968, MUSIC V was implemented in FORTRAN, which allowed for a higher-level of expressivity. The expressivity of musical programming languages was further enhanced when the Hierarchical Music Specification Language (HMSL) introduced pattern transformation in the

1980s. Permutations on patterns are essential to music expression; much of the music that exists follows the concept of theme and variation to some extent.

The introduction of Common Music in 1989 saw a huge development in music languages. CM implemented an object-oriented pattern library, and included such pattern generating forms as the Markov Model, which has been shown in some cases to be able to model and predict human behavior (Pentland and Liu 1999). Some modern languages like ChucK and SuperCollider add the domain of realtime synthesis and live coding through the process of multithreading. This on-the-fly programming is similar to the way humans find themselves in the world, creating and responding to circumstance and adapting to situations. Visual programming languages such as Max/Msp, PureData, and Reaktor bring about a new domain where the syntax of a program is nearly invisible and structure of the program is thought of in terms of data flow (Simoni and Dannenberg 2013; McLean 2011).

For the creative mind, these languages are but tools for the realization of their art work; Ready-to-hand. Poets are not necessarily creating new words each time they want to challenge a traditional conception; they use words that are already in existence in a manner that is not traditional. Similarly, acoustic instrumentalists do not necessarily create new instruments to realize new musical possibility; they simply take new approaches with the instruments that they have. The technological artist, therefore, is not necessarily constrained to only implement explicitly in their art; the challenge lies in finding approaches to programming implicitly in order to realize the transcendent.

2.3 Implicit Programming

This section presents Machine Learning and Biofeedback as tools of modern technology, grounded in techne, to account for the transcendent in technological art. First a background of artificial intelligence is presented, showing historically how intelligence has been implemented in computers, then Machine Learning and biofeedback are presented.

2.3.1 Background

Artificial Intelligence was long criticized for its initial assumptions that intelligence and human thought could be simulated and executed in computers through logical operations. Hubert

Dreyfus, a philosophy professor at MIT from 1960-68, was one of the leading critics of AI and 1964 released the first critique, "Alchemy and Artificial Intelligence". Dreyfus's thoughts were highly influenced by the philosophy of Heidegger and Merleau-Ponty, and he criticized AI research for what he identified to be four assumptions (Figure 6):

"1. A biological assumption that on some level of operation—usually supposed to be that of neurons—the brain processes information in discrete operations by way of some biological equivalent of on/off switches."

"2. A psychological assumption that the mind can be viewed as a device operating on bits of information according to formal rules."

"3. An epistemological assumption that all knowledge can be formalized, that is, that whatever can be understood can be expressed in terms of logical relations, more exactly in terms of Boolean function…."

"4. Finally, since all information fed into digital computers must be in bits, the computer model of the mind presupposes that all relevant information about the world, everything essential to the producing intelligent behavior, must be in principle be analyzable as a set of situation free determinate elements. (Ontological assumption)" (Dreyfus 1992)

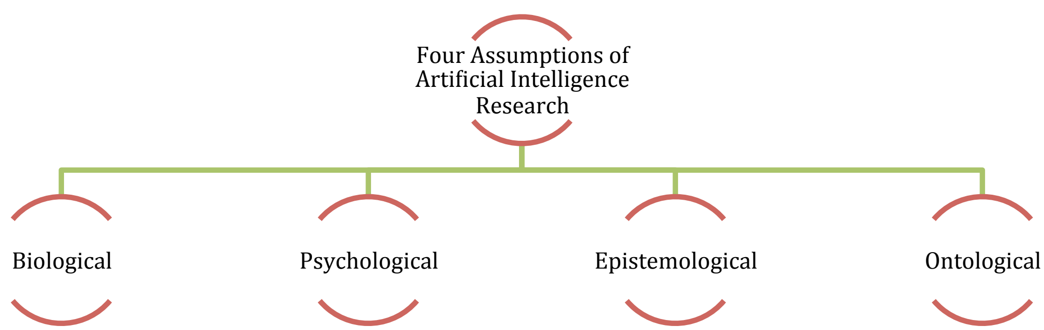


Figure 6: Four Assumptions of Artificial Intelligence Research

Such an approach to AI would present the same issues as other modern technology when presented in the context of techne. Dreyfus's criticisms, however, have proven to be very transformative on the field of AI. Interest in the original approach to developing AI, now referred to as Good Old-Fashioned Artificial Intelligence (GOFAI), began to diminish in the late 80's. As Rodney Brooks, who was one of the leaders in this transformation, remarked in his influential essay, Elephants Don't Play Chess: "The field Symbol systems in their purest forms assume a knowable objective truth. It is only with much complexity that modal logics, or non-monotonic logics, can be built which better enable a system to have, beliefs gleaned from partial views of a chaotic world". (Brooks 1990)

Much of today's AI research intends to account for our unconscious interacting, rather than the original symbolic manipulation approaches. Machine learning is one such example of this.

2.3.2 Machine Learning

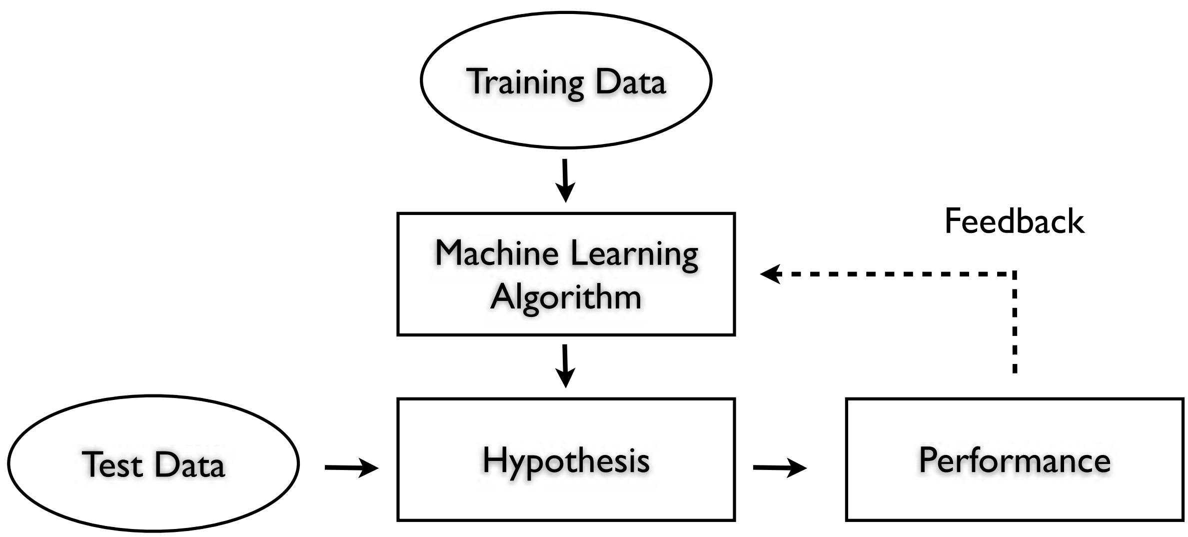


Figure 7: Machine Learning

Though Dreyfus has criticized the classical methods of AI, he also provided valuable insight into how knowledge seems to be acquired. Dreyfus has identified at least five stages, referred to as the Theory of Skill Acquisition, that one must go through to evolve from what he calls "knowing-that" to "knowing-how" (similar to "Present-at Hand" and "Ready-to-Hand"). Dreyfus's 5th stage, that of expertise, as he notes himself, is particularly "consonant" with modern machine learning algorithms (see Figure 7):

Figure 8: Theory of Skill Acquisition

"The proficient performer, immersed in the world of his skillful activity, sees what needs to be done, but decides how to do it. The expert not only sees what needs to be achieved; thanks to a vast repertoire of situational discriminations he sees how to achieve his goal. The ability to make more subtle and refined discriminations is what distinguishes the expert from the proficient performer. The expert has learned to distinguish among many situations, all seen as similar by the proficient performer, those situations requiring one action from those demanding another. That is, with enough experience in a variety of situations, all seen from the same perspective but requiring different tactical decisions, the brain of the expert performer gradually decomposes this class of situations into subclasses, each of which shares the same action. This allows the immediate intuitive situational response that is characteristic of expertise". (Dreyfus 1998)

The expert relies on intuition rather than rationalistic skills or guidelines. "Knowing-how", like Ready-to-Hand, is our normal way of understanding. Dreyfus gives the example of the expert driver, who without calculating is able to perform all the subtle moves involve with driving, such as feeling when to slow down on an off ramp. Similarly, master musicians perform very subtle task that improve performance that they themselves are not even aware of, often referred to as muscle memory. In this way Machine Learning algorithms, specifically the Neural Network, appealed to Dreyfus, as it does to the author, as a way of accounting for those aspects that transcend calculability.

2.3.2.1 Neural Networks

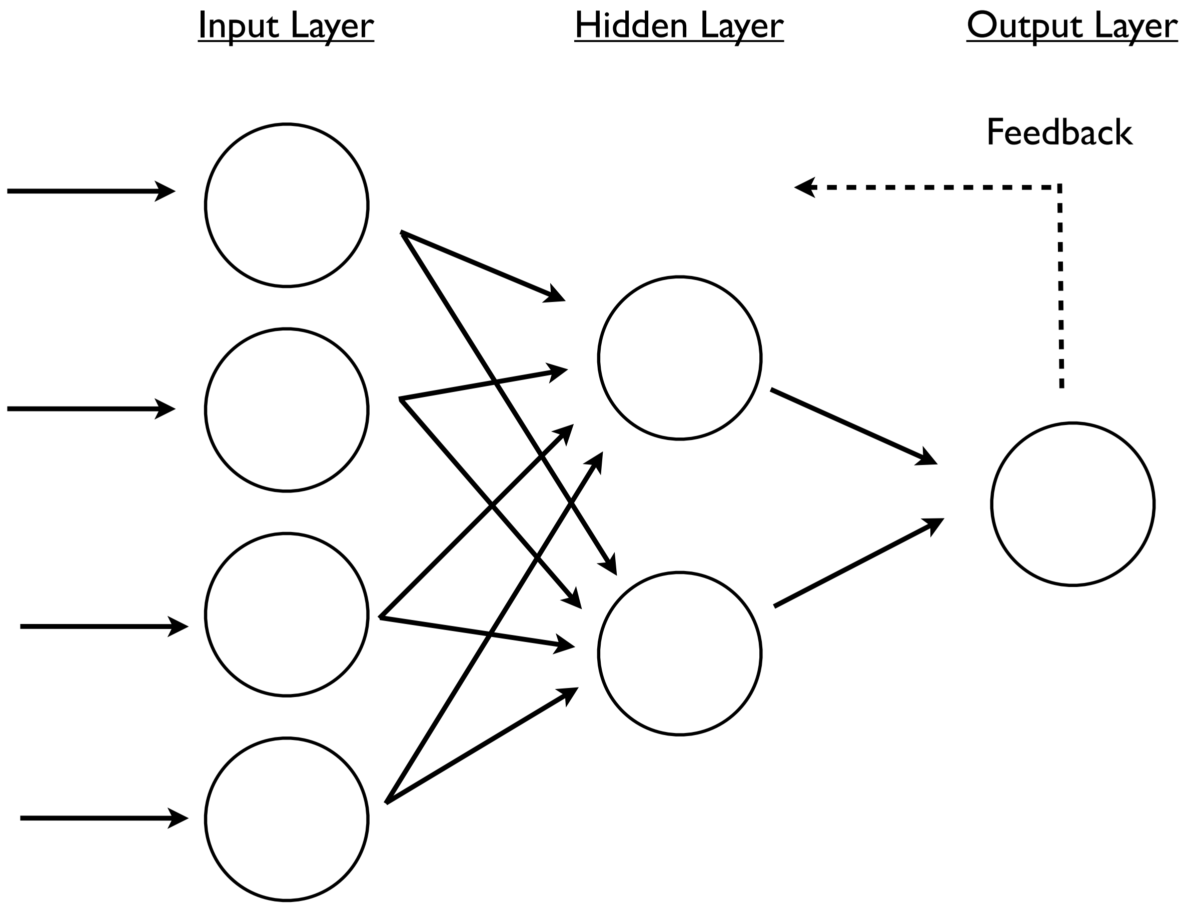


Figure 9: Artificial Neural Network

Artificial Neural Network algorithms (see Figure 9) were created to capture the behavioral and adaptive behaviors of their biological counterparts (Floreano and Mattiussi 2008). They are constructed of layers of interconnected artificial neurons. The input layer receives input from a given environment, the output layer outputs values to that environment, and in between those layers lies any number of hidden layers which only communicate with other neurons in the network.

Each neuron in a system has connection strength, threshold, and an activation function. The product of the input and a synaptic weight determines the input of a neuron; a synaptic weight is initially assigned a random negative or positive real value. The activation state of the neuron is determined by running the sum of all incoming values through an activation function. There are various types of activation functions, some of which are non-continuous such as binary (0,1) and bipolar (-1,1) step functions, and some continuous like the sigmoid function.

Let us imagine this in the context of a simple feedforward network. We provide two inputs to a neuron, plus a bias node. These values are then multiplied by the value of their corresponding synaptic weight, at which their sum will be ran through an activation function. The result at this point would be random, because we have yet to train the network.

The training process of a simple one-layer feedforward network would consist of computing the error of the output using the Delta Rule. The delta rule states that the error of the system is the difference between the desired result and the computed result. The next step of training involves taking that result, called the delta weight, and adding it to the original value of the synaptic weight. The delta rule is only applicable to problems of linear separability. For multilayer feedforward networks, backpropagation of error is required. As its name suggest, the error computed by the delta function has to be propagated back into all the hidden and output neurons. The weights are updated by taking the product of its output delta and input activation, its gradient, and subtracting a learning constant from it.

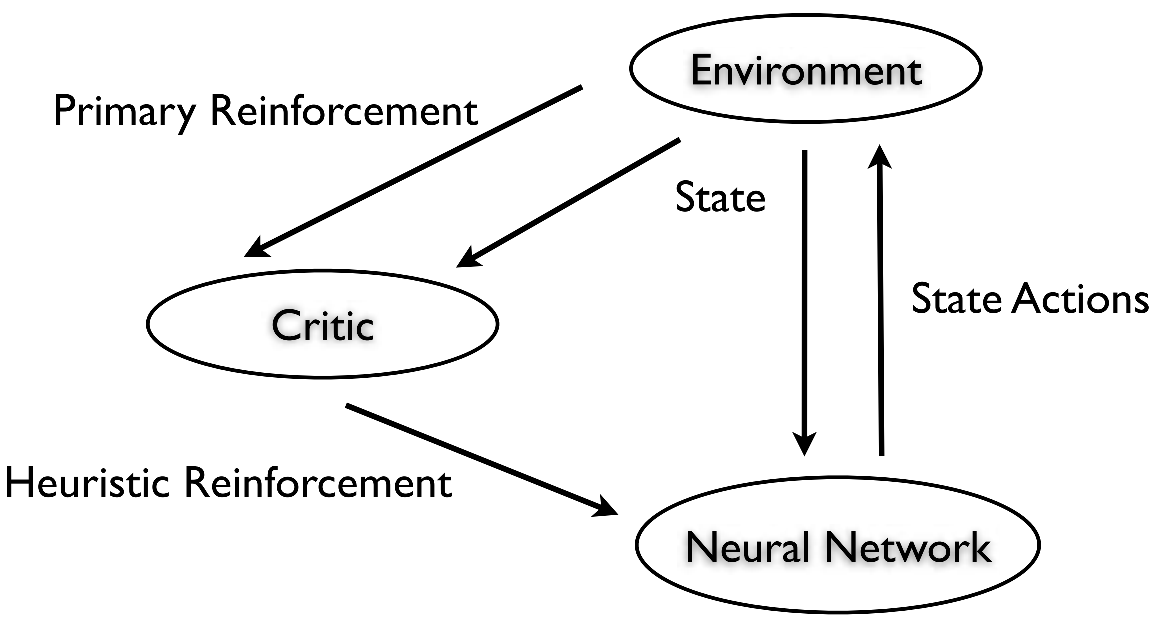


Figure 10: Reinforcement Learning

When environments are unpredictable, or only partially known, they require the use of reinforcement learning algorithms (see Figure 10). These algorithms allow an agent to learn its behavior through from its environment through a system of reward. The rewards are in the form of positive feedback for actions determined to be favorable, and negative feedback for unfavorable actions.

Neural Networks provide a model of intuition rather than symbolic representation. Like Dreyfus's expert, the neural network's vast experience enables them to immediate identify a situation. Their learning methods provide a context where experience can affect the current input, with out proclaiming to know what these specific memories are. This supports the idea of technology, in its understanding as techne, accounting for the transcendent.

2.3.3 Biofeedback

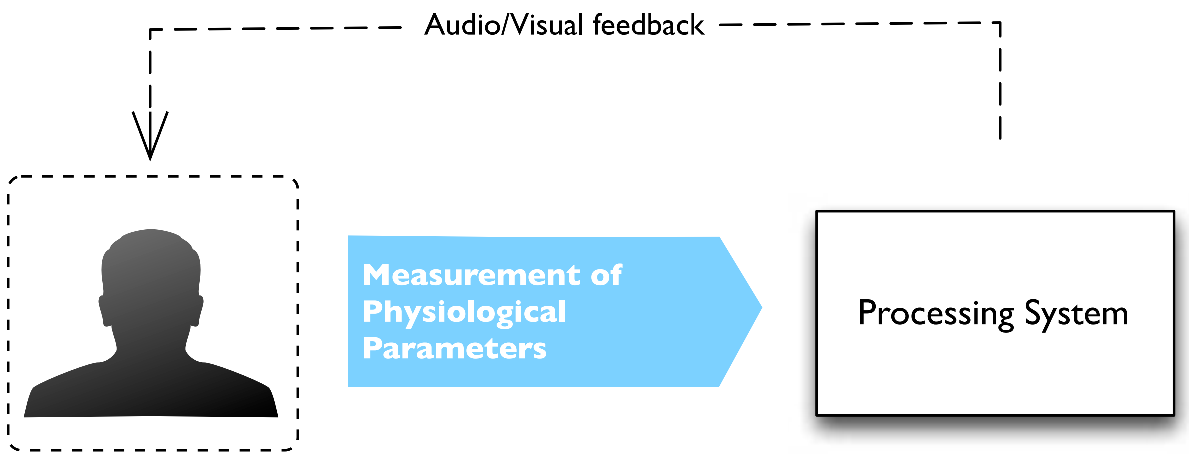


Figure 11: Biofeedback

David Rosenboom explains biofeedback (Figure 11) as the "presentation to an organism, through sensory input channels, of information about the state and/or course of change of a biological process in that organism, for the purpose of achieving some measure of regulation or performance control over that process, or simply for the purpose of internal exploration and enhanced self-awareness" (Rosenboom 1990).

The word 'biofeedback' was coined in the 1960s and has been studied since. Scientist recognized that biofeedback was a way for humans to gain some control over bodily functions that before seemed completely involuntary.

Scientific research has yet to provide significant explanation on how the phenomenon works (West 2009). This inability to reduce the processes biofeedback to discrete function biological functions however seems to allude to some aspect of transcendence in life. The use of biofeedback in art thus provides a direct means of implementing the transcendent in technology-based art.

2.3.3.1 Neurofeedback (EEG)

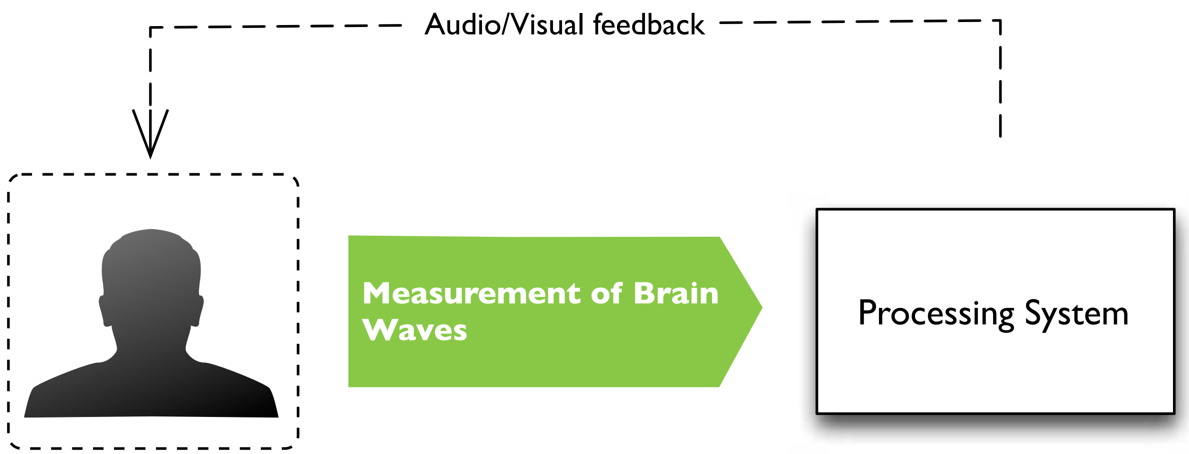


Figure 12: Neurofeedback

Electroencephalography (EEG) is a method of recording the brain's electrical activity along the scalp. This method calculates the magnitude of several wavebands across the brain, including Delta, Theta, Alpha, Beta, and Gamma. The method of biofeedback that employs EEG is called neurofeedback (see Figure 12).

The Alpha band of waves has been the waves most associate with biofeedback in the arts. Alvin Lucier was the first to use brain waves in the realization of music (Lucier 1976). Lucier, in his piece, placed loudspeakers on snare drums, through which he amplified the burst of alpha waves, which he achieved through meditation, causing the snare to resonate. Pioneers such as David Rosenboom, who stands as one of the leading authorities in this area of research, and has contributed significantly to its advancement and popularity, followed Lucier's work (Rosenboom 1976).

Also a pioneer in this field, Richard Teitelbaum designed several pieces where he used brain waves as "control frequency, amplitude, spectrum and trigger inputs for the voltage controlled oscillators, amplifiers, filters and envelope follower/Schmidt trigger modules of the modular Moog" (Teitelbaum 2006). In the late 1970's he began to extend his work with biofeedback to include other media.

2.3.4 Summary

This chapter has presented the understanding of art as poiesis as grounding on which to pursue the transcendent in technological art. The poietic philosophy says that art is the bringing-forth of truth through work, and truth has been described a something that unveils itself implicitly. Despite the seemingly inherent challenges with using algorithms and programming languages in technology, this chapter has shown the evolution of programming languages from low-level explicitness to high-level metaphorical expressivity. It also demonstrated that it is possible to use these languages in ways that are contrary to calculability and explicitness they are usually associated with. Furthermore, this chapter has identified Machine Learning and Biofeedback as ways of implementing the transcendent in technological art.

Chapter 3 Digital Organism

Systems ecology, when introduced, appeared as an attempt to reduce the living organism and its environment to a construction of systems that function as subordinates of other systems. While this formulation of living organisms operating in systems holds some relevance to how organisms operate in an environment, a negative effect of such understanding is that it could de-emphasize the individual organism and rather emphasize the system in which the organism would function as a mechanical node (Tansley 1935). Much of this initial research in the field of systems ecology was inspired by the study of mechanics, and in effect was the application of machine theory on to natural concepts (Odum). The question that that this raises in relation to the transcendent aspects of life is, "what do we lose when we limit our modeling of life to a discrete and calculable construct of subsystems?"

The *Digital Organism* project emerged as a way of addressing, through the creation of technological art, what appeared as an emphasis primarily on the systematic reductions of the living organism, in some modern understandings of life, rather than an emphasis on some of the more transcendent qualities. Specifically, the interest was in how biofeedback could be used to create an agency and transcendent engagement between a participant and a digitally modeled organism.

The project consisted of an installation environment in which audience members could interact with a digital modeled representation of an organism. The organism was projected on a wall and the users EEG data was the main form of interaction with the organism. Additionally, IR sensing was used to detect the users position in relation to the organism, and machine learning was incorporated in defining the organism motion in relation to the user. The organism was directly exposed to their brainwave patterns through sonic re-simulation projected inside the space using sub speakers.

The *Digital Organism* project brought forth the question of "how are we to account for the intuitive, immanent, or affectual in a digital art representation of life?" The hope was that through this project the link between intentionality and the transcendent in understanding organisms would be explored. It was also an aim to understand what affectual behaviors transgressed the boundaries between real and artificial life, and what behaviors may have been lost in the scientific modeling of life.

Section 1 discusses the concept of "Artificial Life". Section 2 explores what the project is in depth, and how it was designed with the goal of producing a transcendent relationship between the participant and the organism. In section 3, there is discussion on some outcomes of the projects installation. Section 4 provides some reflections on the project and future plans.

3.1 Artificial Life

A concept that is particularly relevant to this project is that of "Artificial Life". Christopher Langton, one of the founders of Artificial Life (A-Life), has said that, "Artificial Life is a field of study devoted to understanding life by attempting to abstract the fundamental dynamical principles underlying biological phenomena, and recreating these dynamics in other physical media—such as computers—making them accessible to new kinds of experimental manipulation and testing" (Langton 1993).

Artists have taken concepts of A-Life and implemented them in their work. While this project may fall into this category of art, it in no way aims to explicitly reflect any actual biological processes of a living organism. The digital organism project aims at creating a transcendent connection between the participant and the user and all consideration are solely towards that end.

3.2 Project Description

There were two primary concerns in designing this project: "How to encourage a complex relationship between the participants and the digital organism towards the realization of poiesis" and "aesthetic considerations". All aspects of design were reflections of these fundamental concerns.

Encouraging a complex relationship with artwork, to some extent, requires complexity in the artwork itself. The philosopher David Chalmers, stated: Where there is simple information processing, there is simple experience, and where there is complex information processing, there is complex experience (Chalmers 1995). A common challenge in creating any digital environment is that there has often been a trade off between the amount of complexity and controllability. This trade off is particularly noticeable in aspects of digital motion (Sims 1994).

With this in mind, the elements of the digital organism's motion were central to design in this project. Motion provides the organism it's autonomy and also creates context for a visible form of interaction with the participants. The organism's complexity and interaction is implemented primarily in its motion on the micro and macro level.

3.2.1 Visual Construction

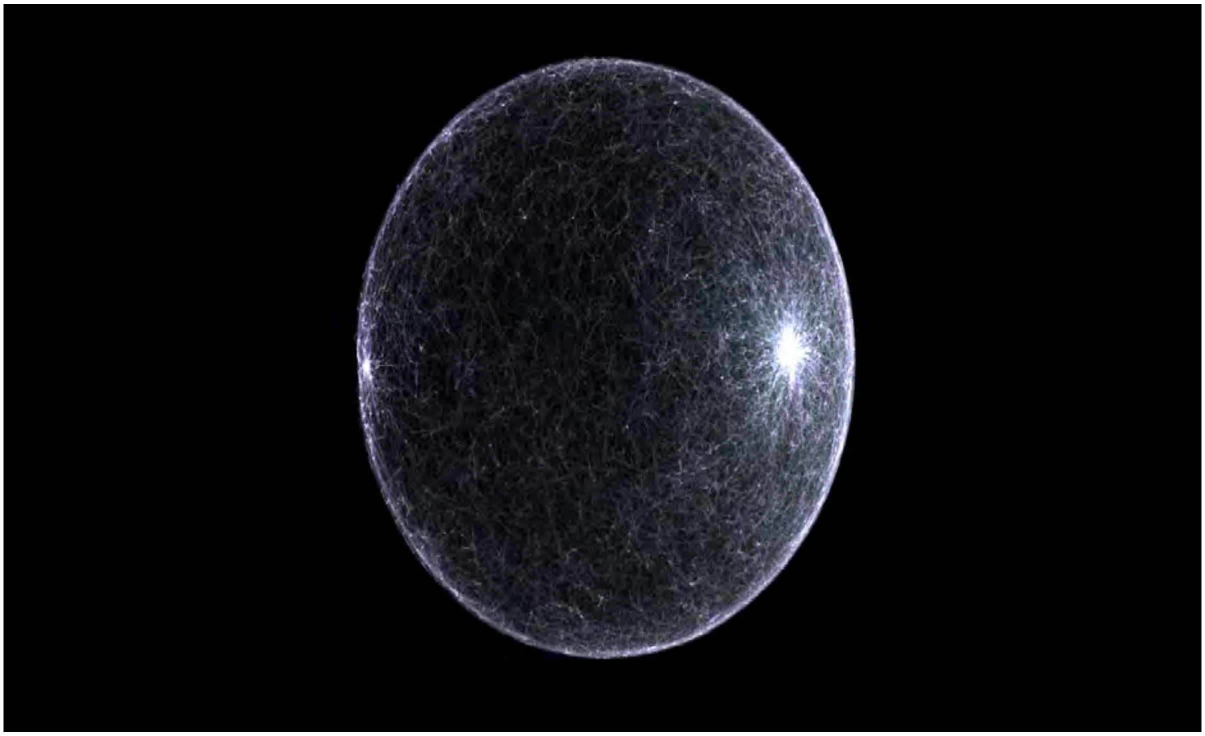


Figure 13: Spherical Organism

The first implementation of complexity happens on the micro-level of construction in the organism. If we are to imagine the elements that compose a physical organism, we often think of complex behaviors and relations on lower-levels. Rocha describes these "complex systems" as "any system featuring a large number of interacting components (agents, processes, etc.) whose aggregate activity is nonlinear (not derivable from the summations of the activity of individual components) and typically exhibits hierarchical self-organization under selective pressures"(Rocha 1999).

On the micro-level, the organism is constructed of a mesh of hundreds of particles whose individual movements is determined partially by noise in three-dimensions (x, y, z). Introducing noise to the elements of motion in the organism provides an organic, incalculable, and almost chaotic element to the design. Joseph Nechteval describes noise in the statement, "Noise is often loud, elaborate, interlaced and filigreed—but almost always gradient and highly phenomenological" (Nechvatal 2011).

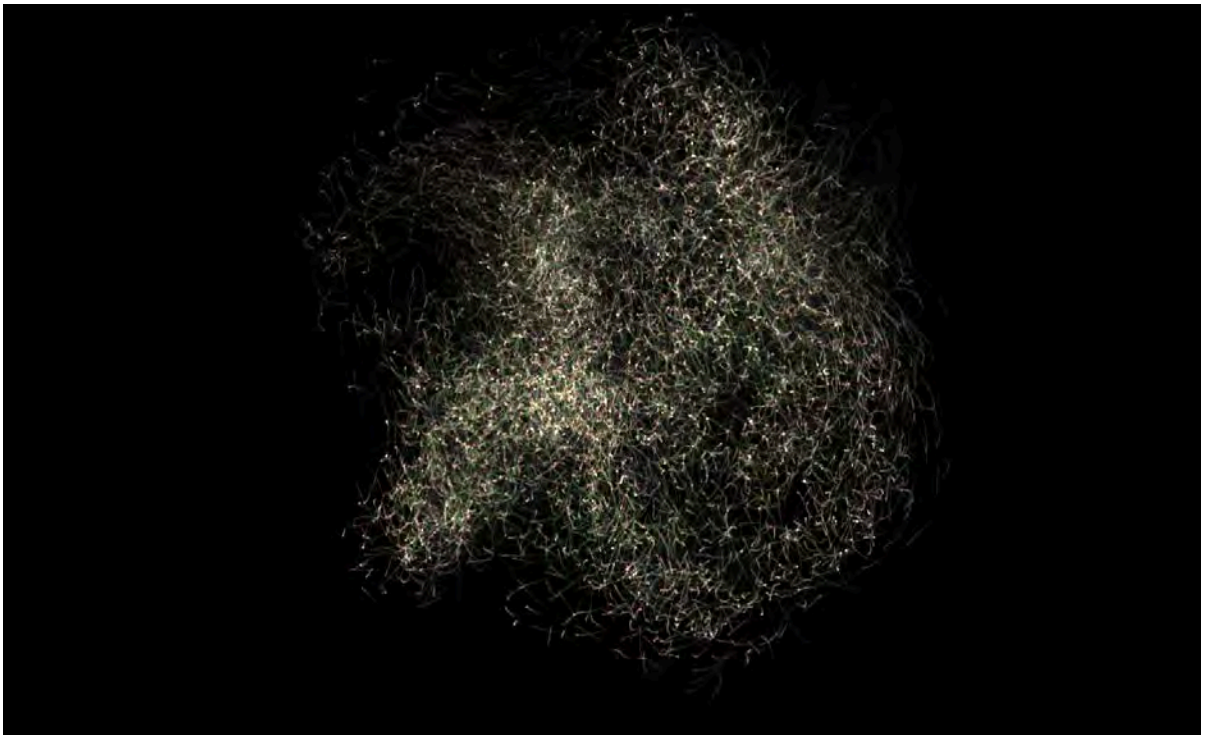


Figure 14: Noise Displacement

Additionally, spring force is applied to this motion, which simulates causality and interconnectivity between each particle. The organism is allowed to transition structural states. In an initial state, particles are constrained to the dimensions of a sphere (see Figure 13), providing a seemingly embryotic structure for the organism (MacLennan 2011). The final state that the organism may reach is one in by which the particles are used to displace the spherical dimensions (see Figure 14). The organism can interpolate these states when triggered by a cue described in the macro movement in the organism. The velocities of the particles are inversely proportional to the magnitude of the alpha wave band in the brain, therefore a relaxed mind will experience a slowing down of motion.

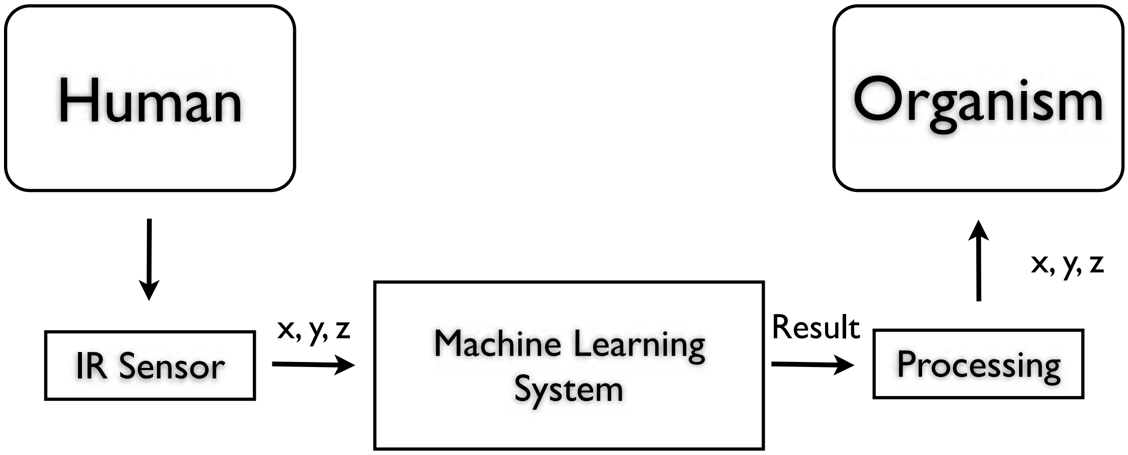


Figure 15: Organism's Motion Architecture

In designing the organism's movement as a whole, it was important to consider how two individuals act in relation to each other. The agency between the participant and the organism had to be thought of in terms of complexity and non-linearity in order to encourage the transcendent aspects to be revealed. Movement interaction then, as a whole, had to encourage this relationship.

We explored the idea of collecting sensor data, which allowed for accelerometer and gravity readings while individuals were interacting with each other, and using it as a model for the organism movement in interaction. With this, it was possible to use the Microsoft Kinect to track the user's position in relation to the organism, and with Machine Learning algorithms trained on the mobile data, allow the organism to move in an organic manner (see Figure 15). A threshold was set so that once the organism reached or exceeded a specific radius it transitioned states on the micro level.

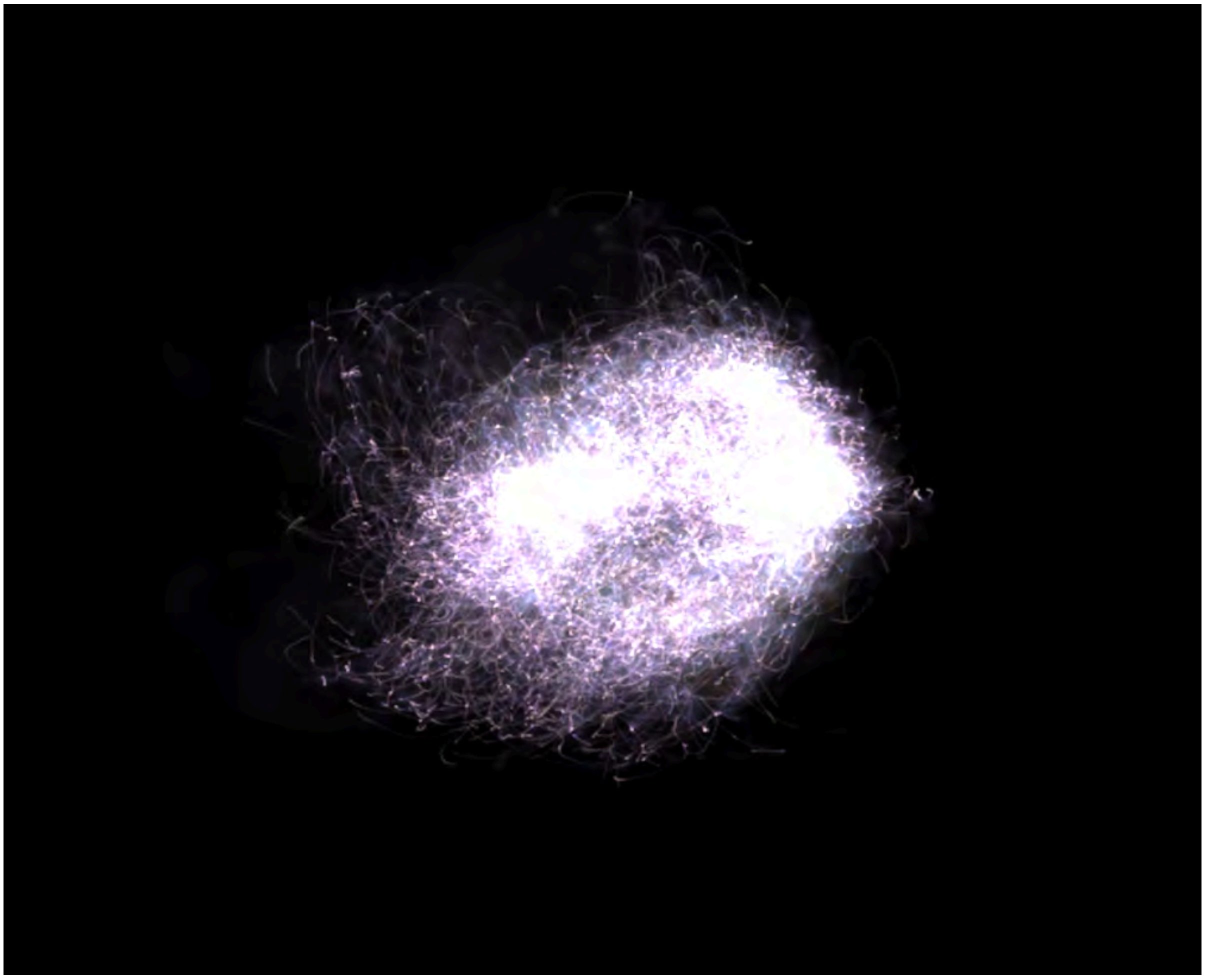


Figure 16: Glowing Organism

The aesthetic design of the organism was influenced by the phenomenon of bioluminescence (Meighen 1991). Glowing was used to simulate this luminescence on each particle, using blending in OpenGL (Shreiner 2009). Additionally, each particle created a glowing trail. The color of the organism is created randomly as a result of sudden spikes in EEG Data. These effects can be seen in Figure 16.

3.2.2 Audio Construction

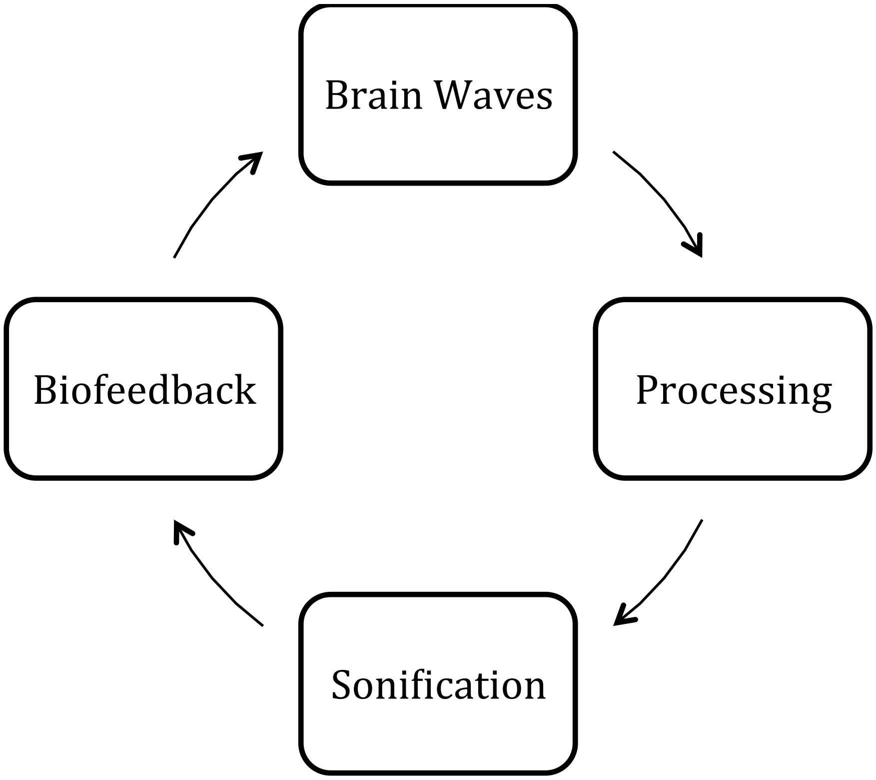


Figure 17: Audio Construction

The sonic component was composed using data from the brainwaves and provided a context for the audience's interaction, in addition it gave the organism a sound of it's own. The basis of the audio production was the brain waves themselves. The raw EEG data was turned into a wavetable and cubic interpolation was applied to the playback. The magnitude of the alpha wave was used to control the frequency of a difference tone sound generation, sliding between 7 and 13hz. All brainwave frequencies were also multiplied into higher octaves to produce resonant filters that were fed pink noise signals.

The organism's sound was created using the magnitude of these brain wave signals to determine the frequencies of a bank of triangle oscillators. Incoming values were interpolated with and the sliding effects caused a symphony of unpredictable difference tones.

In Figure 17, the flow of the audio generation can be seen. The brainwaves enter the processing system, in this case raw EEG data and the alpha wave magnitude. This data is then sonified using wavetable synthesis, difference tones, and resonant filters over pink noise. The sonification is then fedback to the organism through audio speakers.

3.3 Installation

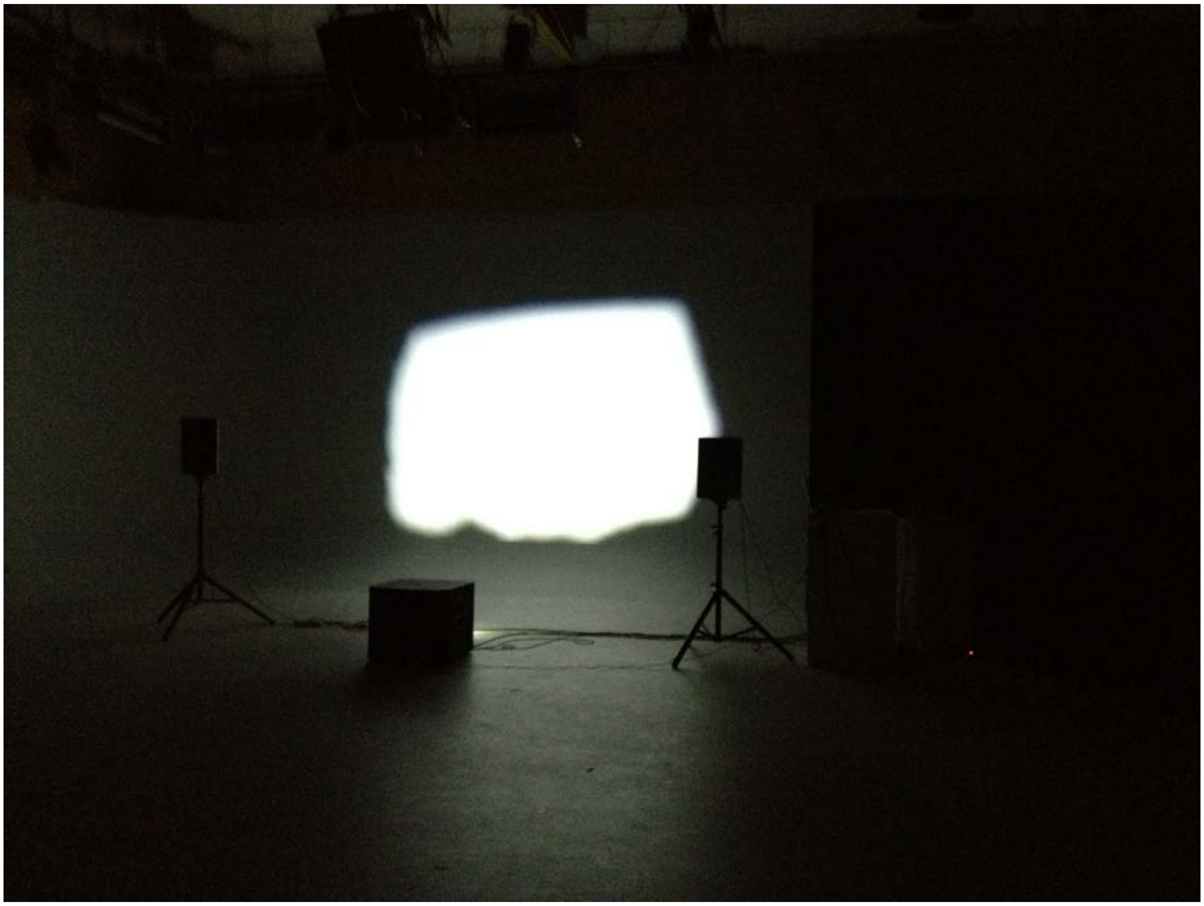


Figure 18: Installation Space

The installation took place in a completely dark room where the organism was the only source of light (see Figure 18). This encouraged the building of interaction, and prevented interference from other outside environmental factors.

The installation was premiered at CalArts. In the three 45-minute showings, Geoff Derven, a collaborator in developing the concept of "Participatory Life", prepared an introduction speech, and demonstrated the installation to the audience, before inviting several individuals to participate:

"Hello everyone, and welcome to Participatory Life.

For the majority of the past few centuries, we've viewed life as an object. In our studies, whether it be philosophy, science, or religion, we've tended to think other organisms as their own entities, separate from our bodies, existing out in the world. What we'd like to propose is a more participatory understanding of life. Think for instance of the relationship between the flower and the bee. This relationship is akin to counterpoint, in that two organisms create a relationship with a life of its own."

We've created an organism that will present itself both visually and sonically. This organism was designed to interact with you through your movement, and you thoughts. Your relationship with this organism will be not one of mastery, but of mutual influence between yourself and the organism. After an initial presentation, several audience member will be invited to participate."

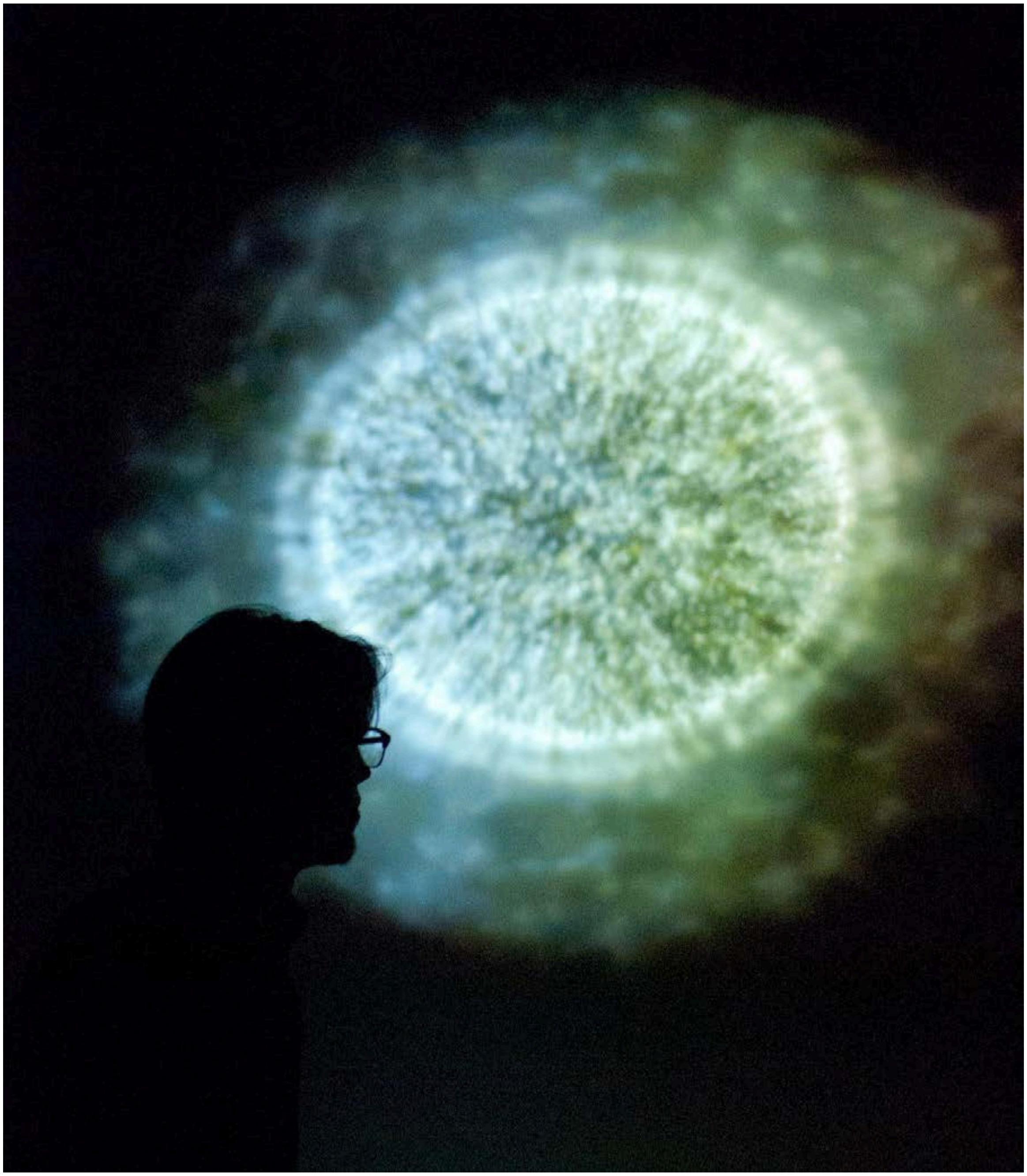


Figure 19: Organism and Participant

The space used for the installation was a lot larger than what was planned for, this is what led to there being audience rather than individual just entering the installation on their own accord, as was hoped. A smaller space could've have provided a more immersive interaction with the organism, and a more immersive sonic experience. The audience observing could possibly have caused some interference in this.

About 25-30 people attended each showing, and 4-5 from each showing participated. Additionally, after the final showing, another hour was dedicated to people who wanted to participate in the installation. Figure 19 shows the organism, and a participant in the installation.

3.4 Conclusion and Reflections

This chapter presented the digital organism, a project developed as a way to address the issues of reduction presented by some of modern sciences views of living organisms. This project suggests the use of machine learning algorithms and biofeedback as a way of producing, and encouraging, transcendence in the relationship between the organism and participants in the installation. Several design aspects of the organisms further encouraged this sense of the transcendent, such as the use of noise to control particle direction in the micro construction and the indeterminate symphony of difference tones the organism produced.

The behaviors observed in participants seemed to be congruent, for the most part, with the goal of this project. The participants, probably in part due to the demonstration and introduction to the installation, took a considerable amount of time and consideration in interacting with the organism.

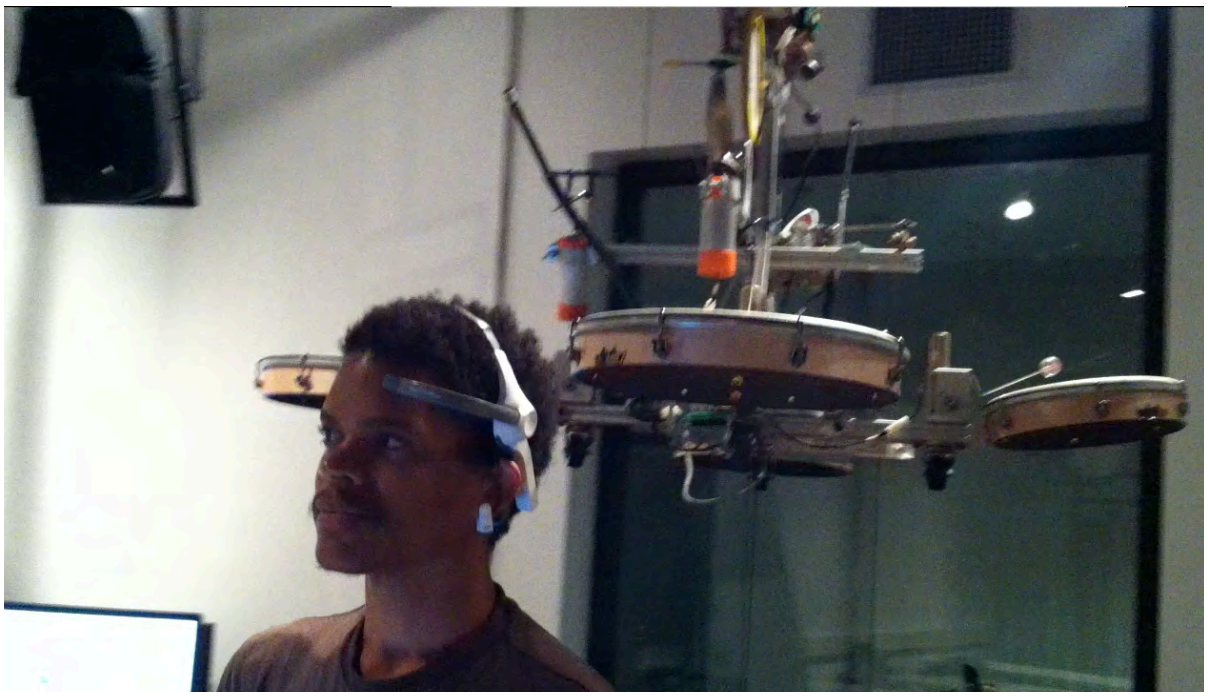
There were a few occasions where a participant recognized that a Microsoft kinect was being used, or that their motion in some way was related to the organism. In these cases, an attempt to test the parameters, or gain more controllability was observed in their behavior. In one interaction, a participant began performing cartwheels. Additionally, participants reported attempting to control the difference tone present in the sub speakers without success, which was proportional to the magnitude of their alpha wave band. Such behavior is expected, as there is a natural tendency to want to calculate, control, and predict. However, the particular uses of biofeedback and machine learning in this project were designed to deny such attempts at control, in order to encourage an interactive and transcendent relationship.

Overall, the organism project turned out quite successful. Participants spent considerable time interacting with the organism, and Biofeedback and Machine Learning helped to create transcendent relationships between the participants and the organism. Several follow up projects have been developed, or are currently in development. Many of these forge a stronger connection between the sonic and visual organism. Additionally, work is in process on a version for mobile devices that incorporates objectives in which the user and organism attempt to accomplish together.

Biofeedback was implemented loosely in this project, controlling particle speeds and triggering morphogenic transformations in the visual organism. In the Kronos Project, Biofeedback and Machine Learning are directly implemented in a coupled construction for control in an interactive music system.

Chapter 4

Kronos Project



The earliest implementation of biofeedback in the arts was in the use of brainwaves to resonate percussion instruments (as described in 2.3.3.1). Lucier with his piece opened up the artistic world to this new paradigm of music creation an feedback interaction (Lucier 1976). Artists for decades since have explored this power of neurofeedback in the creation of music, and the expansion of human nervous system to external instruments (Rosenboom 1990). The Kronos project follows in the lineage of a great body of artistic work designed to implement biofeedback methods in the creation of music, and extends this paradigm into the domain of percussive musical robotics.

The goal of the Kronos project was to explore how biofeedback and machine learning could work together to create an interactive musical system using robotics. Joel Chadabe, a pioneer in the development of interactive musical systems, has described these systems as "mutually influential", meaning the performer himself is influenced by the instrument's output Chadabe states that, "Interactive instruments embody all of the nuance, power, and potential of deterministic instruments, but the way they function allows for anyone, from the most skilled and musically talented performers to the most unskilled members of the large public, to participate in a musical process" (Chadabe 2002).

The initial implementations of the Kronos project focused on the direct correlation between brainwave patterns and actuator events, and the use of machine learning algorithms to directly classify brain pattern events for control of musical systems. The implementation described in this section introduced a custom interactive machine-learning based algorithm, the Christopher-Vallis Neurofeedback Network (CVNN), which relies on biofeedback for dynamic modification of individual neuron's activation. The final presentation was demonstrated in a live performance using three robotic instruments of the CalArts Machine Lab (A. Kapur et al. 2011). Section 1 presents the design of the Kronos system, and how the transcendent was implemented is describe in section 2. Section 3 provides details on the performance that took place at CalArts. Further reflections on this project are provided in section 4.

4.1 Kronos Design

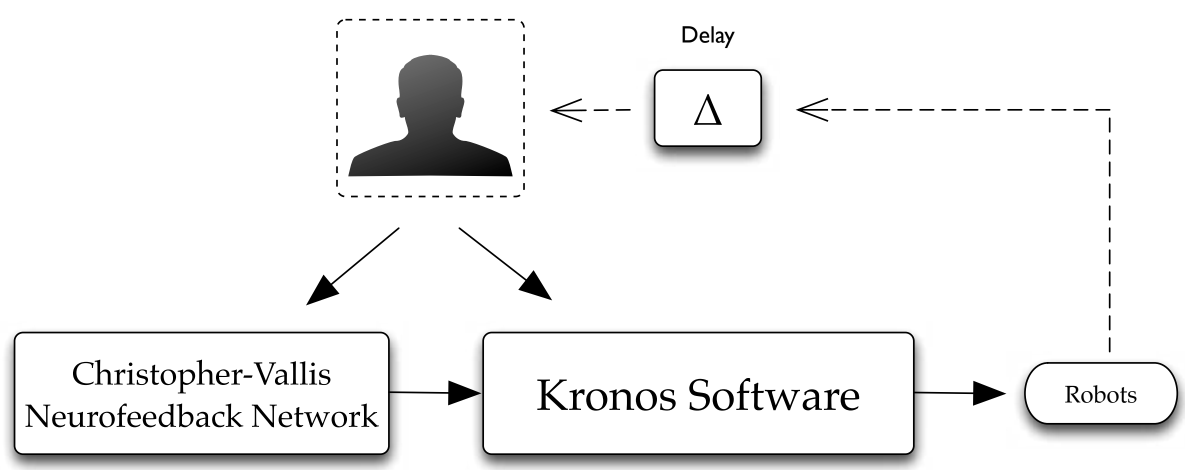


Figure 20: Kronos System Architecture

There were two primary considerations in developing this project: Determining an algorithm that could best incorporate and utilize biofeedback, and developing a performance system that maximized the impression of using the brain as a controller. These considerations led to the creation of a custom algorithm, and a highly biofeedback integrated software component.

4.1.1 Christopher-Vallis Neurofeedback Network

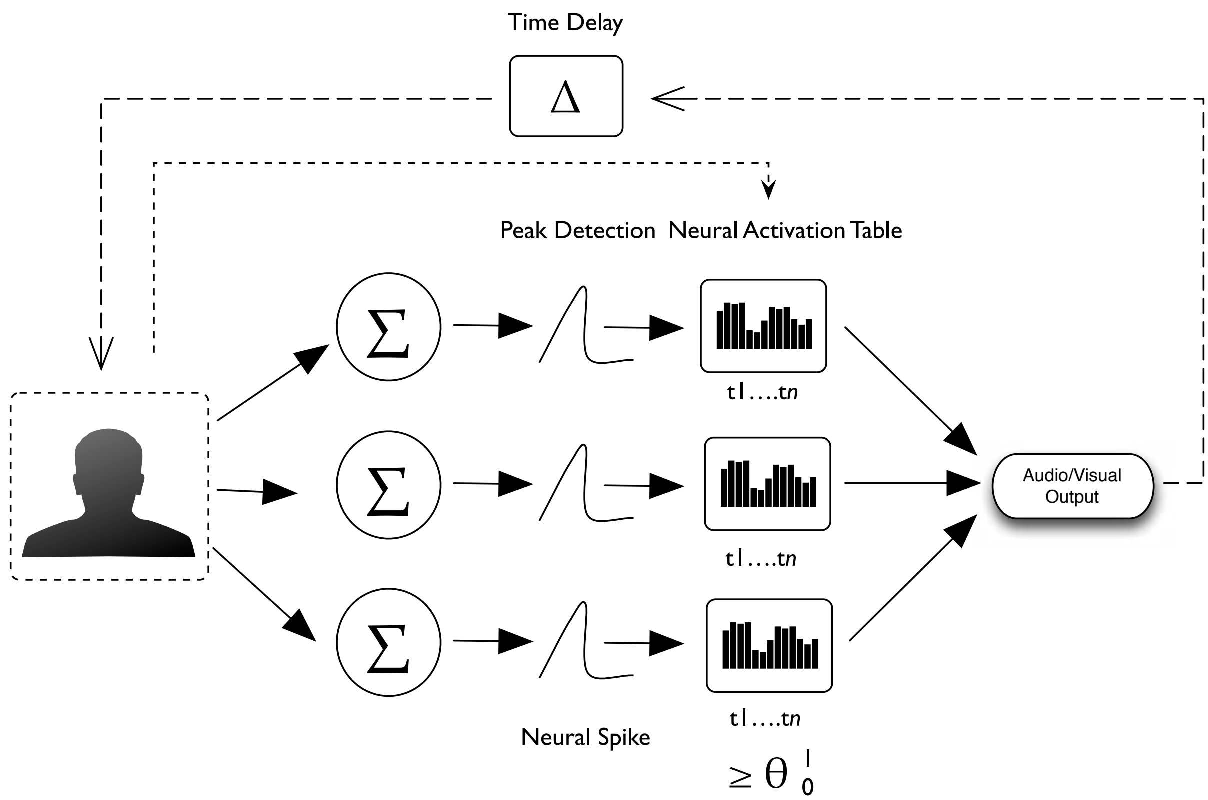


Figure 21: CVNN

The CVNN (Figure 21) was created to allow for the dynamic coupling of the brain and artificial neurons through a feedback connection. The CV neuron (shown in Figure 22) is very similar to the previously mentioned neuron models (see Neural Networks) and takes, as input, features extracted from EEG data. These features can include Raw EEG values, brainwave magnitudes (Delta, Theta, Alpha, Beta, Gamma), or any number of preprocessed features. The summation of input data is then analyzed to detect spikes, referred to as neural spikes. The magnitudes of these spikes are passed through an activation table to determine the activation level of each neuron.

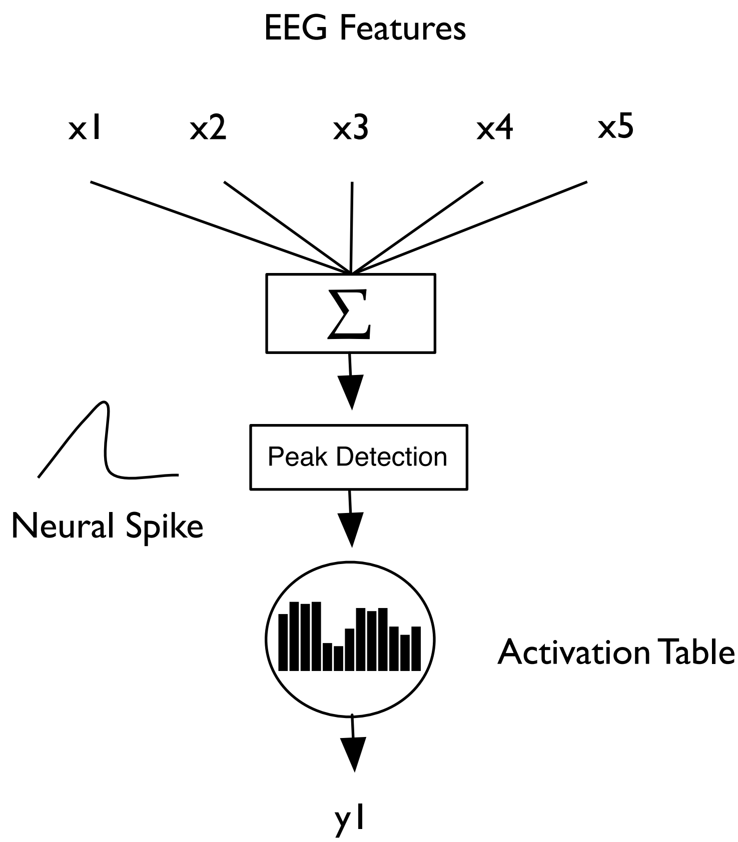


Figure 22: CV Neuron

The activation function, which exist in place of other functions such as the sigmoid, is created from an array of values collected from the significantly downsampled brain features used as input, and updated only when a trigger opens a gate for new values to be passed in. This table allows for the brain to form a temporary memory of the function for each time step, but also to dynamically modify the function.

The benefit of this mechanism is that the algorithm can adapt to lower or elevated activity levels in the brain. The activation output of the neuron is then realized through audio/visual medium and fed back to the organism's brain. The brain will update the activation level at the next timestep after a temporal delay, and when the gate is opened it will update the neural activation table. This algorithm was inspired by research into existing time-dependent neural systems (Floreano and Mattiussi 2008).

4.1.2 Performance System Design

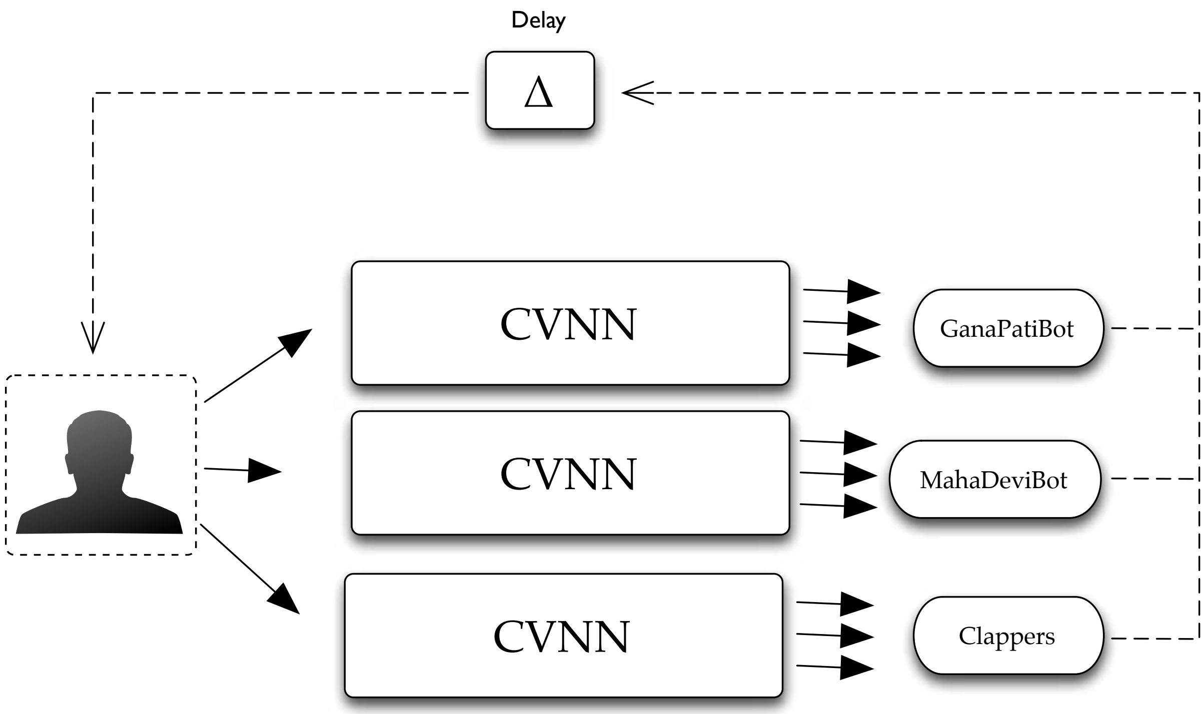


Figure 23: CVNN to Musical Robots

In developing this performance, it was important aesthetically to use as little extraneous movement as possible, as to not distract the audience from the actuality that the brain was truly in control. The CVNN provided basis for direct control of individual actuators in the robots, as seen in Figure 23. Brain wave data was sampled at 512hz and distributed arbitrarily across the neural activation arrays set up for each of the robots' actuators, which allowed for the avoidance of robot homophony. The neural sigmoid arrays were sixteen values in length, and EEG raw signal input was downsampled to 125 bpm, which created a static rhythmic base for the musical performance.

The mechanisms designed for selecting which robot to control was based on spikes in brainwave data created through blinking interference. A spike threshold was set for each robot and when exceeded the robot's activation state was toggled. Three robots of the CalArts Machine lab were selected for the performance: GanaPatiBot, MahaDeviBot (Figure 24), and the Clappers (Ajay Kapur et al. 2010). Events were sent to the robots via midi messages over a network server.

4.2 Performance

The performance was presented at the Machine Lab on December 13th, 2012 as a part of the "Meet the Bots" concert. The duration of the piece was about 5 minutes, and about 40 – 50 audience members were in attendance. The room was completely dark because the clappers have LEDs built in that light up when they are triggered. The other robots were lit by LEDs attached to actuators. The performers were lit by laptop screens and desk lights.

Prior to the performance, the EEG scanner stopped communicating its USB dongle. This led to a 6-8 minute delay in the start of the performance. The stress caused by this delay effected the initial interaction between performers in the system, in that the performer had little control over brain wave fluctuation. The system should have been able to account for this, but an over quantization of data caused for some difficulty.

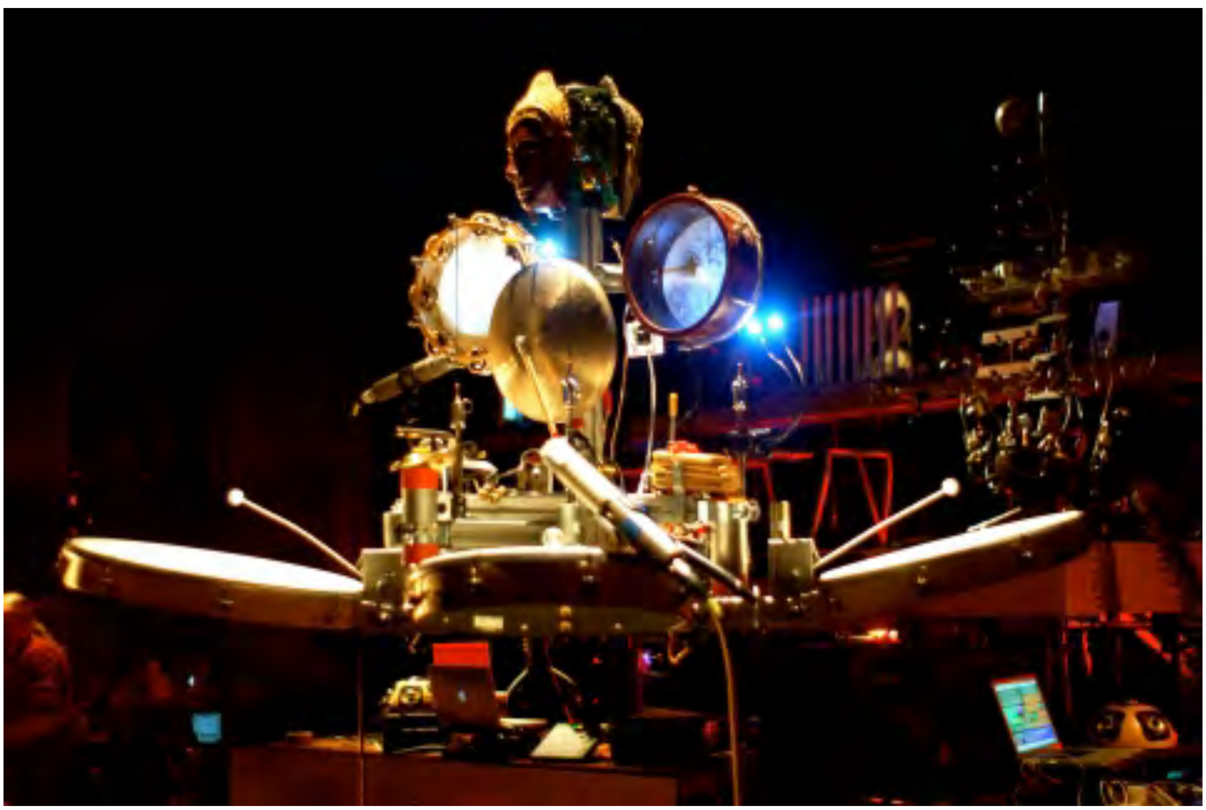


Figure 24: MahadeviBot

The blinking mechanism worked quite well, yet there were a few occasions where they didn't work as intended. Outside of aesthetic considerations for this performance, Machine Learning algorithms performed well in classifying other gestures through EEG data and would have worked better.

4.3 Conclusion and Reflections

This chapter has presented the Kronos project, a project designed to implement the brain and robots in an interactive music system. A performance at the CalArts Machine Lab was the conclusion of this project. It's construction led to the creation of a new machine learning based algorithm, the Christopher-Vallis Neural Network (CVNN).

The CVNN algorithm showed incredible results. In the initial test of the system it was shown that after a short period of time, as a result of biofeedback, the user gained fine control in the selection of specific actuators and their triggering. This created a highly interactive and interesting musical situation. It created the sense of dialogue between the user and the robots that is often experienced by performers and their instruments. This connection supersedes bio-chemical description (see 2.3.3). The brain showed a remarkable ability to adapt and gain expert like mastery in a system of 3 robots with a combined 40 actuators (refer to Dreyfus's description of expert in 2.3.2). With this, the CVNN proved to be an effective way of expressing and encouraging the transcendent.

The Kronos Project was successful in implementing the transcendent in technological art. This project made way for further research into developing algorithms with biofeedback, giving rise to an interest in the exploration of affect in large groups of people as a means of community-driven diffuse biofeedback. This led to the development of a project in Affective Computing.

Chapter 5

Mood and Creativity

Affect is essential to human intrapersonal and interpersonal interaction; as such, affect plays an important role in how individuals experience the world and apply themselves in activities. Research has shown that environmental factors can have a major impact on affect. For artists, it is important to work in environments that are conducive to creativity. An artist's studio is often designed not only to facilitate the end goal of producing works, but also to facilitate the lower level processes of creative inspiration and ideation (in a way that directly and affectively contributes to the artist's creative output). Since the Académie des Beaux-Arts first organized art education in Paris in 1648, art education has moved from the Atelier method of master-apprentice workshop training, to formal institutionalized education in specified artistic disciplines. As it is known that environmental factors play a significant role in affect, and affect plays a significant role in the act of creative ideation, imagine being able to design aspects of an art school based on information collected about the mood of art students in relation to certain environmental aspects. Such research could lead to a more creative artistic output and would be conducive to a creative community.

The field of Affective Computing is interested in using computers to recognize and recreate affect (PICARD, COMPUTING, AND EDITURA 1997). Researchers in the field of Affective computing have long been interested in the relationship between affect and creativity. Several studies have examined the interdependencies of these two phenomena and how they contribute to creative ideation. Sowden and Dawsen show the effect of mood on creative ideation and evaluation in (Sowden and Dawson 2011), and a direct correlation between positive mood and creative output is shown in (Davis 2009). Feist examines several theories about affect and creativity in artists, and valuable insight illustrating that both positive and negative affect can contribute to increased levels of creativity in artists (Feist 1999). There have also been studies that show the impact of affect on academic performance in educational settings. These studies question how affective environments can contribute to better learning in schools and a higher level of academic production from students (Kort, Reilly, and Picard 2001; Craig et al. 2004).

Furthermore, studies have investigated the effects that moods induced from art, specifically music, have on creativity. Adaman and Blaney show that elated subjects scored significantly higher than depressed subjects in creativity, and that both of these groups outscored neutral subjects (Adaman and Blaney 1995). Also, some have criticized the traditionally accepted connection between positive mood and creative output, illustrating that in some cases positive mood may impair creativity, where as negative and neutral moods could enhance it (Kaufmann 2003; George and Zhou 2002).

The study described in this chapter aims to examine the correlation between mood and creativity in an environment that is specifically established, and dependent, upon the fostering of artistic creativity in individuals: A college for the arts (specifically, California Institute of the Arts). This research places affect in an environment that has a large dynamic of creative output. It examines how the relationship between affect and the environment corresponds to creativity in students from different artistic fields, and provides insight on whether the relationship between mood and creativity in artists, differ from that of previous understanding.

Section 2 of this paper describes two methods employed in collecting mood and creativity data for analysis. It also describes several analysis methodologies used. Section 3 describes the results of the data analysis in each employed collection method. Lastly, Section 4 discusses the results and possible implications of this research.

5.1 Motivation and Related Work

There seems to always be this tension in society between conformism and individuality. Many in the favor of individuality, passionately reject any notion that human behavior can be described in terms of any formula. Likewise, behaviorists often lean toward human behavior being highly formulaic and influenced by external and internal stimuli. As described in 1.1, it is possible for humans to exist in multiple "dimensions" simultaneously, and therefore to be influenced by several internal and external drives, which can create behavioral patterns seem to emerge in certain contexts.

Philip Ball, in his book *Critical Mass* (Ball 2006), suggests that even in the face of free will, we might be able to make predictions about the collective behavior of people using a "physics of society". Ball, suggests that this is possible without proclaiming to know the exact cause of particular behaviors in individuals, and that his "physics of society" could accommodate such transcendent characteristics. Ball also points to several historical figures philosophized on applying principles of mathematic and physics to society; of those including Thomas Hobbes (Hobbes 1969).

Heidegger proposed a concept, "Das man" (The One) (Heidegger 2008), also seems to explain why the patterns in society seem to emerge. The One, in Heideggerian philosophy, is a mode of inauthentic being, in which the individual chooses to do things because it is as "one does" or "as people do" in a given context (e.g. cultural). "Das Man" is one of our primary ways of being in the world and being with others.

5.2 Method

5.2.1 System Design

This system employed in this research was designed to measure affect, specifically mood, in an art school. Two collection methods were used: sticky notes, and QR codes. Through these methods, students would record information concerning their current mood, which would then be added to a database for analysis (Figure 25).

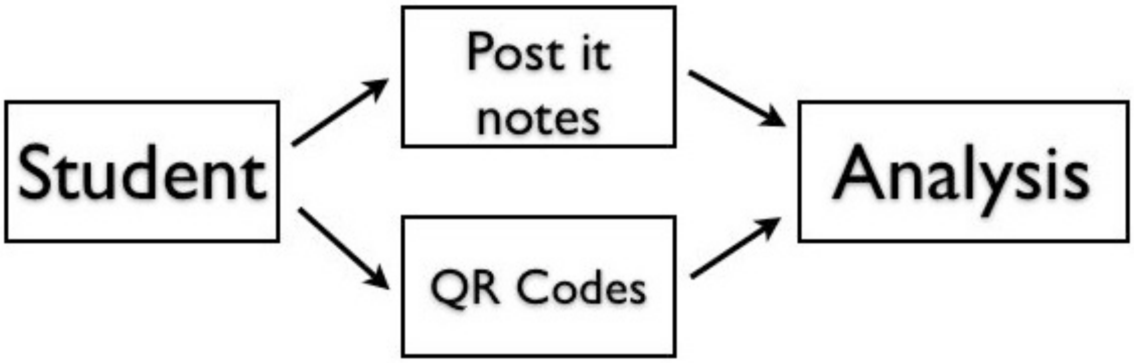


Figure 25: System Overview

5.2.2 Data Collection

This section describes two methods used for collecting the user data used throughout this research.

5.2.2.1 Sticky notes ("Post-it notes")

In the sticky note method, participants were ask to place sticky notes on different locations throughout the hallways at California Institute of the Arts (CalArts). The color of the notes were to correspond with specific mood indicators (Orange = Negative, Yellow = Neutral, Green = Positive). In the contents of the notes, participants were asked to include a timestamp and a short reflection on their current mood.

In addition to the data collected for the notes themselves, information was collected about the size of the hallway where the notes were placed (small, medium, large). This parameter was computed by comparative analysis with the other hallways in CalArts.

Instructions were provided on posters alongside the sticky notes to inform students how to fill out and participate (Figure 26). An initial thirty-five posters with these instruction and sticky notes attached were placed throughout CalArts. Sticky notes were replenished throughout the duration of the study, which took place over the course of 4-weeks.

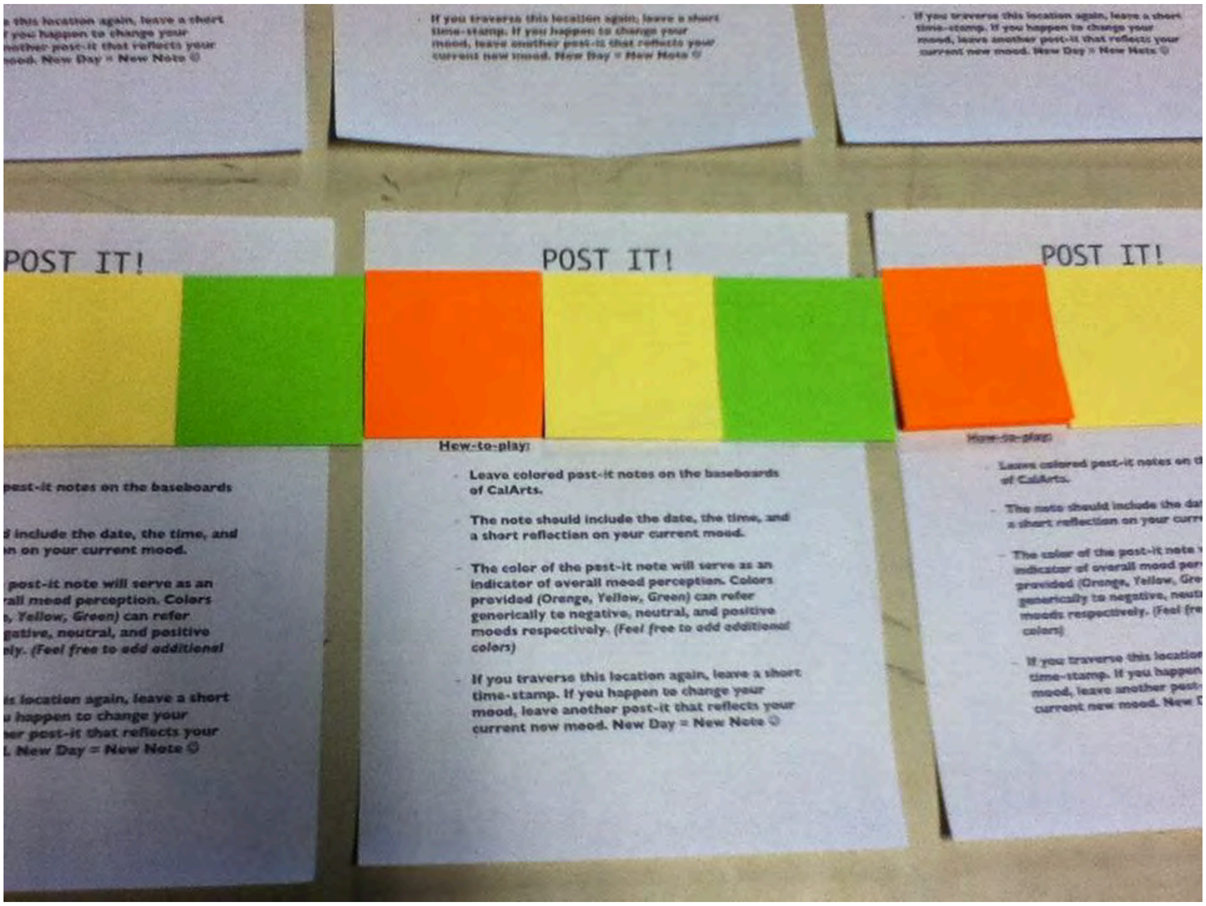


Figure 26: Sticky notes and Poster

5.2.3 QR codes

The QR code method allowed students to scan a QR code poster in their respective school that was indicative of their current mood (Negative, Neutral, Positive). Scanning the QR code with their phone or other mobile devices would direct the student to a short web-based questionnaire. This form asked four questions: 1) The students gender (male/female), 2) the number of people present in the hallway (0-2, 3-5, >5), 3) the option to add a more specific mood descriptor, and 4) how creative the student was feeling (scale: 1-5, with 1 being not creative, and 5 being extremely creative). Additionally, a benefit of using the QR code and digital form technique is that the form automatically provided a timestamp for each submission.

Six initial posters (as shown in Figure 27) were posted in two selected hallways within five departments (Animation, Dance, Music, and Theater). Additionally, instructions on how to scan the QR codes and recommended mobile applications were posted next to the QR code posters. The project was advertised in daily school announcements, bulletins, and via social media.

Figure 27: QR Codes Poster

5.2.4 Analysis Methodology

Statistical analysis of the data collected from the sticky note and QR code methods was performed. Data from the sticky notes had to be manually aggregated into a usable analysis format, in this case an excel spreadsheet. A benefit of using a simple technology such as QR code scanning was that the QR code method used Google forms which automatically collated the data entries into a spreadsheet ready for statistical analysis.

5.3 Results

In this section, the results of the analysis are presented and interpreted. The results show the distribution moods in relation to the time of day, the size of the hallway, and the activity levels in the hallway. This section goes on to show the relationship between affect and creativity in this study, and how moods differed between disciplines.

5.3.1 Time of day and Mood

Students at CalArts have 24-hour on-site access to facilities and university resources. It is common to see students walking the hallways at 3am, or hard at work in their studios at any point in the day or evening. As such, it was important to investigate the relationship between the time of day and mood. In compiling this data, it was found that the submissions could be categorized into four time segments: Early Morning, Morning, Afternoon, and Evening.

"Early morning" refers to the hours between 12AM and 6AM. During these hours, the data showed that 47% of the moods were negative, 24% were neutral, and 29% positive. "Morning" refers the time between 6AM and 12PM (noon). During theses hours, the data showed that 44% of the moods were negative, 39% were neutral, and 17% were positive. "Afternoon" refers to the time between 12PM and 6PM. During these hours, the data showed 30% negative moods, 19% neutral moods, and 51% positive moods. "Evening" refers to the time between 6PM and 12AM. The data showed 39% negative moods, 22% neutral moods, and 39% positive moods. These results are summarized in Figure 28.

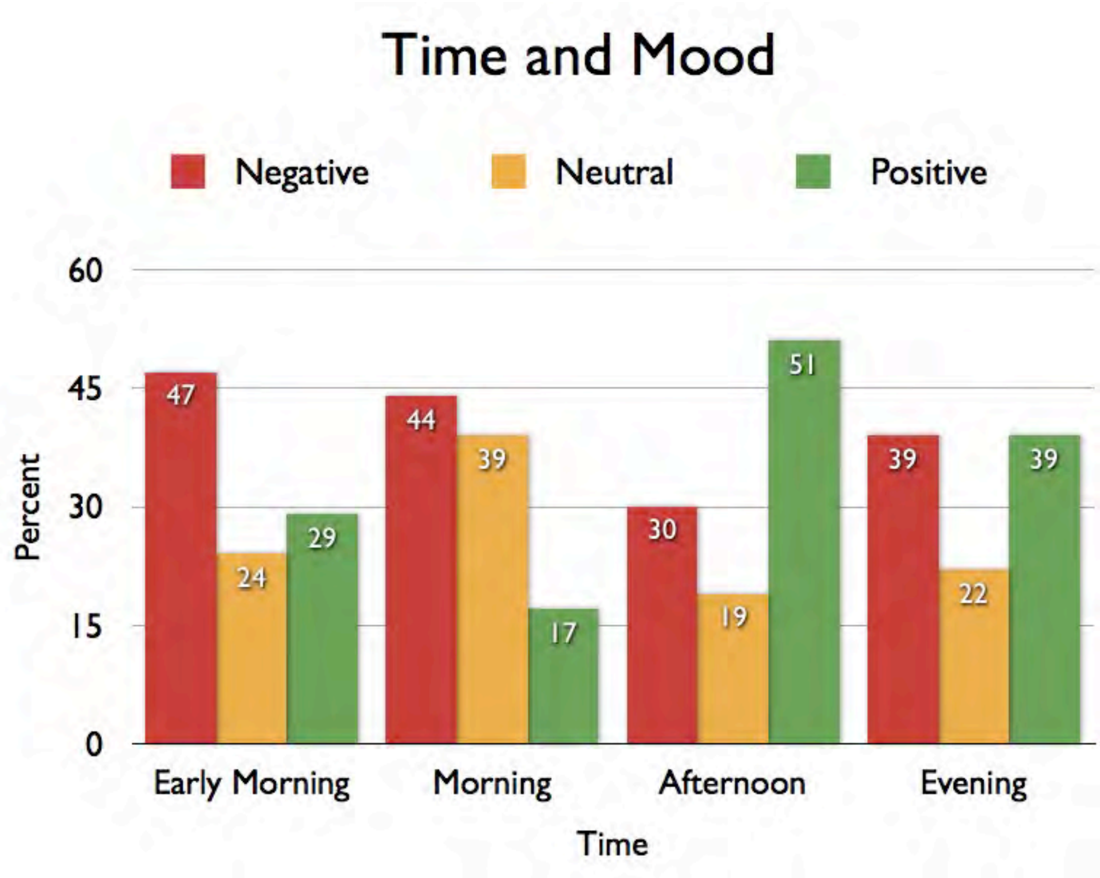


Figure 28: Time of day and Mood

Interestingly, the "Afternoon" ranks the most positive (51%) time period at CalArts, and also the period with the lowest percentages of negative (30%) and neutral moods (19%). The analysis shows that as time sequences forward from this point, positive mood decreases, as negative and neutral moods increase until it reaches the opposite end of the polar spectrum in the "Morning". In the morning time, negative moods are at there second highest percentage (44%, which is a 3% decrease from "Early Morning" reports), neutral data is its highest percentage (39%), and positive data is at its lowest percentage (17%).

As an observation, the cafeteria at CalArts is most active at noon, with individuals often flowing out the doors. The campus is seemingly more awake, and openly social than other time periods as well. One factor could be that this fulfilling of physiological needs enhances the amount of positive mood (Cabanac 1971). Higher percentages of negative moods recorded in the "Early Morning (47%)" and "Morning (44%)" could be the result of several factors.

The "Early Morning", as many of the sticky notes revealed, is often dedicated to the completion of scripts, editing of films, and late-night recording sessions, all of which are tasks that can cause large amounts of stress or exhaustion (see E). Medical studies have shown that college "all-nighters" can further compound the amount of stress and depression in these students (Voelker 2004). Furthermore, the lack of sleep can be a contributing factor in the high number of negative moods reported in the "Morning". Another factor that can contribute to these numbers are a lack of proper breakfast, as many students at this time period opt not to eat because of tiredness (Smith, Clark, and Gallagher 1999).

5.3.2 Hallway size and Mood

Building off prior research that shows the implications of architectural design on mood, data was collected about the size of the hallway for each submission received, both through the sticky note and QR code methods. This data was aggregated and used to form an image of how the size of the hallways could relate to the moods of students (and ultimately, levels of creativity).

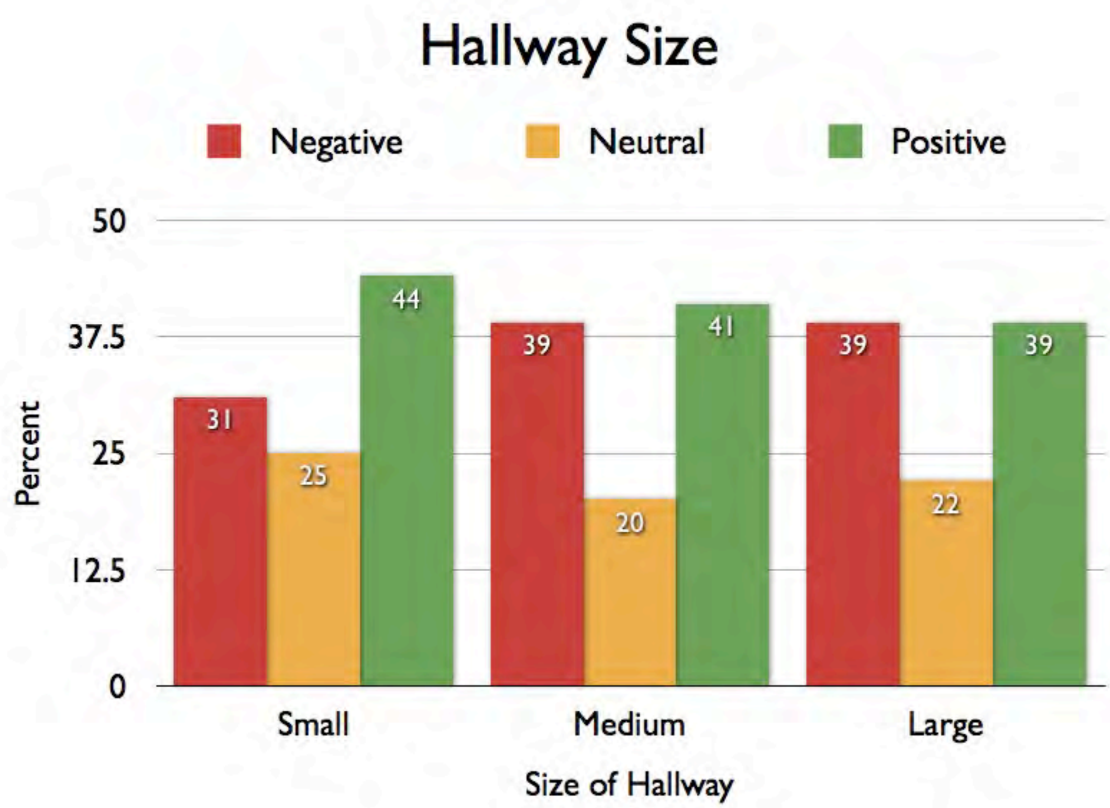


Figure 29: Hallway Size and Mood

The results show that the different hallway sizes were fairly similar in mood distribution. Small hallways showed 31% negative, 25% neutral, and 44% positive moods. Medium hallways showed 39% negative, 20% neutral, and 41% positive moods. Large hallways showed 39% negative, 22% neutral, and 39% positive moods. These results are summarized in Figure 29.

On average, students exhibited around 22% neutrality in mood in all three hallway sizes (small, medium, and large). Smaller hallways contributed to a 5% increase in positive mood when compared to larger hallways (44% vs. 39%), as well as an 8% decrease in negative mood. This shows that in artistic learning environments, smaller hallways may result in increased levels of positive mood. While small and medium sized hallways were less polarizing than small and large sized hallways in terms of positive mood (only a 3% decrease for medium sized hallways compared to small), medium sized hallways exhibited an 8% increase in negative mood in the students compared to smaller hallways.

5.3.3 Activity Level

Activity level refers to the number of individuals present in a given hallway at the time in which a student was inputting their mood data. Participants were asked to input data on how many people were present in the hallway (0-2, 3-5, >5) at the time in order to determine how activity levels could be affecting moods. The results show that activity levels of 0-2, and 3-5 had a polarizing affect on mood. Low hall activity (between 0-2 people present) resulted in 34% negative, 14% neutral, and 52% positive moods. More active hallways (between 3-5 people) resulted in 44% negative, and 56% positive moods. Highly active hallways with >5 people showed an even distribution of moods, 33% negative, 33% neutral, 33% positive. These results are summarized in Figure 30.

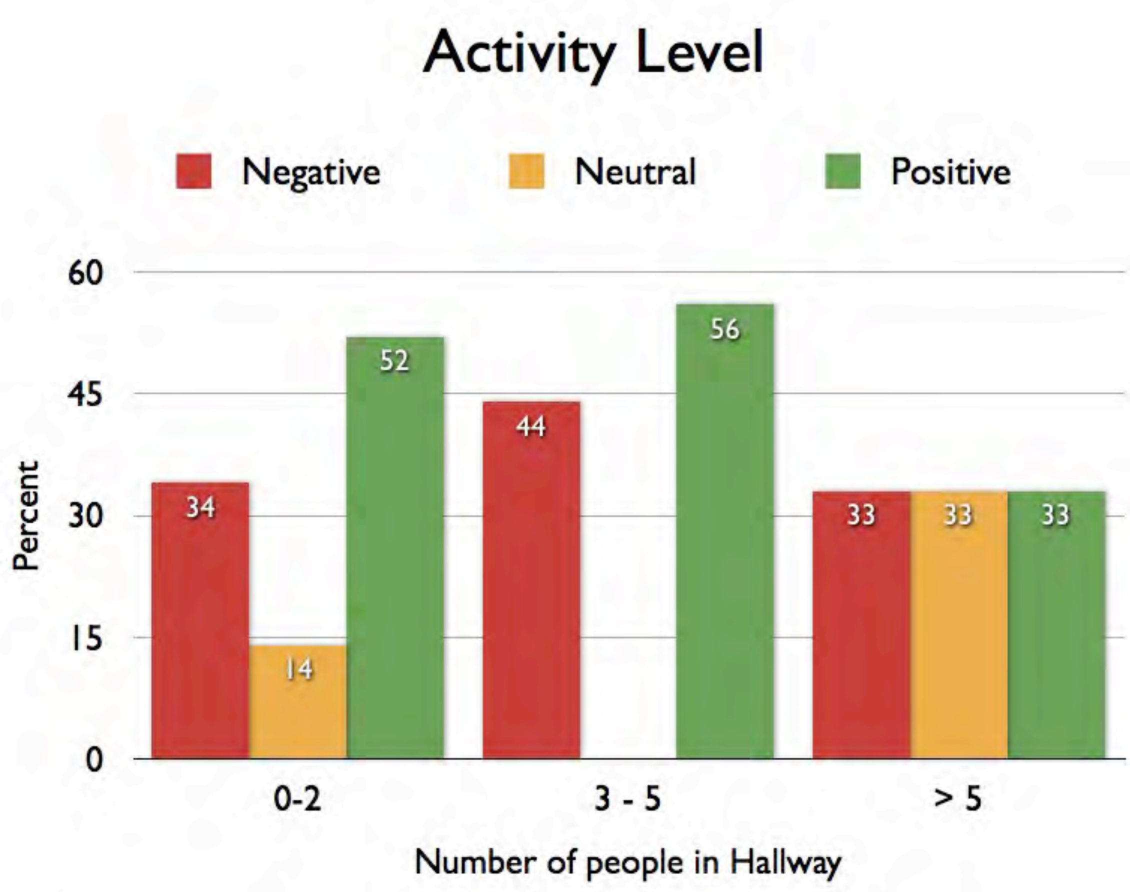


Figure 30: Activity Level and Mood

Lower activity levels show a polarization in the mood data (0-2: negative 34%, neutral 14%, positive 52%. 3-5: 44% negative, 56% positive). This polarization may be the result of a split between individuals preferring lower or higher amounts of social interaction. Even so, both levels showed higher percentages of positive individuals (with positive moods having a 19 percentage point advantage over negative mood in activity levels of 0-2, and a 12 point advantage in levels 3-5. The even distribution of moods in hallways with activity level >5, show a balance of people being social, indifferent, and less social.

5.3.4 Mood and Creativity

The life force of CalArts (and arguably that of any art institution) is the creativity of its students. It was important to see what role mood had in students artistic creativity. Participants were asked to rank their level of creativity on a scale of 1-5, 1 being the least creative and 5 being the most. As shown in Figure 31, 80% of those who felt the least amount of creativity reported being in a negative mood, while the remaining 20% were neutral. Those who ranked the second least in creativity reported 55% negative, 11% neutral, and 33% positive moods. Those who ranked third in creativity levels (median creativity levels) reported 35% negative, 11% neutral, and 57% positive. Those who ranked fourth in creativity level reported 11% negative, 23% neutral, and 66% positive moods. The students ranked most creative reported 100% positive moods.

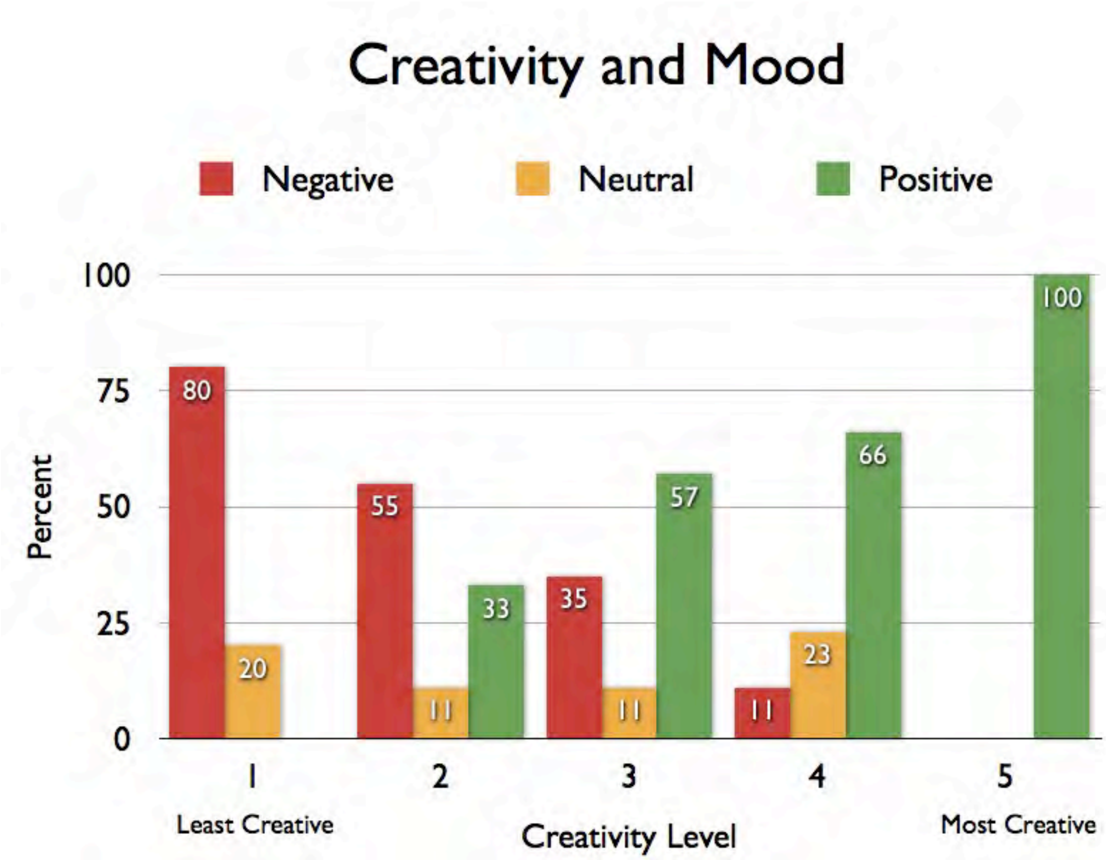


Figure 31: Creativity Level and Mood

These results largely confirm the traditionally accepted notion that positive mood enhances creativity [3], showing, almost uniformly, positive moods correspond to higher levels of creativity and negative moods to lower levels. In level 3 on the creativity scale (35% negative, 11% neutral, 57% positive), the median, a mood percentage reversal is observed with that of level 2 (55% negative, 11% neutral, 33% positive). From left to right, it is clear that creativity increases as a function of mood levels changing from negative to positive.

5.3.5 Mood Descriptors: What people were "feeling"

Participants were asked to further describe their mood by selecting a word from a list of common mood descriptors reported on a preliminary sticky note study and descriptors taken from other mood studies (Strapparava and Mihalcea 2008; Mishne 2005; Gill et al. 2008) (optionally, they could add their own descriptor). These results are shown in Figure 32.

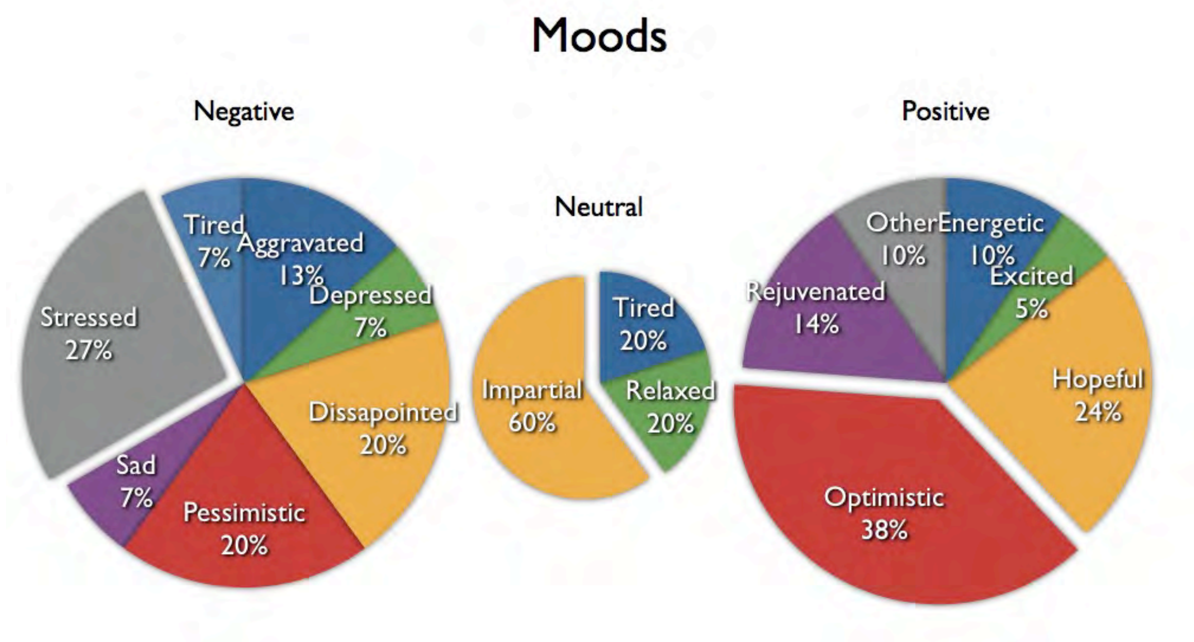


Figure 32 Mood Distribution

An analysis of the moods shows that stress (27%), pessimism (20%), and disappointed (20%) were the three leading factors resulting in negative moods. Impartialness (60%) was the leading neutral mood descriptor. Optimism (38%) and hopefulness (24%), made up 62% of the positive mood descriptors, leading the reported positive moods. Interestingly, the biggest factors negatively affecting the students' moods were related to stress and disappointment (rather than sadness or depression, which faired the least in negative mood), while positive moods were caused by factors in the future, namely optimism and hopefulness (as opposed to happiness which scored in the bottom 10% of "other").

5.3.6 Mood and Discipline

Like many art schools modeled in tradition to the Académie des Beaux-Arts, CalArts is an interdisciplinary institution made up of many different programs or disciplines; therefore, it is important to examine how the mood results varied between artistic disciplines. While the university itself encourages interdisciplinary work and projects, the building is separated into wings by discipline. As mentioned previously, hallways were chosen in different departments, and they are most frequented by students in those respective programs.

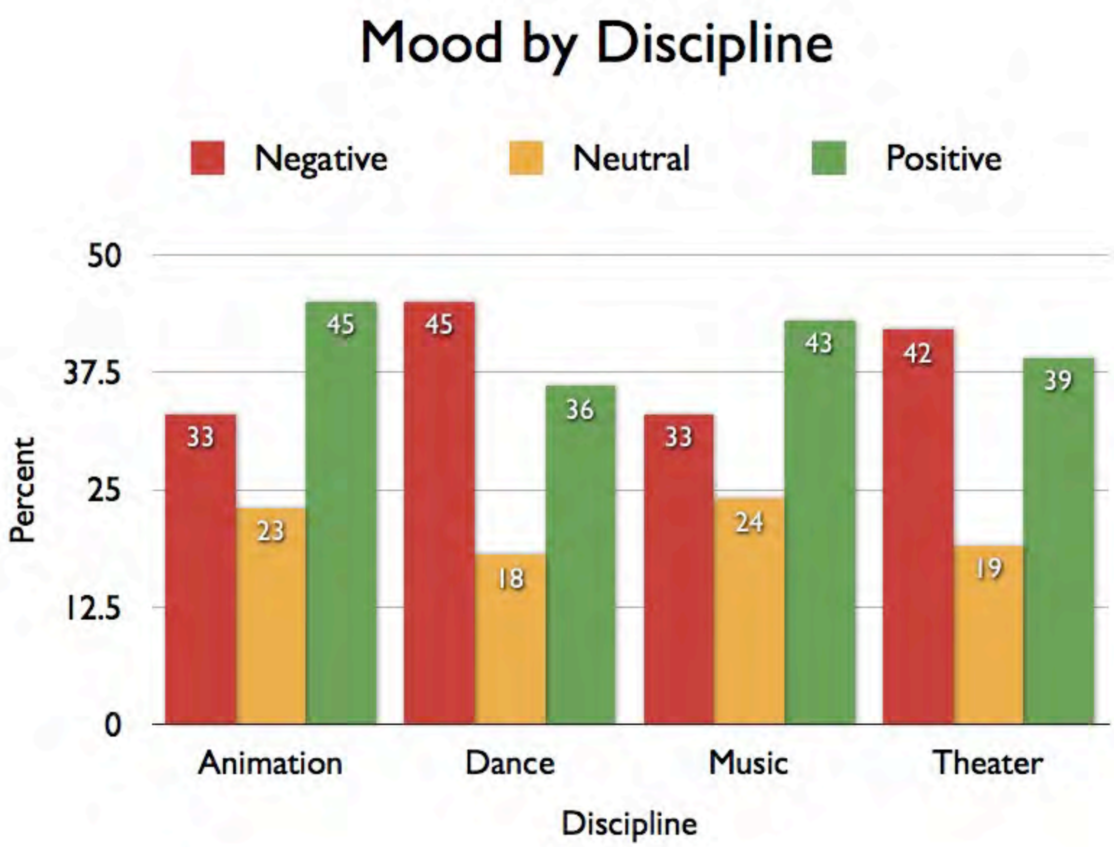


Figure 33: Mood by Discipline

The four disciplines analyzed in this study can be grouped into 2 categories based on their similar results: animation and music, and dance and theater. The results of the dance (45% negative, 18% neutral, and 36% positive) and theater (42% negative, 19% neutral, and 39%) disciplines reveal only a slight margin (3% max.) of deviation from each other in moods. They also both show higher percentages of negative moods than positive moods. Interestingly, these two disciplines are generally the most physically taxing, and most often require the longest hours. They also have some of most rigid scheduling. A lot of the projects in these disciplines are also group projects (e.g. theater productions, choreographed productions).

The results of the animation (33% negative, 23% neutral, and 45% positive moods) and music (33% negative, 24% neutral, and 43% positive) discipline were also very similar. Students of these two disciplines exhibit similar behavioral patterns, often working on personal projects, or working privately in studios and practice rooms. These results are in accord with the work of Anthony Kemp, who has examined the association between musicians, introversion, and independence (Kemp 1996). Additionally, the scheduling in these schools typically allow for more flexibility in course selection.

5.4 Discussion

5.4.1 Challenges of collecting data

Collecting mood data using the sticky note and QR code methods presented different challenges. The sticky note method created a huge mess throughout the hallways at CalArts, and often did not stick to the wall surfaces for very long. Additionally, students were observed removing notes from walls to read them, and not replacing them back on the wall afterward. Furthermore, many students would forget to leave either dates, or timestamps. Because of this, the authors were required to check for new notes at least at the end of every time-period, a moderation process that was both time consuming and inefficient. Empty stacks of sticky notes also often disappeared from intended dispensaries, requiring frequent replenishing. One unique byproduct that was both problematic and interesting was that posters and sticky notes often became sketchpads for artists.

A challenge that existed in both of the applied methods is that they required the participants to notice them, and to step away from their current occupations. Hallways are used as transit zones and many students might not stop to explore the content on walls, which means these methods could have possibly missed a lot of valuable data, simply because students did not notice them or just did not have time to participate. In addition, scanning the QR codes would require students to either have a Smartphone or other mobile device handy.

Ultimately, using QR codes was chosen as a simple technological improvement upon the sticky note method for a number of reasons. Firstly, different QR codes for negative, neutral, and positive could be generated for individual hallways in individual departments. This meant that the hallway and department were automatically known just by scanning the QR code. Additionally, the questionnaire submission was automatically time-stamped. All of this meant less questions and directions needed to instruct the participants to conduct the survey, while reducing the amount of time needed for the participants to actually complete the task. Lastly, using QR codes as the acquisition method enabled results to be collected in a form ready to be analyzed, whereas the sticky note method required manual data entry, and tedious intervention by the researchers.

5.4.2 Art school Architecture

The results presented in this study show that in an art institution, student mood is affected by environmental factors, and that mood is directly linked to a student's level of creativity. This is congruent with the findings of Spencer and Baum (Spencer and Baum 1997), who illustrate that design characteristics such as social density, referred to as activity level in this study, affect people both directly and indirectly. Thus it is important for art schools to think more strategically about their architectural design, in order to maximize the creative potentials of the student body. Just as office environments have incorporated space planning to maximize creativity and mental agility (Brookes and Kaplan 1972), its is crucial for art institutions to similarly do the same. Utilizing the results of studies in activity levels, such aspects as hallway placement and size, and in relation to the number of students, can be constructed in a way that is conducive to the creative and educational goals of the students and the school. CalArts could use this data to implement some design changes in order facilitate more positive moods, and thus higher levels of creativity, in the dance and theater. Design changes have been shown to increase positive mood in educational environments (Weinstein 1979).

5.4.3 Schedule Optimization

As this study has shown, hallway activity and time of day also affects an art student's mood and creativity. With this in mind, course schedules can be designed to take advantage of results collected both about hallway activity, and also about the time of day. Considering how mood, and thus creativity, can be affected by the time of day can help further optimize student and course schedules in order to increase levels of productivity and creative ideation.

Classroom size determinations can consider the relationship between creativity and activity levels. The results (in section III.C) collected from data show that smaller class size could lead to increased amounts of creativity from the students.

5.4.4 Artistic Mood

Different studies have suggested that some artists exhibit strong relationships between positive mood and increased levels of creativity [4], and others, that negative affect could lead to high levels of creativity (Akinola and Mendes 2008; Kinney and Richards 2007). While this relationship may certainly exist for artists, the results of this study strongly suggest that in an educational context positive mood is directly related to increased creativity, and negative mood diminishes creativity. This means that positive affect is important consideration in the creation of institutions, such as art schools, with the goal of supporting creativity ideation in their student body.

5.4.5 Future work

The results of this research have provided valuable data for consideration in art school development and planning. It has reaffirmed several standing theories about the relationship between affect and creativity, while providing more detailed look into some environmental aspects that contribute to affect in artistic learning environments.

This research could benefit from even more affect data and perhaps further question. An interesting survey could ask students to specify what time they normally feel most creative and see how that data corresponds to the results formulated. It could also be interesting to analyze how results differ over larger scales of time such as days or weeks, and further analysis into the difference between artistic disciplines.

Chapter 6

Conclusion

6.1 Summary

This thesis has presented three projects that were developed with the intent of accounting for the transcendent aspects of life in technological art. The ideas of "Transcendence", and "Art" were given context in the philosophy of Heidegger. Heidegger's concepts of "Poeisis", "Techne", and "Aletheia" served as grounding in the pursuit of this transcendent in technological. Algorithms and explicit execution in programming languages were identified a challenges to realizing this goal, however it was shown that it is possible to realize implicitness through these languages, and that they had been evolving in ways that account for more metaphorical expressivity.

Machine learning and biofeedback were presented as methods for implementing the transcendent in technological art. The three projects introduced in this work were centered on these concepts and their integration into couple systems. In the digital organism project, biofeedback was implemented loosely in the construction of the visual organism and strongly in the sonic component, while machine learning was used as a way to create interaction and autonomy in the organism's motion. The Kronos Project relied on biofeedback and the integration of machine learning into a highly interactive system called the "Kronos Model for Mind Interaction". The implications of the Mood and Creativity forsee the affect of large groups of people, in an environment, as the source of biofeedback.

6.2 Final Thoughts

After two years of working on these projects, I feel a lot has been accomplished in realizing the transcendent in technological art. Discoveries such as the CVNN (4.1.1) have been made through this work, which opens the door for further investigation and integrations of biofeedback in machine learning systems. Art schools can benefit significantly from the research in the Mood and Creativity study, which shows that positive affect is directly related to increased creativity. The digital organism project has significant implications on the awareness of other organisms, and environmental impact.

Still, the methods discussed in this thesis are only a couple of ways in which the transcendent can be accounted for in technological art. The fact that music is made using modern technology, can say a lot towards implementing the transcendent in modern technology. Different people perceive music, regardless of its intended purpose, differently. However, it is also true that lack of conscious awareness can lead to mechanical thought and rigid perception, which presents a problem when one wants to account for the transcendent aspects of life in art (Chapter 1). Thus, it is not enough to simply create music with modern technology, all technological artists should be encouraged by the examinations and works presented in this thesis to seek out ways of accounting for the transcendent in their own art.

6.3 Future Work

The research presented in this project will be further developed in my PhD research in Computational Neuroscience/Neural Engineering, Electro-Physiology, and Mechatronics at Victoria University of Wellington, in the Engineering and Computer Science Department. Further questions brought forth by this research will be explored, such as "To what degree of control can we gain over the live creation of music through the possessing of brain data with existing machine learning algorithms?" and "Can more sufficient algorithms be designed for feature extraction and brain data classification towards this goal?". Projects that can be further enhanced by this research include the Kronos project, which could see advancement in the CVNN algorithm (4.1.1), and also robotics ergonomically designed for the algorithms implementation. Furthermore, more sufficient EEG devices could be designed for implementation of biofeedback.

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